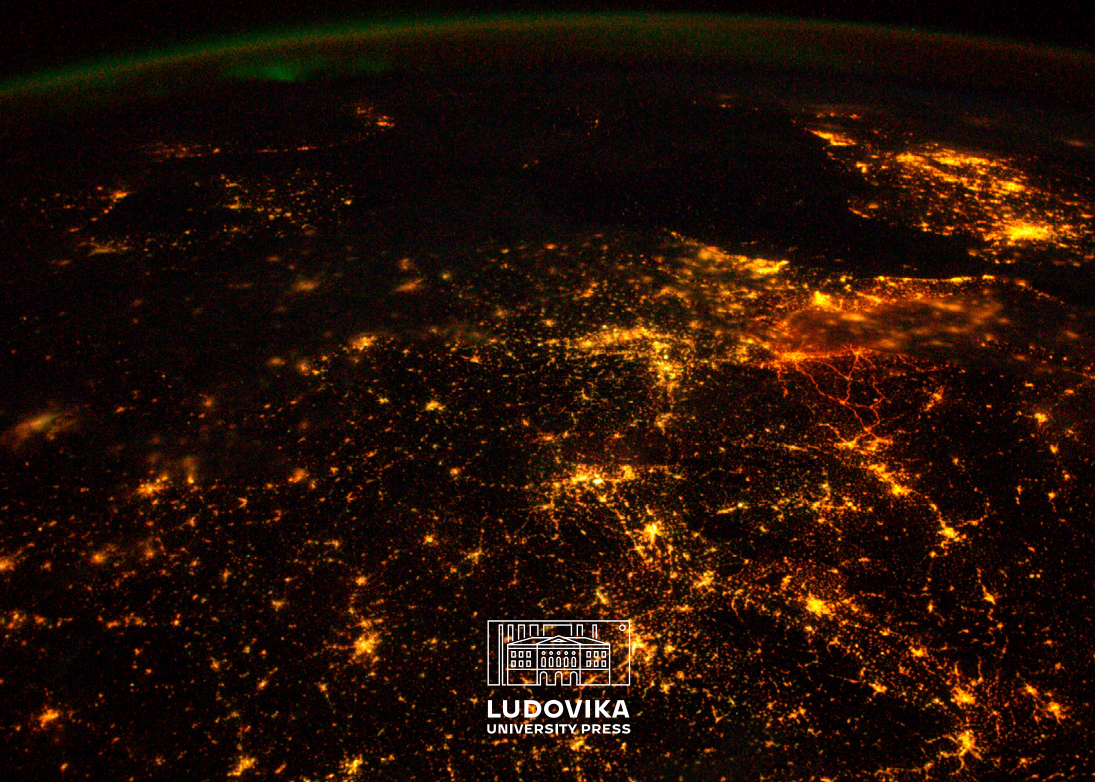
The New Space Age
Legal and Policy Perspectives

Edited by

Balázs Bartóki-Gönczy – Gábor Sulyok



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Contents

Editors' preface

Space applications and services have become an essential part of the everyday life of humankind in recent years. While the second half of the 20th century saw the beginning and gradual development of space activities, mostly in the context of rivalry between the superpowers, the first decades of the third millennium have brought about a development of unprecedented intensity, mainly due to the increasing involvement of private actors. Even though it remains the case that few actors possess autonomous launch capabilities, more than ninety states, almost half of the international community of states, already have some kind of space experience. The global space economy is continuously and dynamically growing, and has proven to be extremely resilient; according to certain forecasts, its value may reach one trillion U.S. dollars within fifteen years. As outer space is becoming increasingly contested, congested and competitive, and as space systems are increasingly regarded as critical infrastructures, sensitive questions and considerations relating to defence and security are unavoidably emerging, further complicating the overall picture.

The normative framework of space activities must adapt to these new realities and challenges. Although selected national legislations have begun to react to the altered circumstances, international regulation in this area has barely changed in the last fifty years, leading many commentators and stakeholders to openly question its effectiveness. Keeping in mind that the prevailing geopolitical environment is rather unfavourable for the further development of international space law due to a lack of consensus on most of the topical issues, it is more important than ever for the scholarly community to engage in a constructive and progressive dialogue in an effort to propose feasible solutions to political decision-makers. Equally important is the task of educating the future generations of space lawyers and policy-makers.

These ambitions led twenty-five academics and professionals to contribute to the present volume on the legal and policy perspectives of the new space age. The twenty-three chapters in this book cover four main topics. The first part presents a panoramic view of the new space age, followed by three further parts discussing the topics of regulation, sustainability and defence.

This book could not have been completed without the essential support of several outstanding colleagues. We would like to seize this opportunity to express our sincere gratitude to Mónika Ganczer, Philippe Ch.-A. Guillot, Heinrich Kreft and András Mező for their thorough and constructive reviews, to the Ludovika University Press for their professional work and guidance, and to Kincső Enikő Gyalog, Barbara Horváth and Borbála Telek-Huszár for their continuous and invaluable assistance. We are also grateful to the National Media and Infocommunications Authority for the generous financial support.

Together with our co-authors, we sincerely hope that the present volume will make a valuable contribution to the ongoing scientific discourse, and that it will benefit not only academics and professionals, but also students who are interested in space law and policy. It is most likely that it will be the task of these students to find solutions to many of the problems discussed in the present volume, and to continue, improve and complete the work of the preceding generations.

Budapest, 15 September 2024.
Balázs Bartóki-Gönczy and *Gábor Sulyok*

Foreword
A Global Shift in Space Governance

INTRODUCTION

The global space ecosystem is experiencing an unprecedented revolution, largely driven by the emergence of New Space. This term refers to the new wave of commercial space activities spearheaded by private companies, which have introduced innovative technologies, reduced costs and increased the accessibility of space. New Space has transformed the space industry, once dominated by government space agencies and traditional aerospace companies such as Boeing, Lockheed Martin and Arianespace, into a competitive market where private entities play a central role. New Space began in the United States (U.S.), where companies including SpaceX, Blue Origin and others pioneered advancements in space launch technologies, satellite communications and human space flight. These private actors, supported by public–private partnerships, have reduced costs and accelerated access to space, making space activities more attractive to private investment. The success of New Space in the U.S. has prompted other nations and regions to follow suit. Europe, where the private sector has been encouraged by new space policies, China, with its expanding commercial space industry, and nations such as India and Japan, have also embraced this trend. The global expansion of New Space marks a new chapter in space exploration and utilisation, but it also challenges the international legal framework governing outer space, as the traditional space law framework, designed to regulate state actors, is now being applied to private enterprises engaged in space activities.

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LEGAL FRAMEWORK AND STATE RESPONSIBILITY IN SPACE ACTIVITIES

Space activities remain tightly regulated under international law, particularly by the Outer Space Treaty of 1967. Despite the impression of legal disorder brought about by the rapid expansion of New Space, the sector continues to operate within a well-established legal framework that places the State at the centre of space governance. The Outer Space Treaty provides the foundational principles governing outer space. Several key articles in the treaty directly relate to private space activities and the responsibilities of states.

Article VI of the Outer Space Treaty establishes that states bear international responsibility for national space activities, regardless of whether they are conducted by governmental or private entities. This means that even if a private company conducts space operations, the state under whose jurisdiction the company operates is responsible for ensuring that these activities comply with international law. States must supervise and regulate private space activities, which has led to the adoption of national space laws and authorisation regimes to ensure adequate oversight of the private sphere.

Article VII extends state liability to damage caused by space objects. The launching state is internationally liable for any damage caused by objects launched into space, regardless of whether the operation was conducted by a government agency or a private entity. This principle ensures that states remain accountable for the actions of their private operators in space.

Article VIII establishes that the state which registers a space object retains jurisdiction and control over the object in space. This ensures that the state applying for the launch remains responsible for the space object, and its legal and regulatory framework governs the object.

These articles collectively ensure that, while private actors can operate in space, states remain responsible for supervising and controlling their activities. Many countries have introduced national space laws that require private companies to obtain authorisation before engaging in space activities, to ensure compliance with international obligations.

THE LEGAL DISARRAY OF NEW SPACE AND THE NEED FOR AN UPDATED FRAMEWORK

While the international legal framework under the Outer Space Treaty provides a solid foundation for the regulation of space activities, the rapid expansion of these activities, particularly through New Space, has created legal uncertainties that must be addressed. Developments such as the proliferation of satellite constellations, CubeSats, and the prospect of resource exploitation on celestial bodies have created complex legal challenges.

With the surge in the number of satellites, especially mega-constellations like SpaceX's Starlink, concerns about space debris, collisions and radio frequency interference have grown. Moreover, the lack of comprehensive international regulations to manage space traffic and prevent collisions between objects in orbit poses a risk to the sustainability of space activities. Space traffic management (STM) is an emerging field requiring international coordination to prevent space congestion and mitigate the creation of debris.

The legal regime surrounding the exploitation of resources from celestial bodies, such as the Moon or asteroids, is another area of contention. The Artemis Accords, signed in 2020, led by the United States, aims to promote international cooperation in the exploration of celestial bodies and resource utilisation. These agreements are seen by some as conflicting with the 1979 Moon Agreement, although only 17 countries have ratified that treaty. The Moon Agreement suggests that the Moon and other celestial bodies are part of the "common heritage of mankind", implying that any benefits deriving from their exploitation should be shared among states parties. This tension between differing legal frameworks raises questions about the governance of space resources and the potential for conflicts of interest between nations.

Another legal challenge is the possibility of "flags of convenience" in space, where companies register space objects in countries with less stringent regulations to avoid oversight. Similar to the practice in maritime law, this could lead to regulatory loopholes that undermine the safety, sustainability and equitable use of space.

In response to this revolution, there have been significant legal and regulatory advances. The International Telecommunication Union (ITU) has adapted a set of Radio Regulations to introduce specific provisions for satellite constellations and CubeSats, addressing the challenges posed by the growing number of satellites in orbit. Additionally, at the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS), a working group has been established to examine the legal regime governing the exploitation of resources on celestial bodies. However, discussions on establishing an international Space Traffic Management (STM) regime – essential for coordinating the increasing volume of space traffic – are more challenging, as such a system would need to be inherently international in scope and enforcement.

At the same time, the private space industry is increasingly pushing for a seat at the table in the development of space governance. Companies involved in New Space recognise the importance of helping shape the norms and regulations that will govern future space activities. This involvement marks a shift in how space law is traditionally developed, with private actors now playing a more active role alongside governments in defining the rules for space operations. As New Space disrupts the traditional model of space law development, the industry itself is advocating for a more agile, collaborative approach to regulation.

CONCLUSION

The rapid rise of New Space poses an important question: is this new era of space exploration and utilisation a true advancement for humanity, or does it represent the increasing control of private interests over a shared resource? While the innovations brought by private companies have undeniably accelerated space access, are we witnessing the unchecked exploitation of space and a technological race that risks losing sight of the broader purpose of space exploration? The possibility of overexploitation raises alarms about the sustainability of space for future generations. In this context, only the adoption of a comprehensive international legal framework can ensure that New Space develops harmoniously, in line with the spirit of the Outer Space Treaty. Article I of the treaty reminds us that the exploration and use of outer space shall be the province of all humankind, and its exploration and use must be conducted for the benefit of all states, irrespective of their level of technological development. To uphold this principle, it is essential that the international community comes together to establish updated legal norms that respect the collective interests of humanity while fostering responsible technological advancements.

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Part One:
Panorama

Marco Ferrazzani – Hristina Talkova

Legal Perspectives for New Space Business Ventures in Europe

INTRODUCTION

Space has long ceased to be the sole domain of governmental actors. New technologies and continuous advancements in space-based end-to-end services fuel the development of space applications, and new business opportunities are emerging in relation to space data exploitation. The commercialisation movement is already well established in the United States, and the markets in other spacefaring nations, including in Europe, are mirroring this evolution. Public actors have been gradually making room for commercial undertakings, which also opens up a variety of legal questions related to new collaboration models as the European space landscape is also becoming increasingly diversified, with numerous new services in development. With the prospect of increasing revenues from both commercial and institutional applications, numerous players, new market entrants and established actors alike are trying to position themselves on this new market.

The European Space Agency (hereinafter: ESA) has been not only a witness but an active participant and collaborator in European commercialisation efforts in the past years. It offers an important platform for creating new opportunities and concepts that intend to allow the European industry to realise its full potential. As an international intergovernmental organisation, the mission of ESA is to shape the development of Europe's space capability and to ensure that investment in space continues to deliver benefits to the citizens of Europe and the world. This article intends to provide an overview of the European space sector and commercialisation efforts currently supported by the European Space Agency.

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INTERNATIONAL SPACE LAW PERSPECTIVES OF COMMERCIAL SPACE ACTIVITIES

While private space actors were not existent at the dawn of the space age and as such, the creation of the international legal framework, their future involvement and activities were foreseen by the drafters of the Outer Space Treaty. Article VI of the Outer Space Treaty includes a reference towards the activities of non-governmental actors, namely:

> "States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the Moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty. The activities of non-governmental entities in outer space, including the Moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty."

The past few years have been offering record launch numbers, many new services and operators blossoming from the public investment for the space sector. Space activities are continuing to grow, which brings challenges and opportunities for the new emerging spacefaring actors, both for new spacefaring states and established spacefaring states growing their space economy.[1] While the global space sector experienced a slight decline in investments in 2022, the space industry has been consistently growing, with a compound annual growth rate (CAGR) of 14% since 2019.[2] The European space sector saw significant growth in 2022–2023, with total investments reaching €1 billion, up by 64% compared to 2021.[3] Enacting national space legislation is highly advantageous for states to secure activities of new space actors and position their commercial

[1] Coykendall et al. 2023.
[2] ESPI 2023: 1.
[3] ESPI 2023: 1.

entities in a legally sound and stable landscape.[4] Further clarifications on how national space legislation can be beneficial are discussed in a separate section of this publication.

EUROPEAN SPACE AGENCY (ESA): PURPOSE, ACTIVITIES AND INVOLVEMENT IN SPACE COMMERCIALISATION

Although commercialisation may be a relatively new trend for the space sector, ESA's creation and origins lies not only in the desire of member states to strengthen European cooperation for space activities such as space research and technology, including their space applications for peaceful purposes,[5] but also in establishing a coherent industrial policy to improve the competitiveness of European industry and develop an appropriate industrial structure to foster market developments,[6] encourage opportunities for new players through ESA acting as the governmental mechanism and forum for its member states.

In addition to these activities, however, ESA has initiatives focused on sustainable space activities, applying high standards to its mission and promoting the responsible use of outer space through its own missions and other initiatives. In addition to publishing an annual ESA Space Environment Report showcasing the most recent numbers and data from monitoring the space environment,[7] ESA was also the first international organisation to accept the rights and obligations of three of the UN space treaties: Rescue and Return Agreement, Liability Convention and the Registration Convention.[8]

4 Gerhard 2009: 123.
5 ESA Convention, preamble.
6 ESA Convention, Article VII.
7 See ESA Environmental Report 2023.
8 See the Declaration on the Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects launched into Outer Space ESRO/AF(75)58 of 25 June 1975, ESA/C/XXII/RES.3 of 13 December 1977; the ESRO Council Decision on the Declaration of Acceptance of the Convention on the Registration of Space Objects of 12

ESA in the context of international space law

In the context of international space law, Article VI Sentence 3 of the Outer Space Treaty references the activities of international organisations as follows: "When activities are carried on in outer space, including the Moon and other celestial bodies, by an international organization, responsibility for compliance with this Treaty shall be borne both by the international organization and by the States Parties to the Treaty participating in such organization." Already discussed during the negotiations of the UN General Assembly Resolution 1962 (XVIII) and further concretised in Article VI Sentence 3, this principle foresees that states parties to the Outer Space Treaty, when conducting space activities through an international intergovernmental organisation, should use their best efforts to secure compliance by the international organisation with the obligations set forth in the Outer Space Treaty.[9]

In this regard, it must be noted that what exactly is an activity of an international organisation is not defined within the Treaty itself. For the purposes of this chapter and the below mentioned commercialisation initiatives of ESA, while not going into the details and legal considerations of what activity is considered an activity of ESA, it should be noted that not all initiatives supporting the development and exploitation in a market can be considered a space activity of ESA under the Outer Space Treaty, as this should be considered on an ad hoc basis for each specific case. ESA has not accepted the rights and obligations of the Outer Space Treaty as it does not foresee for such a declaration of acceptance for international organisations – nevertheless, ESA acts in conformity with international space law and has declared acceptance to the rights and obligations to the Registration Convention, the Rescue and Return Agreement and the Liability Convention.[10] All of ESA's Member States have furthermore ratified

December 1978, subsequently attributed to ESA after the entry into force of the Convention for the Establishment of a European Space Agency (ESA Convention) in 1980.

9 Gerhard 2009: 122.

10 See UN Committee on the Peaceful Uses of Outer Space 2024.

the Outer Space Treaty,[11] which gives rise to certain obligations of the state parties in connection also with Article XXII paragraph 1 Liability Convention and Article VII paragraph 1 Registration Convention.[12]

ESA Convention and "Raison d'être"

The European Space Agency has strived to be a pioneer for research and development of space technologies in Europe since its inception. Following the existence of two organisations related to space activities in Europe – the European Launcher Development Organisation (ELDO) and the European Space Research Organisation (ESRO), a convention was drafted in 1975 to combine both of their objectives and set up a "European space agency", broadening the scope of work and allowing for a coordinated European space programme.[13] The ESA Convention was opened for signature in 1975 and entered into force in 1980.[14]

Article II of the ESA Convention outlines that

> "the purpose of the Agency shall be to provide for and to promote, for exclusively peaceful purposes, cooperation among European States in space research and technology and their space applications, with a view to their being used for scientific purposes and for operational space applications systems".[15]

Peaceful purposes as enshrined within the ESA Convention should also be considered in line with Article IV Sentence 1 of the Outer Space Treaty, under which outer space should be used for exclusively peaceful purposes.[16] While previously debated if both terminology is coherent, it should be noted that the

[11] See UN Committee on the Peaceful Uses of Outer Space 2024.
[12] Gerhard 2009: 123.
[13] ESA 2015.
[14] ESA 2015.
[15] ESA Convention, Article II.
[16] Schrogl–Neumann 2009: 83.

interpretation of 'peaceful purposes' for the purpose of the ESA Convention should not be regarded as an expression of generally accepted State practice when it comes to international space law and Article IV Outer Space Treaty, as the interpretation within the framework of the ESA Convention is only relevant for ESA Member States.[17] The concrete debate is not subject to analysis in this article.

Additionally, ESA's purpose further relates to elaborating and implementing a long-term European space policy,[18] by recommending space objectives to the Member States, and by concerting the policies of the Member States with respect to other national and international organisations and institutions; by conducting space programmes and activities; and by coordinating the European space programme and national programmes, by integrating the latter progressively and as completely as possible into the European space programme.[19] In this regard, coordinating between different national ventures and allowing for a streamlined European approach is strongly enshrined within the workings of the Agency. In the past 40 years, ESA has continuously provided opportunities for Member States to boost the competitiveness of its national industry, allowing direct engagement through its wide range of programmes and placement of contracts. Most recently, ESA is also targeting solutions for business incubation and technology transfer, as well as enabling individuals to contribute to European space research and interact with space industry experts. These efforts are conducted under the legal framework of the Agency, which is compliant with its international legal obligations and which offers various opportunities to new space business ventures in Europe.

New Space is considered for the purpose of this article as activities led by private companies and new players to complement and develop new business taking as opportunity the classic governmental programmes where private industry traditionally acts as supplier for the governmental programmes.[20]

17 Schrogl–Neumann 2009: 84.

18 For a brief outline of ESA–EU initiatives see below in this chapter.

19 ESA Convention, Article II.

20 ESPI 2023: 25.

This model relies on public funding, whereas some New Space companies generally rely also on private endeavours and investments by other private players, combining public and private funding for new business models and being accessible for new markets.[21]

Industrial policy

ESA's industrial policy is one of the cornerstones of its work. Noted in the ESA Convention as one of its purposes that is to elaborate and implement the industrial policy appropriate for ESA programmes and to recommend a coherent industrial policy to its Member States,[22] and further outlined in Article VII and Annex V of the ESA Convention, the industrial policy – also sometimes referred to as geo-return policy – has always been oriented towards maximising investment and supporting competitiveness. Article VII of the ESA Convention describes the design of the industrial policy as to:

- meet the requirements of the European space programme and the coordinated national space programmes in a cost-effective manner
- improve the worldwide competitiveness of European industry by maintaining and developing space technology and by encouraging the rationalisation and development of an industrial structure appropriate to market requirements, making use in the first place of the existing industrial potential of all Member States
- ensure that all Member States participate in an equitable manner, having regard to their financial contribution, in implementing the European space programme and in the associated development of space technology; in particular the Agency shall, for the execution of its programmes, grant preference to the fullest extent possible to industry in all Member States, which shall be given the maximum opportunity to participate in the work of technological interest undertaken for the Agency

21 ESPI 2023: 25.
22 ESA Convention, Article II para. (d).

- exploit the advantages of free competitive bidding in all cases, except where this would be incompatible with other defined objectives of industrial policy

For the implementation of the industrial policy, the ESA Director General has to act in conformity with the ESA Convention and its Annex V, including directives of the ESA Council.[23] ESA Council is responsible for reviewing industrial potential and industrial structure in relation to the Agency's activities, particularly the general structure of industry, and industrial groupings; the degree of specialisation desirable in industry and the methods of achieving it; the coordination of relevant national industrial policies, as well as interaction with any relevant industrial policies of other international bodies, the relationship between industrial production capacity and potential markets and the organisation of contacts with industry.[24] These actions should allow the ESA Council to monitor and, where appropriate, adapt the Agency's industrial policy.[25]

Pertaining to the placement of contracts, ESA shall give preference to industry and organisations of its Member States. In case of optional programmes,[26] preference is given to the industry and organisations in the participating States.[27] ESA Council can determine that ESA may derogate from this preference clause. To determine whether a company is considered to belong to one respective Member State, the criteria to be considered are: location of the company's registered office, decision-making centres and research centres, and territory

[23] See ESA Convention, Article X: The bodies of the Agency shall be the Council and the Director General assisted by a staff.

[24] ESA Convention, Annex V Article I.

[25] ESA Convention, Annex V Article I.

[26] ESA optional programmes are governed by a programme declaration and implementing rules. Member States can choose to subscribe to a variety of optional programmes. See more in ESA Convention Article V: The activities of the Agency shall include mandatory activities, in which all Member States participate, and optional activities, in which all Member States participate apart from those that formally declare themselves not interested in participating therein.

[27] ESA Convention, Annex V Article II.

on which the work is also carried out. In cases of doubt, ESA Council shall decide whether or not a company is considered to belong to a specific Member State. The geographical distribution is governed by the following rules:

> "A Member State's overall return coefficient shall be the ratio between its percentage share of the total value of all contracts awarded among all Member States and its total percentage contributions. However, in the calculation of this overall return coefficient, no account shall be taken of contracts placed in, or contributions made by, Member States in a programme undertaken under Article VIII of the Convention for the establishment of a European Space Research Organisation,[28] provided that the relevant Arrangement contains provisions to this effect or that all participating States subsequently unanimously so agree; under Article V, 1 b[29] of the ESA Convention provided that all original participating States unanimously so agree."[30]

Formal reviews of the geographical distribution of contracts shall take place every five years, with an interim review before the end of the third year.[31] The distribution of contracts between formal reviews of the situation should be such that, at the time of each formal review, the cumulative overall return coefficient of each Member State does not substantially deviate from the ideal value. At the time of each formal review, the Council may revise the lower limit for the cumulative return coefficient for the subsequent period, provided that it shall never be lower than 0.8.[32] If, between two formal reviews, a trend is identified indicating that the overall return coefficient of any Member State

[28] The Ariane Arrangement of 21 September 1973 was an optional programme under Article VIII of the ESRO Convention.

[29] "With respect to the optional activities, ESA shall ensure, in accordance with ESA Convention Annex III, the execution of programmes which may in particular include: the design, development, construction, launching, placing in orbit, and control of satellites and other space systems; the design, development, construction, and operation of launch facilities and space transport systems."

[30] ESA Convention, Annex V, Article IV.

[31] ESA Convention, Annex V, Article IV para. 5.

[32] ESA Convention, Annex V, Article IV para. 6.

is likely to be below the lower limit of 0.8, the ESA Director General shall submit to ESA Council proposals in which the need to remedy the situation takes precedence over the Agency's rules governing the placing of contracts.[33]

ESA's geo-return policy, in most cases, can be summarised in the guarantee for ESA Member States that their financial contributions to optional programs will be returned to their national industry in the form of contracts to companies from that Member State.[34] At the time of its inception, it constituted a unique system allowing for equal measure of growth and advancement in different European countries, accelerating the space sector and distributing the financial contributions in the most balanced way possible.[35] With the heightened commercialisation of the sector, newer initiatives have been taken up by the Agency to ensure European competitiveness on a global scale. Such goal of economic development is not limited in scope nor in areas of some Member States, by a a specific consideration of a Member State funding. So the opportunities are open to all economic actors from each ESA Member State, irrespective of their location.

Since 2021, ESA also has a dedicated Directorate for Commercialisation, Industry and Procurement, responsible for implementing the industrial policy of ESA, representing the ESA Director General in his relations with industry as well as elaborating and implementing the Agency's procurement rules and policies.[36] The Directorate intends to support the industrialisation and commercialisation of space products and services, giving the European space industry an adequate access to global investment opportunities and fostering innovation and development.[37] While the rapid commercialisation of the sector brings forth certain challenges,[38] it is necessary to stress that a steady

33 ESA Convention, Annex V, Article V.
34 Foust 2023.
35 Hoffmann 2022.
36 ESA 2021.
37 ESA 2021.
38 Coykendall et al. 2023.

growth in the European space ecosystem is supported by ESA and functions in a stable legal framework.

There have been discussions on potential reforms of ESA's geo-return policy in the past,[39] although no formal reform has taken place. Remaining unchanged for many years, the geo-return policy faces certain challenges and might in the future adapt to the new space market. This will most likely change the procurement policies currently in place, which should be carefully reviewed and considered by all actors. CNES President Philippe Baptiste addressed, in his speech at Space Tech Expo Bremen 2023, the cost competitiveness of European industry on the global market. Reducing costs and simplifying the system should enable the best possible products to stem from the European market.[40] Flexibility will allow the geo-return method to be adapted to the variety of new players which are in the process of establishing themselves in the European space sector. ESA's Director for Commercialisation has confirmed that the questions about geo-return will be handled in the most competition- and competitiveness-friendly manner, so that it is enhanced to the best possible way if needed.[41]

When assessing additional funding for New Space companies, as outlined above already, there has been a high increase of investment particularly in the European space startup sector – in 2022, approximately €1 billion were invested in over 112 deals, with a 65% increase in investment since 2021.[42] In this regard, ESA's industrial return policy should, however, be clearly differentiated from direct public investments in startups, which remains a separate mechanism of financial support for the space ecosystem.[43] Investments in European space startups are largely led by European investors,[44] however, it should be noted

39 Ferrazzani 1997: 26–28, 31.
40 Foust 2023.
41 Foust 2023.
42 ESPI 2023: 4.
43 ESPI 2023: 8.
44 ESPI 2023: 11.

that there have been rising concerns over acquisitions of strategic European startups by foreign organisations in the past few years.[45]

Commercialisation initiatives and Scaleup Programme

ESA's commercialisation initiatives aim to scale up European ambitions and prepare the regional space sector for the global space ecosystem. Described as a "space value chain", various stages of space activities – upstream, downstream, midstream – and development of space-related products are interconnected globally, with private players surging and taking over the market for the past ten years – as opposed to governmental actors who dominated the sector prior to the increased commercialisation.[46] Cross-border and cross-sector collaboration, involvement of both private and public investments is essential for scaling up the space sector and allowing it to be a competitive place for business growth as opposed to other adjacent sectors.[47]

At the ESA Council of Ministerial Level in November 2022, ESA Directors led by the Director of Commercialisation, Industry and Procurement submitted a cross-directorate proposal for an ESA optional programme, ScaleUp.[48] This programme is focused on making Europe a hub for space commercialisation and grow space companies in their possibility to seize new opportunities,[49] structured in two elements: "Innovate"[50] and "Invest". The Innovate element aims to transform ideas into business, develop space products or services in the upstream–downstream for industrial use. The Invest as the second step should allow companies to better take risk in the investment sector, access

45 EUSPA–EIB 2021: iii/iv.
46 Coykendall et al. 2023.
47 Coykendall et al. 2023.
48 See more on the ScaleUp proposal at https://vision.esa.int/scaleup/.
49 ESA ScaleUp 2022.
50 Current ESA Member States subscribed to this element are Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland and the United Kingdom.

the market and attract private and public investments by introducing support tools.[51] ESA aims to act as external support to business development both as an enabler and a customer.

The aim of the programme is to enable industry to take more risks, introduce more innovation and allow for faster access to the market. ESA's institutional missions and the classic "geo-return" structure as outlined above are completely different to this new approach to research and development. Outside the scope of the programme, ESA already supports the creation of Business Incubation Centres across ESA Member States and fosters disruptive innovation within its Phi Lab, to promote technology transfer and patenting.[52]

It should be noted that there has been increased private sector investment in space activities, as a number of venture capital firms and private equity firms have been involved in the market, coupled with an increase of private companies entering the market to offer space-related products and services.[53] As part of its commercialisation efforts, ESA supports a framework of Business Incubation Centres (BICs) as a network of "incubators" supporting space-related startups in Europe.[54] BICs are connected to their local industry, universities, research organisations, government and investor communities in order to ensure the best possible national and regional link to advise interested startups with new business partners across Europe.[55] This entrepreneurial support for New Space does not only come in the form of business advice, funding and coaching, but also legal advice and partnership opportunities that set up New Space companies on the market.

In this respect, it can be briefly noted that at the time of the drafting of this article (April 2024), an initiative is underway for a regional legislative framework that will have an effect on commercial space actors in Europe. In the most recent report on the European single market, space is mentioned

51 ESA ScaleUp 2022.
52 ESA ScaleUp 2022.
53 Coykendall et al. 2023.
54 See more on the BICs at https://commercialisation.esa.int/esa-business-incubation-centres/.
55 Coykendall et al. 2023.

as an aspect which can benefit from increased certainty pertaining to common rules and private capital supporting opportunities, to unlock growth and increase competitiveness in the sector.[56] As already discussed above, historically, the geo-return policy has been Europe's way to ensure that investment defined and funded by Member States is proportionally allocated through contracts to their respective industries.

CONCLUSION

The European Space Agency and its legal framework are fully equipped for the transformation of the European market and accepting new initiatives. In this regard, it can be noted that while these initiatives have not been undertaken as early as some other world regions, ESA is working on boosting European capabilities and allowing for a sustainable and transparent development of the European space sector and developing regional capabilities. Commercialisation and New Space should be seen as an interdisciplinary issue for the sector, and providing a legal framework for its own programmes and supporting private initiatives is the extent to which the Agency is able to go under the mandate given by its Member States.

The most important aspect for New Space companies in Europe should be a clarity over the opportunities they can benefit from at the regional level, and clarity over national and regional space legal and regulatory framework they are operating in. Technology development is essential for accelerating the European space sector, and it should be noted that a certain criticism of the past concerning the hindering effect of legal frameworks should be connotated as the opposite – legal clarity and transparency is a positive and enabling factor for new emerging companies which can serve as an opportunity for them pertaining to partnerships, funding and more.

[56] Letta 2024: 76.

Aligning with its intention to boost commercialisation in the sector, ESA's ScaleUp programme intends to particularly tackle the growth alongside commercial partnership opportunities particularly for the next ten years and in light of the next upcoming ESA Council meetings on ministerial level. Engagement from particularly newer spacefaring states in Europe will be crucial for the overall development of the sector. As such, a potential upcoming geo-return reform on ESA side and regional legislative developments in Europe will surely bring the utmost clarity to the situation for emerging space companies, and supplement existing space sector actors' initiatives in the most complementary way possible. A full legal analysis for new space businesses will be possible once these two initiatives are finalised.

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Philippe Ch.-A. Guillot

Legal Challenges of Space Geopolitics

Introduction: The Legal Order of Outer Space (Corpus Juris Spatialis)

The law on outer space is built on the 1967 *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies* (hereinafter: the OST), which was signed by 132 countries including the permanent members of the United Nations' Security Council together with other (now) major space powers, and on the *Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space* of 19 December 1967, (which entered into force on 3 December 1968), the *Convention on International Liability for Damage Caused by Space Objects* of 29 November 1971, (which entered into force on 1 September 1972), the *Convention on Registration of Objects Launched into Outer Space* of 12 November 1974, (entered into force on 15 September 1976) and the *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies* (hereinafter: the Moon Agreement) of 5 December 1979, (which entered into force on 11 July 1984). However, the Moon Agreement has been ratified by only a few states, none of which currently conduct significant space activities.[1] The main principles of the legal order existing in these documents are the free access to outer space, the peaceful purposes of space endeavours, the

1 Latest accessions: Panama (11 August 2023) and Croatia (13 March 2023); Saudi Arabia had acceded the Agreement on 18 July 2012, but withdrew on 5 January 2023; France and India are signatories but have not so far ratified the Agreement.

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non-appropriation of outer space and celestial bodies, and what the OST calls, in ambiguous and aspirational language,[2] the "Province of All Mankind" (*apanage de l'humanité toute entière,* which in the French version is equally unclear) and the Moon Agreement terms the "Common Heritage of Humanity". As Luca Follis points out:

> "This lofty phrase [Province of All Mankind] speaks to the utopian spirit and idealistic culture that animated the Space Age in the post-war period, even if a lack of consensus over its meaning prefigured the fissures that would develop in the international community during the Moon Treaty negotiations."[3]

This "utopian spirit and idealistic culture" is quite at odds with the current climate in which the major space powers – and more generally most states in the world arena – are openly seeking to maximise their self-interests, regardless of the common good and of the rule of law. With the heightened rivalry between the great powers, the threat of weaponisation and the rush for celestial resources, outer space is now affected by space geopolitics, and has even begun to be regarded as "an independent battlefield".[4]

Of course, this is not exactly a novelty: when the Soviet Union launched Sputnik, Senator Lyndon B. Johnson declared that "whoever controls space controls the world", referring to Mackinder's famous declaration "whoever controls the heartland, will forever seek to dominate the Eurasian landmass and ultimately the world". Indeed, since the beginning of the century, scholars and practitioners have applied geopolitical thinking to outer space.

[2] Blount 2021: 110.
[3] Follis 2018: 185.
[4] Roche 2016: 99.

SPACE GEOPOLITICS

A concept first invented by the Swedish political scientist Rudolf Kjellen in 1899, geopolitics is considered not to be a formal theory but instead an "attempt to reveal textually and cartographically the complex relationship between geography and politics at a variety of spatial scales from the local to the global".[5] Space geopolitical thought simply adds a new scale to this classical vision.

According to USAF Lieutenant Colonel Martin France, three factors play a major role as regards space power: geography, the character of the population and the character of the government. The proof is that "the two largest economies in the world [i.e. the USA and the European Union] are also the two most robust space powers".[6] In addition, geographical position is crucial to the launch of a satellite because proximity to the equator allows the satellite to be boost eastwards, although geopolitics encompasses more than just geography. Nicolas Peter emphasises that

> "[t]he foundations of space power range from obvious hardware elements (such as launch sites, launch vehicles, telemetry tracking and communications sites, on-orbit satellites, and other spacecraft) to socio-economic elements (such as human capital) through to political and regulatory elements such as the number of seats in international organizations and other relevant bodies".[7]

Nayef Al-Rodhan defines *space power* as

> "the ability of a state to use space to sustain and enhance its seven capacities [...] [social and health, domestic politics, economics, environment, science and human potential, military and security and international diplomacy]. In addition, the governance and sustainability

[5] Hefferman 2000: 28.
[6] France 2000: 239–240.
[7] Peter 2009: 2.

> of state power will need to employ a *symbiotic realism* approach to global relations and a *multi-sum security principle* approach to global security.[8] Ultimately, space will either be safe for everyone or for no one".[9]

Everett C. Dolman proposes an *Astropolitik* model which he defines as a "determinist political theory that manipulates the relationship between state power and outer-space control for the purpose of extending the dominance of a single state over the whole of the Earth".[10] As a result of an anarchical international system and the competition between states, "the reality of confrontation in space politics pervades the reality of the ideal of true cooperation and political unity in space which has never been genuine, and in the near term seems unlikely".[11] All attempts to regulate weapon use in space are merely "a slick diplomatic maneuver" according to Dolman.[12] Dolman argues that as long as the world is not democratic, unilateral hegemony in space will remain the sole means to ensure peace and prosperity for all, given that the "state that dominates space is specifically chosen by the rigors of competition as a politically and morally *superior* nation, culture, and economy".[13] Thus, he proposes that the United States should 1. withdraw from the outer Space Treaty and should abandon the "global commons approach" in favour of "free-market sovereignty in space";[14] 2. deploy a space-based Ballistic Missile Defence system which would enable the military control of low Earth orbit; 3. establish a specialised U.S. space coordination agency.[15]

8 "In a globalized world, security can no longer be thought of as a zero-sum game involving states alone. Global security, instead, has five dimensions that include human, environmental, national, transnational and transcultural security, and, therefore, global security and the security of any state or culture cannot be achieved without good governance at all levels that guarantees security through justice for all individuals, states and cultures." Al-Rodhan 2007: 133.

9 Al-Rodhan 2012: 25.

10 Dolman 2002: 15.

11 Dolman 2002: 2.

12 Dolman 2002: 8.

13 Dolman 2002: 15.

14 Dolman 2002: 157.

15 Dolman 2002: 165.

In contrast, Daniel Deudney regards institutionalised cooperation as the most suitable way of promoting peace,[16] and believes in what have been coined the *astropolitics of collaboration*.[17] Jonathan Havercroft and Raymond Duvall argue that the U.S. weaponisation of space would allow the United States to control all states under its hegemony, and lead to the creation of a "space-based empire".[18]

However, the present international *Zeitgeist* is not akin to a single state hegemony, but favours instead a multipolar world, although the danger of such a world lies in the potential "clash of empires" if selfishness takes advantage of common good. It is quite a threatening prospect if we consider that "as long as terrestrial geopolitics is characterized as competitive, and space is considered 'congested, confronted and competitive',[19] self-interest will rule".[20]

FROM "PROVINCE OF MANKIND" TO A FIELD OF CONFRONTATION

The OST constitutes an agreement to treat outer space in a fundamentally different manner than nearly all other global commons in the last five hundred years. Having long foreseen the dangers of remaking outer space into the next frontier for colonisation, resource extraction, and militarisation, the OST permits only "peaceful use" in the "province of all mankind". The OST prohibits claims of sovereignty *by means of use or appropriation or by any other means*. That is to say that a state cannot plant a flag on a celestial body and call that body its own, regardless of what contemporary would-be colonisers might

16 Deudney 1983.
17 Havercroft–Duvall 2009: 48.
18 Havercroft–Duvall 2009: 57.
19 United Nations General Assembly 2013b.
20 Johnson-Freese 2017: 23.

think. The U.S. flag planted on the Moon was a purely symbolic gesture and did not mean that the USA took possession of this celestial body. It was like a flag planted by an alpinist on a foreign mountain, rather than the flag of a colonial military expedition on a so-called *terra nullius* in past centuries.

Thus, space is a shared resource, open to all nations and private companies, and even to rich tourists. However, without proper management, the destruction of space's fragile "ecosystem" is a real possibility.

Collisions between satellites and space debris, exploding rocket fairings and intentional attacks contribute to an eventual "Kessler Syndrome" in space, a hypothetical future where whirling clouds of debris prevent satellites from surviving in orbit.[21] Given that satellites are the privileged instruments of globalisation as vectors of the mastery of information, ensuring military superiority to those who possess these resources, they have also created a certain level of dependency on the part of space actors due to the widespread civilian reliance on positioning, navigation, and timing services and telecommunications, as well as the global banking architecture and economy.[22] Satellites are vulnerable in several ways: due to their ever-changing location, it is impossible for a space actor to ensure constant surveillance, preventing adequate satellite protection; satellites may face, for instance, physical destruction, interference with communications or disorientation, or even cyberattacks leading to their temporary or permanent inoperability. Similarly, the multiplication of space actors – often referred to as the "New Space"[23] – increases the number of these risks and threats. Moreover, as Nicolas Roche points out, the "growing dependence on space (military strategy relies increasingly on space systems) tends to enhance its own vulnerability".[24]

The emergence of space military services, the rapid domestic and transnational growth in the commercial sector, and a general deviation from

21 La Vone 2014.

22 Lefebvre 2016.

23 Jaluzot et al. 2020: 126.

24 Roche 2016: 104.

an acceptance of space's inherent value as a peaceful domain have conspired to make states fear constraints on their actions in space. Recognising the widespread mistrust among major space powers of constraint, any solution involving the United Nations (UN) that is legally binding would need to be modest, as well as something in the interest of all nations, given that the motto of assisting "humanity to absorb benefits of space assets [...] cannot be achieved by voluntary self-regulation by spacefaring countries for reason of controls on technology transfer or due to domestic compulsions – political, legal, or financial".[25]

Some commentators have suggested that an amendment to the Outer Space Treaty would be the easiest way of safeguarding the orbital environment, and that an easy starting point would be to ban the use of kinetic weapons in space that would create debris.[26] A further step would be for signatories to commit to not developing or testing anti-satellite weapons (ASAT), and a final step would be a commitment to deorbit satellites and spacecraft close to the end of their service life.[27] There are approximately 37,000 pieces of debris larger than a softball in earth orbit, and potentially 1 million larger than a marble.[28] About 50% of all debris in space comes from accidental satellite collision in space, and from two Russian and Chinese ASAT tests.[29] Given that any one of these objects may be travelling in excess of 7 km per second, debris poses an indiscriminate danger to any nation that has or relies upon space-based assets.[30] Since the means exists to reversibly and non-destructively interfere with satellites, or at the very least to destructively target them without generating debris, this proposal would not be too difficult to pass within the UN.[31]

25 Sachdeva 2017: 37.
26 Hoffmann 2020: 327–352.
27 United Nations Secretary-General 2021: 8.
28 Ligor–Matthews 2022.
29 Defense Intelligence Agency 2022: 37.
30 NASA 2021.
31 United States of America 2021: 2.

RIVALRY BETWEEN MAIN SPACE POWERS

Russia's military doctrine views space as a warfighting domain, and Russia intends to achieve supremacy in space to win future wars.[32] Likewise, according to a sinologist scholar: "The Chinese military have made no secret of their wish to use space for military purposes."[33] However, the challenge to the legal order of outer space is not confined to the incompatibility between national military doctrines and international norms, but also in states' deeds: in 2017, a Russian satellite, known as *Luch* or *Olymp-K,* came close enough to the jointly operated French–Italian military satellite *Athena-Fidus* to intercept communications.[34]

The past few years in the West have not been totally smooth, either. During Donald Trump's presidency, rhetoric about a U.S. militarisation of space, combined with a sharp decline in engagement with the USA's long-time allies, isolated many long-time American allies, even if U.S. companies and civilian agencies still worked with their counterparts in Europe to maintain long-time ties.[35] Combined with a lack of any known American weaponisation of space, it appears that the militarised language is not as great a cause for concern as was previously believed. American and allied supremacy in space, combined with a free market's informal ties, augmented on the civil government level, such as in the case of the James Webb Space telescope, which 14 separate countries helped to create and the joint NASA–European Space Agency Artemis moon programme all increase the likelihood of the rule of law amenable to the established liberal world order.

Due to U.S. and EU legal restrictions on the exportation of sensitive technology – notably on dual-use goods – and to economic sanctions against Russia following its invasion of Ukraine, Moscow and Beijing cannot embark on the Artemis program. Consequently, an alternative project of a Moon "village" is contemplated by China and Russia. There is a considerable risk that in the near

[32] Johnson-Freese 2017: 21.
[33] Harvey 2019: 503.
[34] Harrison 2020: 17.
[35] Davis Cross 2022: 134–143.

future an Artemis lunar base will face a Sino–Russian one. In such a scenario, confidence-building measures would be required to avoid an "accidental" war. The UN should encourage its member states to adopt behaviour-based transparency and confidence-building measures. Although voluntary, such measures could eventually become the basis of new treaties. Several publications by the Secretary-General contain practical guidelines that the majority of nations are willing to accept, such as the publication of a state's military, civil and scientific space policies. In the event of a potentially concerning situation, where another nation's actions may be misinterpreted, such as the testing of sub-satellites ejected from a "nesting doll", states can refer to the actor's policies to discern whether the intent was peaceful or otherwise. Data sharing that contributes to space situational awareness is already an established practice for many states.[36] Publishing findings on major research and space programs could increase trust in "military and non-military matters", as well as providing opportunities for civil agencies to partner on research projects.[37]

A further step is information exchange between states concerning a satellite's general purpose, as well as sharing details of military and state space expenditure.[38] When a nation conducts a risky manoeuvre with its own satellites that could affect another nation's assets (such as rendezvous and proximity operations on its own assets), they should notify nearby nations which could be affected in case of an accident. More generally, coordination, or at least a forewarning, of space launches will also foster a culture of decency and predictability between the space forces of nations, with the "Hague Code of Conduct against Ballistic Missile Proliferation" being a precedent.[39]

The UN is undoubtedly the most powerful international organisation capable of setting norms or rules of behaviour. If no consensus can be reached within the UN, the North Atlantic Treaty Organization (NATO) is the next international actor that could reliably set norms and precedents amenable to

[36] United Nations General Assembly 2013a: 14.
[37] United Nations General Assembly 2013a: 16.
[38] United Nations General Assembly 2013a: 16.
[39] United Nations General Assembly 2013a: 17.

the liberal West. NATO has different motivations than the UN; namely, as a political-military organisation NATO has a responsibility to protect its Allies from aggression. Preserving space as the "province of all mankind" is therefore not of premier importance to it, and that attitude will inform which norms and rules it would champion. Recognising the realities of increased ASAT weapons by its potential adversaries (China, Russia) and by states outside NATO membership (India), NATO expects to operate in a "disrupted, denied, and degraded environment", which threatens the "national and Euro-Atlantic prosperity, security, and stability".[40] It is for this reason that the Allies agreed at the 2021 Brussels Summit that an attack on military or national architecture could be reason to invoke the collective defence clause, Article 5, a declaration that was added to its 2019 Space Policy.[41]

MILITARY BUILD-UP OF AERO-SPATIAL FORCES

There is an obvious international tendency towards creating and/or modifying armies to include the space dimension. This underlines the intensification of the phenomenon of "creeping weaponisation" to quote the former French Minister of the Armed Forces.[42] In 2011, Russia created the Aerospace Defence Force, merging its former Space Forces (created in 1992) with the Air Force in order, according to Defence Minister Sergei Shoigu, "to concentrate in a single command all responsibility for formulating military and technical policy for the development of troops dealing with tasks in the aerospace theatre".[43]

In 2015, China created the Strategic Support Force as the component of the People's Liberation Army in charge of space, cyber, electronic and psychological warfare capabilities to protect these new "strategic frontiers".[44] The United

[40] NATO 2022.
[41] NATO 2022.
[42] Parly 2019.
[43] Cako 2020: 149–150.
[44] Costello–McReynolds 2018: 8.

States followed a different path in 2019 when they created a Space Force that is both independent from the U.S. Air Force and separate from the Cyber Command. The same year, France turned its Joint Space Command into a Space Command *(Commandement de l'Espace),* part of the Air Force which in 2020 was renamed the French Air and Space Force *(Armée de l'Air et de l'Espace).* This was not just a change of name, but the reorganisation of the Space Command was intended to set a more coherent mission for it – all the French military resources for ensuring space situation awareness were already operated by the Air Force, apart from a vessel belonging to the Navy – and to vest in it new powers and to grant the Air and Space Force new *matériel,* notably "watch dog" satellites, i.e. small satellites equipped with non-kinetic defence measures in charge of protecting observation–telecommunication satellites. Last but not least, it also sent a signal to France's "strategic competitors". On 1 April 2021, the United Kingdom also established a Joint Space Command.

SPACE WEAPONISATION

The militarisation of outer space is generally described as the passive military use of outer space, i.e. activities in which satellites play a non-aggressive role (positioning, reconnaissance or surveillance systems), whereas the weaponisation of outer space is the deployment of offensive weapons which could be part of a direct engagement in warfare (whether they are Earth to Space, Space to Earth or Space to Space weapons).[45]

In a recent development, the definition of weaponisation has evolved slightly, considering the incorporation of defence capabilities into a satellite, thus breaking with its previously primarily offensive nature:[46] some defensive features have been introduced, such as the encryption of messages by navigation

[45] Frigoli 2018: 51.

[46] Lefebvre 2016: 137.

satellites or the presence of on-board cameras on satellites to ensure a degree of self-protection. On-board self-protective weapons and "watchdog" satellites would be the next step.

This issue of offensive nature raises the question of whether the concept of space weaponisation remains compatible with Article IV of the OST on the use of outer space *exclusively for peaceful purposes.* Moreover, space is recognised by public international law to be the *Province of All Mankind,* again emphasising the peaceful use of space. Thus, the very principle of the weaponisation of space does not seem *prima facie* to be compatible with the current international legal framework.

Furthermore, the space environment is characterised by its free accessibility to all nations, as expressed in Article I of the OST. Would not this increasingly routine and minor weaponisation constitute an impediment to this core right of the Space Treaty? Indeed, the offensive function of weaponisation and, thus, dissuasive identity could restrict and constrain open accessibility.

Many states seek to prevent the placement of weapons in space. China, as well as Russia, India and Canada, supported the *Prevention of an Arms Race in Outer Space* initiative during the 1981 Geneva Convention on Disarmament, reaffirming the fundamental principles of the OST and adding a further principle, according to which the weaponisation of space should be prohibited, and favouring the "sanctuarisation" of space. However, the USA opposed this last principle. In February 2008, Russia and China introduced a draft of an agreement on the *Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects,* but it was dismissed by the USA as a "diplomatic ploy", and criticised for its lack of verification measures and the exclusion of ground-based ASAT weapons.[47] For their part, the member states of the European Union (EU) opposed the Sino–Russian initiative, claiming that these proposals were neither clear, nor sufficiently comprehensive.[48]

47 Mills–Butchard 2021: 13.
48 Shapira–Baram 2019: 15.

An EU draft of an *International Code of Conduct* for outer space activities was elaborated outside the United Nations but this method – which took eight years – proved to be counter-productive as many countries felt excluded.[49]

If Russia and China were to accept the interdiction of kinetic weapons in space, this would be a productive solution.[50] However, the dual-use nature of space assets for military and civil means would make this proposal difficult to enforce for other scenarios.[51] A satellite equipped with a grabbing arm and a net, used ostensibly for the collection of space debris, could easily be repurposed as an offensive weapon. A better proposal would be putting weapons in space in the first place,[52] otherwise states could not be prevented from arming their space assets in order to exert their inherent right of self-defence, as envisaged in Article 51 of the UN Charter, if need be.

COMPETITION FOR SPACE RESOURCES

The OST declares space open to all for peaceful exploration and discovery. Commercial enterprises now make up a huge proportion of the actors in space. Governments and militaries have long set the rules and norms in the heavens, but they are no longer the only game in town, and it seems they will never be again. Indeed, a few private companies are significantly more powerful than some nations in terms of their potential space power. Thus, international organisations should involve those non-state actors that wield significant influence in the domain, as well as nascent space powers, in a new space governance system. However, this does not mean that the OST principles should be abandoned. Appropriation by states is prohibited by Article II of the OST, and this principle should remain in force.

49 Brachet 2016: 6–7.
50 United Nations General Assembly 2013c: 18.
51 Davis Cross 2022: 136.
52 United Nations Secretary-General 2021: 12.

Contrary to the language of the U.S. 2015 *Spurring Private Aerospace Competitiveness and Entrepreneurship Act* (a.k.a. Space Act) signed into law by President Obama, "you cannot claim 'finders keepers' and then set up a mine that pulverizes other worlds into commodities to be sold to the highest bidder, even if you are a U.S. citizen".[53] The Space Act and the Luxembourg's law on spatial activities enable a state to grant exploitation licences for the resources of celestial bodies, but how could they grant to private companies a right to something they do not own? Voices from the Global South stress that:

> "Not only have such claims of possessory rights not been recognised in the past, but there is also global consensus regarding its illegality. It therefore forms a part of customary international law, despite the Moon Agreement not having been widely ratified. In this light, the legalisation of space mining is a sheer violation of the elemental principles of international space law."[54]

Besides, Article VI of the OST extends the responsibilities of launching states to all *national activities,* including those of *non-governmental entities* that *shall require authorisation and continuing supervision by the appropriate state party to the treaty.* Furthermore, launching states are liable for damages caused to other treaty parties and natural or juridical persons belonging to those states. As a young Danish scholar writes: "This provision establishes a much stricter connection between states and activities by private actors that can be attributed to treaty parties than for example the regime of the high seas does."[55] Both U.S. and Luxembourgian laws are silent on the potential environmental implications of private actors' use of space resources, and on how the benefits of the use of space resources by private actors could be *carried out for the benefit and in the interests of all countries* as required by Article I, paragraph I of the OST. Outer

53 Klinger 2021: 661.
54 Mallick–Rajagopalan 2019: 12.
55 Lachmann 2019: 12.

space is a global common "in the sense that the damage or destruction of outer space environment by one will result in the inability to use the environment for all. Therefore, it is in the self-interest of all countries that consider outer space as a 'vital interest' to do all they can do to preserve the environment".[56]

CONCLUSION

Space is still the final frontier, although it resembles more of a Wild West than an unspoiled Eden. The rules and laws preventing conflict in the heavens have worked so far, but the treaties ratified decades ago are said to no longer reflect the problems and motivations of today.[57] A more "congested, contested, and competitive" space environment increases the probability of accidents in space, including inadvertently offending the sensibilities of another nation in the absence of shared norms, values and laws. A consensus on the ostensible obsolescence of the current outer space legal regime is nevertheless far from being reached. Many scholars – including the present author – and practitioners are still in favour of a "traditionalist" approach: while they do not deny the value of taking into consideration the changes that have affected the outer space ecosystem in the recent years or decades – *inter alia* the huge rise in numbers of states having some space activities and the impressive development of a private sector – they advocate for the durability of the principles of the OST. Those "utopian" and "idealistic" principles are needed more than ever today in face of the *Realpolitik* challenges to the outer space legal order.

[56] Johnson-Freese 2017: 22.
[57] Howell 2017.

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Norbert Aradi

The EU's Space Policy Framework from a Defence and Security Policy Approach: A Belated Rush or an Elaborated Trial?

INTRODUCTION

2021 was a year of transformation for the European Union's space policy; by making several structural changes, the Space Programme Regulation created the European Union Agency for the Space Programme (EUSPA).[1] The EU aims to stimulate its space economy, strengthen and broaden the sector's market base, and develop European capacities while boosting the region's overall competitiveness. However, the actual framework for such a comprehensive approach to space is the fruit of several decades of dealing with multifaceted challenges. In recent years, space has become a geopolitically strategic area where it is essential to protect the broad European interests and to ensure autonomous access and freedom of action in the political, business and, more recently, defence fields of space – in several cases, including the Member States' competencies. It was not always as straightforward as it is now, however. The perception of space in Europe has slightly shifted, as the main focus of the broad European space policy has encompassed the principle of peaceful use (e.g. ESA Convention Article 2).[2] Nevertheless, the recent imbalances of geopolitics and the prospect of threats emerging either in space or via interconnecting domains (such as cyberspace) have encouraged the notion of enhancing the defence aspect of civilian space programmes. This has been a lengthy process; as such, this chapter elaborates on how the

1 Regulation (EU) 2021/696.
2 ESA Convention and Council Rules of Procedure, Article II, 13.

DOI: https://doi.org/10.36250/01208_04

EU's space policy framework has developed over recent years and whether its responses to the rapidly shifting space environment are a "belated rush or a painstaking process".

THE FORMULATION OF THE EUROPEAN SPACE POLICY

A historical overview

After the Second World War, the two superpowers' intercontinental ballistic missile (ICBM) research programs intensified just as much as their pursuit of space technologies. The then spacefaring nations were competing to optimise space exploration and the use of space (e.g. Sputnik in 1957). Simultaneously, their counterparts – the non-spacefaring countries – tried to use their influence to broadly and jointly restrain the activities associated or thought to be associated with space. The interplay between these two groups of nations created a conceptual "skirt" under which the foundational treaties regarding space were born. These treaties are the 1967 Outer Space Treaty, the 1968 Astronaut Agreement, the 1972 Liability Convention, the 1976 Registration Treaty and the 1979 Moon Agreement – the number of states party to these treaties, however, significantly varies.

During the 1950s, the European conceptualisation of space essentially amounted to investments by a few countries (mainly France, Italy and the United Kingdom). Unfortunately, although quite understandably, considering the political, economic and societal challenges Europe faced during the Cold War, even the most developed powers lacked the resources to establish capabilities comparable to the competing superpowers. This decades-long trial to enter the space race, despite various attempts at space cooperation,[3] contributed to an eventual "revision" to the continent's approach to space

[3] European Preparatory Commission for Space Research (COPERS) 1961; European Space Research Organisation (ESRO) 1962; European Launcher Development Organisation (ELDO) 1962; European Space Conference (ESC) established under ELDO in 1966.

with the establishment of the European Space Agency (ESA) in 1975 (with ten founding member states[4]). The role of ESA was and remains to establish overarching capabilities for Europe, from launchers through satellite systems to space activities in exploration and scientific research. The activities of the ESA allowed Europe to gain a foothold in space in the 20th century and it eventually became one of the critical pillars of Europe's space policy in the 21st century.

THE CONCEPTUALISATION OF THE EU'S SPACE POLICY, THE RISE OF A "NEW" SPACE POWER?

Coherent policy implementations without an outline of power – in our case, space power – would be left without structure and direction. Academics have argued as to whether sea power theories can be applied to space or not. In reflection on such an idea, a slight detour can help create a context to understand how space power can be realised. In his book *The Influence of Sea Power upon History,* Alfred Thayer Mahan, a military theorist, made a formerly unquantifiable (military) domain relevant. He argued that the importance of sea superiority had been greatly underestimated. Mahan's views gained attention, eventually leading to a naval arms race between Germany and Great Britain in the lead up to World War I.[5] Building upon Mahan's theories, Julian Stafford Corbett released a book entitled *Some Principles of Military Strategy* a decade later. Even though Corbett makes it clear in his book that the sea is a multi-dimensional area with various factors influencing the conceptualisation of an effective strategy, his main argument was that sea power ultimately means control over maritime communications – perceived as shared channels of communication. Within these, sea power includes the ability to supply troops and gather information, with forms of command based on their magnitude and duration, allowing a nation to freely access and

4 Belgium, Germany, Denmark, France, the United Kingdom, Italy, the Netherlands, Sweden, Switzerland and Spain.

5 Townsend 2019: 14.

utilise the sea to further its interests while being able to prevent an adversary from gaining the same advantage.[6] It only takes a little imagination to see the resemblance between Corbett's ideas about channels of communication and some aspects of several nations' space strategies or their overall approach to space policies (for example in the U.S. Space Force's mission statement). This is logical since activities conducted in space strongly impact activities in other environments, similarly to the sea or the air. Unfortunately, it would be difficult to directly apply Mahan's or Corbett's theories to space instead of the sea; space is still a primarily untested area for several activities (transport, mass material extraction, additive manufacturing, and of course, war).

Thus, the question arises: How did the EU, as such, create a coherent policy approach to allow its evolution into a space power? In its *Resolution on Community participation in space research* (1979), the European Parliament "stresses the importance of the benefits which the Community could derive in the short term from space activities", specifying sectors such as telecommunications, earth observation, agriculture, scientific research and highlighting the industrial benefits of technology deriving from space research.[7] ESA was still at the forefront of European space policy throughout the following years until 1988, when the European Commission issued its communication on "The European Community and Space: A Coherent Approach".[8] The Commission argued that since the ESA's expertise is indispensable, the EU's ties to the Agency should be strengthened through a complementary EU framework. Furthermore, the European Parliament also drew up six guidelines to cover the aforementioned types of space-related activities. As such, an EP resolution in 1991,[9] and an EC Communication in 1992[10] resulted in a broad framework of milestones to be achieved to consolidate a European space industry and space policy.[11] As a result,

6 Straub 2015: 66.
7 Commission of the European Communities 1979: 42–43.
8 Commission of the European Communities 1988.
9 Commission of the European Communities 1991: 26–27.
10 European Commission 1992.
11 Hörber–Stephenson 2016: 39.

the European Commission established connections with the ESA at the beginning of the 21st century, adopting a unified space strategy in 2000 and a space policy in 2003, and developed two flagship space programs: Galileo (satellite navigation) and Copernicus (Earth observation) – in conjunction with the ESA under the terms of an agreement between the institutions in 2004. Over the next years, the role of the EU in "governing" space strengthened; the Lisbon Treaty in 2009 marked a new beginning for an institutional approach to space, recognising shared competencies between the EU and its Member States.[12] In the years that followed, the notions of the security of space infrastructure, autonomous access to space and the mitigation of dependence on specific technologies and services, and ultimately defence and security in space have gained a critical role in the general flow of European space policy. Nowadays, it has been clearly established that European space policy is managed jointly by the EU, the ESA and the Member States. However, maintaining Europe's ambitions with regard to space, and from a certain angle its status of being a "space power" in the wake of modern-day conflicts and the rise of private actors pose quite a challenge.

SECURITY PARADIGMS OF A BROAD EUROPEAN SPACE STRATEGY

In 2016, the Commission outlined a space strategy for Europe in a communication,[13] emphasising the importance of space for security and the ability to assert Europe's presence and capabilities in space. The EU's vision and objectives were based on a set of strategic elements – autonomous access to space, satellite communications and navigation, and Earth observation – which are also reflected in the European External Action Service's (EEAS) "EU Global Strategy document".[14] From a global landscape perspective, the EU's space

[12] Reillon 2017: 11–18.
[13] European Commission 2016.
[14] European External Action Service 2016: 45.

policy is crucial for several reasons. Firstly, space technologies are pivotal to the EU's societal and economic functions, which are deeply woven into our daily lives. Programmes such as Copernicus, Galileo and EGNOS provide essential geo-localisation and Earth observation services, empowering the EU to pursue various objectives independently, aiding in the monitoring of greenhouse gas emissions, border control, enhancing digital transition, combating crime, overseeing transportation, providing weather forecasts, supporting agriculture and more. The integration of space technology into EU sectoral policies has become integral in recent years, significantly shaping our way of life. At the same time, the vulnerability of our societies to potential disruptions in this domain grew in parallel to these developments, necessitating the safeguarding of space infrastructure. The 2016 strategy takes stock of the possible risks – including cyberattacks – and highlights the pressing need to reinforce policy and infrastructure connected to space. One of the distinctive aspects of the EU's space policy lies in its concerted effort to fuse – to a certain degree – civil and defence space capabilities. The EU acknowledges that assets such as Galileo (for example, through its Public Regulated Service – PRS[15]) and Copernicus may serve dual roles. Tailoring the programmes to both civilian and defence–security needs is in line with the demand for optimal resource utilisation and strengthens security measures across member states. This convergence of civil and defence capabilities is a linchpin of the "space for security" notion, a cornerstone of the EU's most recent Space Strategy for Security and Defence (SSSD).[16] The SSSD aims to leverage space assets for crisis management and rapid disaster response and to facilitate using certain assets to benefit military operations while respecting international treaties and obligations. It reflects a comprehensive approach, merging the promotion of secure satellite communication, enhancing space situational awareness and establishing a sophisticated intent to develop a satellite-based early warning, mainly through sharing indispensable data.

15 Cozzenz 2021.

16 European Commission 2023.

Moreover, this integration serves a pivotal role in the context of the Common Security and Defence Policy (CSDP). It aligns with the objectives of strengthening the EU's security architecture and augments the interoperability between EU member states and NATO.[17] It also heralds an interconnected approach to security, enabling the development of efficient responses to emerging threats while ensuring a more cohesive defence framework. The recent strides in EU–NATO relations have further underscored the significance of such integration. The synergies between the EU's SSSD and NATO's initiatives[18] in specific interpretation can signify a collective commitment towards bolstering security measures across the transatlantic alliance.

In conclusion, the evolving integration in the security and defence sectors within the European Union in the post-Maastricht phases parallels a significant shift in the approach to space matters, transitioning from mainly scientific or commercial perspectives to a more strategic outlook. This transition coincided with the establishment of the EU space programme, initially presented as a collection of civilian initiatives, while recognising their strategic value by being funded and owned by the EU. The Space Regulation acknowledges the EU space infrastructure's critical nature, calling for a security-centric framework to oversee the EU Space Programme.[19] Exploiting the potential for security of a broad European space policy has been emphasised for several years by certain states and notably by the European Space Policy Institute (ESPI), which have argued that the deficit between socio-economic decisions and defence hinders the EU's potential as a space power.[20] Article 189 of the Treaty on the Functioning of the European Union (TFEU) underscores the need for policy implementation within European space policy objectives. Among these policies, the CSDP emerges as a potential beneficiary of implementing the European space policy. Correspondingly, the Strategic Compass,[21] part of the CFSP,

[17] Council of the European Union 2023.
[18] See more in NATO 2022.
[19] Council Decision (CFSP) 2021/698.
[20] European Space Policy Institute 2020.
[21] Council of the European Union 2022.

highlights the significance of space-related services within the Union's Space Programme for the future development of European defence capabilities.

Gazing into the future, a European Union Space Law proposal has come into the spotlight due to recent Council processes, as possibly representing another measure to expand the purview of addressing specific space threats. However, the persistent legal uncertainties accompanying these initiatives require continued scrutiny and legal assessment. Despite the existing constraints, the ongoing developments in the space sector may catalyse future advancements within the CSDP – and, as such, might eventually pave the way for establishing defence capacities aligning with Article 42(2) TEU,[22] illustrating the potential convergence between space policies and the broader European security architecture.

EU core institutions' roles in shaping the Union's space policy

Building on the previous topics, the EU's space policy is beginning to present itself as a strategic response to address the multifaceted challenges of contemporary society. Among these challenges, combatting the impacts of climate change and propelling technological innovation, while ingraining space technology, data and services into citizens' daily lives are paramount concerns. This policy blueprint aligns seamlessly with and even promotes crucial EU priorities, encompassing the driving force behind the European Green Deal, the relentless pursuit of digital transformation, the steadfast preservation of the European way of life, and the endeavour to amplify the EU's global influence on the international stage while reducing its dependence on third actors, with the aim of ultimately achieving the strategic autonomy it craves.

What distinguishes the EU's space policy from others is its fusion of the EU space programme with synergies such as Horizon Europe Cluster 4,[23] which

[22] Treaty on European Union, Provisions on the Common Security and Defence Policy, Article 42 (ex Article 17).

[23] See more in European Commission 2024.

is dedicated to space research and innovation. Notably, within this collective approach, a series of targeted initiatives aim to increase the competitiveness of space systems and European actors by streamlining access to space into the concept of strategic research and innovation agendas. These ambitious roadmaps, predominantly fuelled by funding from the EU, espouse the objective of strengthening the competitive edge of the Union and advancing the overarching goals of InvestEU. The EU's space policy is engineered to cultivate a vibrant and resilient space ecosystem within the EU and even the broader European sphere.

Crucially, the TFEU, articulated explicitly within Articles 4 and 189,[24] sets the EU the task of devising and executing an encompassing EU space policy. This institutionalised commitment, anchored within the EU's legal framework, underscores the firm dedication of the bloc to exploring the vast potential of space for the benefit and advancement of societal, economic and strategic landscapes within the EU's purview.

EUROPEAN COMMISSION

As the "architect" of EU policies, the European Commission exercises significant influence in defining the strategic vision and operational framework for the EU's space policy. While its proposals are subject to scrutiny and approval by other EU institutions, the Commission actively manages and supervises the EU's flagship space programmes (e.g. Copernicus) and developing space programmes (e.g. IRIS²). It ensures the alignment of these programmes with broader EU policy goals and oversees their development and implementation. The Directorate-General for Defence Industry and Space (DG DEFIS) spearheads space-related activities within the Commission; its proposals and initiatives reflect the EU's broad strategic vision for space through a solid scope of defining strategic goals and outlining budgetary allocations for space

[24] The Treaty on the Functioning of the European Union, 5–6, 86–87.

programmes. In the Multiannual Financial Framework (MFF) for 2021–2027, the EU allocated €14.8 billion to space-related activities, emphasising investment in existing and functioning flagship programmes and the new entrants to the overall space programme. Even though the total budget for the 2021–2027 period is a significant increase compared to previous ones, it still falls short of the budget of the largest global competitor in the field, the USA, which spent 24 billion USD on NASA in 2022 alone.[25]

As the initiator of this effort, this budgetary allocation underscores the Commission's commitment to the core ideas of Europe's space capabilities (fostering innovation, leveraging space data, etc.). The mid-term review of space regulation to be conducted by the Commission (based on its legislation)[26] aims to assess the progress of space programmes vis-à-vis their objectives, ensuring their alignment with emerging needs and technological advancements. While evaluating the effectiveness of existing policies, program performance and budget utilisation, the mid-term review may serve as a tool to recalibrate specific strategies for more cohesive outcomes. Working to meet the Commission's responsibilities, the European Union Space Programme Committees (EUSPC),[27] under its guidance, are fulfilling vital functions in shaping, executing and supervising the EU's policies and initiatives concerning each space programme component. The Commission's role is also significant in promoting international cooperation in space. In some instances, for example, upon authorisation by the Council, the Commission negotiates agreements with non-EU countries or international entities to foster collaboration in space research, exploration and satellite systems – such as the most recent objective of establishing cooperation in launching EU satellites into orbit via SpaceX.[28] These agreements aim to enhance the EU's access to space-related resources, technologies and expertise; however, in some cases, they are concluded precisely because of their unavailability, filling in the gaps in European capacities.

[25] EPP 2022: 2.
[26] Article 102 of Regulation (EU) 2021/696.
[27] As set out in Regulation (EU) 2021/696.
[28] Foust 2023.

COUNCIL OF THE EUROPEAN UNION

The Council plays a key role in shaping the strategic direction and political priorities of the EU's space policy. Within its remit, high-level discussions and decisions shape the overarching objectives of space-related activities, primarily endorsing broad policy frameworks and space programme elements. The Council facilitates a high degree of coordination among member states and serves as a forum for exchanging national and EU policy implications, aligning strategies and achieving consensus on shared objectives. Through summits and different levels of Council meetings such as the Working Party on Space[29] or the Competitiveness Council,[30] member states deliberate on and agree upon overarching policies that outline the EU's ambitions in space. These discussions enshrine critical aspects within the EU's strategy for a coherent space policy. For example, in terms of budgetary negotiations, the Council's mandate involves deliberations and unanimous agreements on financial allocations for various EU programs, significantly impacting the scale and implementation of the space programme and future projects – in contrast to the Commission's role in assessing the financial needs (based on EU policy objectives).

Furthermore, the European Council's political support is vital for significant space initiatives. Strategic endorsement by the Council is essential for specific investments in and even applications of the space programme. The Council's engagement also extends internationally, mainly by authorising aforementioned agreements with non-EU countries or international organisations to foster collaboration in different aspects of the space sector.

EUROPEAN PARLIAMENT

Although the Parliament does not directly manage or execute the operational aspects of space programmes, it plays a crucial role in shaping, overseeing and

29 See more in Decision establishing a Working Party on Space 14274/1/10.

30 See more at https://www.consilium.europa.eu/en/council-eu/configurations/compet/.

scrutinising the EU's space policy. Parliamentary committees, such as the Industry, Research, and Energy Committee[31] (which coordinates space policy), discuss and debate proposals that, for instance, the European Commission puts forward. These committees scrutinise and discuss recommendations on possible legislative initiatives, appropriate budget allocations and general policy guidelines concerning space activities. The European Parliament exercises its authority through the ordinary legislative procedure,[32] where it co-legislates regulations and directives, allowing Members of the European Parliament (MEPs) to propose amendments, discuss priorities and approve the EU budget. In its comprehensive role, the Parliament monitors the implementation and performance of the EU space programme through MEPs, evaluating the programme's progress and impact, ensuring their alignment with EU policy goals and their strict financial accountability. Discussions and reviews allow MEPs to channel and shape the general direction of the EU's space policy, directing the bloc's stance and priorities in space exploration and utilisation through its deliberations and resolutions.

EUROPEAN UNION AGENCY FOR THE SPACE PROGRAMME

The European Union Agency for the Space Programme (EUSPA) serves as the entity that is responsible for supporting the implementation, operation and promotion of the space programme components, focusing on user uptake and program security. Inseparable from the EU's institutional framework, EUSPA functions in strong cooperation mainly with the European Commission. At its core, EUSPA focuses on the management, advancement and effective utilisation of prominent EU space programs, making vital contributions to the vast array of the EU's space programs covering for example navigation. EUSPA assumes a multi-directive role by overseeing the operational aspects of the space programme components, ensuring reliability, precision and accessibility.

31 See more at https://www.europarl.europa.eu/committees/en/itre/home/highlights.

32 The Treaty on the Functioning of the European Union Article 189 (2) 85.

The Agency acts at the forefront of promoting and utilising space assets across varying sectors. The Agency's mandate extends to enhancing the resilience and security of EU space infrastructure (including through the recently acquired Space Surveillance and Tracking front desk), focusing on safeguarding critical space assets from potential threats, mainly cybersecurity risks and signal interference, thus ensuring the uninterrupted provision of services. Through several bodies (like the Admin Board), EUSPA connects the governance of space between EU member states and industry stakeholders mainly by the constant reporting and sharing of assessments delivered under its aegis.[33]

While specific details about the internal Security Accreditation Board (SAB) within EUSPA might not be openly accessible, the overarching principles of space security governance are paramount in managing and protecting the EU's space assets and services. Setting up security protocols and standards to protect sensitive data, communications and infrastructure connected to space assets are just a few of the common steps the SAB takes to protect vital space infrastructure and data in the larger context of space security. It also plays an essential role in risk assessments, which are used to identify and eliminate threats to space systems, such as those posed by physical vulnerabilities, signal interference and cybersecurity risks. The SAB processes ensure compliance with security standards and regulations, particularly in relation to approving satellite launches, authorising system operations (including services and signal transmission in space), and permitting ground station operations.[34]

THE EUROPEAN EXTERNAL ACTION SERVICE

The European External Action Service (EEAS) in close cooperation with the EU Satellite Centre[35] is the linchpin orchestrating the intricate interplay between the EU's foreign policy strategies and the wide and expanding

[33] Regulation (EU) 2021/696.

[34] Regulation (EU) 2021/696, Chapter II, 43–46.

[35] Council Decision 2014/401/CFSP.

fields of space exploration and utilisation. Its role resonates deeply within European circles due to its comprehensive approach and strategic alignment with the EU's broader geopolitical imperatives. At the forefront of its agenda lies the seamless integration of space policy within the expansive tapestry of the EU's foreign policy architecture. This nuanced approach strategically knits together the aspirations of space exploration with the overarching diplomatic agendas of the union; discerning and leveraging opportunities for global partnerships in space exploration and providing a necessary framework for the security of the Programme in the field of external relations.[36] Such integration empowers the EEAS to wield space capabilities as instrumental tools for fostering international cooperation and jointly addressing global challenges. Armed with its diplomatic prowess, the EEAS diligently forges and nurtures alliances and collaborations across various nations and international entities concerning space-related initiatives, which ultimately propels the EU into a prominent position within the global space arena, allowing it to gain a foothold amongst other stakeholders. Recognising the evolving geopolitical landscape and the inherent vulnerabilities of space assets, the EEAS plays a strategic role in confronting pertinent space security concerns,[37] andadroitly navigates potential risks related to space assets, ensuring the alignment of space policy with the EU's geopolitical imperatives. By advocating for global space security initiatives and actively contributing to the formulation of norms, the EEAS safeguards EU space assets and strengthens the EU's strategic posture, while its adept engagement in global space governance forums, particularly its active participation in influential platforms such as the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS),[38] underpins its commitment to fostering multilateral relationships by steering negotiations and advocating for inclusive and peaceful space exploration. Aligned with the fundamental values of the EU, the EEAS intricately weaves space policy into initiatives championing sustainable development, environmental stewardship

36 Regulation (EU) 2021/696, 9.

37 Council Decision (CFSP) 2021/698.

38 For more see the website of the EEAS at https://www.eeas.europa.eu/eeas/space_en.

and humanitarian aid. Last but not least it actively contributes to disaster response and humanitarian endeavours by leveraging sophisticated space-based technologies, such as satellite imagery, thus solidifying the EU's commitment to global welfare.

THE SIGNIFICANCE OF SPACE ASSETS IN DEFENCE AND SECURITY

Space has evolved into a heavily contested domain since the launch of Sputnik 1 in 1957. This transformation has seen rapid advancements in satellite technology, with the two superpowers dominating the sector during the first space age (1957–1991). Space rapidly became a theatre of competition, with both nations developing counter-space capabilities. From the 1959 Bold Orion missile test to the 1962 Starfish Prime nuclear test by the United States and the Soviet Union's co-orbital anti-satellite system, the militarisation of space gained momentum. The proliferation of ASAT weapon development continued through the 1980s, signalling a further intensification of the militarisation process. However, after a period of relative dormancy in formal debris-producing ASAT tests, the Chinese ASAT test in 2007[39] and Russia's recent test in 2021 contributed to a resurgence of concerns regarding space weaponisation and security threats. As the world transitioned from the Cold War era in 1991, a "second space age" emerged, marked by increased commercialisation and diversification of space capabilities across numerous nations (Japan, China, India and European countries). Later, the eventual appearance of prominent large space companies (including SpaceX, Virgin Galactic, etc.) significantly influenced the commercial space sector, reshaping traditional approaches and fostering ambitions for space tourism and innovative satellite constellations.[40]

The "proliferation" of space capabilities beyond traditional powers has led to a more diverse and competitive era in space exploration. Policymakers within

[39] Harrison et al. 2017.

[40] Del Canto Viterale 2023.

the European Union conceptualise the need to modernise norms and treaties addressing space to adapt to this evolving landscape. The evolution of EU space assets transcends their initial civilian objectives, driving a pivotal shift in defence and security paradigms. Beyond their evident civilian utility, assets have emerged as enablers in fortifying Europe's defence capabilities, contributing to technological advancements and improving its global positioning in the security landscape. Navigation and Earth observation applications of space technology perform critical functions in civilian life while serving as strategic assets for defence and security, providing an unmatchable operational upper hand in specific scenarios. Precise position, navigation and timing (PNT) data provide unparalleled advantages (like Galileo's PRS) in military operations, ensuring resilient and accurate positioning in various scenarios. With comprehensive Earth observation capabilities, border surveillance, natural or man-made environmental damage, disaster management and intelligence gathering, it amplifies Europe's situational awareness and crisis response capacities.[41]

The European Defence Agency (EDA)[42] and the EEAS consistently highlight the dual-use potential of EU space assets in their publications and reports. They emphasise the transformative impact of satellite communications, high-precision navigation and Earth observation data on bolstering military situational awareness, intelligence capabilities and crisis response. Although the ESA covers the civilian aspects of space – in accordance with its Convention – several cooperation efforts and initiatives further underscore the strategic relevance of space assets in security architectures which can bolster Europe's security resilience. The EU SSSD articulates a comprehensive vision for harnessing space assets to safeguard EU interests, underscoring the imperative nature of further solidifying the pivotal role of Space Situational Awareness (SSA), Space Surveillance and Tracking (SST), as well as the Member States' prerogatives relying on Space Domain Awareness (SDA).[43]

41 Harrison et al. 2021.
42 European Defence Agency 2021.
43 Council of the European Union 2023.

Academic scholarship on space activities spans diverse domains, including international relations, security studies and technological knowledge. As such, it sheds light on the multifaceted implications of EU space assets. Articles in journals such as *European Security* and the *Journal of Strategic Studies* investigate the transformative potential of space assets, outlining their substantial impact on reshaping security paradigms, augmenting strategic decision-making and fostering international cooperation. In essence, the multifaceted roles of EU space assets encompass defence and security, technological innovation, global positioning and international collaboration. The use of space assets for defence and security purposes has evolved significantly over the years; space has transitioned from a domain that is primarily associated with scientific exploration to a critical enabler of military and security operations. For some time now, EU institutions have effectively upheld the distinctions between the military and civilian use of European space capabilities. However, these boundaries are beginning to become increasingly blurred due to the more open drive for harnessing space as a domain of European security, including for military and defence-related uses. This idea sets out the paradigm shift of "peaceful uses" given that in international treaties, there is no explicit prohibition of a collective array of military activity in space – as those documents restrict themselves to imposing obligations against the use of space for deploying force against other states.[44]

KEY SECURITY CHALLENGES IN SPACE FOR THE EU

Global security threats in the space field are arising from a variety of directions. Foremost among these challenges is the issue of space debris and sustainability. The proliferation of defunct satellites, rocket parts and remnants of past collisions has led to an immense congestion of space debris, posing a substantial collision risk to operational satellites. Managing this escalating problem makes

[44] Klimburg-Witjes 2023: 830–839.

implementing vigilant strategies on a multi-spectrum basis is imperative. Initiatives focused on debris mitigation aim to reduce space debris generation by advocating responsible behaviour and highly standardised satellites, launch practices and end-of-life disposal methods. Complementing these, there are efforts to develop pioneering technologies for Active Debris Removal (ADR), seeking to extract debris and mitigate collision risks actively – even though ADR is still more of an initiative than an existing practice.[45]

Space security concerns also loom beyond the strategic landscape with fears being voiced about potential threats ranging from the proliferation of technology to the sabotaging of space assets. Developing and testing different Anti-Satellite (ASAT) weapons (from kinetic to electronic) raises concerns about deliberate harm to space assets. Additionally, vulnerabilities of space systems to cyber threats, which could disrupt crucial communication, navigation and surveillance capacities, present an even more pressing concern, primarily in light of the recent experiences of armed conflict returning to Europe. Unauthorised interference with or falsification of navigation signals through jamming and spoofing further impacts military operations and security.[46]

Amidst these challenges, regulatory and legal predicaments have arisen. Either the absence of or the dated perspective of comprehensive international agreements governing space and the corresponding dual capable technology initiatives pose substantial regulatory and legal challenges. The lack of explicit treaties and regulations addressing arms control in, to and from space hampers efforts to prevent an actual arms race, jeopardising the crucial sanctuary of space. Establishing universally accepted norms of (responsible) behaviour in space could be pivotal to avoid weaponisation and to prevent the escalation of tensions stemming from misinterpretation or miscommunication. Liability in space activities, especially regarding potential conflicts arising from certain space-based assets, presents intricate legal challenges that require careful consideration and the identification of the "best" way forward for the space policy of the EU.

45 Sullivan – Ben-Itzhak 2023: 135–139.

46 Chatterjee 2014: 41–42.

CONCLUSION

Over many decades, the EU's approach to space has evolved from fragmented efforts by individual member states to a collaborative and strategic framework involving key institutions. The establishment of the European Space Agency in 1975 laid the groundwork for Europe's entry into space exploration and satellite technology, culminating in the developing of flagship programs for the EU and Europe in the 21st century. Throughout its journey, the EU's core institutions have played integral roles in shaping, implementing and overseeing the EU's space strategy. The strategic integration of space assets for defence and security purposes marked a pivotal shift in the EU's approach, acknowledging space systems' dual-use nature and their significance in fortifying Europe's security architecture. Despite some differences of opinion, a nuanced landscape emerges where timeliness meets the intricacies of trial and refinement.

Significant challenges concerning the "traditional" framework for independent access to space and Europe's past space exploration activities in an era of space commercialisation require the pursuit of a multi-pillar strategy on uncharted territories for decision-makers within European borders (launcher policy, human-crewed spaceflight, etc.). Close cooperation between the ESA and the EU is essential to ensure that the space policy pursued by the world's space powers is matched by a mechanism for the European region to build on its dominance and independence. Promoting the governmental and institutional needs for space-based applications requires a public policy approach, as it is clear that both security and defence policy considerations and the need to ensure an institutionalised internal market for the relevant European industries are becoming essential in the "New Space" era. International cooperation is essential for challenging new types of space missions, whether they be of a scientific nature or otherwise. Europe must be able to play a leading role to ensure that it has the necessary level of autonomy while building critical competencies that can be further exploited in future partnerships. Finally, in addition to stimulating space-related R&D investments (e.g. through Horizon Europe or Cassini), it is necessary to develop infrastructures and policy guidelines that, to return to the comparison made earlier in this article, could ultimately lead Europe to the American approach to national power, whereby in our interpretation a space power creates and exercises all four instruments of power (diplomatic, informational, military, economic). Nevertheless, the evolution of the EU's space policy deliberately balances the rush to adapt to emerging challenges with the imperative to craft sophisticated and sustainable strategies. As the EU moves through this complicated landscape, it embodies both a sense of urgency in addressing immediate needs and a commitment to refining and reinforcing its space policy for the long haul. This convergence of urgency and deliberate refinement shapes a path towards a more responsive and resilient space policy framework, that will be essential for carefully preparing both civilian defence, and security-oriented space policy for the complex set of challenges which are likely to await over the next decades.

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Part Two:
Trends in Regulation

Maximilian Bertamini

New Space Dynamics and the Development of Space Law: Exposing Weaknesses and Suggesting Alternatives

Introduction

In 2019 humanity celebrated the 50th anniversary of the first moon landing, an achievement that inspired millions and evoked visions of humanity's future in space. Looking back at this milestone, one is struck by how much has changed since the early days of spaceflight. Although the launch of space objects is not as frequent as that of aeroplanes, we are witnessing a notable increase in the amount of space traffic, operated both by States and private entities. At the same time, new uses for outer space are constantly being developed, be they commercial, military, or scientific in nature. These developments are widely recognised. On the one hand, they are recognised by States, as demonstrated by the rising adoption of national space strategies and by the increasing international support for the *Artemis Accords,* a document dedicated to establishing a "common vision [...] to enhance the governance of the civil exploration and use of outer space".[1] On the other hand, they are also recognised by scholars, who have been inspired by developments in the space sector to reflect on and restate the current state of international space law in the McGill Manual on the International Law Applicable to Military Uses of Outer Space (MILAMOS).[2] The new uses *for*

[1] NASA 2020: Section 1.

[2] Jakhu–Freeland 2022.

DOI: https://doi.org/10.36250/01208_05

space, the new users *of* space and the new engagement *with* these dynamics are often – as in this book – captured in the term "New Space", and many observers are already proclaiming a New Space Age.[3]

While the Space Age is new, the international law governing it is relatively old. At least, it is old in the sense that it does not directly or extensively address the dynamics and phenomena that characterise the New Space Age. Conventional space law research therefore tends to focus on the question of how far existing law governs and impacts New Space endeavours.[4] Considering the speed and scale at which New Space dynamics are unfolding, this Chapter will take a different perspective and in fact reverse the questions asked in conventional space law literature. Instead of asking how international outer space law impacts commercial, military and scientific uses of outer space, including by private actors, this Chapter will investigate the extent to which the New Space dynamics can impact the development of international outer space law.

The aim of this Chapter is to show that New Space dynamics can and in fact should have an impact on the development of international outer space law in several ways. It will demonstrate which of these New Space dynamics can and should have an impact on the development of space law. When the Chapter refers to the *development* of outer space law, it does not necessarily mean the creation of new law. Although the creation of new space law will also be considered in this Chapter, its focus will mostly lie on the development of the *understanding* and handling of *existing* space law in space law research. The existing law will, after all, not simply vanish with the creation of new law.

[3] For example Del Canto Viterale 2023: 232–233; The Washington Post 2023; Ciocca et al. 2021: 4–6.

[4] Regarding resource exploitation in space, which also serves as the example in this Chapter, see Bonin–Tronchetti 2010: 6–21; De Man 2016.

By analysing the example of the concept "national appropriation" in Article II[5] of the Outer Space Treaty[6] (OST), it will be argued that the New Space dynamics identified earlier require space lawyers to engage more critically and more comprehensively with the established arguments and beliefs of space law in order to allow a doctrinally sound and practical application of existing space law to modern space endeavours.[7]

Translated into methodological terms, the Chapter combines different approaches. On the one hand, Article II OST will be interpreted with a focus on applying the provision to modern phenomena. While it may have practical applications, the approach does *not* focus on desired outcomes. Instead, it demonstrates, where ordinary tools of treaty interpretation have been underexplored and how they can be better exploited to facilitate practical interpretations of international outer space law even with conservative approaches to treaty interpretation. On the other hand, the Chapter will offer reflections not only on how existing law can govern and address the emerging practice in the exploration and exploitation of outer space, but also on how this newly emerging practice may shape the interpretation of the Outer Space Treaty as subsequent practice under Article 31(3)(b)[8] of the Vienna Convention on the Law of Treaties[9] (VCLT).

5 Most of the Chapter will revolve around Article II OST, but in so far as the proper understanding of "national activities" in the OST is concerned, recourse will also be made to Article VI OST as well.

6 Treaty on principles governing the activities of States in the exploration and use of outer space, including the moon and other celestial bodies, 27 January 1967, 610 UNTS 205.

7 Conducting the required critical research requires a lot of fundamental research and is thus far beyond the scope of this Chapter. A lot of it will, however, be contributed by the author's upcoming PhD thesis.

8 Technically speaking, references to Article 31 VCLT in the context of space law in this text should be understood as references to the customary international law codified in Article 31 VCLT (see Dörr 2018: 561) given that Article 4 VCLT stipulates that the VCLT itself can only be applied to treaties which were concluded before the VCLT entered into force in 1980.

9 Vienna Convention on the Law of Treaties, 23 May 1969, 1155 UNTS 331.

Accordingly, the structure of the Chapter is as follows. First, the two trends of New Space with the greatest impact on the development of outer space law will be introduced, namely the shift in space utilisation from a theoretical to a practical issue and the shift in users of space from being mostly States to being mostly non-State actors. In the next section, it will be demonstrated how these developments push the results of prior legal engagement with Article II OST to their breaking point and at the same time offer insights into which type of engagement would be necessary to find doctrinally sound and practical ways to understand the provision. Finally, the Chapter will draw conclusions from the analysis, reflect in the abstract on the impact of New Space dynamics on international law-making in general and summarise the implications of the findings for the development of outer space law.

NEW DYNAMICS – PRACTICE AND PRIVATES

This Chapter will focus on two specific dynamics characterising the New Space Age, namely the increasing "practicalisation" and privatisation of space projects. These dynamics constitute a shift from previously existing standards in spacefaring and are likely to have an impact on the development of international outer space law.

Realising space utilisation – A shift from theory to practice

This Chapter operates on the hypothesis that, as more technology becomes available, the possibilities of utilising the benefits of space for commercial, military and scientific purposes will steadily increase. Since 2016, there has been a sharp rise in space objects being launched, especially from the United States.[10] While the number of launches does not directly correspond to that of new space objects since 2016, as many of these objects belong to mega constellations

10 United Nations Office for Outer Space Affairs 2023.

like *StarLink,* there is also a significant increase in launches. The boom in launches and space objects goes hand in hand with a growing space industry, focused among other things on the development of space mining techniques,[11] space travel[12] and the deployment of ever smaller satellites.[13] Although this dynamic is at this point not yet a ubiquitous phenomenon and even varies among developed countries with advanced spacefaring experience, at present the global space industry is already worth hundreds of billions of dollars and economic experts expect it to double or even triple in size by the year 2040.[14] As a growing sector of industry sets its sights on outer space, the extraction and utilisation of resources in space may also be on the horizon. The possibilities for such utilisation have already been studied and developed in principle: in 2021 for example, a team of student researchers from *Technische Universität Berlin* developed the Lunar Rover *LUIEE* (Lunar Ice Extraction & Electrolysis), a device capable of extracting lunar ice and separating the oxygen and hydrogen bound therein through electrolysis.[15] This process makes hydrogen available for fuel production in outer space which in turn has the potential to significantly reduce the costs of spacefaring, since it may allow expensive space objects operated by propulsion systems to be refuelled. Minerals mined in space could potentially be used as filament for 3D printers, which have been proven[16] to operate normally under Zero G conditions.

Against the background of the predicted major economic growth in the space sector combined with realistic prospects for the use of space resources, it is at the very least plausible that many new forms of space exploration and exploitation will be tested. Not only that, but if they are tested successfully, it is reasonable to assume that such technologies would also be developed further and increasingly put to use in outer space.

11 Vernile 2018: 42–50.
12 Vernile 2018: 51–60.
13 Vernile 2018: 61–70.
14 New Space Economy s. a.
15 Technische Universität Berlin 2021.
16 Prater et al. 2018: 412–415.

This will change the way in which we need to engage with space law. It is one thing to discuss the implications of space law for certain utilisation practices, when they do not yet occur on a large scale. It is an entirely different issue, when real world practices lead to real world legal disputes which are then debated and decided in court. Determining the legality of space utilisation on a case-by-case basis requires space lawyers to *apply* the vague principles constituting today's space law to real world facts with real world consequences. To eventually produce the legal certainty[17] that can legitimately be expected from the courts, space lawyers will have to find a reliable path through the many theories that have been devised about the correct way of understanding space law principles, which frequently contradict one another in their results. We will have to find doctrinally sound definitions for the black letter law terms found in the provisions of the Outer Space Treaty or the Liability Convention,[18] because these are what the courts can eventually apply – not the theories about them. This requires space lawyers to engage with space law in a way that pays much greater attention to the technical and doctrinal handling of the law compared to the largely academic and theoretical discussions which have dominated the discourse so far. Section *Article II OST – Established inadequacy* of this Chapter will exemplify what this means for the proper treatment of Article II OST when it comes to resource acquisition. One implication can be mentioned here already: in order to generate insights into a practical way of handling and applying space law to real world cases, it will be necessary for space lawyers to leave their comfort zones and (critically) assess terms and concepts of space law in relation to definitions and concepts from the rest of international law that are already well-established in practice.

17 For the importance of legal certainty in space see Johnson 2011: 1517.

18 Convention on the international liability for damage caused by space objects, 29 March 1972, 961 UNTS 187.

The "privatisation" of spacefaring – A shift from states to companies

A second and less hypothetical dynamic of modern spacefaring which can be observed and which will determine how we should engage with space law is the increasingly private nature of space activities.[19] A first wave of companies have developed their own launch systems and capabilities, and more and more small private actors are collaborating with such companies and space agencies to put their own space objects in orbit.

This dynamic does not mean that States and their practice do not continue to shape the law of outer space, but it does imply that outer space will slowly but surely transform into an environment that is strongly characterised by the presence of private economic actors.[20] The presence of States in space through their space agencies and their own missions will not necessarily diminish as a consequence, but States will operate in an environment that is increasingly crowded by actors which are *prima facie* not directly bound by outer space law.[21] At the same time, the practices established by these actors, as well as the standards and best practices that will necessarily arise out of their interaction, could become a challenge to standards and practices that are simultaneously developed among States.

This development is interesting because it raises questions regarding the genesis of the rules of international law, which are generally created by States. Of course, the mere presence of non-State actors and their practice does not immediately impact existing rules of international law or create new ones. It does, however, shift the spotlight away from direct State practice and raises two questions in doing so:

[19] Vernile 2018: XXV–XXVII.

[20] Vernile 2018: XXV.

[21] States do of course owe one another to ensure compliance of their national activities conducted by non-governmental entities under Article VI OST, but the exact requirements and consequences of this obligation – so this Chapter will argue below – are far less clear than they are presented in the established space law discourse.

First, is attribution of private conduct in space to the appropriate States truly as straightforward and low in requirements as is often suggested?[22] If it is, then private conduct in space is eventually State conduct in space and may directly shape the understanding of space law as subsequent practice pursuant to Article 31(3)(b) VCLT.[23] If, however, attribution of "national activities" (Article VI OST) does not function in a generalised fashion, but only if certain conditions are met, then space lawyers will have to carefully differentiate between which practices are relevant and less relevant for the purposes of identifying subsequent practice through private actors. At the very least, a critical revisit of the law of attribution and its application in an outer space context will be appropriate. The results of this critical revisit may very well have an impact on the future development of space law. The second sub-section of section *Article II OST – Established inadequacy* of this Chapter will offer further thoughts on this matter.

Second, if certain conduct by private actors in space should not be attributable to States, what sort of impact can the conduct of such actors have on the development of space law? Technically, this question contains two issues. The first one is whether the large influx of private actors in the space sector warrants a rethink of the doctrine of international law sources. After all, the practice of private seafarers and merchants has shaped international regimes already.[24] The second issue raised in the question is whether the conduct of

[22] See for example BACA 1993: 1065–1066.

[23] GARDINER 2015: 266; International Law Commission 2018b: 37, Commentary 2 to Conclusion 5. While the ILC first and foremost considers attributable practice of non-State actors relevant when they exercise governmental authority, it did not directly reject the possibility of considering conduct that is attributable to a State based on effective control under Article 8 ARSIWA. Considering that attribution under Article VI OST would only extend to "national" activities in the first place, it can very well be argued that attributable non-State practices under Article VI OST can and should be considered practice in the application of the OST, cf. International Law Commission 1966: 222, Commentary 15 to Article 27.

[24] Consider for example the *lex mercatoria* or the references in the United Nations Convention for the Law of the Sea to the already established "generally accepted international rules and standards" as well as "regulations, procedures and practices" of seafaring.

private actors can impact the development of space law not through their attribution, but through how States *react* to and *regulate* it, which could also be considered a form of subsequent practice.

ARTICLE II OST – ESTABLISHED INADEQUACY

To demonstrate the implications that the two shifts in spacefaring practice identified above will have on the development of space law, this Section will highlight how the "practicalisation" and privatisation of space exploration and exploitation can and should affect the established interpretations of Article II OST. It is virtually – and rightfully – undisputed in international space law that Article II OST governs extractive practices regarding resources in outer space.[25] That is, at least in so far as the extraction of resources is aimed at economic benefits, which are likely to require extractive actors to obtain some forms of rights over the extracted resources.[26] The acquisition of rights over space resources is, in turn, governed by the non-appropriation principle of Article II OST. This also explains why *NASA* chose to include in the *Artemis Accords* a reference stating that the mere extraction of resources in outer space is not automatically an appropriation in the sense of Article II OST.[27] Article 11 of the Agreement governing the Activities of States on the Moon and Other Celestial Bodies[28] (Moon Agreement) contains a more explicit regulation regarding the acquisition of property rights over resources in outer space, but the low adoption rate of that treaty makes Article 11 of the Moon Agreement a provision of negligible relevance compared to Article II OST.[29]

25 See for example Baca 1993: 1065–1067; De Man 2016; Jakhu–Freeland 2009: 53–54, 58–59; Hobe et al. 2009; Paliouras 2014: 46–49; Tennen 2016: 283–285; Tronchetti 2009: 29–33.

26 Hertzfeld – von der Dunk 2005.

27 NASA 2020: Section 10(2).

28 Agreement governing the Activities of States on the Moon and Other Celestial Bodies, 5 December 1979, 1363 UNTS 3.

29 Johnson 2011: 1497; Rostoff 2017: 380; Sprankling 2014: 180.

Against this backdrop, it is not surprising that a great deal of academic thought has been articulated regarding *how exactly* Article II OST governs the extraction of resources and the acquisition of various rights over various things in space. One aspect of this broad body of literature concerns the question of whether and how the conduct of private actors can and should be subsumed under Article II OST. First of all, in order to understand the implications of New Space dynamics on the development of the international law of outer space, it is necessary to understand the positions advanced on such questions in the existing discourse, which will be presented below. This Chapter argues that the existing positions on the important questions of space law in the orbit of Article II OST – while very well established and accepted in international space law discourse – are proving inadequate in light of the emerging New Space dynamics and the shift in thinking that they require.

"Appropriation" – The need for new perspectives

This sub-section of the Chapter will argue in favour of the need to begin engaging with the concept of appropriation in Article II OST in a doctrinal and comprehensive way. The shift in thinking that is required in light of the New Space dynamics when engaging with Article II OST and with the very concept that it rules out will become apparent when contrasting the norm typology of Article II OST with the practical scenarios to be governed by the provision (a). An immediate consequence of this shift in thinking, this sub-section argues, is that shortcomings in the existing interpretations of Article II OST and its applications to resource acquisition scenarios will become apparent (b). To overcome these shortcomings, the sub-section will finally suggest some avenues for further research that promise to eventually render Article II OST both more applicable to practical cases with a certain degree of legal certainty and to make it more doctrinally sound by taking the wording and requirements of Article II OST seriously (c).

Reflecting on norm typology – Principles and practice

Article II OST is commonly referred to as a *principle,*[30] which is not surprising considering that the Outer Space Treaty itself is properly called the "Treaty on *principles* governing the activities of States in the exploration and use of outer space, including the moon and other celestial bodies",[31] and which is based on a UN General Assembly resolution declaring the "Legal *Principles* Governing the Activities of States in the Exploration and Use of Outer Space".[32] Neither the Outer Space Treaty nor the Declaration of Principles contains any reference to the implications of non-appropriation being a principle rather than a rule. It is clear, however, from general legal theory that principles and rules – while equally binding –differ in how they govern the conduct of legal subjects. This difference was eloquently discussed by Robert Alexy in his *Theory of Constitutional Rights.*[33] Although he was writing in the context of German constitutional law, Alexy approached the distinction between principles and rules at a fairly abstract and general level. In his words:

> "The decisive point in distinguishing rules from principles is that principles are norms which require that something is realized to the greatest extent possible given the legal and factual possibilities. Principles are optimization requirements, characterized by the fact that they can be satisfied to varying degrees, and that the appropriate degree of satisfaction depends not only on what is factually possible but also on what is legally possible. The scope of the legally possible is determined by opposing principles and rules.
>
> By contrast, rules are norms which are always either fulfilled or not. If a rule validly applies, then the requirement is to do exactly what it says, neither more nor less. In this way rules

30 See De Man 2016; Freeland 2013; Paliouras 2014; Pershing 2019.

31 Emphasis added.

32 UNGA Res. 1962(XVIII), emphasis added.

33 Alexy 2010.

> contain fixed points in the field of the factually and legally possible. This means that the distinction between rules and principles is a qualitative one and not one of degree. Every norm is either a norm or a principle."[34]

While the definition of a rule provided by Alexy is abstract enough to function outside of a constitutional law context, his characterisation of principles does not directly match the normative content of Article II OST. That is because Article II OST establishes a legal status for outer space as an area rather than, for example, guaranteeing a liberty. As a matter of logic, the determination of the legal status of an area is something that is realised to the greatest extent possible from the moment at which the norm determining that status becomes binding. From this point onwards, the conduct of actors can only be evaluated against the norm in terms of their compliance with it and not in terms of realisation. This remains true at least until a point is reached at which an overwhelmingly conflicting practice either changes the interpretation of a status-determining provision in the sense of Article 31(3)(b) VCLT or when it eventually overrides the provision determining the status entirely as a new specialised norm of customary international law. Not every status-determining norm is necessarily excluded from being a principle in Alexy's sense. Consider, for example, the constitutional provisions that determine the status of a State's form of government: the fact that Germany is a democracy according to Article 20(1) of the German Basic Law does not automatically realise democracy in Germany. Instead, public procedures, elections and other possible manifestations of democracy must still be organised and conducted in a manner which is as democratic as possible, in a conscious effort towards democratisation on a day-by-day basis. What follows from this is that status-determining norms can be principles, if they relate to an entity with the capacity to shape and reflect its own actions. For Article II OST as a norm that determines the legal status of an inanimate area, this is not the case.

34 Alexy 2010: 47–48.

There are, however, other possible criteria for distinguishing principles from rules. Alexy himself notes that the level of generality[35] of a norm could potentially be considered a criterion, as well as a norm's significance[36] for the legal order.[37] Principles could perhaps be characterised as an aspirational type of legal norm. From the perspectives of generality or abstractness and of its significance[38] for the system of outer space law, Article II OST may very well qualify as a principle. At this point it should be noted that the references to Article II OST as a principle in the scholarly literature and in the Outer Space Treaty were probably not intended to establish a categorical distinction between different categories of norms. Terminological inconsistency[39] may very well be a plausible alternative explanation. After all, the prohibition (= rule) on the use of force in Article 2(4) of the United Nations Charter is contained in an article governing the fundamental "Principles" of the organisation. Nevertheless, as this Chapter will demonstrate below, the way in which Article II OST is actually discussed in the context of the legality of property acquisition over space resources indicates that space lawyers regard it as a principle rather than as a rule.

This is problematic, because the difficulty with principles is that – unlike rules – they are not designed to answer in clear terms how a legal subject that is bound by the norm should behave in a concrete real-world scenario. In the context of resource extraction and other emerging practices, however, concrete real-world scenarios are exactly what New Space dynamics are likely to produce. To state with a practicable level of legal certainty whether an endeavour involving space resources is lawful or not, it is necessary to apply

35 Raz 1972: 838. In his text, Raz develops the level of a norm's generality regarding the description of conduct, so it may not fit very well for a status determining a provision like Article II OST either. Nevertheless, Article II OST is very abstract in describing the conduct that it regulates by listing different modalities of appropriation including the maximally general appropriation "by any other means". In this sense, non-appropriation could indeed be considered a principle.

36 Peczenik 1971: 30–32.

37 Alexy 2010: 45–46.

38 Paliouras 2014: 37–38.

39 Consider the principle of *falsa demonstratio non nocet*. Lardy 1914: 7.

a rule rather than a principle. Can Article II OST be treated like a rule? This Chapter argues that it can and should be. The argument for this is as follows: in essence, the determination of outer space as non-appropriable logically means that any appropriation of outer space is – framed negatively – *prohibited* by Article II OST. Framed as a duty, States are under an obligation not to appropriate outer space. Both understandings, which are closely related, imply that Article II OST is a norm that can be complied with, one that requires actors to do exactly what it says[40] or to abstain from exactly what it rules out, namely appropriation.

That being said, how well a legal norm can function as a rule necessarily depends on the clarity of its elements. Just as the prohibition of theft requires a clear understanding what "theft" is, how it can be conducted and how it is distinguished from comparable acts that are not prohibited, the functioning of Article II OST as a rule hinges on a clear definition of appropriation as its central concept. In light of the modalities of appropriation that Article II OST lists explicitly, such a definition must encompass how and why an appropriation can be conducted through claims of sovereignty, occupation and use. Based on a comparative analysis of the three explicitly mentioned modalities of appropriation, the most abstract modality of appropriation "by any other means" could potentially also be filled with meaning. Having established a meaning for appropriation, conduct could be assessed against that yardstick and legal certainty would be achievable for various questions of space resource exploitation.

The regulation style of Article II OST makes it possible to treat the provision as a rule, which should ultimately be more decisive than the common references to non-appropriation as a principle, considering how little the implications of such references have been explained and reflected on. Such a shift in thinking about Article II OST would be necessary to keep the norm relevant in light of the New Space dynamic of "practicalisation". Legal research in outer space law

[40] Alexy 2010: 48.

should therefore begin to entertain the idea of conceptualising Article II OST as a rule. At the very least, it should focus on finding definitions for the elements of Article II OST, particularly for the central concept of appropriation.

Inadequacies in appropriation arguments

Against the backdrop of the preceding considerations about Article II OST, the most prominent existing arguments about space resource acquisition and Article II OST prove inadequate in several regards, which will be highlighted in this part of the Chapter.

Since a great deal has been written about Article II OST and the legality of "space mining", the following overview of some of the prominent arguments in this discussion is, of course, not to be understood as a comprehensive and perfectly inclusive representation of every argument made in outer space law literature regarding Article II OST. The goal of the overview is rather to flesh out some of the most prominent lines of argument, which often function as the basis for more differentiated arguments. The scholarly works chosen to represent the general positions are selected as mere examples and many others could have been chosen in their place. Discussing certain authors' works specifically is thus not intended to elevate their work over that of others or *vice versa*. Before discussing some of the prominent arguments and their shortcomings, it is important to emphasise that the intention is not to dismiss these arguments as necessarily wrong. After all, they are largely based on valid methods of (international) legal reasoning and follow an inner logic. This is why they need to be taken into consideration to gain a comprehensive understanding of all the legal implications of Article II OST for resource extraction in space. Nevertheless, they are based on legal research that merely scratches the surface of what would be possible and necessary in order to render Article II OST future proof and its application both doctrinally sound and legally certain with a view to the increasing "practicalisation" of spacefaring.

The arguments

The first line of argument about the appropriation of space resources seeks to prohibit the acquisition of certain rights over resources and focuses on the nature of the rights that cannot be acquired under Article II OST. In essence, proponents of this line of argument are of the opinion that the acquisition of property or sovereignty over space and its resources is prohibited by Article II OST. The argument has been articulated in a variety of ways, which range from a "broad reading"[41] of Article II OST regarding sovereignty and property to the outright prohibition of exclusive[42] rights.[43] It draws its authority from the inclusive status of outer space as a global commons that the Outer Space Treaty arguably[44] seeks to establish to prevent the repetition of the race for the acquisition of sovereignty[45] that took place between states in previous centuries. Further support is derived from a statement made during the negotiations preceding the conclusion of the Outer Space Treaty in the United Nations Committee on Peaceful Uses of Outer Space (UN COPUOS) in which the

41 See for example Gangale 2009: 33–34; Lachs 1972: 44; Pershing 2019: 154–157.

42 See for example De Man 2016: 320, who holds that exclusion is problematic under Article II OST when it is not based on use; Husby 1994: 364.

43 Further arguments include for example the OST's object and purpose to prevent any kind of power struggle over outer space and its resources, see Gawronski 2018: 179; Jakhu–Freeland 2009: 49; Hobe et al. 2009. Another argument that is often raised in support of this position is that the prohibition on the exercise of state sovereignty over space precludes the creation of property rights, which many authors allege flow from national sovereignty. See for example Cheng 1997: 233, 400. The assumption underlying this final argument, namely that property flows only from national law and cannot exist independently of national legal orders, may have been true for a long time. However, as the ideological divide between socialism and capitalism was overcome in practice, the economy became globalised and human rights – including a right to property – succeeded at the international level, these assumptions can and in fact should be challenged today. For an in-depth analysis of this argument, readers are directed to the author's upcoming PhD thesis as well as to Sprankling 2014.

44 Although a 2020 Executive Order from the United States of America takes a different stand, see President of the United States of America 2020: Section 1. See also Bertamini 2020.

45 See Jakhu–Freeland 2009: 49; Hobe et al. 2009.

Belgian representative pointed out that it was apparently without contradiction that the non-appropriation clause was supposed to extend to both sovereignty and property rights.[46]

A different and equally well-established line of argument allows property acquisition over space resources pursuant to Article II OST. It is based on the fact that the wording of Article II OST does not explicitly prohibit the acquisition of property rights over resources.[47] Authors advancing this position agree that the appropriation of outer space itself, especially in relation to territory, remains prohibited, but contend that the extraction of and acquisition of property rights over such extracted resources is allowed. In essence this position relies on a peculiarity of international law, articulated most prominently in the *Lotus* judgment delivered by the *Permanent Court of International Justice* (PCIJ).[48] In that case the Court proclaimed:

> "[T]he rules of law binding upon States therefore emanate from their own free will as expressed in conventions or by usages generally accepted as expressing principles of law and established in order to regulate the relations between these co-existing independent communities or with a view to the achievement of common aims. Restrictions upon the independence of States cannot therefore be presumed."[49]

In other words: limitations of State sovereignty, such as the prohibition of certain conduct, cannot be presumed. Instead, the sovereignty-based nature of international legal relations requires that restrictions of sovereignty are based in law that States willingly subject themselves to. If Article II OST was supposed to prohibit States from acquiring rights over resources in outer space, i.e. if Article II OST is to be interpreted in a way that assumes that

46 Statement by Mr Bal in United Nations Committee on the Peaceful Uses of Outer Space 1966: 7.
47 See for example Hobe 2019: 160; Johnson 2011: 1507; Pop 2008: 135–142, 150–151; Sprankling 2014: 187–189.
48 PCIJ *(Lotus)* 1927.
49 PCIJ *(Lotus)* 1927: 18.

States subjected themselves to a prohibition of acquiring rights over resources in space, the provision should have mentioned that in a clearer fashion, much as the Moon Agreement does.

These two lines of argument regarding the legality of rights acquisition over space resources under Article II OST are the most prominent and established ones, judging by their frequent reappearance in space law discourses. Next to them, other lines and facets of argument are also briefly worth mentioning here. There is, for example, the occasional discussion[50] of an analogy between outer space and the High Seas, according to which space resources should be acquirable despite Article II OST, just like fish can be caught and owned despite Article 89 of the United Nations Convention on the Law of the Sea[51] (UNCLOS), which rules out the subjection of the High Seas under State sovereignty. Another prominent and established facet of the resource appropriation discourse is the distinction between land and movable resources, according to which the former are covered by Article II OST in light of the Outer Space Treaty's purpose, while the latter are not.[52]

The problem(s) with the arguments

Although the arguments presented are valid legal arguments, they suffer from a number of interrelated flaws that render the arguments inadequate in two regards. First, the arguments presented above are unable to provide legal certainty in the application of Article II OST to real-world cases. Secondly, they mostly ignore the modalities spelled out in the text of Article II OST.

In terms of legal certainty, the very fact that most[53] of the arguments are based on valid methods of international legal argumentation makes the

[50] See for example Blanchette-Séguin 2017: 966–969; Brooks 1966: 322; Pop 2008: 139; Williams 1987: 147.

[51] United Nations Convention on the Law of the Sea, 10 December 1982, 1833 UNTS 3.

[52] Alshdaifat 2018: 32–33; Bonin–Tronchetti 2010: 6–14; Cheng 1997: 400–401.

[53] Because analogies take a State's commitment to a provision of law limiting the State's sovereignty in one context and transfer it to justify a similar restriction in a different context – one to which the State has not committed – analogies in international law are

contradictions between them problematic. The first two lines of argument alone come to diametrically opposing results regarding the legality of resource acquisition in space. That is, of course, unless one considers the distinction between land and resources to be relevant and applies the first line of argument only to land and the second one only to resources. Such a distinction does not, however, flow from the reasoning behind either line of argument. Furthermore, the Outer Space Treaty nowhere makes such a distinction itself. Indeed, in light of the treaty's objective of preventing power struggles between States over outer space, the distinction between land and resources becomes less and less relevant today, as valuable resources rather than land are the chief focus of space actors. Power struggles may just as well arise over resources as over land, especially considering that many resources on Earth are destined to expire at some point in time. As of now there is no decisive legal consideration that helps decide between the first two lines of argument. This leaves actors which plan to realise the immense potential of exploiting the resources of outer space for the benefit of humanity in a legal limbo of not knowing whether their plans are lawful. Even worse: the contradiction between the major lines of argument in the absence of a decisive element renders Article II OST powerless to regulate a very important and potentially seminal use of outer space. In circumstances like this, it is likely that political will and the practice of opportunistic actors which may not be overly concerned about the legality of their actions will eventually shape the law of outer space and not the other way round. The first examples of such unilateral steps being taken are reflected in the national space legislation of various States, which attempt to create facts by allowing their nationals to acquire property rights over space resources. Although contemporary space law authors still tend to only refer to the laws of Luxembourg (2017) and the United States (2015) in this context, in fact many other States are following suit and their laws should also be considered. For example, Japan and the United Arab

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a problematic concept in light of the PCIJ's finding in *Lotus*. The analogy between the law of the High Seas and outer space law is thus doctrinally doubtful.

Emirates have enacted similar legislation[54] and India adopted a Space Policy in 2023 under which non-governmental entities or NGEs are encouraged to

> "engage in the commercial recovery of an asteroid resource or a space resource. Any NGE engaged in such process shall be entitled to possess, own, transport, use, and sell any such asteroid resource or space resource obtained in accordance with applicable law, including the international obligations of India."[55]

Legal researchers in outer space law should be aware[56] of this trend and ask themselves whether our hands are effectively tied or whether there are relevant methods of legal thinking which are underrepresented in the discourse.

At the doctrinal level, there is a second problem with the arguments presented above; a problem that they all have in common and one that is connected to the first problem in terms of underrepresented methods of legal thinking. Although all the lines of argument presented above say something about the results of applying Article II OST, none of them reach their respective conclusions by actually applying the law, i.e. by attaching a certain meaning to the individual elements of the norm, such as appropriation or a claim of sovereignty, and subsuming a set of facts to these elements. It is striking that only a select few scholars[57] engage in the systematic and technical interpretation

[54] A tentative English translation of the Japanese Act on the Promotion of Business Activities for the Exploration and Development of Space Resources (Act 83 of 2021) is available at https://www8.cao.go.jp/space/english/resource/documents/act83_2021.pdf. The UAE Federal Law No. 12 of 2019 on the Regulation of the Space Sector does not explicitly allow for the acquisition of property rights over space resources, but its Article 18(1) allows the possibility that space resources are acquired and used for commercial purposes. Said law is available at https://www.moj.gov.ae/assets/2020/Federal%20Law%20No%2012%20of%202019%20on%20THE%20REGULATION%20OF%20THE%20SPACE%20SECTOR.pdf.aspx.

[55] Indian Space Policy – 2023, available at https://www.isro.gov.in/media_isro/pdf/IndianSpacePolicy2023.pdf.

[56] Blount 2018: 122–123.

[57] Such as Blount 2018: 101–104; Jakhu–Freeland 2009: 48–55; Hobe et al. 2009; Schwab 2008: 56–70.

of the actual terms of Article II OST through the lens of Article 31 VCLT, and even these discussions are confined to only a small number of pages. That understanding a norm properly requires a definition of its terms should go without saying for any lawyer.[58]

If one thinks of Article II OST as a principle and is not overly concerned with treating the provision as a legal rule with meaningful requirements, then a technical legal interpretation of the black letter law may not appear as relevant. It may also very well be true that many do not deem it necessary to interpret what is meant by a "claim of sovereignty", a "use" of something or an "appropriation", as most will have some immediate association in mind. However, the "practicalisation" of spacefaring makes understanding the elements of the norm relevant and associations an often treacherous undertaking, especially in a discipline as focussed on the meaning of a text as law. Even if one followed the broadest interpretation that Article II OST is concerned with the prevention of exclusive rights over outer space in the form of sovereignty and property, the question still remains as to how exactly these rights are acquired in international law. It is this process of acquisition which must be understood from a legal perspective, because this is what the conduct of actors in outer space can be measured against under Article II OST. This in turn requires difficult, but not impossible, fundamental research into sovereignty and property as well as their acquisition under international law. In light of the increasing "practicalisation" of spacefaring, space lawyers must be able to categorically state what an appropriation is and how it is brought about, rather than philosophising over what its results are. How else can we tell the limits of what an actor may *do* in outer space? After all, both the exploration and use of outer space are necessarily manifested as *actions.* This should not come as a surprise, considering the full title of the Outer Space Treaty and its various provisions which focus on *activities* in outer space.

58 For the interpretation of international treaties see in particular Dörr 2018: 578–579; Fitzmaurice 1957: 220–223; Gardiner 2015: 66; International Court of Justice 1952: 105, 122.

A constructive suggestion – Promising avenues for new research

To overcome the shortcomings of existing appropriation arguments and to place future interpretations of Article II OST on robust doctrinal legs, new research is necessary.[59] This Chapter suggests treating Article II OST as a rule rather than as a principle for this purpose. Such a treatment is accompanied by a very concrete implication for the concept of appropriation. If the Outer Space Treaty's non-appropriation clause is understood as a rule, i.e. as a norm where the requirement is to do exactly what it says,[60] then appropriation must be understood as a requirement relating to an activity and not as a mere description of the results of an activity. In other words: appropriation must be entertained as a concept that concerns the process of acquiring something, rather than one that is concerned with the results of rights acquisition.[61]

Departing from this point, the next step towards filling appropriation as a concept of international law with meaning is to attribute a meaning to the modalities of appropriation listed in Article II OST. While it is true that the modality "by any other means" makes the list open ended, the explicitly listed modalities are the best indicator of what can constitute an appropriation in the first place. The fact that the list of examples for a concept is open ended does not, after all, mean that the concept itself has no definable meaning. Once all listed modes of appropriation have been studied and translated into tests for assessing behaviour, they can be compared in the search for common denominators among the modes of appropriation. Such common denominators have the potential to give meaning to the abstract modality of appropriation "by any other means" spelled out at the end of Article II OST. This last step especially will be very important for New Space practices, which might develop

59 Conducting this research itself is unfortunately far beyond the scope of this Chapter. It is, however, conducted in comprehensive fashion in the author's upcoming PhD thesis.

60 Alexy 2010: 48.

61 For appropriation as an act rather than as the result of an act see also Blount 2018: 102. While Blount only refers to a dictionary in his interpretation of appropriation as active conduct, his assessment is ultimately correct. After all it resonates with the ordinary meaning of the term in line with Article 31(1) VCLT.

means to utilise space in the future which have not yet been envisaged. Such practices could be potentially problematic in light of Article II OST without being identical to one of the explicitly mentioned modalities of appropriation.

Giving meaning to the modalities of appropriation in Article II OST may seem a straightforward undertaking at first, but it is in fact quite the opposite. Stating with confidence what a claim of sovereignty is requires a firm understanding of what sovereignty is, how it can be acquired and by whom. What steps need to be undertaken in order to acquire sovereignty? How much control and independence are required? What role is played by recognition by other States? What is the role of law in the acquisition of sovereignty? As sovereignty is an essentially contested[62] concept, answering these questions alone is very demanding. The same is true of the acquisition of property in international law. Does international law even recognise property as a concept[63] or is it true that property is a concept of national law only, as has been written[64] in the past? If international law knows property independent of national laws, how is it acquired? To what extent can modes of property acquisition from national law be considered general principles of law [Article 38(1)(c) of the Statute of the International Court of Justice] for the purposes of international law? What steps does an actor need to undertake to acquire property?

62 BESSON 2011: para. 4.

63 Consider for example the work of SPRANKLING 2014.

64 HARRIMAN 1926: 104, 107. In fact, the collapse of the Iron Curtain in favour of capitalism, the establishment of a globalised world economy with a need to have investments protected reliably, the success of human rights, including the right to property at least in regional human rights treaties, as well as the regulation of global commons show that there is room today for property in international law. See SPRANKLING 2014: 14–20. Nevertheless, developments in the conditions relevant for property in international law have so far been ignored in space law debates about the acquisition of property over resources. Symptomatic of this is a statement by the International Institute for Space Law's (IISL) Board of Directors from 2009, which held that: "Since there is no territorial jurisdiction in outer space or on celestial bodies, there can be no private ownership of parts thereof, as this would presuppose the existence of a territorial sovereign competent to confer such titles of ownership." This may have been true in the past, but developments in property law and the circumstances shaping property law give plenty of reasons to be considerably more critical.

Answering these questions requires thorough foundational research in international law, not only in the area of space law. However, it is possible to answer them, and without at least attempting to do so, there is no way of interpreting the concept of appropriation comprehensively and of doing justice to the modalities which the text of Article II OST clearly spells out.

"Responsibility" for "national" activities – Basics of attribution revisited

The two New Space dynamics predicted in this Chapter do not only have an impact on the material aspects of the Outer Space Treaty's non-appropriation clause. The advent of a more active and a more privately-controlled world of spacefaring also puts a spotlight on the question of whether and to what extent States bear responsibility for private actors. Article II OST does not rule out just any appropriation of outer space, but only "national" appropriation. "National" is a concept which the Outer Space Treaty picks up again in its Article VI, which deals with the responsibility of States for national activities carried out by private entities *inter alia*.

Under which circumstances space-related private conduct can be attributed to States has important implications for the development of outer space law through subsequent practice,[65] as well as for questions of liability. Space lawyers have recognised this and discussed the attribution of private activity in space alongside the concept of "national" activities. Many seem to agree that all private conduct in space is in one way or another attributable to States, mostly via Article VI OST.[66] Nevertheless, as other observers have pointed out,[67] there is still considerable doubt as to the precise functioning of attribution in outer space law and the degree of responsibility created thereby for States. This is where another implication of New Space dynamics for the development of outer space law comes into play: in order to resolve problematic space law issues,

65 See Article 31(3)(b) VCLT.

66 See for example BACA 1993: 1065–1066; GANGALE 2009: 37.

67 Among others see CHENG 1997: 633; VON DER DUNK 2011: 9.

such as the responsibility for private actors, space law research must widen its horizons and engage with the generally accepted doctrines of international law – in this case the doctrine of attribution.

When the Outer Space Treaty was concluded, the Draft Articles on the Responsibility of States for Internationally Wrongful Acts (ARSIWA) compiled by the International Law Commission (ILC) had yet to be formulated, so the debates about attribution in outer space law were mostly not articulated in the vocabulary of attribution that international law uses today. Aside from the vocabulary, however, the normative contents of attributing private conduct to States do not flow from the ARSIWA themselves, but from customary international law, resting on long-standing practices that predate the ARSIWA. This sub-section will make the case that debates about attribution and State responsibility in outer space should return to these established basics of attribution in international law. The reasoning behind this is twofold: for one thing, thinking about attribution and responsibility in terms of general international law will bring space law in line with the international legal system or at least highlight where explanation and justification is required in cases where space law departs from the general law on attribution. Even if one accepted that Article VI OST was *lex specialis* regarding the attribution norms under Articles 4–11 ARSIWA in the sense of Article 55 ARSIWA, awareness of the extent of such speciality would be welcome in terms of legal certainty. For another, approaching the attribution of private conduct in space from a properly understood ARSIWA angle will hopefully prevent some of the graver misunderstandings about attribution that shape the current discourse.

Before engaging with this issue any further, some clarifications on concepts are appropriate. These clarifications concern a) the concept of responsibility; b) the threshold for the attribution of private conduct under international law; and c) the role of jurisdiction for attribution. After clarifying these concepts, the sub-section will point out d) how these general concepts have been misunderstood in the space law discourse about attribution and make the case that it is worthwhile for space lawyers to revisit them.

Responsibility

Article VI OST refers to the "international responsibility" that States bear for "national activities". The concept of responsibility has many meanings in international law. As Volker Röben demonstrated in impressive fashion in 2012, many different meanings of "responsibility" coexist in international law at the same time.[68] These refer *inter alia* to the existence of primary obligations, due diligence and secondary consequences attaching to the violation of primary obligations.[69] Only the latter of these is responsibility in the sense of State responsibility under the ARSIWA and only here does attribution under the law of State responsibility matter. In light of this, the formulation in Article VI OST raises questions as to whether the responsibility mentioned on Article VI OST is really (only) about attribution and State responsibility in the sense of the ARSIWA. That is because the provision refers to responsibility "for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty". Such responsibility is logically directed at ensuring that private actors do not engage in conduct that would conflict with the primary obligations under space law if such conduct were carried out by a State. It is therefore not aimed at treating breaches of primary obligations that have *already occurred* as breaches by States. It is a responsibility aimed at *preventing* breaches of law rather than one *incurred by* breaches of the law. In consequence, if a private entity for which a State bears responsibility under Article VI OST engages in conduct contrary to what the Outer Space Treaty requires, the legal consequence is that the responsible State breaches Article VI OST. Unless the requirements for attribution are met, the consequence is generally *not* that the State in question has itself, through the attributable conduct of a private entity, acted contrary to a substantive provision of the Outer Space Treaty. This is the consequence of the fundamentally accepted distinction between responsibility in the sense of a primary legal obligation and responsibility in the sense of secondary obligations incurred from breaching primary obligations. While

[68] Röben 2012: 102–104.

[69] Röben 2012: 102–104.

there are also elements of Article VI OST which resonate better with State responsibility in the sense of the secondary level of responsibility (attribution and the ARSIWA in general), the mix of responsibilities in Article VI OST complicates matters and simultaneously demonstrates how important it is to know what concept we are talking about as lawyers. On a sidenote: the vagueness and legal uncertainty deriving from this (perhaps overlooked or simply unintended) mix of responsibilities in Article VI OST raise doubts as to whether such a norm can be considered the more specialised norm in the sense of *lex specialis*.

The threshold for the attribution of private conduct in international law

As a classically State-centred order, attributing the conduct of non-State actors to States is somewhat of an exception[70] and therefore comes with a high threshold. This is especially true of private conduct that is not conducted in the exercise of State authority or in the context of fulfilling State functions, but which is simply "controlled" by a State in the sense of Article 8 ARSIWA. It is in this spirit that the *International Court of Justice's* (ICJ) finding in its *Nicaragua*[71] judgment must be understood. In this judgment the Court established that the control-based attribution of private conduct to a State in the sense of Article 8 ARSIWA generally requires that a State effectively controls, instructs or directs the concrete conduct of a non-State entity. This was also upheld in the ICJ's *Genocide* judgment.[72] All in all, this threshold is relatively high and difficult to establish in practice.[73] This is a conclusion that is ultimately also shared by the *ILC* in its commentaries on Article 8 ARSIWA.[74]

70 International Law Commission 2001: 47, Commentary 1 to Article 8 ARSIWA.

71 See the holding paragraphs for what was necessary to attribute private conduct in International Court of Justice 1986: 146.

72 International Court of Justice 2007: 208.

73 Talmon 2009: 503.

74 International Law Commission 2001: 47, Commentaries 1 and 3 to Article 8 ARSIWA.

In contrast, the so-called "overall control" test, originally established by the *International Criminal Tribunal for the Former Yugoslavia* in the context of individual criminal responsibility[75] was rejected. This test has been misinterpreted as applying to attribution in the context of State responsibility and holds that conduct is attributable to a State when the State controls the overall circumstances under which private conduct occurs, but not the individual conduct itself. The *ICJ* explicitly rejected this test as a basis for attribution in international law because it

> "has the major drawback of broadening the scope of State responsibility well beyond the fundamental principle governing the law of international responsibility: a State is responsible only for its own conduct, that is to say the conduct of persons acting, on whatever basis, on its behalf.
> [...]
> In this regard the "overall control" test is unsuitable, for it stretches too far, almost to breaking point, the connection which must exist between the conduct of a State's organs and its international responsibility."[76]

The role of jurisdiction for attribution

As will be shown in what follows, jurisdiction plays no role in the attribution of conduct to a State under international law. Jurisdiction and attribution are, in fact, unrelated concepts. The tendency of space lawyers to seek to establish a connection between these two concepts is thus problematic.

Similarly to the concept of responsibility, the notion of jurisdiction has several distinct meanings in international law.[77] It can, first, relate to a court's competence to hear and decide a case. Second, it can relate to a State's competence to make and enforce rules for its territory and nationals. Third, it can relate

75 International Criminal Tribunal for the Former Yugoslavia 1999: 58–59.
76 International Court of Justice 2007: 210.
77 Extremely instructive on this matter – even far beyond a human rights context – is Milanović 2008.

to the effective control over individuals as a basis for the existence of primary human rights obligations.[78] In a nutshell, none of these three meanings have anything to do with the attribution of private conduct to a State. The second meaning of jurisdiction concerns the authority States have to govern private entities. The third meaning concerns which primary obligations States have towards individuals under human rights law.

Therefore, when it comes to jurisdiction, the focus is not on attribution, nor is it on private entities acting on behalf of the State. The only similarity between jurisdiction and attribution under Article 8 ARSIWA is this: effective control over an individual's capacity to enjoy human rights is required to establish a State's jurisdiction-based obligations in a human rights context [cf. Article 2(1) of the International Covenant on Civil and Political Rights] and effective control is also required for attribution under Article 8 ARSIWA. This does not, however, mean that the jurisdiction in the form of effective control referred to in the context of human rights law is a factor in terms of attribution, as the contexts in which effective control is exercised are different.[79]

Similarly, a State's jurisdiction over its territory and nationals is not to be confused with the considerations of attribution. If at all, this sort of jurisdiction comes with responsibility in the sense of obligations *towards* those under it. Similarly, private ships flying the flag of a State are also not attributed to that State, even though it has jurisdiction over the ship according to Article 92(1) UNCLOS.[80]

Another concept that is linked to this meaning of jurisdiction is that of the obligations of due diligence: a State must ensure that violations of international law do not emanate from its sphere of jurisdiction. If a State fails to exercise this due diligence, it is a *direct* violation of the State's international (due diligence) obligations. It does not, however, make the unlawful conduct emanating from

78 See Article 2(1) of the International Covenant on Civil and Political Rights.

79 Milanović 2008: 436–448.

80 Although it should also be mentioned that the Flag State system is not transferrable to space objects, see Sprankling 2014: 194.

its sphere of jurisdiction, such as from its territory, *attributable* to the State in terms of State responsibility under the ARSIWA.[81]

The necessity of stronger awareness regarding attribution basics in space law

Having reviewed the basics of attribution in international law – of which outer space law is part and parcel – many arguments about the attribution of private actors in space to States should cause a certain degree of discomfort in lawyers. It becomes evident that many of these arguments clash with fundamental considerations of State responsibility. It is worth emphasising again that the reason for this is not to criticise the work of individual authors, but to demonstrate that the discipline of space law as such is prone to misunderstanding some of the concepts of general international law, and this is a situation which needs to be changed.

Contrary to the high threshold for the attribution of private conduct to States in international law, space lawyers have repeatedly suggested that the attribution of private conduct under space law is not the exception, but the norm.[82] Some scholars erroneously argue, without providing suitable grounds or references, that the duty in Article VI OST to continuously supervise private actors makes their conduct attributable under Article 11 ARSIWA, which concerns adopting private conduct as a State's own.[83] Neither the ILC's commentary on Article 11 ARSIWA nor the international jurisprudence in which attribution via Article 11 ARSIWA was discussed support such an argument in the slightest. One reason for this is that mere supervision does not *adopt* the supervised conduct as a State's own. Another reason is that Article 11 ARSIWA is about subsequent or retroactive attribution,[84] while the authorisation of private conduct which Article VI OST refers to

81 Sprankling 2014: 442; International Court of Justice 2007: 220–226.
82 For example Baca 1993: 1065–1066; E. Pellander in SichTRaum 2021: 32:51–33:03.
83 Blount–Robinson 2016: 167.
84 International Law Commission 2001: 52, Commentary 1 to Article 11 ARSIWA.

should logically happen *before* anything is launched to or done in outer space by a private entity. A useful analysis of attribution and space law was written by Frans von der Dunk in 2011. His article deserves praise because it recognises that attribution arguments for space law contradict the way that attribution normally works in international law[85] and because in some parts it employs a critical analytical perspective[86] on the arguments presented. Unfortunately, however, this article uncritically discusses jurisdiction as a basis for attribution under international law.[87]

It is also unfortunate how the authors of MILAMOS, all of whom are well-renowned international space lawyers, have restated what "national" activities are. In rule 102 of MILAMOS, the authors created a list of activities that are to be considered "national" under space law *de lege lata*.[88] In doing so, they combined the activities of a State with those of entities under the jurisdiction of a state with those attributable to a State.[89] While it was sensible of them to keep the categories of jurisdiction and attribution separate in their restatement of national activities, they squandered an opportunity to differentiate between the implications of and responsibility incurred under each of these activities.[90] After all, Article VI OST establishes States' "responsibility" for national activities without differentiating between the possible responsibilities that could be incurred by each category of national activity. However, differentiating between due diligence, State responsibility under the ARSIWA and responsibility towards entities under a State's jurisdiction is necessary under international law: both from the perspective of applying the law correctly and from that of ensuring legal certainty.

Taking the different concepts of international law which are mixed up in Article VI OST seriously and distinguishing between them is necessary to come

85 Von der Dunk 2011: 9.
86 Von der Dunk 2011: 9–14.
87 Von der Dunk 2011: 14–17.
88 Jakhu–Freeland 2022: 4, 9.
89 Jakhu–Freeland 2022: 9.
90 Bertamini 2022.

to a doctrinally sound answer to the question of which type of national activities the "national appropriation" in Article II OST is concerned with. It is also directly relevant to the question of which behaviour in outer space is relevant in terms of *State* practice, especially in light of the increasing privatisation of spacefaring. The attribution of non-State actors in space will have to be critically reassessed in the future. Considering the high threshold of effective control for attribution and the fact that the remoteness of outer space makes particularly difficult to properly supervise any conduct in space with the technological means that are currently available, new bases for attribution may need to be considered, if the attribution of private actors in space is indeed intended to be a regular affair.

In essence, the takeaway from this Section is that space lawyers need to remember the basics of international law in so far as they relate to space law. From this point on, existing arguments should be critically engaged with. Doing so is essential in order to create new and well-founded interpretations of provisions that still cause confusion almost 60 years after their creation such as Articles II and VI OST. Equally importantly, it is also necessary to formulate convincing arguments to the effect that space law *consciously* does things differently from general international law. Otherwise, such arguments are difficult to distinguish from simply misunderstanding international law.

CONCLUSIONS AND REFLECTIONS – TAKING THE DEVELOPMENT OF SPACE LAW SERIOUSLY

In light of the emerging New Space dynamics, the international law of outer space is at a crossroads. The "practicalisation" and privatisation of spacefaring have two major implications for the development of international outer space law. The first of these emphasises the interplay of international law(-making) and non-State actors.

Traditionally, non-State actors do not play a role in the development of international law. Their practice does not contribute to the emergence of customary law, for example.[91] However, in the wake of a surging private space economy where private actors are likely to create the most traffic in space, their practice is likely to shape the reality of spacefaring. This is something that international (space) law cannot ignore, and represents an opportunity to ponder the genesis of international law norms.

Despite its general focus on States, international law is not blind towards the practices and impacts of private entities. Consider, for example, the field of business and human rights.[92] Even though multinational corporations are not directly bound by human rights law, they have a great influence on the enjoyment of human rights in practice, which States should address in their domestic regulation in order to fulfil their international obligations. This realisation has led to the *UN Guiding Principles on Business and Human Rights*. International law is also known to incorporate reference standards for conduct that were not developed by States. For example, the so-called *lex mercatoria* as a body of norms governing transnational business can be incorporated[93] into international dispute resolution via provisions such as Article 10 of the Inter-American Convention on the Law Applicable to International Contracts.[94] It is also likely that the long history of maritime navigation, which significantly predates the existence of States, has shaped some of the rules of international maritime law of today, for example in the generally accepted international rules or standards that UNCLOS refers to in various articles.

Even if we feel that private entities in space should not contribute to establishing practical standards which might crystallise into law, their conduct may still influence the development of space law in two ways. In so far as private conduct is attributable to States, this conduct can potentially be considered

[91] International Law Commission 2018a: 130, Commentary 1 to Conclusion 4 and 132, Commentary 8 to Conclusion 4.

[92] Office of the High Commissioner for Human Rights 2011.

[93] Schill 2011: 20–23.

[94] Not registered with the UN Secretariat.

State practice,[95] which is relevant both for the interpretation of existing space law and for the development of new customary law. However, it is not only attributable conduct which may be relevant. Since States are under an obligation to authorise and supervise national space activities, even when conducted by private entities, pursuant to Article VI OST, they are in a position to react to the plans and practices of private space actors. How States will govern the space actors under their jurisdiction through national space laws but also through concrete authorisations or rejections of missions is immediately relevant practice for the development of space law.[96] Space lawyers should thus pay close attention to the passing of national space legislation and regulative practice as well as to the emerging practices of all actors in outer space.

The second major implication of the "practicalisation" and privatisation of spacefaring is that it is likely to push many established doctrines of space law to a breaking point. As space lawyers, we have two options for dealing with this situation. We can either stick to the arguments that we know, overlook their inadequacies, and blame the law itself in a cry for new international regulation,[97] regardless of how unrealistic such a new regime may be. Or we can embrace the idea that there is room to improve the understanding and practicality of the space law that we have by engaging with it diligently through the lens of general international law. Accepting that space law is a part of international law means that a good space lawyer must first be a good general international lawyer.

This Chapter argues in favour of the second option. It does so not only because the appearance of new space law does not simply get rid of the existing space law, which we will still have to deal with in some way. Also, and perhaps most importantly, this argument rests on the author's strong conviction that the Outer Space Treaty, in particular, is a beautifully idealistic, relevant and

95 This is at least what the terminology "endorsement" in International Law Commission 2018a: 132, Commentary 8 to Conclusion 4 suggests. After all, endorsement of private conduct is also the anchor for attribution in Article 11 ARSIWA.

96 International Law Commission 2018: 132, Commentary 8 to Conclusion 4.

97 See for example Pershing 2019: 170–178; Tronchetti 2009.

optimistic piece of international law, which deserves to be taken seriously. To take space law seriously means to engage critically with the arguments that the discourse has produced so far.[98] Making apologetic references instead to a "space law specific understanding" of concepts would be the easy way out, but it would be the wrong way. While space law certainly modifies certain concepts of international law by restricting what would otherwise be part of States' sovereignty, this Chapter has shown that the line between a space law-specific understanding of these concepts and misunderstanding them altogether is slim. After all, some of the critiques of established arguments and their reproduction point out that not only do they clash with the basics of international law, but to an extent they are incompatible with techniques of legal argumentation in general.[99]

The Chapter has demonstrated what needs to be improved in the space law discourse and suggested avenues for research which might make a difference. While its focus lay on Articles II and VI OST, its general position is abstract from these two articles and can also be transferred to other provisions of space law. A critical generalist international law perspective will benefit any space law discourse and help to steer the development of space law in a direction which can take it out of the academic niche in which it has existed for too long.

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98 Bertamini 2023; Bertamini 2022.

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Dalma Takó

The Role of Soft Law Instruments in the New Space Age

INTRODUCTION

International space law is an increasingly important and dynamically developing field, which is currently facing new challenges, demands and situations. The nature of space activities is gradually changing, while new types of activity and new actors are continuously appearing on the stage of outer space. This article will present only some of the examples that could be mentioned, but they clearly show that the field of space law is constantly evolving. These changes need to be governed by international regulation, which should serve as an essential starting point and framework for all space activities. However, international law-making relating to outer space is also facing challenges in the New Space Age and among these, the changes regarding the form and possibilities of regulation deserve particular attention.

Until the 1980s, international space legislation was clearly dominated by the creation of legally binding norms, mainly international treaties. Since then, however, binding documents have been increasingly overshadowed by the emergence of non-binding, so-called soft law instruments.[1] This type of regulation has gradually gained more and more ground, and nowadays the members of the international community seem more inclined to apply these flexible regulatory options instead of creating new legally binding treaties or amending existing ones. The possible reasons for and the consequences of this

[1] Neef 2021: 572–573.

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changing role of soft law deserves special attention due to the inevitable role of international legislation in space law.

With these trends in mind, this study deals with the question of how and why soft law has become the new and main form of international space legislation. In order to analyse this question, it is first necessary to consider the definition and the specificities of the binding and non-binding instruments governing outer space and to identify the exact differences between the two categories. With the help of these clarifications, the reasons for and the consequences of the changing role of soft law instruments can be better understood, as well as the impact the use of soft law instruments have had, or may have, on international space law.

HARD LAW AND SOFT LAW IN INTERNATIONAL SPACE LAW

Legally binding regulatory instruments governing outer space

As noted in the introduction, during the 1960s and 1970s international legislation regarding outer space was characterised by the creation of legally binding documents – so-called hard law[2] – mainly international treaties. The exploration and use of outer space and the principles of space law were laid down in a number of international treaties[3] of which the following five multilateral treaties deserve to be mentioned (these treaties are hereinafter collectively referred to as space treaties):

– *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, 1967* (hereinafter: Outer Space Treaty)
– *Agreement on the Rescue of Astronauts, the Return of Astronauts and Return of Objects Launched into Outer Space, 1968* (hereinafter: Rescue Agreement)

[2] According to Peter Martinez: "The international legal framework for space activities rests on two pillars: hard law and soft law." Martinez 2020: 522.

[3] Tronchetti 2011: 626.

- *Convention on International Liability for Damage Caused by Space Objects, 1972* (hereinafter: Liability Convention)
- *Convention on Registration of Objects Launched into Outer Space, 1975* (hereinafter: Registration Convention)
- *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, 1979* (hereinafter: Moon Agreement)

These treaties laid down the basic rules of international space law and have been particularly important ever since their conclusion. The common feature of all these documents is that they are multilateral international treaties,[4] meaning that their aim is to create legally binding rights and obligations for the parties and to achieve as broad cooperation as possible, depending on how many entities wish to become parties to the agreements. On this issue, it is worth examining the number of the parties to each treaty individually: the Outer Space Treaty has 112 parties, the Rescue Agreement has 99, the Liability Convention has 98 and the Registration Convention has 72.[5] Compared to this, the number of parties to the Moon Agreement is much smaller, with only 17 parties having expressed their consent to be bound by the treaty.[6] Based on this, it can be seen that compared to the Outer Space Treaty, the number of the parties to international agreements on outer space has gradually decreased over the years. While not very significant, but discernible for the Rescue Agreement, the Liability Convention and the Registration Convention, in case of the Moon Agreement, however, the decrease is much more dramatic.

The small number of the parties in the Moon Agreement was the beginning of a tendency that can be described as the marginalisation of binding multilateral international treaties within space law. This tendency does not mean the

[4] This term refers to the fact that the agreements regulate the relations of more than two parties. United Nations 2012: 33.

[5] Data as of 1 January 2022. UN Committee on the Peaceful Uses of Outer Space 2022: 10.

[6] According to Balázs Bartóki-Gönczy, the reason for the small number of parties of the Moon Agreement "was basically that the nations with advanced industry were not willing to give up in advance the possibility of not appropriating the resources of the celestial bodies". Bartóki-Gönczy 2020: 95.

eclipse of existing international treaties governing the outer space, but instead refers to the fact that despite the original plans, the Moon Agreement did not gain wide support and that states did not manage to conclude any multilateral international treaties regarding space law after 1979.[7] This failure of the Moon Agreement[8] and later binding legislation to attract interest shows that by the 1980s, the process of concluding international treaties in the field of space law had clearly come to a halt.[9] Several explanations have suggested that the reason for this was that the main space treaties have exhausted the issues on which states were prepared to enter into international legal obligations.[10]

Therefore, as the creation of new binding international treaties was impossible, the members of the international community had to turn to other regulatory methods, including the creation of soft law documents, the development of customary international law, or the conclusion of special bilateral or plurilateral treaties.[11] Among these options, soft law has gained a leading role, thus this category deserves further examination.

Soft law instruments in international space law

As has been noted, the category of non-binding soft law started to proliferate in the 1980s, by which time it had become clear that states could not agree to create new binding norms.[12] In connection with this phenomenon, the first question concerns what exactly is meant by the term soft law. Although it is not possible to provide a totally clear definition, the category of soft law most likely includes documents that: 1. have some legal relevance but do not appear in the form of a legal source recognised by international law; 2. and also those that appear in

7 Rachel Neef, for example, mentions the failure of the draft treaty between China and Russia on the prevention of the threat of arms sales and violence in outer space. NEEF 2021: 573.

8 FREELAND–YUN 2020: 432.

9 Peter Martinez opines that the "discussions on legally binding instruments have become deadlocked". MARTINEZ 2020: 523.

10 TRONCHETTI 2011: 628–629.

11 TRONCHETTI 2013: 14, 85.

12 TRONCHETTI 2013: 148, 85; TRONCHETTI 2011: 619.

the form of a source of law recognised by international law, but which – because of their generality, vagueness or subjectivity – cannot be invoked or enforced.[13] The most typical examples of soft law include memoranda of understanding,[14] certain UN General Assembly resolutions which do not have the status of customary law,[15] various directives, principles, guidelines,[16] declarations, recommendations, programmes[17] and codes of conduct.[18]

While there are many examples of each of the above categories in the field of international space law, only some of them will be briefly described here for illustrative purposes. Firstly, in connection with the category of Memoranda of Understanding, one of the latest examples of these are the so-called Artemis Accords,[19] which was initiated by the United States. The signature of this document was organised as a virtual ceremony on 13 October 2020 at the 71st International Astronautical Congress. At this time, 8 states signed the document,[20] which was later followed by a further 26 states,[21] bringing the total

[13] László Blutman states with regard to the concept of soft law that although the term does not have a clear legal definition, it has the two mentioned distinct meanings. Blutman 2008: 28.

[14] According to Anthony Aust, these agreements are important tools in the hands of the parties, with a large number of bilateral and multilateral MOUs being created every year. Aust 2010: 51–52.

[15] According to Steven Freeland and Zhao Yun "UNGA resolutions are a major type of soft law documents". Freeland–Yun 2020: 417.

[16] Freeland–Yun 2020: 413.

[17] Martinez 2020: 522; Aust 2010: 11; Kolb 2016: 171.

[18] For example, the European Union draft Code of Conduct for outer space activities. Su–Lixin 2014: 34–39.

[19] The official English title of the document is *Artemis Accords. Principles for a Safe, Peaceful, and Prosperous Future* (hereinafter: Artemis Accords).

[20] These states were Australia, Canada, Italy, Japan, Luxembourg, the United States of America, the United Arab Emirates and the United Kingdom. NASA 2020.

[21] The agreement itself provides for the possibility of expanding the number of signatories, as its final provisions stipulate that after 13 October 2020, any state wishing to become a signatory to the agreement may notify the U.S. Government of its intention to do so. Artemis Accords, Final provisions.

number of signatories to 34.[22] The importance and the role of this document will be mentioned later in the study. Examples of principles that have been adopted internationally include those adopted by the General Assembly of the United Nations, for example the Declaration of Legal Principles Governing the Activities of States in the Exploration and Uses of Outer Space; or the Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries. Resolutions of the General Assembly include: Resolution 1721 A and B (XVI) of 20 December 1961: International Co-Operation in the Peaceful Uses of Outer Space; Resolution 68/74 of 11 December 2013: Recommendations on national legislation relevant to the peaceful exploration and use of outer space. It is also worth mentioning the category of guidelines, which are also numerous in many areas of international space law. For example, the United Nations Committee on the Peaceful Uses of Outer Space (hereinafter: UN COPUOS) has been developing documents of this type since the 1990s, dealing with important issues such as space debris[23] and the sustainability of space activities.[24]

In connection with the aforementioned principles, resolutions and guidelines, it is important to note that their content may reflect customary international law, if it can be proved that states follow a general and consistent practice in relation to a certain issue and if they regard this practice as law, or in other words as an obligation. With these conditions, a certain rule contained in a soft law document may be binding, and this phenomenon will be discussed

[22] The acceding countries were Angola, Argentina, Bahrain, Belgium, Brazil, Bulgaria, Colombia, the Czech Republic, Ecuador, France, Germany, Iceland, India, Israel, Mexico, the Netherlands, New Zealand, Nigeria, Poland, the Republic of Korea, Romania, Rwanda, Saudi Arabia, Singapore, Spain and Ukraine. Interestingly, the Isle of Man, a British Crown Dependency, has also declared itself a signatory to the agreement. Government of the Isle of Man 2021.

[23] UNOOSA 2010; Martinez 2020: 530.

[24] Committee on the Peaceful Uses of Outer Space 2018; Freeland–Yun 2020: 416–417.

later in this study. At this point, based on the mentioned examples it can be stated that soft law has been prominent in international space law since the very beginning of the regulation of this field. However, whereas during the 1960s and 1970s its role was merely to supplement or prepare the hard rules contained in space treaties, from the 1980s onwards it has gradually taken a leading role and has become the primary instrument for the international regulation of outer space. In order to explore the causes and consequences of this process, it is worth comparing the specific features of soft law documents with those of binding international treaties.

SPECIFICITIES OF INTERNATIONAL TREATIES AND SOFT LAW INSTRUMENTS

International treaties and soft law instruments differ in a number of respects. The first and most important difference between them is that, while international treaties are legally binding documents, soft law is not.[25] In practice, this is reflected in the fact that while international treaties can be enforced by the means provided for by international law, the same cannot be said of soft law instruments.[26] This means, among other things, that disregarding soft law does not give rise to international responsibility and that these documents cannot be invoked before UN bodies.[27] Furthermore, no countermeasures can be applied and no compensation can be claimed if soft law is not upheld.[28] These specificities also mean that states do not have to comply with soft law but are free to choose to ignore it.[29]

25 Tronchetti 2013: 6–7.
26 Schmalenbach 2012: 41.
27 Schmalenbach 2012: 42; Tronchetti 2011: 622.
28 Tronchetti 2011: 622.
29 Byrd 2022: 831.

In addition to the legal aspects, there are also significant differences in the content of international treaties and soft law documents. International treaties usually contain terms referring to the existence of binding force, including the words "to subject", "subjection", "right", "obliged" or "obligation".[30] In non-binding soft law documents, the parties tend to omit these terms or to replace them with words such as "to aspire", "endeavour", "to intend" or "intention."[31] In this respect, it is worth noting that the name of a document should not be taken as a guide, since some documents

> "may at first sight appear to be international treaties, both in terms of the title and the parties, but the words and expressions used in it in several cases show that the document is drawn up by States to settle their affairs quickly, to express their political will, to reach a flexible agreement and not to conclude an international treaty".[32]

In addition to the issues of content, there are also differences in the way these documents are created and the form they take. The conclusion of international treaties is a complex and lengthy process, each step of which is precisely regulated by the international law of treaties. No such constraints exist on soft law instruments, and the parties have practically complete freedom in the drafting of such material. As a result, the creation of soft law is usually much easier, quicker and simpler than that of international treaties.[33]

A further difference is that international treaties are required by the Charter of the United Nations to be registered in the United Nations Treaty Collection. According to the Charter: "Every treaty and every international agreement entered into by any Member of the United Nations after the present Charter comes into force shall as soon as possible be registered with

30 Such expressions in a given document indicate that the parties intended to create a binding agreement, an international treaty. Kolb 2016: 19; Aust 2010: 54, 398.

31 When such terms are used, it is likely that the parties did not intend to attach binding force to the document, but merely to create a soft law instrument. Klabbers 2013: 45.

32 Szalai 2018: 16.

33 Remuss 2011: 539.

the Secretariat and published by it."[34] However, such registration is not required for soft law instruments.[35]

By identifying these characteristics of international treaties and soft law instruments, it is possible to determine in practice which category a given document belongs to. In connection with this question, it is first and foremost the intention of the parties that determines whether the document is legally binding or not. The main factors that help to reveal the intention of the parties are the content of the document and the circumstances in which it was drawn up.[36]

To illustrate this process of classification, it is worth taking the example of the Artemis Accords mentioned earlier, which may appear to be an international treaty at first glance. However, several details reveal that the signatories intended to create a non-binding document. This is suggested by the wording of the preamble, which states that the document is intended to establish a political understanding between the signatories.[37] Besides, the first clause states that the agreement merely represents a political commitment to the principles it sets out.[38] The soft law nature of the document is further confirmed by the fact that it is formally divided into sections rather than articles, and that the document uses the term principles in several instances to refer to the matters it contains.[39]

Another important aspect of the Artemis Accords is that the signatories did not wish to register the document in the United Nations Treaty Collection. The final provisions of the document expressly state that "the Government of the United States of America will maintain the original text of these Accords and transmit to the Secretary-General of the United Nations a copy of these Accords, which is not eligible for registration under Article 102 of the Charter of

[34] Charter of the United Nations, Article 102.

[35] As Anikó Szalai notes, soft law instruments "do not need to be registered in the UN Treaty Collection, nor do they need to be promulgated or published in domestic law". Szalai 2018: [17].

[36] Aust 2010: 52.

[37] Artemis Accords, Preamble.

[38] Artemis Accords, Section 1.

[39] The title, the preamble, the first and second sections and the final provisions of the document all contain the term principles. NASA 2020.

the United Nations".[40] Finally, it is worth highlighting that the final provisions of the Accords state that the signatories commit to consult periodically on the implementation of the principles contained in the document and on potential areas for future cooperation.[41]

All of the above suggests that the signatories intended to create a non-binding document that could be easily reviewed and amended, if necessary, in the light of future needs. Based on this, it can be concluded that the Artemis Accords takes the form of a non-binding *soft law* document, namely a Memorandum of Understanding.[42]

POSSIBLE CAUSES AND CONSEQUENCES OF THE RISE OF SOFT LAW INSTRUMENTS

Having identified the characteristics of international treaties and soft law instruments, it is now possible to examine the causes of the rise of the use of soft law documents and the consequences of this process, namely the effect of soft law on international space law.

Based on the characteristics of soft law instruments described in the previous section, it is clear that these documents have a number of advantages. They are quick and easy to create and amend, therefore they can undoubtedly provide an immediate and flexible solution to issues requiring urgent action.[43] They can thus help to adapt to new situations and technological developments,[44] which is particularly important in the rapidly changing field of international space law.[45] These features of soft law are clearly preferable to the lengthy and complex process of preparing and amending international treaties, and the resulting

40 Artemis Accords, Section 13.

41 Artemis Accords, Section 13.

42 Committee on the Peaceful Uses of Outer Space 2021: 3.

43 Tronchetti 2011: 626.

44 According to Peter Martinez: "Soft law can also be more responsive to developments in technology than legally binding instruments." Martinez 2020: 562.

45 Byrd 2022: 832.

uncertainty that they will enter into force.[46] In addition, soft law documents can be signed even by those actors of the international community that do not have, or do not clearly have the capacity to conclude international treaties.[47] A further advantage of such soft law agreements is that, since the documents do not create rights and obligations, their signatories can comply with or ignore the content of these materials according to their needs and will. This is an attractive alternative for interest-driven states, who for the above-mentioned reasons prefer to create soft law instruments.[48] Due to these advantages, soft law was able to help to overcome the deadlock caused by the impossibility of concluding international treaties[49] and has become the dominant approach[50] and the primary instrument for space governance and for the development of space law.[51] This crucial role of soft law has also been recognised by the UN COPUOS.[52]

It has become evident that the simple and quick creation of agreements and the freedom given to their signatories are the main reasons for the rise of soft law instruments. Keeping this in mind, it is also worth examining the possible consequences of the trend related to the prominence of the documents in question. In this respect, it is important to note that, although soft law documents do not have binding force, they can influence the behaviour of

[46] Kolb 2016: 270; Boyle 2019: 102.

[47] These include, among others, transnational corporations or non-governmental organisations. Lyall–Larsen 2009: 51–52.

[48] According to Robert Kolb, the following circumstances play a role in the rise of non-binding instruments: the need for flexibility and short reaction times, the desire to involve non-state actors, and the possibility of confidentiality, of keeping the agreement secret. Kolb 2016: 270.

[49] Freeland–Yun 2020: 415.

[50] Neef 2021: 572–573.

[51] Fabio Tronchetti, for example, argues that the adoption of soft law instruments is currently the most viable way to deal with space issues at international level. Tronchetti 2013: 85; Byrd 2022: 834; Neef 2021: 572–573; Ferreira-Snyman 2021: 34. Łukasz Kułaga also argues that over the past 40 years "general international space law has developed primarily through soft law instruments". Kułaga 2023: 28.

[52] United Nations 2019: 30.

states and other entities along with the development of international space law in a number of ways.[53] Among these, the following options deserve mention:

1. Soft law can provide guidance on the interpretation and implementation of the provisions of international treaties.[54]
2. Soft law can be the starting point of a process leading to an international treaty.[55]
3. Soft law can contribute to the development of customary international law.[56]
4. Soft law may be suitable for unification if its content is made binding in the national legislation of several spacefaring States.
5. Soft law can be declaratory in nature, setting unwritten rules that already exist in practice in international law.

Among these possibilities, it is worth paying particular attention to situations when a soft law document contributes to the development of customary international law. In order to achieve customary status, two conditions are necessary, namely the general and consistent practice of states and the so-called *opinio iuris sive necessitatis*.[57] These conditions can easily be met in case of soft law documents, which in fact means that if a soft law document is generally and consistently applied by states in practice and is regarded as law, it acquires the

[53] Tronchetti 2011: 624.

[54] Francis Lyall and Paul B. Larsen also emphasise this guiding character of soft law. The authors further argue that soft law can effectively complement binding rules on outer space, which in turn contributes to the effectiveness of space law. Lyall–Larsen 2009: 51–52. Peter Martinez explains that soft law material relating to a treaty can be considered an expression of subsequent practice in the application of the treaty and should be taken into account in the interpretation of the treaty under Article 31(3) of the 1969 Vienna Convention on the Law of Treaties. Martinez 2020: 531.

[55] This function of soft law is also mentioned by Laura C. Byrd. Byrd 2022: 834.

[56] Anel Ferreira-Snyman confirms that soft law can serve as a basis for binding standards in the future. Ferreira-Snyman 2021: 34–35. According to Peter Martinez, widely adopted and implemented non-binding technical standards, guidelines and other resolutions can be cited as evidence of customary international law. Martinez 2020: 531.

[57] Tronchetti 2011: 625.

status of customary law.[58] As a result, an originally non-binding document can become a legally binding norm.[59] This process, namely law-making through soft law documents, means that it is possible to influence the development of international space law through non-legally binding material without the strict requirements of international treaties.

The above-mentioned way of regulation may seem flexible and expedient and it can undoubtedly be useful, and even necessary in certain cases, especially when urgent action is required.[60] However, this process may also be open to abuse,[61] for instance to circumvent or undermine certain provisions of international treaties.[62] This may happen, for example, when states interpret an international treaty in the manner stipulated in a soft law document. If states regularly and consistently apply and invoke the originally soft law document in practice, and regard it as law, the document – and the interpretation contained in it – may gain customary law status and thus may become a legally binding norm. If this interpretation is consistent with the object and purpose of the original treaty, then no problem arises. However, it may also open up the possibility of a kind of disguised circumvention of the object and purpose of the treaty, which raises considerable difficulties.

The above-mentioned phenomenon can be illustrated by the example of the Artemis Accords. According to the document, the agreement is designed to provide a safe, transparent and sustainable framework for current and future space activities for the benefit of all humanity, and to promote international cooperation in space.[63] The Accords state that they aim to establish principles,

58 Freeland–Yun 2020: 432. According to Tanja Masson-Zwaan, this is why soft law documents should not be underestimated, as they can become customary law and thus binding for states, given the right state practice and opinio iuris. Masson-Zwaan 2023: 47, 89.

59 According to Fabio Tronchetti, this has already been the case for a number of UN General Assembly resolutions. Tronchetti 2011: 625; Aust 2010: 11.

60 Peter Martinez argues that in some situations, soft law is preferable to a legally binding document. Martinez 2020: 562.

61 Lyall–Larsen 2009: 51–52.

62 Szalai 2018: [69].

63 Artemis Accords, Preamble and Section 1.

guidelines and best practices to enhance the governance of the civil exploration and use of outer space with the intention of advancing the Artemis Program.[64]

In order to achieve the mentioned goals, the Accords lays down several principles, some of which merely repeat and confirm certain provisions of space treaties.[65] This is the case for those parts of the document that cover the peaceful uses of outer space, the provision of transparency and data sharing, the establishment of an obligation to provide emergency assistance and the requirement for registration. However, the document also contains two sections – namely sections 10 and 11 in connection with the exploitation of space resources and the creation of safe zones – that raise significant questions. Addressing these issues, several authors have claimed that the content of the Accords is incompatible with relevant rules of international space law,[66] as outer space and space resources are the common heritage of mankind, in connection with which any form of appropriation, acquisition of property or extension of state sovereignty is prohibited.[67] These authors argue that the Outer Space Treaty and especially the Moon Agreement govern these questions and that the mentioned rules have customary law status as well, irrespective of

64 Artemis Accords, Section 1. Artemis is a multi-stage programme, one of the key goals of which is to put the first woman and the next man on the Moon in 2024 and establish a permanent presence there. The experience gained will be used for future expeditions to Mars. Mallowan et al. 2021: 156. The Programme is mentioned in the preamble and the first section of the Accords. Both parts state that the signatories intend to use the Accords to support the future exploration and use of space, in particular the Artemis Program. Artemis Accords, Preamble and Section 1.

65 In this respect, the content of the Accords is in line with the objective of the preamble, which is to reinforce the provisions of the Outer Space Treaty, the Rescue Agreement, the Liability Convention and the Registration Convention. Artemis Accords, Preamble.

66 Mosteshar 2020: 601–602.

67 Hasin 2020: 105–106. According to Sa'id Mosteshar, the Artemis agreement in fact undermines certain provisions of the space treaties. Mosteshar 2020: 601–602. Many authors consider that security zones bear many similarities to territorial sovereignty, in that they provide for the possibility of exercising exclusive control over a territory, thereby infringing the right of free access to outer space. Ferreira-Snyman 2021: 31–32; Neef 2021: 570–572; Larsen 2021: 42–43.

the mentioned treaties.[68] According to these commentators, the customary status of the rules in question can be proved by reference to the preparatory materials for the Outer Space Treaty and the unanimous UN General Assembly resolutions adopted prior to the treaty.[69] However, other authors consider that the exploitation of space resources and the creation of safety zones is possible, because the Outer Space Treaty does not explicitly prohibit these activities and the existence of prohibiting customary transparency and data sharing, the establishment of an obligation to provide emergency assistance and the requirement for registration. However, the document also contains two sections – namely section 10 and 11 in connection with the exploitation of space resources and the creation of safe zones – that raise significant questions. Addressing these issues, several authors have claimed that the content of the Accords is incompatible with relevant rules of international space law,[70] as outer space and space resources are the common heritage of mankind, in connection with which any form of appropriation, acquisition of property or extension of state sovereignty is prohibited.[71] These authors argue that the Outer Space Treaty and especially the Moon Agreement govern these questions and that the mentioned rules have customary law status as well, irrespective of the mentioned

[68] These authors believe that Article II of the Outer Space Treaty prohibits all forms of appropriation, hence the prohibition on the acquisition of property and the extension of sovereignty extends to the celestial bodies themselves and their resources. They also argue that the Moon Agreement explicitly states that the acquisition of property and the extension of sovereignty are prohibited both on the surface and in the subsurface of the Moon, and that the collection and transport of natural resources is only possible for the purposes of scientific research, on the basis of the principle of equitable sharing and within the framework of an international regime for exploitation. Moon Agreement, Articles 6 and 11; Nagy–Jeney 2002: 368, 370; Pershing 2019: 151.

[69] Pershing 2019: 154, 156.

[70] Mosteshar 2020: 601–602.

[71] Hasin 2020: 105–106. According to Sa'id Mosteshar, the Artemis agreement in fact undermines certain provisions of the space treaties. Mosteshar 2020: 601–602. Many authors consider that security zones bear many similarities to territorial sovereignty, in that they provide for the possibility of exercising exclusive control over a territory, thereby infringing the right of free access to outer space. Ferreira-Snyman 2021: 31–32; Neef 2021: 570–572; Larsen 2021: 42–43.

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72 These authors believe that Article II of the Outer Space Treaty prohibits all forms of appropriation, hence the prohibition on the acquisition of property and the extension of sovereignty extends to the celestial bodies themselves and their resources. They also argue that the Moon Agreement explicitly states that the acquisition of property and the extension of sovereignty are prohibited both on the surface and in the subsurface of the Moon, and that the collection and transport of natural resources is only possible for the purposes of scientific research, on the basis of the principle of equitable sharing and within the framework of an international regime for exploitation. Moon Agreement, Articles 6 and 11; Nagy–Jeney 2002: 368, 370; Pershing 2019: 151.

73 Pershing 2019: 154, 156.

74 These authors argue that neither the acquisition of ownership, nor the exploitation and sale of the internal material of celestial bodies, or for example asteroids can be considered prohibited activities. Punczman 2020: 40; Cheng 1997: 273; Zannoni 2020: 334. In connection with the legality of safety zones, several authors argue that there is also a so-called keep-out zone around the International Space Station, where special rules of conduct apply. Other authors have pointed to the legality of existing safety zones in maritime law, which are provided for in the 1982 UN Convention on the Law of the Sea at Montego Bay. Hasin 2020: 153; Mallowan et al. 2021: 160; Newsome 2016: 43–44.

75 John S. Goehring, Elya A. Taichman, Gershon Hasin and Sa'id Mosteshar, for example all believe that there is no international consensus on the status of space resources and the legality of their extraction and use, and that the issue cannot be clearly decided. Similarly, Ádám Punczman states that "the legal status of the commercial appropriation of celestial resources is questionable". Goehring 2021: 585–586; Taichman 2021: 114; Hasin 2020: 105–106; Mosteshar 2020: 598–600; Punczman 2020: 36.

76 Hasin 2020: 80–81. This is reinforced by the fact that only 4 of the 193 UN member states have so far been able to collect samples from space. These states were the United States, the Soviet Union/Russia, China and Japan. Punczman 2020: 33–34.

Based on the above, arguments can be made both for and against the legality of the Artemis Accords. However, what seems to be clear is that the Artemis Accords is trying to exploit the uncertainties and shortcomings in the interpretation of the space treaties by setting out a particular interpretation of the disputed provisions of the treaties. According to this specific interpretation, safety zones may be established in outer space in order to act with due regard and to avoid harmful interference, and neither these zones, nor the exploitation of space resources, nor the commercial use of the resources exploited, constitute an appropriation.

By following the above-mentioned interpretation, the presumed aim of the United States is to create customary law in the field of space law, by disseminating the specific interpretation contained in the Accords as widely as possible.[77] This is evident, for example, from the Preamble of the document, which says that the Accords seeks to achieve global consensus on critical issues related to space exploration and use.[78] If a large number of states apply the parts in question of the Accords and if they regard it as law, accepting the binding nature of Sections 10 and 11, then all the conditions of customary international law may be met.[79]

This would, however, have a significant impact on Articles II of the Outer Space Treaty and Articles 6 and 11 of the Moon Agreement, which would be, in a sense, undermined by the customary nature of Sections 10 and 11 of the Accords.[80] The reason for this possibility is that there is no hierarchy between the sources of international law, so that international treaties and customary international law are on the same level. Thus, it is conceivable that, after an international treaty has been concluded between the parties, they may engage in contrary practices. In such a case, by virtue of the principle of *lex posterior*

77 Mosteshar 2020: 601–602; Taichman 2021: 131–132; Smith 2021: 661.
78 Artemis Accords, Preamble.
79 According to Charles Elizey, the process is moving in the direction of making the interpretation of the Artemis Accords customary international law. Elizey 2021: 208.
80 The term derogation refers to the creation of customary law contrary to an international treaty, which is described by the foreign word desuetudo. Szalai 2018: [69].

derogat legi priori, the later rule derogates from the earlier one.[81] In case of the Artemis Accords, this would mean that the States which have signed the document and followed its practice – in other words which have participated in forming customary international law[82] – would be bound by the content of the Artemis Accords as customary law, rather than by the above-mentioned provisions of space treaties. Thus, a kind of derogation of certain provisions of space treaties may occur.

Recognising these possible difficulties, several authors have drawn attention to the dangers of misusing soft law documents. In addition to the derogation of international treaties, some authors have pointed out another problem regarding soft law. In recent years these documents have often been regarded as representing the final stage in the legislative process, which means that members of the international community do not attempt to create a binding document to regulate a particular issue, but settle instead for an easily created non-binding soft law document.[83] In relation to this tendency, many authors argue that it would be more appropriate to consider soft law as a starting point or intermediate step in the process of legislation.[84] The author of this study also believes that the usage of soft law documents should only serve as an exceptional stop-gap solution and not a final method of legislation. This means that while soft law documents should be used in situations where it is not possible to wait for the creation of a binding norm due to time constraints

[81] In this respect, Anikó Szalai explains that customary international law rarely impairs the entire treaty, "but rather has a terminating effect only on certain provisions". Szalai 2018: [69].

[82] As Gábor Sulyok states: "states are bound only by the rules of international law which they have participated in creating or, if not, which they have expressly recognized as binding". Sulyok 2005: 68.

[83] Remuss 2011: 539. "As a result, the direction of development of law – which assumes that one should first negotiate a soft law document and then, on its basis, a treaty or other binding instrument – is no longer evident." Kułaga 2023: 28.

[84] Pecujlic 2017: 150.

or other circumstances,[85] members of the international community should continue to favour transparent, legally binding regulatory approaches.[86]

CONCLUSION

As this study has demonstrated, at present in the field of international space law, states are choosing to assert their interests and opinions through soft law instruments rather than adopting new binding international treaties or amending existing ones.[87] This is undoubtedly an easier and much quicker solution than concluding binding treaties, thus soft law documents can provide a flexible solution to issues that require urgent action. They can also help to adapt to new situations, technological developments and to reach agreements with entities outside states and international organisations.[88] They can be used for example to establish interpretative principles or forms of conduct that the signatories wish to follow and which – in time and with the necessary conditions – may become legally binding customary international law.[89]

However, the use of soft law instruments can also raise difficult questions, including the misuse of these materials, which may mean circumventing and undermining certain provisions of international treaties. Moreover, it is worth mentioning that this kind of misuse is not always entirely obvious, as the document may hide its real purpose behind interpretative issues. This is the case, for example, with the Artemis Accords, which seemingly aim to affirm the content of space treaties, while actually aiming to apply a special interpretation of certain provisions of the Outer Space Treaty and the Moon Agreement, thus creating customary international law.

85 Masson-Zwaan 2023: 4.
86 Lyall–Larsen 2009: 51–52.
87 This tendency can be called a "turning away from multilateralism". Bartóki-Gönczy – Nagy 2023: 891.
88 Lyall–Larsen 2009: 51–52; Kolb 2016: 270.
89 Neef 2021: 578–580.

Based on all the above, it can be seen that the role of soft law instruments has changed significantly in the field of international space law during recent decades, particularly in the last few years. From being a simple, secondary tool that supplements hard law rules, soft law has nowadays become a primary tool for regulating and developing international space law.[90] Although the original use of soft law was to fill in the gaps created by the lack of further legally binding international treaties and norms, this category far exceeded this target, gaining a leading role in the legislation of outer space.[91] The questions and issues arising from this phenomenon should be addressed and resolved, with particular regard to defining the framework for this specific law-making process.

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[90] Steven Freeland and Zhao Yun argue that "more recently, a slightly different phase of soft law development for space activities has emerged". FREELAND–YUN 2020: 416.

[91] Martinez highlights that soft law instruments have arisen as a pragmatic response to pressing problems by facilitating international cooperation and acting as a bridge between the formalities of treatymaking and the exigencies of international life. MARTINEZ 2020: 564.

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Balázs Bartóki-Gönczy – Boldizsár Nagy

The Artemis Accords and International Space Law: An Instrument of Renewal or Fragmentation?[1]

Introduction

Forty-five years have passed since 1979, when the Moon Agreement, last UN treaty exclusively dealing with space activities was adopted. The low number of ratifications of that document[2] marked the end of an era. Since then – despite numerous non-binding instruments and the rise of legislation at national level – the universal legal environment of space activities has been effectively frozen.

This seems clearly to be a problem, since in the meantime the perspectives and the significance of human space activities have remarkably grown and the pace of development is further increasing due to commercialisation and technological developments as well as geopolitical transformations and conflicts. The law, in particular public international law, plays a very important role in laying down the rules of the road, without which conflicts and market failures may arise. The *corpus juris spatialis* of today does not give clear answers to certain major problems which could lead to conflicts between states or which might hinder the development of the commercial space sector.

Beyond the imminent challenges of space traffic management and space debris mitigation, the questions that will arise from Moon missions and space resource exploitation need attention from a legal perspective. These could be considered purely theoretical questions for researchers since humanity is far

[1] The present Chapter is partially based on Bartóki-Gönczy – Nagy 2023.

[2] In April 2024 the number of parties stood at 17.

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from being able to "mine" celestial bodies at present. However, considering the commercialisation of the sector where profit is the priority, we would disagree. For companies to commit to investing in research and development into technologies for exploiting space resources on a large scale, legal certainty is required. However, according to some views the Outer Space Treaty is ambiguous with regard to the permissibility of space resource exploitation and to its preconditions.

This alleged ambiguity was highlighted by the United States of America when it unveiled the so-called Artemis Accords (hereinafter: the Accords) on 13 October 2020 which – as we will explain below – is not actually a treaty but which still might influence the development of the normative framework of human space activities on the Moon and possibly on other celestial bodies in the future. The Accords set up a broad cooperative framework, primarily aimed at returning to the Moon. As of May 2024, fourty states have decided to join it. The Accords may give a boost to the development of the legal regime of the exploration and use of outer space, as defined by the existing treaty framework,[3] by supporting the American interpretation of the non-appropriation principle. On the other hand, they may upset the existing legal regime of outer space leading to its fragmentation by causing states to abandon multilateralism. The issue is of high importance as China and Russia are drawing up plans – also involving international cooperation – with regard to the Moon and other celestial bodies, so the danger of parallel systems and interpretations looms large.[4] This chapter highlights those aspects of the Accords that may affect

[3] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, 1967, 610 UNTS 205; Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space, 1968, 672 UNTS 119; Convention on International Liability for Damage Caused by Space Objects, 1972, 961 UNTS 187; Convention on Registration of Objects Launched into Outer Space, 1975, 1023 UNTS 15; Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, 1363 UNTS 21.

[4] See the presentation on the International Lunar Research Station of the Chinese Deep Space Exploration Laboratory of CNSA to UNOOSA at https://www.unoosa.org/documents/pdf/copuos/2023/TPs/ILRS_presentation20230529_.pdf.

the edifice of international law relating to Outer Space. It emphasises the most debated principles of the Accords as an instrument dealing with space resources and safety zones and also addresses the proposed concept of space heritage.

SCOPE OF THE ACCORDS

The territorial scope of the Accords is peculiar: it covers the Moon, Mars, comets and asteroids, including their surface and subsurface, as well as the orbits of the Moon and Mars, together with the Lagrangian points for the Earth–Moon system, and the transit trajectories between these celestial bodies and locations (Section 1.) Other celestial bodies and orbits of the Solar system or beyond are not within the territorial scope of the Accords.

The material scope is also limited, as it only extends to civil space activities conducted by “civil space agencies”, “with the intention of advancing the Artemis Program”.[5] The question of when an agency qualifies as “civil” is not specified and one would not expect that agencies which maintain collaborative projects with military establishments would be excluded – as for example NASA’s cooperation with the DoD.[6]

One of the stated aims of the cooperating partners is to send “the first woman and next man to the Moon”.[7] According to the modified plans, a human crew will fly by the Moon without landing on it in 2025 and will land on the Moon during the Artemis III mission in 2026 or later. The construction of a small space station orbiting around the Moon, the “Gateway” is ongoing

5 Find the updated Artemis program in NASA 2020. It is also worth mentioning that there is an ambiguity whether signatories of the Accords are automatically in an advantageus position to participate in the Artemis program or the Accords and the Program are not so closely related. The latter seems logical considering the high and quickly increasing number of signatories.

6 Vergun 2020.

7 NASA Publishes Artemis Plan to land first woman, next man on the moon in 2024. For the detailed description of the sequence, including Artemis Missions I, II and III see NASA’s Lunar Exploration Program Overview, the Artemis program in NASA 2020.

with the first two (unmanned) elements to be placed in orbit soon. It will be a multi-purpose object, providing support for lunar surface missions, a base for scientific research and a staging point for further deep space exploration.[8] At a later phase the program should establish a continuous presence on the Moon and later reach Mars.

The Accords are open for signature by any state. This lends it the character of a framework. Consequently, the commitments of the signatories towards each other do not presume alliance or onerous cooperation. The regulation of actual cooperation and of issues related to the delicate questions of liability, intellectual property, the transfer of goods and technical data is left to bilateral or multilateral instruments to be adopted in the future. An example of such an agreement is the Memorandum of Understanding between the NASA and the European Space Agency concerning cooperation on the civil lunar gateway signed in Darmstadt and Tulsa on 22 and 27 October 2020[9] which is a 31 page long document addressing all these questions in 24 Articles. Russia officially rejected the possibility of joining the Accords, criticising the initiative as an attempt to privatise outer space.[10]

The other main rival of the U.S., China, is not among the signatories either. This is not only because the internal legal regime of the U.S. prohibits cooperation between NASA and China[11] but also due to the fact that China (together with Russia) is building its own network of allies for their International Lunar Research Station (ILRS) project,[12] which clearly reflects the competition between the space superpowers.

8 Find Gateway NASA at https://www.nasa.gov/mission/gateway/.

9 U.S. Treaties and Other International Acts Series 20-1027.

10 Russian News Agency (TASS).

11 See "Wolf Amendment" in *Public Law* 117–103, 15 March 2022, section 526, 136 Stat. 49, and the International Traffic in Arms Regulations (ITAR).

12 International Lunar Research Station (ILRS) Guide for Partnership.

THE LEGAL CHARACTER OF THE ACCORDS

The Accords do not constitute a treaty. That is stated unequivocally in Section 13, according to which the Accords are "not eligible for registration under Article 102 of the Charter of the United Nations" and is confirmed by Section 1, stating that the Accords "represent a political commitment". Nor do they in their entirety reflect the emerging customary international law, as several states "whose interests are specifically affected", in the words of the International Court of Justice (ICJ) in the North Sea Continental Shelf Case,[13] do not recognise the elements of the envisaged practice as a reflection of custom. Academic commentaries have classified the principles of the Accords into three categories:[14]

- Principles and norms reflecting existing international norms (Sections 1 and 7: Benefit of humankind; Section 3: Exclusively peaceful purposes, accordance with international law; Sections 4 and 8: Transparency and sharing of scientific information; Section 6: Assistance/rescue in outer space; Section 7: Registration; Section 12: Preventing and mitigating space debris).
- Principles and norms which are claimed to simply refine and operationalise existing rules (Section 5: Interoperability; Section 10: Space resources; Section 11: Safety zones – deconfliction of space activities).
- Essentially novel elements (Section 9: Outer Space heritage).

Even those principles of the Accords which are seemingly in line with international law may on closer scrutiny turn out to deviate from the existing rules or limit their scope. For example, the goal of peaceful use is limited to civil space activities (however they may be defined) leaving the increasing militarisation of Outer Space unaffected, while the promise of transparency in Section 4

13 North Sea Continental Shelf, Judgment, I.C.J. Reports 1969, para. 3.
14 Our categorisation relies but does not coincide with Delplano's categories. Delplano 2021.

only extends to space policies and exploration plans, but not to the actual exploration nor to – perhaps more importantly – the practice of exploitation.

For the sake of brevity, not all these principles will be examined here but only the two most debated ones on the exploitation of space resources and the creation of safety zones, both of which raise questions related to the application of Article II of the Outer Space Treaty (the principle of non-appropriation). Subsequently, we will briefly address a genuinely novel element, space heritage.

SPACE RESOURCES

Arguably the most controversial section of the Accords is the provision on the use of space resources.[15] According to Section 10:

1. The Signatories note that the utilization of space resources can benefit humankind by providing critical support for safe and sustainable operations.
2. The Signatories emphasize that the extraction and utilization of space resources, including any recovery from the surface or subsurface of the Moon, Mars, comets, or asteroids, should be executed in a manner that complies with the Outer Space Treaty and in support of safe and sustainable space activities. The Signatories affirm that the extraction of space resources does not inherently constitute national appropriation under Article II of the Outer Space Treaty, and that contracts and other legal instruments relating to space resources should be consistent with that Treaty.
3. The Signatories commit to informing the Secretary-General of the United Nations as well as the public and the international scientific community of their space resource extraction activities in accordance with the Outer Space Treaty.

The basis of the debate is that the wording of the 1967 Outer Space Treaty (hereinafter: OST), ratified by more than 110 states, including all the spacefaring

[15] See also de Zwart et al. 2023: 158.

nations, leaves room for different interpretations. According to Article II of the OST: "Outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means."

The United States' position has been consistent: the OST does not prohibit the exploitation of space resources. Exploitation is a freedom guaranteed by Article I of the OST. The Commercial Space Launch Competitiveness Act of 2015 stipulates:

> "A United States citizen engaged in commercial recovery of an asteroid resource or a space resource under this chapter shall be entitled to any asteroid resource or space resource obtained, including to possess, own, transport, use, and sell the asteroid resource or space resource obtained in accordance with applicable law, including the international obligations of the United States."[16]

The executive order issued by president Trump in April 2020 declares that

> "outer space is a legally and physically unique domain of human activity, and the United States does not view it as a global commons. Accordingly, it shall be the policy of the United States to encourage international support for the public and private recovery and use of resources in outer space, consistent with applicable law".[17]

In line with this position, the Unites States' delegation noted in its submission at the 62nd session of the UN COPUOS Legal Subcommittee in March 2023 that the prohibition of national appropriation articulated in Article II of the OST does not

> "limit ownership to be exercised by States or private entities over those natural resources that have been removed from their 'place' on or below the surface of the Moon or other

16 U.S. Commercial Space Launch Competitiveness Act, *Public Law* 114-90-Nov. 25, 2015, Title IV.

17 The White House 2020.

> celestial bodies. Such removal is permitted by Article I of the Outer Space Treaty, which provides that 'outer space, including the moon and other celestial bodies, shall be free for exploration and use by all States'."[18]

This position is subject to scrutiny.[19] One may note the difference between "exploration and use" on the one hand and "exploitation" on the other. The first phrase actually refers to the "province of all mankind" idea expressed in Article I of the OST and essentially calls for international cooperation to benefit all states, especially the developing states as expressed in the pertinent UN General Assembly resolution.[20] The second term, exploitation, refers to economically viable utilisation, including purely commercial activities. Views on the permissibility of the second vary. Contrary to the U.S. position, the acknowledged scholar, Tronchetti states: "Outer space, being a 'global commons', a state cannot without further ado use its national law to protect private (and public) business interests related to extraterrestrial mining activities."[21]

Critics of the U.S. position also refer to the Moon Agreement which provides that the exploitation of space resources is only possible if the State Parties establish an international regime assuring, inter alia, the equitable sharing by all State Parties of the benefits derived from exploitation while addressing the needs of developing countries and guaranteeing orderly, rational and safe operations.[22]

18 United States – Input to the Working Group on Legal Aspects of Space Resource Activities, 21 March 2023, UN COPUOS, A/AC. 105/C.2/2023/CRP.37.

19 For an intensive refusal of the individual national regulation approach and call for a concerted international action read the open letter signed by more than a hundred scholars at https://outerspaceinstitute.ca/osisite/wp-content/uploads/International-OpenLetterOnSpaceMining.pdf. De Zwart et al. 2023: 158 also note the existence of the debate.

20 Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries UNGA 51/122 of 13 December 1996.

21 Tronchetti 2015: 791.

22 Moon Agreement, Article 5 and 11 (2).

The significance of this rule is reduced by the fact that the agreement had only 17 parties in April 2024, which did not include a single spacefaring nation. The U.S. made no secret of its view that:

> "[T]he United States does not consider the Moon Agreement to be an effective or necessary instrument to guide nation states regarding the promotion of commercial participation in the long-term exploration, scientific discovery, and use of the Moon, Mars, or other celestial bodies. Accordingly, the Secretary of State shall object to any attempt by any other state or international organization to treat the Moon Agreement as reflecting or otherwise expressing customary international law."[23]

Still, India and France, as signatories of the Moon Agreement are bound by the Vienna Convention on the Law of Treaties and so must not defeat the object and purpose of the agreement concerned (Article 18 of the VCLT). To the best of our knowledge neither of these states have indicated that they no longer wish to be party to the Moon Agreement which would absolve them from not undermining its object and purpose. This certainly includes the aspiration to avoid a first come first served regime of natural resource exploitation. Three of the parties to the Moon Agreement (Mexico, Saudi Arabia and Australia) have signed the Artemis Accords.[24] Whilst Australia does not perceive a conflict between the Accords and the Moon Agreement,[25] Saudi Arabia withdrew from the Moon Agreement with effect from 5 January 2024.[26]

A reconciliatory position may be forged if one ignores the U.S. national position and concentrates on the actual text of the Accords. This may be seen as remaining silent on commercial exploitation and only addressing *in situ* extraction and utilisation of resources for safe and sustainable space activities.

23 Presidential Documents 2020: Sec. 2.

24 UN Committee on the Peaceful Uses of Outer Space 2022.

25 UNOOSA, Australia – Input to the Working Group on Legal Aspects of Space Resource Activities A/AC.105/C.2/2023/CRP.7, 20 March 2023, 6.

26 Reference of the depositary notification: C.N.4.2023.TREATIES-XXIV.2, endnote 3 (https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXIV-2&chapter=24&clang=_en).

Such extraction, in our view, should be regarded as use of resources, permitted under Article I of the OST. This seems to be the interpretation of the Accords adopted by Australia[27] and France.[28]

A general exchange of views on potential legal models for regulating activities in the exploration, exploitation and utilisation of space resources took place within the Legal Subcommittee of UN COPUOS. France submitted a position that relied on both the Moon Agreement and the Outer Space Treaty, stressing that the Working Group on Legal Aspects of Space Resource Activities should "look first at the existing legal framework and particularly at the provisions that are widely accepted within the Committee" (OST, Rescue, Liability) but then went on to note that certain "principles and the travaux préparatoires of the 1979 [Moon Agreement] could be of interest to the work of the Group". These principles are applicable both in respect of "the use and processing of resources as life support (primarily concerning oxygen, nitrogen and water), construction or production of fuels, including extraction, processing and refining" and in the "[a]ctivities concerning the return of space resources to Earth".[29] In respect of all space resource activities, France invokes the Moon Agreement's principles and recalls its call for the rational management of resources and the duty to bear in mind the interests of present and future generations. In our view, this can be interpreted as a rejection of an exploitation policy based purely on national empowerment and oversight. In relation to the principles to be developed by the working group, France notes that the future

> "framework could help consolidate the existing international space law instruments, by adding principles that are adapted to space resource activities to them. Such principles could take into account problems related to the sustainable development of outer space activities, especially when it comes to the use of space resources. For example, it could include principles on multilateral and inclusive resource management, sustainable and responsible

[27] De Zwart et al. 2023: 157.

[28] UNOOSA, France – Input to the Working Group on Legal Aspects of Space Resource Activities A/AC.105/C.2/2023/CRP.12, 20 March 2023.

[29] UNOOSA 2023: 2–3.

> resource management, promotion of international collaboration, etc. More generally, this framework could help provide predictability and legal security at the regulatory level, both for the activities of States and their nationals."

Such a predictable framework "would help to ensure consistency of the legislation of the various States" and generate legal certainty that "can only be obtained if the applicable international framework is clarified (types of activities that could be conducted, coordination with other stakeholders, etc.)".[30]

The message is clear: space resource activities need new principles that adapt existing rules, but react to hitherto non-existent practices, including the operations of private ventures. The activities of these private actors as well as those of all states should be subjected to a multilateral, inclusive and sustainable resource management. The Moon and other celestial bodies should not become the new frontier, a new Wild West in outer space.

SAFETY ZONES AS A TOOL OF DECONFLICTION OF SPACE ACTIVITIES

The Accords aim to avoid harmful interference which might occur among states and companies operating on the Moon. Affirming Articles IX and XI of the OST, the Signatories commit to refrain from any intentional actions that may create harmful interference with each other's use of outer space and to provide each other with necessary information regarding the location and nature of space-based activities. A novel feature is the introduction of the idea of the "safety zone" that differs from the usual "keep out zones" such as those applied around the International Space Station.[31] In fact, safety zones enclosing parts of the freely *accessible res communis omnium usus* territories exist – for example, Article 60 of UNCLOS, which allows states to create a 500 m radius

[30] UNOOSA 2023: 6.

[31] Mallowan et al. 2021: 156.

safety zone around installations in the Exclusive Economic Zone on the sea, where otherwise the freedom of navigation ought to be unrestricted.

According to the Accords, a safety zone is an area in which "nominal operations of a relevant activity or an anomalous event could reasonably cause harmful interference" with the operation by the state declaring the safety zone or an actor licenced by the state.[32] The Signatories commit to respect reasonable safety zones to avoid harmful interference with operations under the Accords, including by providing prior notification to other states before conducting operations in a safety zone established pursuant to these Accords and thus coordinating with each other.[33] Moreover, the Accords stipulate that the concept of the safety zone is in line with the principle of free access to all areas of celestial bodies and all other provisions of the Outer Space Treaty in their use of safety zones.[34]

It is worth mentioning that the safety zone concept was first elaborated by the Hague Building Blocks project in 2019, which proposed safety zones as an effective tool to avoid harmful interference, in line with the principle of non-appropriation.[35] The Building Blocks assumed that timely public notice would be given before restricting access to the safety zone and such restriction would only be in place for a limited period of time.[36] Academics and states that have criticised the concept stress that the establishment of a safety zone, the size, scope and temporal dimension of which is indeterminate, may conflict with the "non-appropriation by use" requirement of the OST, especially if the zone's existence is limited only by the very vague terms of "nature of the operation" and reasonability but may entail an indeterminate length until the end of the operation.[37]

[32] Artemis Accords, Section 11, para. 6–7.

[33] Section 11, point 10.

[34] Section 11, point 11.

[35] Building Blocks for the Development of an International Framework on Space Resource Activities, November 2019, Article 11.3.

[36] Building Blocks for the Development of an International Framework on Space Resource Activities, November 2019, Article 11.3.

[37] See Mallowan et al. 2021; Artemis Accords, Section 11.

SPACE HERITAGE

Section 9 of the Accords prescribes that the Signatories preserve outer space heritage, which comprises "historically significant human or robotic landing sites, artifacts, spacecraft, and other evidence of activity on celestial bodies". This is not without precursors. NASA issued very detailed recommendations in 2011 on "How to Protect and Preserve the Historic and Scientific Value of U.S. Government Lunar Artifacts",[38] while the U.S. Congress adopted the One Small Step to Protect Human Heritage in Space Act[39] in 2020, noting that the lunar landing sites are the first archaeological sites with human activity that are not on Earth which provide evidence of the first achievements of humankind in the realm of space travel and exploration and contain artifacts and other evidence of human exploration activities that remain a potential source of cultural, historical, archaeological, anthropological, scientific, and engineering knowledge[40] that should not be interfered with and should be protected by the rules proposed in the NASA recommendations, including exclusion zones and prohibitions of close overflights.

One criticism of the preservation regime to emerge is that it may be seen as a "U.S.-led attempt to protect space artifacts as a subterfuge for securing indefinite rights over lunar territory, and perhaps even creating a mechanism to 'plant the flag' and claim additional territory in the future under the guise of preservation and protection of lunar sites and artifacts" – as noted by no other than the Office of Science and Technology Policy of the U.S. President in 2018.[41] However, that possibility aside, the idea of respecting the early traces of humanity on the Moon and other celestial bodies is certainly worth supporting.

38 NASA 2011.
39 *Public Law* 116–275, 134 Stat. 3359.
40 *Public Law* 116–275, 134 Stat. 3359, Section 2 (7).
41 Office of Science and Technology Policy 2018.

IN QUEST OF A GLOBAL SOLUTION OR THE BEGINNING OF FRAGMENTATION?

Some States, such as the Russian Federation, believe that the questions of the peaceful use of outer space should be dealt with at multilateral fora, namely within the United Nations Committee of Peaceful Use of Outer Space (UN COPUOS). On the initiative of eight members of the COPUOS, the Legal Subcommittee created a Working Group in 2022 including the United States and other signatories of the Accords with a view to developing a set of principles for space resource exploitation and recommending the next steps which might include the development of international norms. This is in line with the intention of the signatories of the Accords who, according to Section 10 "intend to use their experience under the Accords to contribute to multilateral efforts to further develop international practices and rules applicable to the extraction and utilization of space resources, including efforts at the COPUOS".

However, it seems to be clear that, despite the growing interest in this initiative, most of the states do not wish to urge the adoption of binding rules at this early phase but – as Philippe Baptiste, President of the French space agency CNES noted at the first meeting of the Signatories held in September 2022 "the principles discussed or the ideas discussed within the Artemis Accords should be the basis for later discussions in the U.N. framework".

One of the major risks of circumventing the UN COPUOS with such a non-binding but influential initiative is that it might lead to the polarisation of space law, fragmenting its interpretations and application.[42] The Chinese ILRS project, the annexed bilateral cooperation agreements and the recently founded International Lunar Research Station Cooperation Organization (ILRSCO) seem to verify this concern. On the other hand, it is also clear that it has become unlikely that a consensus could be reached within the UN COPUOS on controversial issues such as the interpretation of Articles I and II of the OST in the near future. Therefore, the Accords might be a catalyst

[42] Report of the Legal Subcommittee on its sixty-second session, held in Vienna from 20 to 31 March 2023, A/AC.105/1285, para. 171.

which – through further debates – leads to a solution that is acceptable to all the UN COPUOS member states. The fact that the working group on space resources was founded just after the announcement of the Accords might be a sign of that.

CONCLUSION

The Artemis Accords, despite being ostensibly only a political statement, generated intense debate in the international community. While a positive outcome of the Accords is that they sparked discussion under the auspices of the UN on the legal aspects of space resource exploitation, they also face criticism for turning away from multilateralism, which can lead to the fragmentation of international space law. Another source of ambivalence lies in the duality of confirming several basic principles of international space law while at the same time adopting the particular U.S. interpretation of Article II of the OST allowing and promoting commercial exploitation of space resources without assuring the guarantees foreseen by the Moon Agreement. Some may note the absence of principles on the protection of the space environment beyond the issue of space debris and the protection of landing sites, the question of liability for damages caused during future missions or a dialogue with the ideas of the common heritage of humankind. While the Signatories explicitly aim to use the experience gained in their cooperation in the work undertaken in the UN COPUOS, there is no indication in the Accords that a more detailed, binding legal regime would be necessary to regulate the exploration and exploitation of the celestial bodies. Although we might agree that the adoption of a robust binding legal regime would be premature at this stage, it seems to be an inevitable step to ensure that the future exploitation of this province of all mankind is carried out in the interest of all countries. Indeed, this goal – as a principle – could have been mentioned in the Accords. In short, a challenger has arrived. Now it is the task of the solid system of institutions and actors with a long-term perspective both on the past and the future to accommodate it.

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Krisztina Tilinger

New Space and the Old Problem of Delimitation: Another Chance for the Mesospace Theory

INTRODUCTION

The purpose of this paper is to introduce and develop a method for the delimitation of the near space, while considering how this special zone could be regulated. In my opinion, defining where near space starts and ends is the first step in the very timely law-making process of the delimitation of space. The aim of such law-making is to increase predictability and reduce uncertainty by providing appropriate legal rules for the interests of both the operators and beneficiaries of near-space or high-altitude vehicles and objects operating in or temporarily entering near space, as well as for the general public. After analysing the attempts that have been made to regulate near space, I came to the conclusion that it is not necessary to devise entirely novel methods to satisfy the demands for regulations in this New Space Age, since the law of the sea, having evolved for several hundred years, is already applicable to this area as a legal regime. The law of the sea has many similarities to the situation prevailing in near space, therefore, its legal tools and examples can easily be taken into consideration when regulating near space, either by analogy or by applying them during the law-making process. My research method was the traditional comparative analytical method during which, by analysing and comparing the existing ideas, I drew my own conclusions and made suggestions in relation to the problem of the lack of the delimitation of near space.

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WHY NEAR SPACE MATTERS

The 21st century has witnessed a rapid and exponential growth of commercial and civil activities in unconventional territories, including the high seas and outer space. However, a significant risk is inherent in the commercial, private use of territories which have *res communis omnium usus* status without clear and enforceable legal rules. Both the high seas and outer space have such a legal status. Commercial human activities in these areas were not usual before the 21th century, hence these activities are not appropriately regulated.

Looking at either international or national space law, the need for reform is obvious in this area. The basic space law rules were laid down in five international treaties that were concluded under the umbrella of the United Nations during the 1960s and 1970s. None of them deals with delimitation issues, not to mention near space. Regulating that area of space is becoming increasingly necessary as a consequence of the intensification of sub-orbital human activities. The region of near space, which is beyond the altitude used by civil aviation, is used by near-space vehicles, including suborbital planes, high-altitude balloons and drones.

In this New Space Age a major challenge of space law legislation is how to apply the already existing space law principles to the new commercialisation-induced space activities that have not been addressed before. One of the emerging issues is the lack of the delimitation of outer space. Predictability is clearly a very important condition for commercial space activities. Until it is clearly defined where airspace ends and where outer space begins, neither jurists nor commercial stakeholders know in what cases and on what basis the legal rules and regulations, which are obviously different to those for airspace and for outer space, shall apply.

It is worth considering a real life example from the high seas, which is also a *res communis ominum usus* territory, which illustrates how unregulated human activities can pose great dangers, underlining the necessity of appropriate regulation.

On the 18th of June 2023 a submersible named *Titan* – an underwater vehicle with limited capabilities for manoeuvre – imploded with its pilot and four civil human passengers on board. Its owner and operator, OceanGate, an American company, was providing exploration and tourism services by means of crewed submersibles for scientific services. In 2021, the company made its service available for commercial purposes, as a result of which they launched commercial dives to visit the wreck of the *Titanic* in the North Atlantic Ocean. The *Titanic* sunk on 15 April 1912 and its wreck was discovered on 1 September 1985. Over the last four decades personal damage or death has never occurred during or related to any scientific or commercial expedition to the wreck. In its fourteenth trip, however, the submersible *Titan* operated by OceanGate, with one of its founders and CEO, as well as a scientist and three other persons on board, imploded during its descent, before reaching its destination (probably at a depth of around 3,500 metres). *Titan* lost contact with its mother ship approximately 1 hour and 45 minutes after its descent. After the tragedy, OceanGate immediately suspended its commercial operations and to date has not indicated that it is planning to resume its activities, and certainly there has been no news about offering any similar services again. OceanGate had previously been subject to a significant amount of criticism based on the lack of appropriate safety of its submersibles. This distrust and uncertainty was related to the new technology it employed connected to the shape and material of the body of the vehicle.[1] Indeed, neither independent experts nor any officially recognised authentication or certification body have confirmed the safety of those newly applied technologies or the vehicles themselves.

How is the tragedy of *Titan* relevant to space law? With the intensification of space activities, it is undoubtedly time to prepare for an increase in sub-orbital activities including both space tourism and other private or military activities that do not necessarily reach orbit, but which take place high enough that

[1] According to the company's management, *Titan's* pressure vessel, made of carbon fibre and titanium, was designed with NASA and the University of Washington during a pre-voyage tour, although it later transpired that the institutions referred to were only providing the facilities for tests without any contribution or approval of *Titan*.

the legal regime of air law is not to be applied. In parallel with the growing involvement of private actors in the space industry and the significant reduction of costs of launching vehicles to altitudes above the area where aircraft operate, space travel is becoming accessible to civilian and private individuals. However, there is still a lack of specific rules, whether they be safety standards or permissions for operation. Tommaso Sgobba, the Executive Director at the International Association for the Advancement of Space Safety (IAASS) and former head of spaceflight safety at the European Space Agency (ESA) remarked in an interview with *Space.com* that: "In fact, we have a sort of an analogue here. You have a technology that goes into an extreme environment for the purpose of pleasure that doesn't give much chance to people to survive if something goes badly wrong."[2] Although there is no legal definition of near space, the term usually refers to altitudes which are too high for traditional aircraft to operate. At the same time, space objects cannot stay in orbit in this altitude range either, because the gravity is too strong for them and they cannot reach a sufficient speed to keep them in orbit, which is why this region cannot be termed outer space. This layer of the Earth's atmosphere can be used by special flying objects, namely lighter-than-air or high-altitude balloons, weather surveillance balloons, navigation balloons, drones, suborbital rockets and, according to the newest information, by hypersonic weapons. It is not necessary to explain why special attention needs to be paid to the military aspects of the use of hypersonic weapons and spy balloons in near space. Almost a year ago a statement in a Chinese media outlet referred to near space as a new battlefield, and this rhetoric alarmed security experts.[3] In addition, using the state-of-the-art technology, balloons or drones operating in near space can easily be equipped with high-resolution imaging and telecommunication equipment that can be used for gathering information, for example for weather forecasting, or for communication. One advantage of using vehicles in near space is that the costs of these activities are much lower than those involved in launching and operating satellites in orbit. Another advantage is that, because the objects in

[2] Pultarova 2023.

[3] Connolly 2023.

near space are much closer to the earth, the images or data they capture can be more accurate and of better quality. In addition, from a technical point of view such objects are easier to manoeuvre, as opposed to satellites which once in orbit are difficult to alter in terms of both their activity and their movements.

Coming back to the legal relevance of the example just cited: in case of the *Titan* submersible, the non-compliance of the vehicle with the safety requirements or the lack of any official licence or even registration did not raise legal issues before the tragedy happened, because Titan was not considered to be a vehicle, but instead it was regarded as an object, that was transported via land and sea, and later dropped into the ocean close to the wreck of the *Titanic.* Since the operation happened on the high seas, the safety or other regulations of coastal states were not applicable.[4] I would like to highlight the parallel between the non-regulated activities of submersibles, like the Titan, and the operations of near-space vehicles. It is unquestionable that as the number of such vehicles increase, so too the risk of a tragedy grows. Enacting appropriate laws, either at international or national level, would significantly lower such a risk. Therefore, it is important to proceed with making laws to regulate near space, and a logical starting point for this is the delimitation of near space.

In order to identify what rules are lacking, it is worth reviewing what regulations are already in place in both air law and space law.

DELIMITATION IN AIR LAW

International air law does not define the upper limit of airspace. The reason why this issue has been left open for a very long time was that making a definite decision on this was not of practical relevance to the international community. Air law deals with aviation, i.e. with the aeronautical uses of the airspace.[5] However, distinguished scholars have indicated the necessity of precisely demarcating the limits of airspace in the near future, due to the fact that the technological

[4] Balogh 2023.
[5] Sipos 2023: 39.

development is at a phase when suborbital flights are already a reality.[6] The ICAO (International Civil Aviation Organisation), defines suborbital flight as a "flight up to a very high altitude which does not involve sending the vehicle into orbit". An example of a definition of suborbital flights can be found in national legislation. The U.K. Space Industry Act 2018 includes sub-orbital activities within its definition of "spaceflight activities", and although special rules apply to them, they are clearly defined and regulated by the provisions of the Space Industry Act. According to the Space Industry Act "sub-orbital activity" means launching, procuring the launch of, operating or procuring the return to earth of 1. a rocket or other craft that is capable of operating above the stratosphere; 2. a balloon that is capable of reaching the stratosphere carrying crew or passengers; or 3. an aircraft carrying such a craft, but does not include space activity.

Accordingly, sub-orbital activities carried out in near space are already starting to be regulated, which is a notable trend to be followed by other nations. However, this does not satisfy the demand for an international consensus to agree upon where exactly the near space starts and ends.

DELIMITATION THEORIES IN SPACE LAW

In international law there is no consensus about the definition of near space. Even the delimitation of space has not been clarified, although numerous theories exist about where airspace ends and outer space begins. The airspace that is above the territory of a state is under the sovereignty of the given state, but only until the boundary of outer space, which has a different legal status, the *res communis omnium usus,* as detailed above. Thus, the airspace above the territory of a state is exclusively and completely controlled by that state,[7] while

[6] ICAO Council, 175th Session, Concept of Sub-orbital Flights, Working Paper C-WP/12436, 5 May 2005.

[7] 1944 Chicago Convention on International Civil Aviation.

outer space may be explored or used freely by any state.[8] In national legislation some states have already stipulated what they accept as the boundary of space: 100 kilometres above sea level has been enacted as this limit in the national law of Denmark, Australia and Kazakhstan.[9] However, these theories have not been officially recognised at international level, therefore they can be relied upon only within their national jurisdiction.

Among the international theories, the most promising are those which are based on the spatialist or functionalist approach. Spatialist based theories operate by drawing a concrete line above Earth at a certain height, whether it is based on the laws of nature, for example on aerodynamics, such as the well-known Karman line at 100 km above the sea level or on a simple designation, as was used in the national legislation mentioned in the previous section. Functionality based theories argue that the delimitation should be carried out on the basis of the purpose of the flight: if the function of operating a vehicle in the air qualifies as an air flight then the air law regime should be applied, while in cases in which a flight aims to operate as a space flight, the space law regime shall apply.

Spatialist approaches include the interim zone theories, which will be dealt with in this paper, being both the most recent and the most developed theories. These conceptualisations are based on the delimitation defined in the international law of the sea. The idea behind these theories is that the demarcation of space is not a concrete line, but rather a zone between two levels determined by the given theory. In the law of the sea, the territory of the inland water and the coastal sea are under the exclusive sovereignty of the state to which it belongs, just like in case of the airspace above the territory of a state. Beyond that region there are historically and legally determined zones where the coastal state has certain sovereign rights without controlling those waters completely. These horizontal zones might be applicable vertically in space, creating a transitional zone between airspace and outer space. On the

[8] 1966 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (the Outer Space Treaty).

[9] Bartóki-Gönczy – Sipos 2022: 42–43.

basis of this idea, several theories have been proposed which differ according to the start and end altitudes of the transition zone. One of the three most relevant theories regarding what near space means is the approach devised by Thomas Gangale,[10] who argued that the near space region should be placed between 31 and 81 km. Paul Stephen Dempsey and Maria Manoli placed the zone between 50 and 160 km, while Hao Liu and Fabian Tronchetti[11] argue for an altitude between 18 and 100 km. These theorists argue that near space should have similar legal status as the contiguous zone in the law of the sea, and as such, vehicles of third states should not require permission for passage. The safety of the public might be governed by the international civil aviation regulations and the military use of near space should be banned, except if permitted by the state concerned.[12]

In order to understand the background of the theory of interim zones and some possible reasons for its application for the delimitation of near space, in the following section I will outline the delimitation regime of the law of the sea from which the idea behind these theories originates.

THE LAW OF THE SEA ANALOGY

The international space legislation has a tradition of relying on the international law of the sea, or at least drawing upon it for inspiration. Delimitation is a very important aspect of the law of the sea, both from a political and legal point of view. Many conflicts over the last few centuries have arisen from differing interpretations of the delimitation rules concerning the high seas, which provides space lawyers with a vast pool of examples of the types of issues, which might occur in the case of potential conflicts of interest. The idea of establishing an interim, transitional zone for the near space thus derives, by analogy, from the delimitation regime of the international law of the sea.

10 Gangale 2018.
11 Liu–Tronchetti 2019
12 Bartóki-Gönczy – Sipos 2022: 46.

Historical aspects

The freedom of the seas has been recognised by the international community as a basic principle since the end of the 18th century,[13] which has been confirmed in the 20th century both by political documents[14] and maritime treaties.[15] At the same time, no generally accepted customary law on maritime delimitation was recognised for centuries. For a long time, the principle determined in 1703 by the international lawyer Cornelis van Bynkershoek was followed, namely that the sovereignty of the coastal state extends as far as that state is able to exercise control over the territorial sea: in practice, the range at which foreign ships can be held back by a cannon placed on the coast. The boundary of the territorial sea was later suggested to be 3 nautical miles, which is 5,559 metres, away from the baseline (low water line), although doubts were expressed about this exact distance even during the negotiations at the relevant international maritime conferences in the mid 1990s, as well as in the relevant case law (International Court, English vs. Norwegian fishing case). The codification of the international law of the sea was finalised at the 1958 Geneva conference where four international treaties (one of them concerning the territorial sea and the contiguous zone, hereinafter referred to as the TSC[16]) were adopted. Political interests have subsequently questioned many of the achievements of that conference, including the lack of clarification of the extent of the territorial sea. Finally, the Montego Bay Convention[17] (hereinafter referred to as UNCLOS) concluded in 1982 managed to put an end to many outstanding and legally ambiguous issues by regulating many aspects of the law of the sea, for example maritime delimitation.

13 Bruhács 2010: 104.

14 1918 President Woodrow Wilson's 14 Points, 1941 Atlantic Charter.

15 1958 Geneva Conventions on the Law of the Sea, 1982 United Nations Convention on the Law of the Sea.

16 Published in Hungary by Statutory Decree No. 31 of 1964.

17 United Nations Convention on the Law of the Sea.

Delimitation in the international law of the sea

On the basis of the TSC and the UNCLOS the principles of maritime delimitation define three zones that are relevant for my analysis: the territorial sea, the contiguous zone and the exclusive economic zone. The treaties not only stipulate the geographical extent of such areas but also the rights and obligations of the coastal states and the other actors of the international community.

According to the UNCLOS,[18] the sovereignty of the coastal state over the territorial sea[19] is limited only by the right to innocent passage. Under the right of innocent passage, foreign commercial ships are entitled to navigate through a state's territorial sea unhindered and with the sole purpose of crossing. Submarines and other underwater vehicles are required to navigate on the surface and to show their flag within another state's territorial waters.[20] Temporary suspension of this right might be allowed only in case of distress, force majeure or if it is incidental. The ships need to comply with the regulations of the coastal state and, of course, with the rules of international law. Passage is "innocent" so long as it is not "prejudicial to the peace, good order or security of the coastal state".[21] Passage is non-innocent, for example, in case of fishing, unauthorised scientific activities, collecting data and information, breaching the fiscal, customs or health regulations of the coastal state, environmental contamination, violence, manoeuvres with weapons, etc. If the passage of a vessel ceases to be innocent, the coastal state has the right to temporarily suspend the passage, and in the event of breaching the laws of the coastal state, the offender is rendered liable to prosecution.[22]

The jurisdiction of the coastal state has been extended, but only for special purposes, up to an additional 12 nautical miles to the zone contiguous to the

[18] Article 17 UNCLOS.
[19] The territorial sea is determined as the spatial ambit of the sea counted from the complexly configured baseline up to 12 nautical miles.
[20] Article 20 UNCLOS.
[21] Article 14(4) of the 1958 Convention.
[22] Shaw 2021: 488–491.

territorial sea. The reason behind this is to reserve some rights for the coastal states in order to prevent infringements of their customs, immigration or sanitary laws, or to conserve fishing stocks or other marine resources for the coastal state. This additional sea belt makes it possible to balance the different interests of the coastal states and other marine nations with special regards to their commercial interests. In the contiguous zone, the coastal state may 1. prevent infringement of its customs, fiscal, immigration or sanitary regulations within its territory or territorial sea; 2. punish infringements of the above regulations that are committed within its territory or territorial sea. The concept of the contiguous zone is somewhat vague, due to the fact that historically this zone belonged to the high seas, although with the development of the jurisprudence the contiguous zone now forms part of the coastal state's exclusive economic area.[23]

Traditionally the reason for craving out a more special zone, called the exclusive economic zone (EEZ), from the high sea was the issue of fishing rights. The 1958 Geneva Convention did not reach a conclusion as regards exclusive fishing rights in the contiguous zone, therefore, the economic interest groups of the coastal states, in relation to their fishing rights, attempted to achieve a 200-mile zone for that purpose. The 1982 Convention stipulated the right finally for those states that are in a situation of special dependence on coastal fisheries by establishing the legal regime of the exclusive economic zone. Under Article 56(1) of the 1982 Convention, the coastal state in its economic area has, inter alia, 1. sovereign rights for the purpose of exploring and exploiting, conserving and managing natural resources, whether living or non-living, of the waters superjacent to the seabed and of the seabed and its subsoil, and with regard to other activities for the economic exploitation and exploration of the zone, such as the production of energy from the water, currents and winds; and 2. jurisdiction as provided for in the relevant provisions of this Convention with regard to: a) the establishment and use of artificial islands, installations and structures; b) marine scientific research; c) the protection and preservation of

[23] Shaw 2021: 496.

the marine environment. It is important to emphasise that the exclusive zone is not under the sovereignty of the coastal state but rather that the coastal state exercises sovereign rights in this area.

The rights and obligations of other states in this zone include the freedom of navigation, overflight and the right to lay submarine cables and pipelines. The states shall also have due regard to the rights and duties of the coastal State and shall comply with the laws and regulations adopted by the coastal State in accordance with the provisions of the UNCLOS and other rules of international law.[24]

APPLYING THE LAW OF THE SEA TO THE NEAR SPACE

As we can see from the above analyses, the international law of the sea has already clearly defined special delimitation rules in order to address conflicting economic and political interests. In my opinion – which is mainly based on the concept of the Exclusive Economic Utilization Space zone – the best solution would be to ensure the right of innocent passage to the vehicles or space objects of third states as well as to combine the rules of the contiguous zone and the EEZ and apply them accordingly to the near space zone. In near space, the rights of the coastal state in the contiguous zone and in the EEZ could be, by analogy, accorded to the state above which the region of near space is located. While the complete list of these rights needs to be elaborated by technical, legal and political experts in order to address all the necessary issues, it could certainly include the sovereign rights associated with exploring and using near space for economic purposes, for scientific research and for the protection and preservation of the environment. Appropriate safety and security rules should also be enacted in order to ensure the safety of both the crew of near-space vehicles, as well as members of the public who might be affected in the event of an accident or by any harmful emissions from such vehicles. It is also advisable

[24] Article 58 UNCLOS.

to ensure the right for states to punish infringements of these special rules, as has been established in the rules for coastal states in their contiguous zones.

A similar approach has been followed by the International Association for the Advancement of Space Safety (IAASS), a non-profit organisation based in Noordwijk, The Netherlands that has drafted a proposal for an international treaty regulating near space called the Convention on the Regulation of Near Space. According to this draft treaty: "Near Space extends from 18 km above sea level up to 160 km above sea level", which is an obvious combination of the aforementioned theories in relation to the delimitation of near space. In 2020, an IAASS study was presented to the Legal Subcommittee of the United Nations Office for Outer Space Affairs and is being circulated among civil society.[25]

My suggestions are also based on the very useful and well-developed ideas of Liu Hao and Fabio Tronchetti. In 2019 they came up with the idea of an Exclusive Economic Utilization Space (EUS) zone and they suggested regulating it as such, following the example of the exclusive economic zone taken over from the law of the sea. As mentioned earlier, they defined near space as lying between 18 and 100 km above sea level. They mainly justified the necessity of the special regulation by reference to commercial interests, namely by the intensification of providing Internet, communication, navigation and sensing services by utilising near space. Arguing that the use of near space seems to be a highly profitable endeavour, offering excellent opportunities for startups and newcomers, while noting that high-altitude platforms are much cheaper to launch and operate than traditional satellites, special attention must be paid to it. The only criticism that this approach faced concerned its lack of focus on security concerns, which is, especially in the light of the famous Chinese spy balloon case, a serious issue to take into consideration.

The basic idea of the EUS, which I promote to be followed, is that it shall lie beyond the national sovereignty, although the affected states might retain certain sovereign rights over the EUS pertaining to their territory, as in the legal regime of the EEZ in the law of the sea. The lower limit of the EUS is

[25] Gupta–Sgobba 2022a; 2022b.

suggested to be set at 18 km, which is the altitude above which air flight is impossible due to the low density of the air. The upper limit of 100 km aligns with the demarcation line of the start of outer space which is, however, not recognised by international law, but many states have defined this altitude as the border of space. As we have seen from the previous sections of this paper, the legal status of near space is not clarified in international law. Two regimes, those of air law and space law are comparable in this regard, and the questions of near space are not determinable from the relevant international treaties. Only a very few national legislations have attempted to regulate near space or suborbital activities so far. One of these, already described above is the U.K. Space Industry Act and another example is the Outer Space and High-Altitude Activities Act of New Zealand from 2017. Unfortunately, neither of those Acts defines clearly what exactly near space means, or where it begins or ends, although both of them prescribe special conditions and licences for conducting activities in this zone. Taking into account the uncertainty in relation to both the legal status and the limits of near space, I agree with the reasoning of the EUS theory that defining and clarifying the special legal status of near space is necessary and timely.

Employing the EEZ as a reference model for near space is also justifiable. The sovereign rights of coastal states allow them to explore, exploit, conserve and manage the living resources of their respective EEZs, while also entailing an obligation for them to preserve fisheries and promote their optimal utilisation. The exploration and exploitation of non-living resources (minerals, hydrocarbons and energy) in the EEZ by the coastal state is unrestricted. The jurisdictional rights of coastal states include 1. the establishment and use of artificial islands, installations and structures, around which they have the right to establish safety zones, as well as the right to formulate sanitary, fiscal, custom, safety and immigration laws; 2. marine scientific research; 3. the protection and preservation of the marine environment. Freedom of navigation and freedom of overflight are somewhat restricted to the extent that the regulations of the coastal states have to be respected if they have been adopted according to the UNCLOS. Following these rules, the proposal of the EUS is based on the following elements: a) the utilisation of the EEZ area for exclusively economic purposes; b) the promotion of the optimal use of resources; c) the sovereign right of the coastal state to manage and use its EEZ on a priority basis combined with the limited rights of other countries to participate in activities therein; d) the right of the coastal state to pass and enforce laws in relation to activities occurring within its EEZ and the right to enforce them; and e) the need to ensure safety, security and order within an EEZ. Based on these elements, Liu and Tronchetti's proposal is that the establishment of an EUS would not undermine the sovereignty of the underlying state in its national airspace; the underlying state would retain a priority right to use and administer the exclusive utilisation of space established above its territory and the underlying state would be entitled to regulate and enforce safety and security matters within the EUS established above its land territory and territorial sea. Additionally, the conditions for the deployment and operation of near-space vehicles within an EUS would be agreed upon between the underlying state and the operator prior to the commencement of operation and the underlying state would have the right to deny the deployment of foreign high-altitude vehicles in its EUS based on any perceived threat to its national security and safety interests. Third countries would be entitled to deploy their near-space vehicles in a foreign EUS subject to prior notification and approval by the underlying state, while third countries would also enjoy the right of overflight through a foreign EUS upon prior notification. Besides, the operators of foreign high-altitude vehicles would be obliged to apply for a licence from the underlying state to provide services in its EUS.[26]

In my opinion establishing a *sui generis* legal regime for near space at an international level would promote legal certainty and predictability. This is becoming more and more important in the New Space Age, because of the commercialisation and the intensification of near space activities. Predictability

[26] Liu–Tronchetti 2019: 103.

allows further technical development, encourages innovation, ensures a reliable framework for investors and contributes to the long-term sustainability of space activities.

The theory of the EUS, just like other interim zone theories, has the advantage of introducing the right of innocent passage, as a consequence of which states with smaller territories do not need to ask for permission or licence from all the third countries whose airspace is crossed during the launch of their space objects. The same advantage applies for any state as regards the re-entry of their space objects.[27] It also offers a solution to the ambiguity of legal considerations of commercial suborbital flights, because no matter how long the suborbital vehicle stays in the air, if it is within the limits of near space, it will not qualify as a space activity, and therefore the special rules for near space could be applied without any hesitation. Consequently, there would not be any hesitation or ambiguity around the legal status of such vehicles or activities, and in the event of legal conflicts, the jurisdictions would be determined more easily.

The argument against the necessity of the delimitation of space, which relies on the fact that, so far, no international dispute has arisen, is outdated, as I have demonstrated with the example of the *Titan* catastrophe that illustrates how not having rules for human activities in unconventional territories poses a huge risk.

CONCLUSION

If we look at the historical development of maritime delimitation and the delimitation (or rather the lack of it) of airspace, we might conclude that legal actions were and are always the reflection and consequences of the political and economic interests of the states concerned. International law might provide solutions for the emerging question of the delimitation of near space, and if lawyers want to give guidance to the political and economic dialogue, it is important to be able to demonstrate the possibilities and the legal instruments

[27] Bartóki-Gönczy – Sipos 2022.

that are already available and free to use by analogy. As this paper has shown, the time is here: suborbital flights are a reality, spy balloons, weather surveillance high-altitude vehicles and unmanned drones use the near space region, while at the same time no rules are being followed, which entails risk for their operation.

Considering the example of the *Titan* catastrophe, it may not be too late to learn the lesson from it, of why is it necessary to act and enact laws before any tragedy happens. We might not need to go so far as to prohibit the operation of any crewed vehicles or flights in the near space, but certainly it would be beneficial for both the commercial actors and for the society to enact the rules for delimitation of near space as well as to stipulate the conditions of exploiting and managing near space with the purpose of providing certainty and predictability. I have argued in this paper that the law of the sea has clear rules on the issue of delimitation which might be easily applicable to near space. In order to enact new legal tools for near space, it may be sufficient to rely, by analogy, on the existing ones in the field of the law of the sea, that will only need to be adjusted and formulated in a way which provides an appropriate balance between the different interests of the actors who are using or might use the zone of near space in the future.

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Rosanna Hoffmann

Legislating the Final Frontier: Trends and Challenges of National Space Law

INTRODUCTION

The frontier of outer space has always been a compelling subject of interest, capturing the collective imagination of humanity for decades. Initially, the realm of space was not just a venue for scientific exploration and technological innovation; it was a theatre for geopolitical contestation, primarily dominated by established spacefaring nations. The Cold War era saw an intense race to assert supremacy in space exploration, leading to ground-breaking missions like the Apollo moon landings and the launching of the Sputnik satellite. During this period, the legal frameworks around space were primarily driven by these superpowers, and even though geopolitical turmoil encapsuled this era, consensus was still to be found, culminating in the Outer Space Treaty of 1967.

In recent decades, advancements in technology have made space more accessible, reducing costs and enabling the development of diverse space assets. This has allowed not only emerging economies to engage in space exploration and satellite deployment but also private entities, from major aerospace firms to small tech startups and academia, to expand their presence in space. This broadened participation has added complexity to the governance and legal aspects of space activities. Traditional space powers, contrast with newer and emerging spacefaring nations, must formulate their own space laws aligned with international treaties.

As space activities become more integrated globally, the need for evolving legal frameworks is evident, particularly for nations developing their space law capabilities. These frameworks must balance competitive interests,

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ethical standards, international commitments and environmental aspects. This chapter will delve into the realm of national space laws, trends and challenges, focusing on the key elements of a national space law, and looking into their national implementation. The 'New Space Era' is a period marked by burgeoning commercial activities, international cooperation and rapid technological developments.

THE NECESSITY FOR NATIONAL SPACE LEGISLATION

In an age where outer space is no longer the exclusive domain of a handful of advanced nations, the necessity for well-defined national space laws has never been more pressing. As a myriad of new actors – ranging from emerging nations to commercial entities – venture into space, there exists an urgent need for domestic legal frameworks to guide activities, ensure safety and alignment with international norms. These laws serve as the regulatory bedrock, enabling a harmonious blend of scientific exploration and commercial enterprise. By establishing clear legal frameworks and guidelines, national space laws aim to create a structured and responsible environment for all participants in the evolving landscape of space exploration and utilisation.[1] An increasing number of nations, buoyed by technological advancements and strategic imperatives, are entering this once-exclusive domain. Moreover, private entities and commercial ventures are also playing an increasingly pivotal role, further amplifying the need for well-defined regulatory frameworks.[2]

Given this backdrop, national space laws have become indispensable tools for governance providing the necessary legal framework to address a range of complex issues. These issues can encompass everything from launching satellites for telecommunication, weather monitoring and scientific research, to more advanced ventures like space tourism and asteroid mining. Therefore, these laws serve not only to facilitate domestic activities but also to ensure responsible

[1] Marboe 2015: 127.

[2] Von der Dunk 2020b: 228; Freeland–Jakhu 2017: 2.

behaviour and compliance with international norms and agreements.[3] The benefit of national legal norms lies in their direct applicability and enforceability, unlike obligations derived from public international law, which may not always be enforceable.[4]

The essence of a national space law is to provide a legal framework that is consistent with a state's obligations under international treaties while catering to its specific needs and interests in space. It defines rights and obligations pertaining to space activities under a state's jurisdiction.[5] Some national space laws include the establishment of a national space agency, the operation of a spaceport, the use and distribution of remote sensing data and much more.[6] Whilst there is no definition of a national space law, in a wider sense, it could include all national legislation that may be applicable to space activities.[7]

THE INTERPLAY BETWEEN NATIONAL SPACE LEGISLATION AND THE UNITED NATIONS SPACE TREATIES

The evolution of national space laws cannot be viewed in isolation but must be considered in the context of international space law. National space laws are underpinned by several core principles of the Outer Space Treaty of 1967, including the requirement for authorisation and continuing supervision of space activities by States, the principle of liability for damage caused by space objects, the obligation to avoid harmful contamination of space and celestial bodies, the duty to conduct all activities in outer space with due regard to the corresponding interests of all other States, and the need for States to register space objects with the appropriate national and international bodies, just to

3 Tapio–Soucek 2022: 116–117.
4 Marboe 2015: 128.
5 Freeland–Jakhu 2017: 2.
6 Hobe 2013: 86.
7 Soucek 2016: 53.

name a few.[8] Later in this chapter, the trends and considerations that come with implementing the seven key elements of a national space law, laid forth by the United Nations (UN) General Assembly Resolution A/RES/68/74, will be delved into. This chapter will particularly focus on how these elements are applied in practice and some possible trends to be found.

National space laws are essentially the implementation of these international principles, translating broad treaty provisions into actionable mandates, enabling a state to effectively oversee commercial space activities, reduce unforeseen liabilities and ensure compliance with clear regulatory standards.[9] The Registration Convention requires states to furnish details regarding their space objects to the UN, a requirement that is often incorporated into national space legislation. This ensures transparency and aids in the tracking and identification of space objects, which is crucial for the sustainability and safety of space operations.[10] Liability issues are another area where international and national space laws intersect. The Liability Convention elaborates on the liability of states for damage caused by their space objects, a principle that is reflected in national laws by imposing insurance requirements on space operators to cover potential liabilities resulting from damages caused.[11] For example, the 2009 collision between the inactive Russian satellite Cosmos 2251 and the operational Iridium 33 telecommunications satellite resulted in thousands of pieces of space debris, prompting a complex legal dialogue concerning fault, liability and compensation. This incident, addressed through the mechanisms of both international space law and the national laws of the involved countries, underscored the critical need for robust legal frameworks to manage the challenges posed by space debris.[12]

8 Outer Space Treaty 1967.
9 Lyall–Larsen 2018: 415–416.
10 Registration Convention 1976.
11 Liability Convention 1972.
12 Koplow 2009: 1204–1205.

The Rescue and Return Agreement outlines the responsibilities of states regarding astronauts in distress and the return of space objects, principles that have been incorporated into national laws to facilitate cooperation and mutual assistance in space operations.[13] The interdependence between national and international space law is further exemplified when examining the case of satellite broadcasting and telecommunications. The International Telecommunication Union (ITU) allocates orbital slots and radio frequencies; however, national regulations detail the licensing and operations of satellites within those frameworks.

Moreover, the concept of "due regard" in the Outer Space Treaty and the requirement to avoid harmful interference have been interpreted in various national contexts to mean that states must not only prevent physical interference with the space activities of other states but also avoid any activities that would be detrimental to the sustainability of the space environment.[14] This principle was tested in the 2013 case of Ecuador's Pegaso satellite, which suffered a collision with debris from an old Russian rocket stage. While no liability was formally pursued, the incident highlighted the need for enhanced space situational awareness and debris mitigation strategies at both national and international levels.[15]

The establishment and enforcement of national space laws, thus, serve as a bridge between the objectives set within the international space treaties and the practical considerations of state interests and commercial aspirations. As nations and private entities venture further into space, national legislation must continually adapt, not only to uphold international standards but also to address novel situations that arise as humanity expands its presence in space.

[13] Rescue and Return Agreement 1968.
[14] Popova–Schaus 2018: 7.
[15] Marboe 2016: 14.

THE SEVEN KEY ELEMENTS TO CONSIDER IN A NATIONAL SPACE LAW

The General Assembly Resolution A/RES/68/74 on national space legislation was a result of comprehensive work by a dedicated working group under the Committee on the Peaceful Uses of Outer Space's Legal Subcommittee (COPUOS LSC). During its 52nd session in April 2013, the Legal Subcommittee of the UN COPUOS reached a consensus on a draft that would later form the basis for the UN General Assembly Resolution. The resolution aims to ensure that states implement obligations under international space law, including those set forth in the Outer Space Treaty of 1967. The resolution also encourages states not yet party to these treaties to consider ratification or accession in line with their domestic legislation, further underscoring the importance of incorporating these international principles into national laws. The resolution underscores the importance of national legislation in implementing the obligations under international treaties, fostering responsible and sustainable use of outer space.[16] The resolution outlines key elements crucial for national space laws, which will be explored in detail. These elements include: the scope of application, defining the reach of national laws; authorisation for non-governmental entities to conduct space activities; ongoing supervision of these activities; the registration of space objects; liability and insurance requirements to cover potential damages; ensuring safety in space operations; and guidelines for the transfer of ownership of space objects.[17]

Scope of application

Starting with the first key element, the scope of application in law delineates the boundaries within which legal provisions are effective. It defines the extent of activities, entities and circumstances under which a law is applicable. This

[16] United Nations General Assembly 2013; Brisibe 2013: 728–729.
[17] United Nations General Assembly 2013.

precision is crucial for both the authorities enforcing the law and those subject to it, providing a clear understanding of their rights, obligations and the legal framework guiding their actions.[18]

Under the lens of national space laws, the scope of application defines the legal jurisdiction of a country over space activities. It can include which activities, entities and objects fall under the purview of a specific national space law, based on factors such as the location of launch, the nationality of the operators and the registration of space objects.[19] The scope of application within national space laws can broadly be seen to encompass material scope, territorial jurisdiction and personal jurisdiction, each offering a framework to delineate the legal reach and applicability of these laws.[20] The material scope can include specific activities, operations, or subjects covered by the law. Within national space law, this might mean defining a range of activities from satellite launches to space exploration missions, aiming to clarify which operations are regulated under the law. Territorial jurisdiction, *jurisdictio ratione loci,* generally relates to the geographical extent of the law's applicability. It might only refer to activities within a country's territory or could extend to not only activities taking place within a country's territory, but also to those by its nationals, regardless of the location. Personal jurisdiction, *jurisdictio ratione personae,* pertains to who the law would *in concreto* apply to, potentially covering a broad spectrum of individuals and entities, from citizens to corporations and possibly foreign operators within a nation's jurisdiction.

In examining the scope of application of national space law, one also needs to consider the first sentence of Article VI of the Outer Space Treaty, which stipulates: "States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the Moon and other celestial

[18] De Man 2016: 93.
[19] Soucek 2016: 55.
[20] Gerhard 2009: 114.

bodies, whether such activities are carried on by governmental agencies or by non-governmental entities."[21] This provision underscores the international responsibility of states for activities conducted by their nationals in space. The interpretation of the term 'national activities' can be seen to include activities conducted by individuals or entities possessing the nationality of the respective state. In essence, states are held internationally accountable for space activities undertaken by their nationals, encompassing private companies and other legal entities.[22]

For instance, the Liechtenstein Space Act, similarly to other national space laws, outlines its jurisdiction to include not only activities launched from its territory but also those conducted by its nationals anywhere in the world.[23] The Finnish national space law's scope of application for example extends to space activities conducted within Finland's territory and those outside its territory if undertaken on Finnish-registered vessels or aircraft, or by Finnish citizens or legal entities incorporated in Finland.[24] Similarly, South Africa's Space Affairs Act encompasses a wide range of space activities, including launching, operation of launch facilities, and participation in activities that engage international conventions, treaties, or agreements ratified by South Africa. It applies to activities launched from South African territory and to legal entities incorporated or registered in South Africa involved in space activities abroad that entail international obligations or affect national interests.[25] A trend in the scope of application of national space laws is the increasing consideration of activities beyond traditional spacefaring, that is to say, national governmental activities, to include also private sector engagements and international collaborations, as well as to consider national activities beyond a country's borders.[26]

21 Outer Space Treaty 1967.
22 TRONCHETTI 2014: 26–27.
23 Liechtenstein 2023.
24 Finland 2018.
25 South Africa 1995.
26 SOUCEK 2016: 53.

Authorisation and continuing supervision

The second and third key element are considered together under Article VI of the Outer Space Treaty, which is predominantly seen as the core article within the treaty used to amplify the necessity and importance of implementing a national space law. The authorisation and licensing of non-governmental entities pertaining to space activities is reflected in the second sentence of Article VI, which stipulates that "the activities of non-governmental entities in outer space, including the Moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty".[27] This requirement underscores the importance of regulating private sector involvement in space endeavours to ensure compliance with international obligations and promote responsible behaviour in space exploration and utilisation.[28]

Article VI not only mandates state parties to ensure that non-governmental entities operating in outer space receive proper authorisation but also underscores the need for ongoing state oversight of these entities' activities, that is to say, continuing supervision.[29] The authorisation process for space activities is characterised by national evaluation that could encompass not only the technical and financial viability of proposed missions but also their conformity with international space law and potential environmental impacts.[30] The distinction between authorisation and supervision in the context of space activities lies at the core of the Outer Space Treaty, with each serving a distinct yet complementary function. Authorisation is the initial process by which a state evaluates and grants permission for non-governmental entities to undertake specific space activities.[31] This process can involve a comprehensive review of the proposed space activity, whilst supervision represents an ongoing oversight

27 Outer Space Treaty 1967.
28 Outer Space Treaty 1967; von der Dunk 2020a: 116–117.
29 Von der Dunk 2011: 14.
30 Tronchetti 2014: 26–27.
31 Dempsey 2016: 6.

mechanism that extends beyond the launch phase, encompassing the entire lifespan of a space mission. It ensures continuous compliance with the terms set forth in the authorisation process and helps oversee implementation of regulatory standards, and the mitigation of potential risks associated with space operations.[32]

The dynamic and undeniably hazardous environment of outer space necessitates sustained oversight of space activities to safeguard against unforeseen risks and to ensure the long-term sustainability of outer space activities. Ongoing supervision can be seen as paramount when addressing the challenges posed by the increasing complexity and commercialisation of space activities, particularly in ensuring that these activities do not conflict with international law or cause harm to the space environment. The role of supervision should also be seen in the context of international responsibility and liability, as states must not only authorise but also continuously supervise their non-governmental space actors to fulfil their obligations under international space law.[33] In essence, while authorisation provides the legal basis for conducting space activities, ongoing supervision ensures that these activities remain compliant, safe and responsible throughout their duration.

In France, the process governing the authorisation and supervision of space activities is delineated under the Space Operations Act of 2008,[34] which sets out the requirements for both the initiation and ongoing management of space missions by non-governmental entities. The authorisation process for space activities in France requires a submission from non-governmental entities seeking to conduct space operations, which must, among other components, detail mission objectives, technical and safety plans, and environmental impact assessments. The French Space Agency (CNES), tasked with evaluating these submissions, aims to identify whether they meet safety, security and

[32] Gerhard 2009: 119.
[33] Spencer 2009: 78–79.
[34] France 2008.

environmental standards.[35] Once authorisation by the relevant Ministry is granted, the supervision phase ensures that space operations adhere to their authorised parameters throughout the mission duration. France's authority to adjust, suspend, or revoke licences if non-compliance is detected ensures that space operations that deviate from their authorised course can be addressed to mitigate risks to public safety and security.[36]

The United Kingdom's Space Industry Act of 2018 outlines procedures for non-governmental entities seeking to undertake space activities, mandating demonstrations of safety, environmental sustainability, security and international compliance. This regulatory oversight is managed by the Civil Aviation Authority (CAA). The CAA is responsible for assessing the capabilities of applicants to conduct space operations in a safe and responsible manner.[37] The supervisory role of the CAA involves continuous oversight over licenced space activities to ensure adherence to operational standards and authorisation terms. This includes monitoring operations, requiring periodic compliance reports from licencees, and conducting inspections to verify compliance with safety and operational standards.[38] Furthermore, the CAA has the authority to investigate incidents that may pose risks to public safety or the environment.[39] Like the French Space Operations Act, an important aspect of this supervisory function is the CAA's power to withdraw a licence if a licencee fails to meet the conditions of their authorisation, or if there is a significant risk to public safety, national security or environmental sustainability.[40]

The frameworks established by both the French Space Operations Act and the U.K.'s Space Industry Act are just two examples of national implementation of Article VI of the Outer Space Treaty. Having authorisation and supervision procedures in place for national space activities can be seen

35 France 2008; TRONCHETTI 2014: 31.
36 LAZARE 2013: 210–211.
37 U.K. Space Industry Act 2018.
38 SMITH et al. 2021: 721.
39 U.K. Space Industry Act 2018.
40 U.K. Space Industry Act 2018.

as beneficial for a state as it ensures that operations are conducted within the framework of international law, thereby adhering to obligations enshrined in the Outer Space Treaty.[41]

Registration of space objects

Transitioning to the fourth key element, this sub-section delves into the realm of registration of space objects. This process, integral to ensuring accountability and transparency in the increasingly crowded outer space environment, is mandated *in concreto* by the Registration Convention, which necessitates that States Parties notify the UN on specificities about each object they launch into outer space, including the object's launch date, orbital parameters and general function.[42] The Registration Convention extends the legal framework established by the Outer Space Treaty, particularly in reinforcing the principles of cooperation, mutual assistance, and the peaceful use of outer space by providing a method for identifying space objects, thereby facilitating the application of treaty provisions related to jurisdiction, control and liability.[43] It is, however, important to differentiate between two separate obligations within the Registration Convention, on the one hand, as mentioned above, it stipulates that states should notify the UN and include specific information listed within the Convention itself. On the other hand, the establishment of a national registry for space objects emerges as an additional fundamental obligation for States Parties.[44] This requirement is not merely procedural; it is a critical mechanism to ensure transparency, accountability and the effective management of space activities at national and international levels. The national registry acts as a comprehensive national catalogue of all space objects launched by a state. It is, however, up to each state to decide what

41 Gerhard 2009: 123–124.
42 Jakhu et al. 2018: 407.
43 Schmidt-Tedd et al. 2013: 247; Soucek 2016: 38.
44 Marboe 2015: 135.

information they wish to gather and include within the national registry.[45] The responsibility for registration falls on the 'launching State', defined as the state that launches, procures the launching, or from whose territory or facility the space object is launched.[46]

The necessity for a national registry is underscored by the increasing complexity and commercialisation of space activities. With the proliferation of private entities participating in space missions, the registry serves as a vital link between national governments and international space governance structures. It ensures that states can effectively exercise jurisdiction and control over their national entities, in compliance with Article VI of the Outer Space Treaty, which mandates state responsibility for national activities in outer space, whether conducted by governmental or non-governmental entities. Space object registration, jurisdiction and control, and state responsibility are undeniably interlinked.[47] Furthermore, the national registry facilitates the adherence to and implementation of international guidelines and best practices for space operations.[48]

In Sweden, the Swedish National Space Board is responsible for maintaining a register of space objects for which Sweden is deemed the launching state according to the Swedish Space Activities Decree of 1982.[49] If another state could also be considered a launching state, the space object is registered in Sweden only if there is an agreement between the involved states. One notable entry is Sirius 1, formerly BSB-1A, which was bought by a Swedish company in 1996 and subsequently entered into the Swedish Register after originally being launched and registered by the U.K. The satellite, initially registered in the U.K. as BSB-1A and launched from Cape Canaveral in 1989, was later acquired by Nordiska Satellitaktiebolaget and renamed Sirius 1, illustrating a case of

45 Schmidt-Tedd et al. 2013: 260.
46 Registration Convention 1975; Marboe 2015: 135.
47 Soucek 2016: 38–39.
48 United Nations Committee on the Peaceful Uses of Outer Space 2019.
49 Sweden 1982.

cross-country space object management and registration transfer.[50] Transfer of ownership and national approaches will be delved into further below.

Under the Federal Law on Space Activity of 1993, Russian entities involved in space operations, including launching or operating space objects, are required to register these activities with Roscosmos.[51] Information about the space objects must be provided to Roscosmos one month prior to the launch, and additional details must be submitted within seven days after the launch. Roscosmos then records this data in the national registry and communicates it to the Ministry of Foreign Affairs, which in turn reports it to the UN Secretary-General for inclusion in the UN Register of Objects Launched into Outer Space.[52]

Liability and insurance

The fifth key element of a national space law, namely liability and insurance concerning space activities can be found most directly in the Liability Convention, which sets the stage for states to be held liable for damage caused by their space objects, encouraging the integration of insurance requirements and indemnification procedures within national space laws.[53] Under the Liability Convention, the liability of a launching state for damage caused by its space objects is detailed, encompassing damage on the Earth's surface, to aircraft in flight, or in outer space. It is a victim-oriented regime, with the financial implications of potential damages compelling states to create legal frameworks aimed at ensuring operators or owners of space objects to have adequate coverage for damage claims.[54]

The U.S. Commercial Space Launch Act is such an example, requiring commercial space operators to secure liability insurance that covers third party

50 Lee 2006: 47.
51 Russian Federation 1993.
52 Tronchetti 2014: 30–31.
53 Lyall–Larsen 2018: 104.
54 Soucek 2016: 33.

claims for bodily injury, property damage and government property damage.[55] The Federal Aviation Administration (FAA) determines the necessary insurance amounts, based on a maximum probable loss assessment. Moreover, the Act's indemnification mechanism permits the U.S. Government to cover claims exceeding the insurance amount under certain conditions, showcasing a blend of private sector liability with public safety nets.[56]

In Japan, the Act on Launch and Control of Spacecraft of 2008 (ALCS) mandates that Japanese space operators obtain liability insurance to cover potential damages that could arise during space operations.[57] This insurance requirement ensures that operators are prepared to address any claims of damage caused by their space activities. The law specifies the minimum amount of insurance coverage required, which is determined based on the potential risks associated with each specific mission, taking into account the type of spacecraft, its mission profile and the potential for damage on Earth or in space.[58] The ALCS also establishes a framework for governmental indemnification, where the Japanese Government may step in to cover damages that exceed the insurance coverage, under certain conditions. The indemnification process is subject to stringent evaluation, ensuring that operators adhere to safety standards and regulatory compliance.[59]

Austria presents another example with its specific approach to space liability insurance. The Austrian Outer Space Act of 2011 sets a clear requirement for space operators, mandating a minimum insurance coverage of 60 million euros to address liability for damages caused by space operations.[60] This specific amount is among the highest set by national space laws. Research and educational space activities may qualify for exemption from insurance requirements if they serve public interests such as science, research, or education, have minimal

55 United States 1984.
56 TRONCHETTI 2014: 28–29.
57 Japan 2008; AOKI 2009: 389.
58 AOKI 2012: 126.
59 AOKI 2012: 128.
60 Austria 2011; MARBOE 2012: 34.

associated risks, and the operator demonstrates sufficient financial capacity or provides appropriate security measures, with these conditions balanced against each other during evaluation.[61]

Safety

Transitioning to the aspect of safety considerations to include within a national space law, it becomes evident that ensuring the safe conduct of space activities is a fundamental concern, intricately connected to the broader framework of international space law. Safety measures are essential not only for the protection of human life and the environment but also for safeguarding assets in outer space and on Earth. These measures are crucial to prevent adverse impacts and harmful interference with other space operations.

National space laws are instrumental in implementing safety considerations, aligning with international obligations and reflecting the distinct national security and foreign policy interests of States. Conditions for authorising space activities under these national laws and regulations foster measures to ensure that operations are carried out in a manner that prioritises safety, minimises risks to persons, the environment, or property and prevents harmful interference with other space activities. This involves evaluating the proposed activities against safety and technical standards that are in line with international best practices, including for example the UN Space Debris Mitigation (SDM) Guidelines and Guidelines for the Long-term Sustainability of Outer Space Activities (LTS Guidelines).[62]

Slovenia's Space Activities Act of 2022 is one of many examples of a legislative framework that includes safety aspects, including measures to mitigate space debris in alignment with international standards. The Act specifically requires that space activities conducted under Slovenian jurisdiction adhere to internationally recognised safety and technology standards, including those related to the mitigation of space debris. Incorporating the UN SDM Guidelines, the

[61] Marboe 2012: 34.

[62] Soucek–Tapio 2019: 570–571.

Slovenian Space Activities Act mandates operators to implement measures aimed at reducing debris generation. Moreover, the Act's provisions underscore the necessity of conducting space activities without adverse effects to public health, the environment, or public safety. It stipulates that space activities should not only be safe from a technical perspective but also be considerate of their broader societal and environmental impact.[63]

The emphasis on safety in space activities, and the subsequent national implementation, reflects an endeavour to mitigate risks and promote the sustainable use of outer space. By establishing comprehensive authorisation conditions that prioritise safety, states contribute to fostering a responsible and sustainable space environment, ensuring the protection of human life, the environment and space assets for future generations. As the LTS Guidelines were only adopted in 2019, time will still have to tell how states implement these at a national level. While the explicit incorporation of these guidelines into national laws is emerging gradually, several countries have national space laws and regulations that reflect the principles embodied in the LTS Guidelines and a clear trend can be seen that more are prone to follow.

Transfer of ownership

The transfer of ownership or control of space objects in orbit presents unique challenges and considerations within the realm of national space law, especially regarding the continuity of supervision over non-governmental space activities, and the exercising of jurisdiction and control. The ability to maintain oversight is essential for upholding the principles of liability, safety and sustainability in outer space activities. When ownership of a satellite is transferred to a non-launching state, international responsibilities must be carefully managed. The registration and associated responsibilities, such as liability, jurisdiction and control, cannot be transferred to another state unless it is another launching state involved in the original launch. If the transfer of operation or ownership involves a non-launching

[63] Slovenia 2022.

state, the original state of registry, and *de facto* every original launching state, remains internationally responsible, and the original state of registry can be seen as a quasi-guarantor of obligations related to jurisdiction and control.[64] This state cannot fully absolve itself from its international responsibilities, maintaining a continuous link to ensure comprehensive accountability for the space object. This can be seen to prevent the occurrence of 'flag of convenience' scenarios in space operations, ensuring that the state causative for the launch remains liable for any damages or issues.[65]

Due to the above-mentioned reasons, some national laws require prior authorisation before a change of ownership can take place. Belgium's approach to the transfer of ownership or control of space objects is articulated in its Law on the Activities of Launching, Flight Operations, and Guidance of Space Objects of 2005. This legislation mandates that any transfer to a third party of authorised activities or real or personal rights, including guarantee rights, which transfers the effective control of the space object, may not be carried out without the Minister's prior authorisation. Specifically, the law stipulates that authorisation is required for transferring authorised activities or rights to a third party and states that when the transfer involves an operator not established in Belgium: the Minister may refuse authorisation if there is no specific agreement with the home state of the third party that indemnifies the Belgian State against any international liabilities or claims for damage.[66]

New Zealand's Outer Space and High-altitude Activities Act of 2017 represents another example of a national space law addressing the transfer of ownership or control of space objects. According to the Act, a licencee or permit holder may not transfer an interest in a licence or permit, or if the entity is a body corporate, undergo a change of control without the prior approval of the Minister.[67]

64 Kerrest 2017: 79.
65 Schmidt-Tedd et al. 2013: 256.
66 Belgium 2005; Kerrest 2017: 80.
67 New Zealand 2017.

Following possible internal approvals of transfers of ownership, states might wish to update the satellite's ownership details in their national register of space objects and report the change to the UN Register of Objects Launched into Outer Space.[68] While the Registration Convention primarily delineates the registration requirements for space objects at the time of launch, its provisions hint at broader responsibilities that extend to maintaining up-to-date records on space objects, including changes in ownership.[69] Although the Convention does not explicitly mandate updates on ownership changes in the national or UN Register, the underlying objective to promote transparency, enhance operational safety and foster international cooperation can be interpreted as supporting such updates. Article IV of the Convention suggests that launching States are expected to provide the Secretary-General of the UN with any additional information to preserve the accuracy of the data initially provided under Article II. This clause, while not directly mentioning ownership transfers, implies a responsibility to keep the register current, which could include updates on changes in ownership.[70]

TRENDS AND CHALLENGES

The legal landscape of outer space activities is evolving rapidly, with national space laws expanding beyond the foundational seven key elements to address a wider array of trends and challenges. The following sections highlight some of the many trends and challenges that are shaping the future of national space.

[68] Rodrigues–Memon 2017: 91.
[69] Di Pippo 2016: 367.
[70] Registration Convention 1976.

Legal aspects of Earth observation data

The advancement of Earth observation (EO) technologies has significantly enhanced the capability to monitor and analyse global phenomena from space, providing valuable insights into areas such as climate change, natural disasters, urban development and much more. This surge in EO capabilities has however introduced legal challenges, particularly concerning data privacy, sharing and security. National space laws are evolving to address these challenges, extending the scope of legal considerations well beyond the foundational seven key elements traditionally associated with national space legislation. One of the primary concerns is the management of the vast amounts of data generated by EO satellites. While open access to EO data can significantly benefit scientific research and public policy making, it also raises concerns about privacy and the potential misuse of sensitive information.[71] National laws are thus being developed to strike a balance between facilitating access to EO data for the advancement of knowledge and ensuring the protection of individual privacy and national security interests.[72] This can involve the implementation of regulations that govern the collection, processing, distribution and use of EO data.

Waivers and exceptions for educational and science programmes

Acknowledging space's immense educational and research potential, several states have implemented legislative measures designed to reduce regulatory burdens and provide financial incentives to academic institutions. These legal frameworks aim to lower the barriers to enter the space sector for educational and research entities, thus promoting innovation and the advancement of knowledge. Academic discourse also emphasises the importance of legal and policy frameworks in facilitating educational and scientific access to space. Studies and analyses in space policy literature often highlight the benefits

[71] Bohlmann–Soucek 2018: 189.
[72] Bohlmann–Soucek 2018: 190.

of regulatory measures that support academic institutions, advocating for continued legislative evolution to accommodate the growing role of educational entities in space activities. Countries around the globe are recognising the value of space for educational purposes and are implementing legal frameworks to support this.

Space traffic management

The increasing congestion of Earth's orbit, marked by a growing number of satellites and the persistent issue of space debris, underscores the growing debate around and collective efforts surrounding Space Traffic Management (STM). As the space environment becomes ever more crowded, the potential for collisions and the resultant creation of debris poses risks not only to current space operations but also to the long-term sustainability of space activities. Recognising these challenges, states are beginning to incorporate STM approaches into their national space laws and regulatory frameworks. This includes the implementation of best practices for satellite manoeuvres to avoid potential collisions, the establishment of standards for the safe disposal of satellites at the end of their operational lives, and the development of debris mitigation strategies to minimise the generation of space debris.[73]

Space resources

The burgeoning interest in the exploration, exploitation and utilisation of space resources has ignited a worldwide dialogue surrounding the legal, ethical and environmental implications of space resources. Environmental concerns are often at the forefront in these discussions, as the disruption of celestial bodies could have unforeseen consequences. The Outer Space Treaty stipulates that outer space, including the Moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation,

73 Antoni et al. 2020.

or by any other means.[74] However, the Treaty does not explicitly address the private extraction and ownership of space resources, which states are beginning to consider it on both international and national level. A handful of states have included space resource utilisation and/or exploitation into their national legislation, and a trend is noticeable with more to follow. The debate and inclusion into national legislation also pertains to claiming ownership of the resources and materials extracted from celestial bodies with a possible *raison d'être* being to encourage private entities to invest in space resource exploitation. Granting property rights would create clearer legal clarity for investment and commercial use, making it an economically safer and potentially profitable venture.[75] Established at the sixtieth session of the COPUOS LSC in 2021, the Working Group on Legal Aspects of Space Resource Activities has been mandated to gather relevant information on space resource activities, analyse the existing legal frameworks and assess the need for further international governance.[76] Ultimately, their findings could lead to the adoption of new resolutions or legal instruments by the UN General Assembly to guide future space resource exploration and utilisation.

Legal aspects of launch operations and spaceports

The surge in satellite launch demand, fuelled by advancements in space technology and the increasing use of satellites for communication, EO and scientific research has driven the development and expansion of launch infrastructure globally. This expansion has led to the establishment of new launch sites and spaceports, across various regions, each requiring a comprehensive legal and regulatory framework to govern their operations. The essence of these frameworks is to ensure the safety of launch activities, minimise environmental impacts, and maintain regulatory compliance, including adherence to international space law principles. National laws concerning launch operations and site

[74] Outer Space Treaty 1967: Article II.
[75] Tronchetti 2009: 194.
[76] United Nations 2021: Annex III.

management incorporate licencing requirements for launch providers, detailed safety standards for both the launch process and the operation of launch vehicles, and rigorous environmental impact assessments for the development and operation of launch sites. The establishment of spaceports requires not only significant investment in infrastructure but also a clear regulatory framework that addresses a multitude of considerations, from airspace management to the potential for cross-border environmental impacts.

CONCLUSION

The exploration of outer space has transitioned from a domain dominated by a few spacefaring nations to a more diversified arena, thanks to technological advancements and the decreasing costs of space access. National space legislation now confronts the task of adapting to the nuances of evolving space activities. These laws and regulations are crucial for ensuring that space exploration and utilisation is conducted responsibly, safely and in compliance with international law, while also fostering the development of national space industries. The interplay between national space legislation and international space treaties is fundamental, as it ensures that global standards for space activities are maintained, while also accommodating the specific needs and interests of individual countries.

The expansion of national space laws beyond the foundational key elements – such as the scope of application, authorisation and supervision of non-governmental space activities, registration of space objects, liability and insurance, safety and transfer of ownership – highlights the evolving nature of space activities. Contemporary issues such as EO data privacy, educational and scientific access to space, space traffic management, space resources and the management of launch operations and spaceport activities represent a trend towards a broadening of the legal and regulatory focus. These areas underscore the growing complexities and the need for comprehensive legal frameworks that not only facilitate space exploration and utilisation but also address environmental protection, promote safety and sustainability and ensure adherence to international cooperation norms.

The evolving landscape of outer space activities demands a continuous adaptation of national space laws. This adaptation is essential for navigating the challenges of a 'New Space Era' marked by increased participation, technological advancements and the expanding scope of human activity in space. By developing comprehensive legal frameworks, states can ensure that space remains a realm for peaceful, sustainable and safe exploration and use, safeguarding the interests of future generations.

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Mónika Ganczer

New Space, New Challenges: Nationality in Space Law

INTRODUCTION

The term nationality expresses the idea of belonging to a state in international law both for natural persons, and for legal persons (or in the wording of the Liability Convention, juridical persons) or objects. At the same time, not all languages distinguish between the terms citizenship and nationality. In those languages which mark this duality, the terms nationality and nationalité are used for this legal bond in international law, while citizenship, citoyenneté in domestic law, can be traced back to the historical roots of the etymology of the words.[1]

The issue of nationality in space law has acquired importance in many ways in recent times. In the more than sixty-year history of the use of outer space, the total number of space objects launched into Earth orbit has almost tripled in the last fifteen years, and the number in low Earth orbit has increased tenfold in the last eight years alone.[2] The nationality of space objects is becoming increasingly important because, in times of mass launches, space object registration is not always fully implemented. Only 87%[3] of the manmade objects in space are registered, which has several consequences, including responsibility and liability issues, space traffic management, space debris identification and mitigation. In recent years, space activities have been increasingly carried out

1 Koessler 1946–1947: 62–67; Ganczer 2013: 49–54.
2 European Space Agency, ESA's Annual Space Environment Report, 2023, 4.
3 United Nations Office for Outer Space Affairs, United Nations Register of Objects Launched into Outer Space.

DOI: https://doi.org/10.36250/01208_10

by non-governmental entities, which calls for an examination of the issue of the nationality of legal entities. In 2023, non-governmental entities, rather than states, accounted for more than three quarters of the $546 billion annual space economy.[4] At the time of adoption of the major international treaties of space law, it had not been foreseen that the participation of non-governmental entities would be on such a scale. Nevertheless, legal entities in space activities were taken into account when these treaties were drafted. Current legislation must therefore be reconsidered and revised to ensure the effective implementation of space law and to ensure the safety of space activities more reliably.

NATIONALITY OF SPACE OBJECTS

The term "nationality" refers not only to natural and juridical persons but also to ships, aircraft and space objects, which also means that they belong to a state. The practice of both air law and maritime law had already been established by the time space was first regulated and served as a model for regulating the nationality of space objects. Nationality in the international legal regulation of air law is based on the registration of aircraft.[5] The 1944 Convention on International Civil Aviation states that "[a]ircraft have the nationality of the State in which they are registered",[6] irrespective of the owner of the aircraft, the headquarter of the owner or the nationality of the pilot.[7] There is also a prohibition of dual nationality,[8] although the registry of an aircraft may be

4 See Space Foundation at https://www.spacefoundation.org/2023/07/25/the-space-report-2023-q2/.

5 Convention Relating to the Regulation of Aerial Navigation, Paris, 13 October 1919, Article 6; Pan American Convention on Commercial Aviation, Havana, 20 February 1928, Article 7.

6 Convention on International Civil Aviation (hereinafter: Chicago Convention), Chicago, 7 December 1944, Article 17.

7 Sipos 2018: 103.

8 Convention Relating to the Regulation of Aerial Navigation, Article 8; Pan American Convention on Commercial Aviation, Article 7; Chicago Convention, Article 18.

transferred from one state to another.[9] States also register ships and grant them the right to fly their flag. Under the treaties of the law of the sea, flying the flag of a state determines which state a ship belongs to. There is also an established rule that the nationality of a ship requires the existence of a genuine link between the ship and the state,[10] a requirement that has not been established in space law. The International Tribunal for the Law of the Sea held that the requirement of a genuine link ensures more effective implementation of the obligations of the flag state; however, in the absence of a genuine link, other states do not have the right to refuse to recognise the nationality of the ship.[11] Dual nationality is also prohibited for ships, and a ship flying the flag of two or more states should be considered as not having nationality.[12] Ships may not change their flag during a voyage or while in a port of call unless there is an actual transfer of ownership or change of registry.[13]

The nationality of space objects is that of their state of registry, i.e. the state which performs the registration.[14] The purpose of registration is to ensure retention of "jurisdiction and control" over the space object and its crew by the state of registry.[15] The term "space object" itself is defined in the treaties as

9 Chicago Convention, Article 18.

10 Convention on the High Seas, Geneva, 29 April 1958, 450 UNTS 11, Article 5 (1); United Nations Convention on the Law of the Sea (hereinafter: UNCLOS), Montego Bay, 10 December 1982, 1833 UNTS 397, Article 91 (1).

11 M/V "SAIGA" (No. 2) (Saint Vincent and the Grenadines v. Guinea), Judgment of 1 July 1999, ITLOS Reports 1999, 42.

12 Convention on the High Seas, Article 6; UNCLOS, Article 92.

13 Convention on the High Seas, Article 6 (1); UNCLOS, Article 92 (1).

14 Lopez-Gutierrez 1966: 132–142. Convention on the Registration of Objects Launched into Outer Space (hereinafter: Registration Convention), New York, 12 November 1974, 1023 UNTS 15, Article II (2).

15 Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space, G.A. Res. 1962, 13 December 1963, para. 7, 18 U.N. GAOR Suppl. No. 15 (A/5515), 15, U.N. Doc. A/RES/18/1962 (1963); Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (hereinafter: Outer Space Treaty), London, Moscow, Washington, 27 January 1967, 610 UNTS 205, Article VIII; Registration Convention, Article II (2); Schmidt-Tedd – Soucek 2020. The term "jurisdiction and control" is also used in the

"component parts of a space object as well as its launch vehicle and the parts thereof",[16] and the jurisprudential definition clarifies that this includes objects launched and intended to be launched into outer space.[17]

Several international documents stipulate that registration must be carried out by a launching state,[18] a rule which has become part of customary international law.[19] The importance and the method of registration were mentioned as early as in the UN General Assembly Resolution No. 1721 of 1961.[20] The 1974 Convention on Registration of Objects Launched into Outer Space required the launching State to establish an appropriate registry and to provide the Secretary-General of the United Nations with information specified in the Convention and inform them of any changes to that information.[21] Accordingly, the United Nations Office for Outer Space Affairs maintain registrations under both the General Assembly resolution and the Registration Convention, in parallel.[22] In addition, UN General Assembly Resolution No. 62/101, adopted in 2007, sets out detailed recommendations[23] and the

Moon Agreement. Agreement governing the Activities of States on the Moon and Other Celestial Bodies (hereinafter: Moon Agreement), New York, 5 December 1979, 1363 UNTS 3, Article 12 (1).

16 Convention on International Liability for Damage Caused by Space Objects (hereinafter: Liability Convention), London, Moscow, Washington, 29 March 1972, 961 UNTS 187, Article I (2) (d); Registration Convention, Article I (b).

17 Hobe et al. 2013: 504.

18 International Co-Operation in the Peaceful Uses of Outer Space, G.A. Res. 1721 B (XVI), 20 December 1961, para. B 1, 16 U.N. GAOR Suppl. No. 17 (A/5100), 6, U.N. Doc. A/AC.105/1154 (1961); Outer Space Treaty, Article VIII; Registration Convention, Article II (1).

19 For more information see Schmidt-Tedd – Soucek 2020: 16.

20 International Co-Operation in the Peaceful Uses of Outer Space, G.A. Res. 1721 B (XVI), 20 December 1961, para. B 1–2, 16 U.N. GAOR Suppl. No. 17 (A/5100), 6, U.N. Doc. *A/AC.*105/1154 (1961).

21 Registration Convention, Articles II–IV.

22 Sulyok 2022: 97.

23 Recommendations on Enhancing the Practice of States and International Intergovernmental Organizations in Registering Space Objects, G.A. Res. 62/101, 17 December 2007, 62 U.N. GAOR Suppl. No. 49 (A/62/49 Vol. I), 161, U.N. Doc. A/RES/62/101 (2007).

resulting registration form, which has been in use since 2010, has also been an important step forward in the process of data harmonisation.

The launching state itself means "(i) [a] [s]tate which launches or procures the launching of a space object; (ii) [a] [s]tate from whose territory or facility a space object is launched".[24] Similarly to the situation in air law, the state of registry is not necessarily the same as the owner of the space object, and it is therefore not identical to the owner, to the state or to the non-governmental entity which carries out the related space activities,[25] and thus to any changes to these.[26] The latter changes are only reported to the UN Secretary-General when "additional information" is provided.[27]

In case of a single launching state, it is obvious that the registration will be carried out by that state, so the space object will be a national of that state. If the space object has more than one launching State, they must jointly determine which of them will register it, i.e. only one of them can register the space object concerned. Thus, double registration – and double nationality – is impossible, similarly to the registration of aircraft.[28] The registration can be transferred to another state, but the new registrant can only be another launching state,[29]

24 Liability Convention, Article I (c); Registration Convention, Article I (a). The definitions in the regulations are preceded by the Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space, G.A. Res. 1962, 13 December 1963, para. 8, 18 U.N. GAOR Suppl. No. 15 (A/5515), 15, U.N. Doc. A/RES/18/1962 (1963); Outer Space Treaty, Article VII.

25 Outer Space Treaty, Article VI. Recommendations on Enhancing the Practice of States and International Intergovernmental Organizations in Registering Space Objects, G.A. Res. 62/101, 17 December 2007, Recommendation 4, 62 U.N. GAOR Suppl. No. 49 (A/62/49 Vol. I), 161, U.N. Doc. A/RES/62/101 (2007).

26 Aoki 2020: 392–398.

27 Registration Convention, Article IV (2).

28 Registration Convention, Article II (2). See also Recommendations on Enhancing the Practice of States and International Intergovernmental Organizations in Registering Space Objects, G.A. Res. 62/101, 17 December 2007, Recommendation 3.(b)–(c), 62 U.N. GAOR Suppl. No. 49 (A/62/49 Vol. I), 161, U.N. Doc. A/RES/62/101 (2007). Application of the concept of the "launching State", G.A. Res. 59/115, 10 December 2004, para. 2, 59 U.N. GAOR Suppl. No. 49 (A/59/49 Vol. I), 163, U.N. Doc. A/RES/59/115 (2004).

29 Hobe et al. 2013: 256.

which will also be relevant for the change of ownership explained below. It is worth noting that for an international space station made up of several modules, the launching state of the given module is the state of registry. Under the terms of the relevant international treaty, the jurisdiction and control of the module is exercised by the state of registry, although the jurisdiction and control of the personnel is exercised by the state of nationality of each of the individual crewmembers.[30] It is also interesting to note that registration can be carried out not only by a state, but also by an international organisation, which means that the "launching state", and therefore the "state of nationality" of the space object, will in fact be an international organisation rather than a state. This is possible by means of a declaration of acceptance of the Convention on Registration of Objects Launched into Outer Space by the international organisation in question,[31] which shall then establish a registry under the convention. One such example is the registry of the European Space Agency, which usually indicates the international organisation itself as the "launching State" of space objects launched by the European Space Agency.[32] Looking at the registration documents, the European Space Agency used the term "launching authority" until 2010 and "state of registry" from 2011 for the registration of space objects launched by the Agency,[33] a change of terminology which can be explained by the UNOOSA registration form introduced in 2010.[34]

30 Agreement Among the Government of Canada, Governments of Member States of the European Space Agency, the Government of Japan, the Government of the Russian Federation, and the Government of the United States of America Concerning Cooperation on the Civil International Space Station, Washington, 29 January 1998, Article 5.

31 Registration Convention, Article VII.

32 For more on this see UN Committee on the Peaceful Uses of Outer Space, Space Object Registration by the European Space Agency: Current Policy and Practice, 13 April 2015, A/AC.105/C.2/2015/CRP.18.

33 For registration documents, see Notifications from States and Organizations: European Space Agency (ESA) at https://www.unoosa.org/oosa/en/spaceobjectregister/submissions/esa.html.

34 See UNOOSA, Registration Information Submission Form (as at 1 January 2010). The current form is applicable from 2020.

In case of damage caused by a space object during space activities, the question is whether the nationality of the space object is relevant, i.e. whether or not there is any link of liability to the state of registry. Essentially, the answer is no, since the liability rules of space law demonstrate that liability is not linked to nationality but to the launching state.[35] This is also confirmed by the fact that if the space object is not registered and its nationality is not clear,[36] liability will still be established. Even so, the launching state can be identified and must be proved. Finally, the state from whose territory the space object was launched is usually clear for all space objects, and this state can also be qualified as the launching state. The liability of the launching state is clearly established by the 1971 Convention on International Liability for Damage Caused by Space Objects,[37] but an international agreement under Article XXIII of the convention may make an exception.[38] It may happen that a state which is considered to be a launching state under the Liability Convention may not be listed as such in the registration, nor is the liability of that state excluded by an international agreement. In such cases, the applicability of the Liability Convention and the liability of the launching state should not be affected by the inaccurate registration.

Liability is therefore not directly linked to registration, but it has a role to play, as follows. Registration may contribute to determining the liable state by making the launching state clear. If the space object has one launching state, it will be included in the registry and the state of nationality will be the same as the state that is liable for damages. Of course, it is the fact of launching that

35 Outer Space Treaty, Article VII; Liability Convention, Articles II–XII.

36 See more in Aoki 2020: 374, 387–388.

37 Liability Convention, Article I (c) (2), Article V (3).

38 Cf. Agreement between the Russian Federation and Republic of Kazakhstan on the basic principles and conditions of use of the Baikonur spaceport, Moscow, 28 March 1994; Agreement between the Russian Federation and Republic of Kazakhstan on the development of cooperation on the effective use of the Baikonur complex, Astana, 9 January 2004; Agreement between the Government of the French Republic and the European Space Agency on the launching site and associated installations of the Agency at the Guiana Space Centre (with annexes), 2560 UNTS 25.

establishes liability for damage, rather than the object's registration. In the event of a joint launch (by more than one state or one or more states and an international organisation), the prohibition of multiple registration means that the space object will bear the nationality of only one of the launchers. The nationality of the space object will be the registering launching state, although the registration will have to designate all the launching States.[39] However, the liability will not be that of the state of nationality but will become joint and several.[40]

A clear and coherent registry would therefore contribute not only to the identification, monitoring and tracking of space objects, but also to a better understanding of the liability issues related to them. In addition to the results achieved so far and the practices that have been established, another solution would be to create an obligation to register as a condition for launch. This could be regulated as a binding norm for states either by amending the 1974 Convention or as part of customary international law. Therefore, basic orbital parameters would have to be provided by the registering state as additional information after the launch. The problem of unregistered space objects could be resolved in this way, or at least it would mean that their number would not increase.

NATIONALITY OF THE ENTITY CAUSING DAMAGE

Nationality of non-governmental entities

In space law, space activities are increasingly carried out by non-governmental entities. At the time of the adoption of the five major international treaties on space law, space activities were still essentially state activities, but eventually

39 Registration Convention, Article IV (1) (a).

40 Liability Convention, Article V. See also Application of the concept of the "launching State", G.A. Res. 59/115, 10 December 2004, para. 2, 59 U.N. GAOR Suppl. No. 49 (A/59/49 (Vol. I), 163, U.N. Doc. A/RES/59/115 (2004).

non-governmental entities were considered, even if this led to considerable controversy.[41] A review of the forms of responsibility and liability for the activities of non-governmental entities is certainly necessary in today's changed circumstances. As noted in the introduction, more than three quarters of space activity in the global space economy are now in the hands of private operators.

The nationality of the entity causing damage is not relevant in the case of space activities carried out by clearly a state and/or an international organisation, which are subject to specific liability rules.[42] However, where a non-governmental entity conducts space activities, the nationality of the non-governmental entity and its role in determining the liable state should be examined. Non-governmental entities can be divided into two main categories: natural and juridical persons. The possibility of space activities being carried out by private individuals is unlikely to happen (it should be noted that this was once thought to be the case for non-governmental entities as a whole, and the space activities of juridical persons have superseded this idea). The nationality of natural persons is determined by the domestic legal rules on nationality of the state concerned, usually on the basis of the principles of *ius soli* or *ius sanguinis,* which are limited or restricted by the rules of international law on nationality in so far as the state concerned has undertaken international obligations.[43] Juridical persons also have nationality due to their belonging to a state. In the Barcelona Traction case, the International Court of Justice stressed in 1970 that the nationality of a company is based on a "close and permanent connection" with the State,[44] and "the traditional rule attributes

41 The Soviet Union was explicitly opposed to the inclusion of non-governmental entities, and finally agreed to the U.S. proposal on the basis of the exclusivity of state responsibility. Diederiks-Verschoor – Gormley 1977: 129; Tatsuzawa 1988: 342.

42 See Outer Space Treaty, Articles VI–VII; Liability Convention, Articles III–V; Moon Agreement, Article 14. See the International Organization's activities in outer space in Outer Space Treaty, Article VI, Article XIII; Liability Convention, Article XXII; Moon Agreement, Article 14.

43 Ganczer 2013: 58–63.

44 Case Concerning the Barcelona Traction. Light and Power Company, Limited (Belgium v. Spain), Second Phase, Judgment of 5 February 1970, I.C.J. Reports 1970, 42.

the right of diplomatic protection of a corporate entity to the State under the laws of which it is incorporated and in whose territory it has its registered office", and that these "two criteria have been confirmed by long practice and by numerous international instruments".[45] The principle of registration/incorporation reflects customary international law, and as such it was also included in the 2006 Draft Articles on Diplomatic Protection. Moreover, in this draft, nationality, for the purposes of diplomatic protection, means belonging to the state of incorporation. However, if the juridical person is controlled by nationals of another State or has no substantial business activity in the state of incorporation, and the seat of management and financial control is in another state, it will be regarded as a national of the latter state.[46] In space law, however, the transnational nature of the activity requires the consideration of other nationality principles.[47] UN General Assembly Resolution No. 68/74 includes, in the context of the nationality of juridical persons, the place of establishment, the place of registration and the seat on the territory as optional elements.[48]

In regulating the space activities of non-governmental entities, it is necessary to bear in mind that the nationality of a natural or a juridical person may be multiple or difficult to define. Dual or multiple nationality of natural persons may be more common nowadays, implying several states of nationality. In case of juridical persons, the State of registration and the State of incorporation may not be the same, or the State of incorporation may change over time, or the majority of investors may be nationals of another State, or the company may be a transnational company, which may make it difficult to define its nationality. It is also possible that a given space activity is carried out jointly by natural and/or juridical persons of different nationalities. It is therefore necessary

45 Case Concerning the Barcelona Traction. Light and Power Company, Limited (Belgium v. Spain), Second Phase, Judgment of 5 February 1970, I.C.J. Reports 1970, 42.

46 Draft Articles on Diplomatic Protection, 2006, Article 9.

47 Herczeg 1968: 100–101.

48 Recommendations on national legislation relevant to the peaceful exploration and use of outer space, G.A. Res. 68/74, 11 December 2013, para. 2, 68 U.N. GAOR Suppl. No. 49 (A/68/49 (Vol. I), 260, U.N. Doc. A/RES/68/74 (2013).

to examine whether liability is linked to nationality in the current space law, whether the current regime is appropriate and what form of responsibility and liability would be realistic and ideal for the future.

State responsibility for non-governmental entities

First and foremost, a distinction must be made between *international responsibility,* which may exist for wrongful acts, and *state liability* for damages, which may be the result of both wrongful and non-wrongful acts.[49] It should be noted that international responsibility also involves an obligation on the part of the infringing state to pay compensation.[50]

International responsibility

The first of the relevant documents to address state responsibility for space activities of non-governmental entities was UN General Assembly Resolution 1962 (XVIII),[51] the text of which was incorporated almost identically into the 1967 Outer Space Treaty. According to Article VI of the Outer Space Treaty:

> "States Parties to the Treaty shall bear international responsibility *for national activities* in outer space, including the Moon and other celestial bodies, whether such activities are carried on by governmental agencies or by *non-governmental entities*, and for *assuring* that national activities are carried out *in conformity with* the provisions set forth in the present Treaty. The activities of non-governmental entities in outer space, including the Moon and other celestial bodies, shall require *authorization and continuing supervision by the appropriate State Party* to the Treaty. When activities are carried on in outer space, including the Moon and other celestial bodies, by an international organization, responsibility for

49 For more information see Kecskés 2022: 132; Kis Kelemen 2023: 130.

50 Abhijeet 2020: 358.

51 Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space, G.A. Res. 1962, 13 December 1963, para. 5, 18 U.N. GAOR Suppl. No. 15 (A/5515), 15, U.N. Doc. A/RES/18/1962 (1963).

compliance with this Treaty shall be borne both by the international organization and by the States Parties to the Treaty participating in such organization."[52]

The Outer Space Treaty therefore establishes the responsibility of states for activities in outer space carried out by non-governmental entities. It should be noted that non-governmental entities include natural persons, juridical persons, universities and research institutes.[53] It is necessary to analyse whether their nationality or another characteristic constitutes the main criterion to define the responsible state for their activities.

The expression "national activities" in outer space can provide a guide to this. For the interpretation of this term, several possibilities should be considered. If we read Article VI as a whole, national activities can be used merely to distinguish it from *all activities … carried out by an international organisation,* listed in the third sentence.[54] A narrower meaning of national activity may be that of *activities carried out under the jurisdiction of a state,* which may include activities carried out within its territory under territorial jurisdiction, as well as activities carried out under personal jurisdiction by its nationals, regardless of them being within or outside its territory.[55] National activity, in an even narrower sense, may mean *activities carried out by nationals,* which may be linked to the fact that Article IX refers to space activities carried out by a state or by its nationals while mentioning potentially harmful interference with activities of other states.[56]

The broadest interpretation, that national activity means any activity not carried out by an international organisation, is problematic because it does not provide any guidance as to which state should be considered as conducting

52 Outer Space Treaty, Article VI [emphasis added – M. G.].
53 Hobe et al. 2013: 394.
54 Hobe et al. 2013: 390–391.
55 Brownlie 1983: 165. Not jurisdiction, but a specific link to the state, or the direction or influence of the state is mentioned by Cheng 1998: 26; Silvestrov 1991: 20; Lee 2005: 217.
56 This interpretation is mentioned but disagreed with by Böckstiegel 1991: 13; Böckstiegel 1994: 77–78.

a "national activity" and would thus render the obligation meaningless. Indeed, an important element of the first sentence is that the state is not only responsible for these activities, but must also ensure that they "are carried out in conformity with the provisions set forth in the present Treaty".[57] The travaux préparatoires indicate that the aim of the provision was to ensure that all non-state space activities remained under state responsibility.[58] To make certain that this is done effectively and that states do not evade their obligations, it is necessary to define the state of national activity of each specific space activity more precisely. Responsibility for a space activity and the implementation of the provisions of the treaty can only be ensured if the state concerned is involved in some way and is able to have an impact on the activity in question. This interpretation can therefore be accepted if the term "the appropriate State Party" in the following sentence is taken to clarify the meaning of the national activity of non-governmental entities.

Employing the narrowest interpretation of national activities of non-governmental entities and considering only the activities of nationals as national activities, the distribution of responsibility between states is relatively clear, except for the possible disputes over the determination of the nationality of juridical persons, as mentioned above. However, it may be the case that the responsible state is not the state which is best placed to supervise the activity in question, for example in the case of multinational companies, foreign activities on the territory of the state, transfer of property, or joint activities by nationals of different states.

In today's space law, given the large number of non-governmental entities and their varying state identities, the best interpretation of national activity in the spirit of the drafters of the treaty and the principle of effectiveness[59] is to consider it an activity conducted under the jurisdiction of the state. This ensures that it is equally responsible for activities carried out on the territory and

57 For more on this obligation see Abhijeet 2020: 359–362.

58 Lachs 1972: 122.

59 Vienna Convention on the Law of Treaties, Vienna, 23 May 1969, 1155 UNTS 331, Articles 31(1), 31(4).

quasi-territory of the state and for activities carried out by nationals (whether or not they are on the territory of the state). This, however, needs to be further examined in the light of the analysis of the term "appropriate State" in the second sentence.

In relation to the term "appropriate State", it should be noted that UN General Assembly Resolution 1962 (XVIII) still used the term the "State concerned",[60] which refers to the given state. The meaning of "appropriate State" is more nuanced, and may be interpreted as implying a particular quality of the state, carrying the connotation of the most adequate state for the given situation.

There are many interpretations of the term "appropriate state", and these sometimes overlap. These include 1. the elaboration of the state in the first sentence; 2. the registering state; 3. the launching state; 4. the owner of the space object; 5. the state of territorial jurisdiction; 6. the state of personal jurisdiction (state of nationality of a natural and juridical person); 7. a particular combination of these.[61] The primary wording of "appropriate State" may be interpreted as suggesting that there can be only one appropriate state, but the interpretation of the possibility of there being more than one appropriate state has gained acceptance.[62] The reality of space law today also requires this interpretation because of the complexity of space activities and the frequent occurrence of multiple state ownership. Article VI of the Outer Space Treaty requires "authorization and continuing supervision by the appropriate State Party", so the meaning of "appropriate state" needs to be understood in this context.

The fundamental question concerns which state is in a position to authorise and continuously supervise space activities carried out by non-governmental entities. The state of registry exercises jurisdiction and control over the space

60 Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space, G.A. Res. 1962, 13 December 1963, para. 5, 18 U.N. GAOR Suppl. No. 15 (A/5515), 15, U.N. Doc. A/RES/18/1962 (1963).

61 See Silvestrov 1991: 327–330; Böckstiegel 1991: 77–79; Böckstiegel 1994: 13–15; Abhijeet 2020: 363–365; Hobe et al. 2013: 396–403; Cheng 1998: 26–29; Tatsuzawa 1988: 344; Lee 2005: 218–219; Vereshchetin 1983: 263.

62 Cheng 1997: 609–610; Cheng 1998: 326, 328.

object and over any personnel thereof,[63] and this state can therefore be the appropriate state after launch (indeed, some argue that only the state of registry can be considered the appropriate state after launch).[64] However, the non-governmental entity operating the space object may not be under the jurisdiction of the state of registry, especially since it is not necessarily under its jurisdiction at the pre-launch stage. Similarly, if only the launching state is considered to be the appropriate state, some activities may remain uncontrolled, for example if the launching state is only the state from whose territory the space object was launched, but the activity prior to the launching was not under its jurisdiction. If only the state with territorial jurisdiction were the "appropriate state", that state would not be responsible for and would have no influence over the activities of its nationals if their activities were carried out in whole or in part outside its territory. Finally, if only the state of nationality was the "appropriate state", activities carried out on its territory by a foreign national would be outside the scope of its effective control.

All in all, the term "appropriate state" should be interpreted as involving activities under the jurisdiction of the state, which includes its territorial, quasi-territorial and personal jurisdiction, including, where appropriate, the jurisdiction of the registering state after launch. This interpretation allows for the activities of a non-governmental entity to be backed in all cases by a state, which was the intention of the law-maker. Therefore, with a proper interpretation, there is no need to change the existing rule. This also ensures that launching states can be considered the appropriate state if the activity is within their jurisdiction. Authorisation and continuing supervision can only be ensured by a state if its legal system can cover the activity concerned, for which jurisdiction of the state is essential.

A similar provision in the Moon Agreement and the UN General Assembly Resolution 68/74 is also worth recalling in this regard. The Moon Agreement is more precise than Article VI of the Outer Space Treaty, as Article 14(1) requires states parties to ensure that non-governmental entities "under their

[63] Outer Space Treaty, Article VIII.

[64] Silvestrov 1991: 328.

jurisdiction" carry out activities under the authority and continuing supervision of the appropriate state. Similarly, this concept of jurisdiction is reinforced by paragraph 2 of UN General Assembly Resolution 68/74. In relation to the obligations of launching states and of states responsible for national activities, the Resolution specifies that states "should ascertain national jurisdiction over space activities carried out from territory under its jurisdiction and/or control; likewise, it should issue authorizations for and ensure supervision over space activities carried out elsewhere by its citizens and/or legal persons".[65]

Neither the Outer Space Treaty nor the Moon Agreement contains an explicit and detailed definition of what exactly the obligation of authorisation and continuing supervision by the appropriate state involves. A state can therefore implement it in any way it chooses,[66] as long as it ensures appropriate authorisation and continuing supervision. In practice, this can be implemented either by adopting a domestic legal rule, by contracting with a non-governmental entity, or by means of an administrative act.[67] The practice of states shows that they are increasingly seeking to regulate the licencing of non-governmental entities and the implementation of continuing supervision in their domestic law through national space laws.[68] The domestic regulation of the space activities of non-governmental entities started in Norway in 1969.[69] In the domestic legislation on this area adopted by more than forty states today, it can be observed that there is still a lack of uniformity in practice as regards jurisdiction. While some states base their space law legislation on territorial jurisdiction only and others on personal jurisdiction only, in general, states tend to regulate space activities under both their territorial and personal jurisdiction.[70] A detailed

65 Recommendations on national legislation relevant to the peaceful exploration and use of outer space, G.A. Res. 68/74, 11 December 2013, para. 2, 68 U.N. GAOR Suppl. No. 49 (A/68/49 (Vol. I), 260, U.N. Doc. A/RES/68/74 (2013).

66 Similar views are expressed by Gál 2001: 62; Vereshchetin 1983: 263; von der Dunk 2019: 228; Masson-Zwaan 2008: 537.

67 Abhijeet 2020: 371.

68 Bartóki-Gönczy 2022: 255; von der Dunk 2019: 228; Masson-Zwaan 2008: 537.

69 Bartóki-Gönczy 2020: 101.

70 Lee 2005: 221–224; von der Dunk 2019: 231–236.

recommendation regarding domestic regulation is contained in UN General Assembly Resolution 68/74, the adoption of which as customary international law would encourage domestic regulation to ensure more effective application of international law. The resolution provides for a competent national authority for licensing, appropriate conditions and procedures for granting, modifying, suspending and revoking licences within a legal framework, different licencing and procedures for different space activities, and consistency with international law. To ensure continuing supervision, recommendations include appropriate procedures, monitoring of authorised space activities, including on-site inspections, general reporting system, enforcement mechanisms, and maintenance of a national registry by an appropriate authority. Continuing supervision should also be ensured in the event of a transfer of ownership or control of a space object in orbit, for which it is proposed that national legislation should require reauthorisation or notification of the change.[71]

Liability

In addition to the responsibility of states for space activities carried out by non-governmental entities under Article VI of the Outer Space Treaty, Article VII provides for the liability of launching states for damage. The whole Liability Convention also makes the launching state liable for all damage caused by the space object, i.e. the liability for the damage is always borne by the launching state. Therefore, the concept of the liability of states in all circumstances is also reflected here. It should be noted that, in case of other high-risk activities outside space law, the operator is liable for damage, whereas in space law the liability of the launching state has become general.[72]

It is necessary to establish which non-governmental entities the launching state is liable for. The definition of the launching state has already been discussed in

71 Recommendations on national legislation relevant to the peaceful exploration and use of outer space, G.A. Res. 68/74, 11 December 2013, paras. 2–8, 68 U.N. GAOR Suppl. No. 49 (A/68/49 (Vol. I), 260, U.N. Doc. A/RES/68/74 (2013).

72 Herczeg 1966: 90–91; Kecskés 2020: 130–133.

the section on the nationality of space objects. Thus, the basis for state liability for damage caused by a space object as a result of the activities of non-governmental entities in launching or procuring the launch of the space object or in using state territory or facilities for the launch should be analysed here.

Articles III and IV of the Liability Convention are worth emphasising for this analysis, which stipulate that "the damage is due to its fault or the fault of persons for whom it is responsible", and "their liability [...] shall be based on the fault of [...] persons for whom either is responsible". There is therefore a reference to the non-governmental entities for whom the launching state is liable, hence the phrase "persons for whom it is responsible" must be interpreted in relation to the Liability Convention as a whole. The term "persons" includes both natural and juridical persons, although the Liability Convention does not refer specifically to nationality but is more general in scope. It therefore covers not only personal jurisdiction but also territorial jurisdiction, irrespective of the nationality of the "person". The arguments mentioned earlier in relation to national activity and the appropriate state are worth recalling at this point. The expression "is responsible" implies liability for those entities whose activities in relation to the space object are linked to the launching state in such a way that they are subject to its territorial and/or personal jurisdiction. It is accepted that, in these cases, the systematic interpretation[73] must be based on Article VI of the Outer Space Treaty. If there is one launching state, the state that carries out the national activity as the appropriate state is certainly responsible and liable for damage caused by non-governmental entities under its jurisdiction.[74] If the launching state is not the appropriate state in the case in question, it ought to be liable for the damage in respect of persons under its territorial and/or personal jurisdiction.

Article XIII of the Outer Space Treaty refers to space activities conducted jointly with other states. If the responsibility of several states is to be considered, it is essential to clarify the role of each state. If non-governmental entities are involved in space activities, each appropriate state has an international responsibility for

73 Vienna Convention on the Law of Treaties, Article 31(2)(c).

74 Hobe et al. 2013: 409.

their activities under Article VI of the Outer Space Treaty. Liability, however, under Article VII of the Outer Space Treaty and under the Liability Convention, is only imposed on the launching State(s). If a state is not a launching state,[75] it has international responsibility only under Article VI of the Outer Space Treaty and is not liable. Conversely, if a launching state is not an appropriate state it is liable but does not have international responsibility under Article VI of the Outer Space Treaty. Moreover, if a state is both the appropriate state and the launching state, it is both internationally responsible and liable.

It is important to stress, however, that the combination of international responsibility and liability does not automatically give rise to joint and several liability in case of several States. Joint and several liability only applies to the liability of the launching states in case of a joint launch, within the meaning of Articles IV to V of the Liability Convention. This explanation assumes that all states are party to these treaties. If this is not the case, the question of which provisions can be regarded as customary international law binding on states not party to the Convention is further complicated.

Below is to be found the possible cases of multiple state responsibility and liability:

A – appropriate state
B – appropriate state
C – launching state
D – launching state
E – appropriate state and launching state
A + B + C: appropriate states (A, B) bear international responsibility but not joint and several, launching state (C) bears liability
A + C + D: appropriate state (A) bears international responsibility, launching states (C, D) bear liability, launching states (C, D) bear joint and several liability

75 Vereshchetin 1983: 262–263.

A + C + E: appropriate states (A, E) bear international responsibility, launching states (C, E) bear liability, launching states (C, D) bear joint and several liability, state E bear both international responsibility and liability

C + D + E: appropriate state (E) bears international responsibility, launching states (C, D, E) bear liability, launching states (C, D, E) bear joint and several liability, state E bears both international responsibility and liability

A + B + E: appropriate states (A, B, E) bear international responsibility but not joint and several, launching state (E) bears liability, state E bears both international responsibility and liability

NATIONALITY OF THE VICTIM

In space law, nationality is also an issue with regard to the victim in case of damage caused by space objects. Article VII of the Outer Space Treaty also mentions the liability of the launching states in cases where "on the Earth, in air space or in outer space, including the Moon and other celestial bodies" the injured party is a "natural or juridical person" of "another State Party to the Treaty". The provision was based on the UN General Assembly Resolution 1962,[76] which did not yet include the words "including the Moon and other celestial bodies" at the place of the damage caused and, due to the nature of the document, used "foreign State" instead of "State Party". While the former does not represent a substantive change, the latter limits the scope of natural or juridical persons who may be considered as being injured to the states which are parties to the treaty, which is an obvious change given the treaty provision. The Liability Convention also includes the phrase "natural or juridical persons"[77] of third states as victims, which raises the question of whether it applies to national natural and juridical persons and/or to natural and juridical persons under the

[76] Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space, G.A. Res. 1962, 13 December 1963, para. 8, 18 U.N. GAOR Suppl. No. 15 (A/5515), 15, U.N. Doc. A/RES/18/1962 (1963).

[77] Liability Convention, Article IV (1).

territorial jurisdiction of the state. Article VIII of the Liability Convention, which contains the determination of the state entitled to present a claim, brings us closer to the answer. The first section repeats the phrase mentioned above and then sets out the order of the states which may present the claim. The second paragraph includes the primary right of the state of nationality to present the claim. If the state of nationality does not present a claim, the state in whose territory the natural or juridical person sustained the damage may present it. If none of the above states present a claim or notifies its intention to do so, the State of permanent residence of the injured person has the right to present it.

It follows from the above that the term "natural or juridical person" of the State as an injured party means, on the one hand, nationals and, on the other hand, natural and juridical persons who have sustained damage in the territory of the state, irrespective of their nationality. Moreover, the expression "permanent residents" in Article VIII(3) implies that the phrase "natural [...] persons of the State" also involves damage sustained on a foreign territory by a foreign national or a stateless person, if their permanent residence is in the claimant state. The concept is therefore broader, not necessarily covering only persons under personal and territorial jurisdiction, but also persons having some legal connection with the state.[78]

Applying this broader scope of persons is motivated both by a victim-oriented approach,[79] i.e. to protect as far as possible the interests of the injured party so that it does not go without compensation, and by the need to enable states to act in the interests of their population, whether or not they are nationals. Article VII of the Liability Convention excludes the application of the Convention to damage caused by the space object of the launching State if the victim is a national of that state or a foreign national who participated in the operation of the space object from its launch to its landing or while the foreign national was in the immediate vicinity of the planned launch or recovery area as a result of an invitation by the launching state. The terms "nationals" and "foreign nationals" appearing in the convention must be understood to

[78] Hobe et al. 2013: 460.
[79] Sulyok 2022: 95.

refer to both natural and juridical persons and cannot be limited to natural persons. The Liability Convention also excludes dual or multiple nationals if the liable state is one of the states of nationality. However, the United States of America intended to include dual nationals among the persons whose claims may be presented by states.[80] It would be appropriate to apply the principle of predominant nationality, as found in diplomatic protection,[81] whereby a dual national would be excluded from pursuing a claim only if the liable state was the person's predominant nationality.

Other principles already established in diplomatic protection may serve as an interesting contribution to nationality issues in space law. In the Barcelona Traction case, the International Court of Justice pointed out that the rights and obligations of limited liability companies whose capital is represented by shares are based on a "firm distinction between the separate entity of the company and that of the shareholder", that only the company is the juridical person, and that only the company is entitled to act in matters affecting it.[82] Consequently, diplomatic protection can only be granted to a company by the state of its nationality. This position was reaffirmed by the International Court of Justice in the Ahmadou Sadio Diallo case, which held that there is no exception in customary international law that allows for "protection by substitution",[83] i.e. for diplomatic protection to be granted by a state other than the state of the company's nationality. Accordingly, it would be useful to specify that the primary presenter of a claim for damage caused by a space object to a juridical person may be the state of nationality of the juridical person, rather than the state of nationality of the shareholders. However, in order to maintain

80 Hobe et al. 2013: 454–455.

81 International Law Commission, Draft Articles on Diplomatic Protection 2006, Article 7. Official Records of the General Assembly, Sixty-first Session, Suppl. No. 10 (A/61/10).

82 Case Concerning the Barcelona Traction. Light and Power Company, Limited (Belgium v. Spain), Second Phase, Judgment of 5 February 1970, I.C.J. Reports 1970, 35–36.

83 Ahmadou Sadio Diallo (Republic of Guinea v. Democratic Republic of the Congo), Preliminary Objections, Judgment of 24 May 2007, I.C.J. Reports 2007, 614–615.

a victim-oriented approach, it would be necessary, in the absence of the claim of the state of nationality of the juridical person, to provide for the possibility of the shareholders' state of nationality presenting a claim.

The Liability Convention also includes the concept of damage: Article I(a) states that

> "[t]he term 'damage' means loss of life, personal injury or other impairment of health; or loss of or damage to property of States or of persons, natural or juridical, or property of international intergovernmental organizations".

An important consideration in the assessment of damage is the contribution of the injured party, which may exonerate from the liability of the state in whole or in part. In case of non-governmental entities,

> "exoneration from absolute liability shall be granted to the extent that a launching State establishes that the damage has resulted either wholly or partially from gross negligence or from an act or omission done with intent to cause damage on the part of a claimant State or of *natural or juridical persons it represents*".[84]

The new term "it represents" appears in both Articles VI and XI. However, this does not change the scope of persons, since the scope of persons referred to in Article VIII is included for the purpose of presenting a claim for damages, and of representation by the state acting in their interest. Even in this case, no exoneration is possible if the damage results from activities incompatible with international law, in particular with the UN Charter and the provisions of the Outer Space Treaty.[85] Article XI(2) excludes the possibility of a double claim being submitted,[86] i.e. the injured natural or juridical persons may represent a claim in the courts, administrative tribunals or agencies of the launching

84 Liability Convention, Article VI (1) [emphasis added – M. G.].
85 Liability Convention, Article VI (2).
86 Herczeg 1973: 417.

state, but in such a case the state of nationality cannot claim compensation. In addition, under Article XXIII, states may, by special agreement, either mutually exclude liability or waive the claim for damage.

CONCLUSION

Nationality matters arise in many aspects of space law, and they sometimes generate debates. Difficulties arise in the interpretation and application of the provisions and terms used in international documents in this field. Unfortunately, 23% of space objects are currently still unregistered, which means that proportionally there are more than 7,000 space objects only in orbit around the Earth whose nationality is problematic, and their number is increasing. This is a major problem because without registration, the nationality of the space object, and hence the state that has jurisdiction over it and the personnel thereof, cannot be established. The registration of all space objects is important not only for reasons of nationality but also for the identification of space objects, and hence their tracking, traffic management and the prevention of problems associated with space debris. As an addition to the current rules, registration as a condition for launch would contribute to the obligation to register as customary international law. An obligation to register all space objects would also facilitate the enforcement of responsibility and liability rules, as the record includes the launching state(s), making it clear that the object is associated with this/these state(s). It is important to note that liability is not based on the registry but on the launching statehood, so that an incorrect registry cannot affect the liability of the launching state.

When examining the nationality of the entity causing damage, it should be noted that while the nationality of natural persons is usually clear, the principles underlying the nationality of juridical persons may be disputed. The cross-border nature of the situation of juridical persons today requires that space law also recognise not only the principle of registration/incorporation but also the principles of establishment and the seat on the territory. The aim is to ensure that the state of nationality of the juridical person is the "appropriate State" which would be required to authorise and supervise the juridical person most effectively because of its personal jurisdiction.

International responsibility for the activities of non-governmental entities is governed by Article VI of the Outer Space Treaty, where it should be emphasised that this term applies to both natural and juridical persons. The correct interpretation of the national activity and the appropriate state may be sufficient to ensure state responsibility for non-governmental entities in space law today. According to the proposed interpretation, the appropriate state is responsible for the activities of non-governmental entities under its territorial, quasi-territorial and personal jurisdiction, and thus for the activities of national natural and juridical persons under its personal jurisdiction. On the one hand, there is a need to ensure that non-governmental entities carry out their activities in conformity with the provisions of the Treaty and, on the other hand, there is a need to authorise and continuously supervise the space activities of non-governmental entities. The methods of this authorisation and continuing supervision are not provided for in the legislation in force, although UN General Assembly Resolution 68/74 makes detailed recommendations. Establishing this rule as customary international law would facilitate the establishment of a single licencing and continuing supervision regime and the effective implementation of the obligation concerned under the Outer Space Treaty.

In all cases, the launching state is liable for damage caused by a space object. In the event of damage, liability resulting from the conduct of non-governmental entities is established by the phrase "persons for whom it is responsible". The term "person" in this case again includes both natural and juridical persons, and refers not only to nationals, but also to any non-governmental entities under the launching state's jurisdiction. The launching state is thus liable for non-governmental entities under its territorial, quasi-territorial and personal jurisdiction. In sum, the allocation of liability to the launching state adequately ensures compensation for damage in cases of non-governmental entity involvement. However, if a non-governmental entity linked to several states is involved, for example, in the design, construction, launch and operation of a space object, and that space object causes damage as a result of the fault of the non-governmental entity, a complex web of launching states bearing liability and of appropriate states bearing responsibility may arise. The situation is further complicated by the fact that joint and several liability can only exist between two launching states, but not between two appropriate states or between one launching state and one appropriate state. In the event of a review of the rules of responsibility and liability, it would be desirable to simplify this overly complex system, and to adopt a more effective approach with regard to damage caused through the fault of non-governmental entities.

The Liability Convention describes the injured party by the formula "natural or juridical person of the State" when it determines the state which is entitled to present a claim. This wording covers a broader range of persons than the phrases previously used. A state's nationals (natural and juridical persons); natural and juridical persons who have sustained damage in the territory of a state irrespective of their nationality; and even permanent residents of a state are all included in the category of persons on behalf of whom a state may present a claim. In the latter case, therefore, a claim may be presented even on behalf of a foreigner or a stateless person who has sustained damage abroad, provided that the person is permanently resident in the claimant state. It should be pointed out that the launching state is not liable for damage sustained by, *inter alia,* its own nationals, that is, its natural and juridical persons. The Liability Convention also excludes dual nationals from the scope of victims if one of their nationalities is that of the launching state. In light of the principle of predominant nationality, it would be advisable to exclude these persons only if their predominant nationality is that of the launching state. The determination of the claimant state is likely to raise complex questions since the existence of personal jurisdiction over a juridical person, in other words, the identity of the state of nationality, may be subject to debate. The expression "juridical person of the State" suggests that the state of nationality is definitely entitled to present a claim, but it remains to be seen whether the formula "natural [...] person of the State" has the same effect with respect to the state of nationality of shareholders. The practice of the International Court of Justice in the context of diplomatic protection reveals that the claim of a juridical person may be presented by the state of nationality. However, the right of the state of nationality of investors to present a claim is not self-evident, although the convention's victim-oriented approach may possibly serve as an argument in favour of such an interpretation. Should this interpretation gain ground, the provision concerned would have to be amended to clarify the situation. As regards the provision on exoneration due to victim involvement, the formula "represented by" does not change the aforementioned scope of victims, that is, the natural and juridical persons on behalf of whom a state may present a claim.

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Part Three: Sustainability

Gábor Kecskés

Protection of the Natural Space Environment: A Fresh Outlook

INTRODUCTION

A 2003 study on the protection of the natural environment of space by Mark Williamson begins with a thoughtful and certainly not implausible introduction to the topic, which reads:

> "The construction of the International Space Station in low Earth orbit and the formulation of plans to search for life on Mars indicate that mankind is intent on making the space environment part of its domain. Publicity surrounding space tourism, in-space 'burials' and the sale of lunar 'real estate' suggests that, some time in the 21st century, the space environment will become an extension of our current terrestrial business and domestic environment."[1]

The aforementioned activities in outer space do not seem to be fantastical and futuristic possibilities nowadays. The scale and significance of the human impact on the environment of outer space in recent years is unprecedented and is progressively increasing. Almost 60 years ago, at the dawn of the classical space age, Gyula Gál published his influential book on space law in which he identified the most menacing potential environmental effects of space activity as the infection of outer space with Earth-based micro-organisms and the radioactive contamination of outer space. He labelled such hazards as "upsetting

[1] Williamson 2003: 47, 49.

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the balance of nature" by causing physical or biological changes in space or on celestial bodies, thus endangering the freedom of scientific research and use.[2]

While those threats have remained valid concerns ever since, further hazardous activities (potential pollution and environmental problems and damage) and other potential future hazards have emerged due to the much larger number of space objects and the growth of space debris, along with the ever-increasing space race as well as the commercialisation of space activities and their negative impacts on the natural space environment.[3]

Today, the role of space research is crucial for the maintenance of sustainability on Earth, for predicting our future, and for making our life on Earth more sustainability-driven.[4] At the same time, the media are focusing on the role of the research conducted from outer space for the protection of Earth's environment and for tackling climate change.[5] Meanwhile, the international community has to ask a further question: What about the protection of the universe beyond the Earth? Is it also necessary to pay attention to the sustainable protection of outer space? (Even if its exact borders, components and characteristics are unknown and even scientists admit how little they know about it.)

In spite of the obvious lacuna of knowledge on the frontiers of the given field, the present study will attempt to present a wide-scale analysis of the relevant rules for ecologically protecting the natural space environment. The rules presented and the answers ventured within are rather sporadic and non-convincingly clear by nature and in terms of enforcement but several important conclusions can be drawn from examining these legal regimes.

[2] Gál 1964: 184–189.

[3] See ESA Annual Space Environment Report 2023. Evolution of the number of objects and other relevant tables, figures: 19–68.

[4] For the sustainability aspects of the outer space, see the special issue published by the prestigious *Air and Space Law* journal in 2023. Several articles particularly focus on the specific sustainability aspects. See the introduction of Masson-Zwaan – Johnson 2023: 1–4.

[5] As for the role of space activities on weather predictions and the protection of Earth's atmosphere see Borowitz 2023: 409–436; Rainbow 2023.

THE ECOLOGICAL PROTECTION OF THE NATURAL SPACE ENVIRONMENT

While the protection of the natural space environment (planetary protection) is clearly related to the ecological condition of low Earth orbit, the obligations of protection need to be extended beyond that area. Moreover, nowadays, the debate about the ever-increasing amount of space debris re-entering the Earth's atmosphere (whether it is directed towards the "space cemetery" around Point Nemo or deliberately destroyed by burning up in the atmosphere, etc.) has also became very topical and garnered significant attention.

The protection of the Earth's ecosystem, the complex influence of the celestial bodies of the solar system on life on Earth and the disposal of space debris are closely interlinked to the wider issues of environmental protection (planetary protection).[6] These are also becoming increasingly threatened by 21st century space activities, as the environmental challenges humankind is facing are of utmost importance both for public debate and for decision-makers. It is worth noting, however, that space law-making processes in the 1960s and 1970s did not take place in the climate-conscious, environment-friendly international *Zeitgeist* of today. Without doubt, outer space and the celestial bodies are unequivocally part of the Earth's ecosystem, and are therefore of paramount relevance to general environmental standards. On the one hand, changes in the Earth's atmosphere, climate and climatic conditions have a significant impact on life on Earth, and on the other hand, states are voluntarily launching space objects into orbit around the Earth at an unprecedented scale, which can ultimately cause significant damage anywhere on Earth, not to mention the huge carbon footprint of space launches. At the same time, the communication, meteorological and research activities that are facilitated by space activities not only contribute to the protection of the Earth's environment and environmental sustainability in general, but space exploration and space activities in general are essential to the realisation of our environmental ambitions. Therefore,

[6] Almár 1999; Lyall 1999.

protecting the natural space environment is also a key issue for the preservation of the Earth's and humanity's ecosystem on the surface of the Earth.

Currently, the most challenging environmentally hazardous activities and the greatest potential hazards in low Earth orbit (as well as in geostationary orbit) and on celestial bodies are the following: 1. the growing number of space objects and space debris; 2. deep space mining and space resource management; 3. the increasing level of space vehicle emissions; 4. the maintenance of the natural space environment for future generations; 5. nuclear contamination and the emission of other contaminating substances (e.g. aluminium oxide); 6. the problems of megaconstellations; 7. the lack of space traffic management; and 8. space tourism causing heavily contaminating effects in both outer space and in the atmosphere of the Earth.[7]

Nevertheless, according to Williamson:

> "relatively little consideration has been accorded to the space environment itself in terms of the detrimental effects of space exploration and development, and relatively few practitioners consider the subject worthy of consideration and […] we appear to be in the very early stages of realisation that the space environment has a value, and can be detrimentally affected by our activities".[8]

Indeed, the normative background only sporadically recognises the value of preserving the space environment.

In general public international law, outer space has been accorded the status of *res communis omnium usus,* i.e. any state is entitled to use it freely, but cannot claim sovereignty over it, in accordance with Article II of the 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (hereinafter: Outer Space Treaty or OST).

[7] In 2008, Viikari stated that space debris, nuclear contamination, solar power satellites, manned space stations and exobiological contaminations are the greatest ecological challenges in the outer space. See Viikari 2008: 31–54.

[8] Williamson 2003: 47.

Article II of the OST reads as follows: "Outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means."

Based on the possibility of universal use and the principle of cooperation between States, space activities shall be carried out in the interest of humanity, which includes the interests of environmental protection.

As Article I of the OST stated: "The exploration and use of outer space, including the moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind. Outer space, including the moon and other celestial bodies, shall be free for exploration and use by all States without discrimination of any kind, on a basis of equality and in accordance with international law, and there shall be free access to all areas of celestial bodies. There shall be freedom of scientific investigation in outer space, including the moon and other celestial bodies, and States shall facilitate and encourage international co-operation in such investigation."
Furthermore, Article 9 of the OST also reflects on cooperation and mutual assistance of states, as it states: "In the exploration and use of outer space, including the moon and other celestial bodies, States Parties to the Treaty shall be guided by the principle of co-operation and mutual assistance and shall conduct all their activities in outer space, including the moon and other celestial bodies, with due regard to the corresponding interests of all other States Parties to the Treaty. States [...] shall pursue studies of outer space, including the moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter."

The 1972 Convention on International Liability for Damage Caused by Space Objects (hereinafter: Liability Convention) also calls for cooperation "in the field of the exploration and use of outer space for peaceful purposes", while its main focus, expressed by the term 'damage' is clearly silent on the topic of environmental damage.

As Article I, point b) reads as follows: "The term 'damage' means loss of life, personal injury or other impairment of health; or loss of or damage to property of States or of persons, natural or juridical, or property of international intergovernmental organizations."

However, the state-based and intergovernmental legislation of the late 1960s and early 1970s did not consider the emergence of environmental damage an issue, since the environmental "consciousness" of states at that time was significantly lower than it is today.

The 1979 Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (hereinafter: Moon Agreement), on the other hand, defines the Moon and its natural resources, as well as the other celestial bodies of the Solar system, as the *common heritage of mankind,* granting them a privileged conservation status similar to that of environmental protection, as it relates to the preservation of irreplaceable environmental elements of paramount importance to mankind (Article XI).

Article 11, para 1. of the Moon Agreement reads as follows: "The moon and its natural resources are the common heritage of mankind [...].
2. The moon is not subject to national appropriation by any claim of sovereignty, by means of use or occupation, or by any other means.
3. Neither the surface nor the subsurface of the moon, nor any part thereof or natural resources in place, shall become property of any State, international intergovernmental or non-governmental organization, national organization or non-governmental entity or of any natural person. The placement of personnel, space vehicles, equipment, facilities, stations and installations on or below the surface of the moon, including structures connected with its surface or subsurface, shall not create a right of ownership over the surface or the subsurface of the moon or any areas thereof. The foregoing provisions are without prejudice to the international regime referred to in paragraph 5 of this article.
4. States Parties have the right to exploration and use of the moon without discrimination of any kind, on the basis of equality and in accordance with international law and the terms of this Agreement."

It can thus be concluded that, besides the so-called *res communis omnium usus* idea (adopted by the OST) and the *common heritage of mankind* idea (adopted by the Moon Agreement), the global commons idea[9] is also valid and widely accepted.

Similarly, Article III of the Outer Space Treaty states that

> "States Parties to the Treaty shall carry on activities in the exploration and use of outer space, including the moon and other celestial bodies, in accordance with international law, including the Charter of the United Nations, in the interest of maintaining international peace and security and promoting international co-operation and understanding".

Accordingly, beyond laws specifically relating to space, the relevant rules of general international law also need to be taken into account by analysing the relevant instruments on the protection of natural space environment. Thus, both the general rules of international (mainly environmental) law and the particular rules of space law apply to the ecological protection of the outer space.

The ecological protection of the natural space environment in general international (environmental) law

The regulation on the protection of the environment in general does not have a long history in international law. The first general international environmental (albeit non-binding) document was the 1972 Stockholm Declaration on Human Environment. This soft law (but globally accepted) declaration underlines that

> "States have the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction" (Principle 21).

[9] Mickelson 2019.

The final part of the last sentence refers to outer space, and the wording suggests that states have a responsibility to ensure that activities within their jurisdiction and control do not cause damage to outer space, since the outer space is an area beyond the limits of state jurisdiction according to Article I of the OST. Twenty years later, a similar sentiment could be found in Principle 2 of the 1992 Rio Declaration on Environment and Development which almost literally repeated the wording of the Stockholm Declaration adopted two decades earlier.

In the 1970s, the issue of outer space began to also be included in the international environmental regime, which was just starting to be developed in the late 1970s, although very few international environmental treaties in those years specifically mentioned the protection of outer space explicitly. One crucial field was the avoidance of warfare by using environmentally detrimental weapons and methods. The application of international humanitarian law rules to environmental warfare is, of course, also applicable to outer space.[10] One of the most important cornerstone norms is the 1976 Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (hereinafter: ENMOD), signed under the auspices of the United Nations. The basic philosophy of the ENMOD is for states to undertake not to engage in military or any other hostile use of environmental modification techniques which may have widespread, long-lasting or severe effects (Article I). According to Article 2 of the ENMOD, the

> "term 'environmental modification techniques' refers to any technique for changing – through the deliberate manipulation of natural processes – the dynamics, composition or structure of the Earth, including its biota, lithosphere, hydrosphere and atmosphere, or of outer space".

Hence, the ENMOD clearly prohibits environmental modification techniques for military purposes in outer space.

[10] Henckaerts – Doswald-Beck 2009: 143–158.

Another important source for the protection of the space environment are the climate change treaties. The 1992 United Nations Framework Convention on Climate Change (hereinafter: UNFCCC)[11] includes the "totality of the atmosphere" in the climate system, by adding in Article 1, para 3. that "climate system means the totality of the atmosphere, hydrosphere, biosphere and geosphere and their interactions". Article 2 of the UNFCCC lays down clearly that "States should achieve the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". However, all the climate change treaties are rather Earth-oriented, thus the protection of the Earth is included, while outer space is regarded preferably as a tool or a source of support for that.

The explicit protection of the natural space environment from directly Earth-related activities can be seen most obviously within the regime of the prohibition of nuclear testing.[12] Prior to the first space law treaties, the 1963 Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water clearly prohibited any nuclear weapon test explosion or any other nuclear explosion, at any place under its jurisdiction or control in the atmosphere; beyond its limits, including outer space, or under water, including territorial waters or high seas.[13] Decades later, in a way which harked back to the strict form of prohibition of the 1963 rules, the 1996 Comprehensive Nuclear Test Ban Treaty (although not yet in force) was signed. That treaty banned all nuclear weapons tests by obliging states "not to carry out any nuclear weapon test explosion or any other nuclear explosion, and to prohibit and prevent any such nuclear explosion at any place under its jurisdiction or control" (Article I).

[11] Regarding the UNFCCC, the definitions of the UNFCCC shall also be applied to the further climate change treaties adopted upon the UNFCCC, e.g. the 1997 Kyoto Protocol and the 2015 Paris Agreement.

[12] See also Principles Relevant to the Use of Nuclear Power Sources in Outer Space, *GA Res* 47/68.

[13] See Article 1 para 1. However, relevant spacefaring and at the same time major nuclear weapon states did not ratify the treaty. As for the 1963 Treaty and its relations to outer space see Tabassi–Werzi 2015: 181–220.

As for other, non-binding soft law mechanisms (which can be labelled at most rules of a customary nature), no other relevant documents clearly refer to the same obligations for the ecological protection of the space environment. Neither the United Nations General Assembly Resolution 70/1 *Transforming Our World: The 2030 Agenda for Sustainable Development,* nor the relevant, environmentally important works and drafts of the International Law Commission dealt with the specific issue of planetary protection. However, Tanja Masson-Zwaan has convincingly argued that "space is indeed a major contributor to the realization of practically all of the UN Sustainable Development Goals, whether related to health, education, clean water, or climate".[14] In the post-2015 Sustainable Development Goals (SDGs) agenda, space and the role of space research gained more attention and magnitude thanks to the SDGs.[15]

Conceivably, the customary nature of international environmental law principles could also be considered, since they might also entail that environmental law could be binding in nature. These principles appear in the overwhelming majority of the environmental treaties, as well as constituting parts of the states' environmental legal systems (and the practice of states) as well as being present in the international adjudication. Most of these principles have reached the level of a principle of customary nature, and therefore these principles have become a part of international law. Hence, according to Article III of the OST, states must carry on their activities in the exploration and use of outer space in accordance with these principles as they are customary elements of international law. This list of principles primarily includes prevention, precaution, sustainable development, good neighbourliness, due diligence, the polluter pays principle and common but differentiated responsibility.[16]

14 Masson-Zwaan 2023: 53–55. Masson-Zwaan argues that "we must make sure that we can meet the needs of the present generations, while preserving the space environment for future generations. Only then can we achieve the stated objective of equitable access to the benefits of the exploration and use of outer space for peaceful purposes."

15 See e.g. The Space2030 Agenda 2018; ESPI2040 2023.

16 Viikari 2008: 144–190.

However, these general, abstract principles cannot form a legal regime and a single enforceable obligation to provide effective legal measures for the ecological protection of the natural space environment, since that protection is in legal terms rather vague by nature and has a low profile. That is not a coincidence, as noted above, since the rules of international environmental law typically focus instead on the protection of the Earth's ecosystem.

The ecological protection of the natural space environment in international space law

It is worth recognising that the protection of the natural space environment is covered in somewhat more detail than it is in ecological legal regimes. Before analysing these legal regimes, however, it is necessary to note that no binding international space treaty has explicitly addressed the protection of the environment of outer space, since the classical great wave of law-making took place in the 1960s and 1970s, when the ecological aspects were only barely emerging globally.

Of the first space law instruments, the 1961 Declaration on International Co-operation in the Peaceful Uses of Outer Space, which was a non-binding document, states that

> "international law applies to outer space and celestial bodies, while the outer space and celestial bodies are free for exploration and use by all States in conformity with international law and are not subject to national appropriation".

These basic pillars are repeated in the subsequent 1962 Declaration of Legal Principles, which highlights that outer space and celestial bodies are free for exploration and use by all States on a basis of equality and in accordance with international law. Outer space and celestial bodies are thus not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means. It also emphasises that the activities of States in the exploration and use of outer space shall be carried on in accordance with international law. These cornerstones of space law were later mirrored in Article III of the binding OST. It is worth noting that both the 1961 and 1962 Declarations and some articles of the OST have a possible customary nature in international law, meaning that these rules can be classed as binding rules for the international community according to the concept of customary international law.

Regarding general international law requirements, Article I of the OST underlines that what were at that time solely state-related activities such as the exploration and use of outer space and the planetary environment shall be carried out for the benefit of and in the free interests of states, and shall be the province of all mankind with free access to all areas of celestial bodies based on non-discriminatory and equality approaches in accordance with international law.

More precisely, the "environmental article" of the OST is undoubtedly Article IX. It is worth stressing, however, that the Earth is the focus of the OST and not solely outer space.

The ecological aspects represented in Article IX of the OST first emphasise principles (cooperation, mutual assistance, due regard to the corresponding interests of all other states), before establishing more obvious obligations such as the responsibility to carry out studies and exploration in such a way as to avoid harmful contamination and adverse changes in the Earth's ecosystem. Thirdly, the obligation of consultation and a duty to action on the part of states emerges if a state has reason to believe that an activity or experiment planned by it or its nationals or another state in outer space would cause potentially harmful interference with the activities of other states in the peaceful exploration and use of outer space. Although this article focuses on the states' interests rather than the interest of outer space, the main duty is to avoid harmful contamination and adverse changes in the environment of the Earth (not the outer space). Therefore, the states shall undertake and request appropriate international consultations before proceeding with any such activity or experiment. That due regard analogy with respect to the protection of the natural space environment (along with the protection of the Earth ecosystem) shall not be concluded from the said Article IX of the OST.

The same holds true for two other major space law treaties, since neither the 1968 Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (hereinafter: Rescue Agreement), nor the 1975 Convention on Registration of Objects Launched into Outer Space (hereinafter: Registration Convention) contain specific rules on the protection of the planetary system.

The 1972 Liability Convention does not add relevant regulations for the protection of the planetary system either, since it clearly (or possibly indirectly, if the damage caused in outer space later causes damage on the Earth) excludes the compensability of environmental damage of outer space, since the term 'damage' under the liability convention means "loss of life, personal injury or other impairment of health; or loss of or damage to property of States or of persons, natural or juridical, or property of international intergovernmental organizations". Accordingly, damage to outer space was not included in the Liability Convention, meaning that in case of such damage occurring, no state party shall be deemed liable.

The 1979 Moon Agreement (still in effect, although the major spacefaring nations have not ratified it) takes a somewhat different approach, since the provisions of the Moon Agreement shall also apply to other celestial bodies within the solar system, other than the earth (Article 1), therefore the regulations within the 1979 Agreement are certainly applicable both to the planetary system and outer space as a whole. Similarly, on the basis of the relevant rules of the OST, activities falling under the Moon Agreement shall also be carried out in accordance with international law (particularly with the UN Charter and the relevant space law declarations adopted by the UN General Assembly) in the interest of maintaining international peace and security and promoting international cooperation and mutual understanding, and with due regard to the corresponding interests of all other States Parties (Article 2). In a more concrete obligation, Article 4 of the Moon Agreement directly refers to the basic rules of the exploration and usage of the moon, although these regulations also reflect the interests of other states, while a new element also emerged, since "due regard shall be paid to the interests of present and future generations". That wording, however, also pertains to the Earth's ecosystem and not to the interests of the planetary system itself. Article 7 of the Moon Agreement even exclusively touched upon the protection of the Earth's environment by prohibiting adverse changes and harmful contamination of the environment through the introduction of extra-environmental matter or otherwise.

It can thus be concluded that planetary protection is not a central priority of the five major space law treaties, since their adoption preceded the first initiatives of environmental regulation in the 1970s.

Almost two decades after the signature of the Moon Agreement, even in the context of the more climate-conscious wave of international law-making in the 1990s, the far from globally accepted 1998 International Space Station Intergovernmental Agreement still did not contain a single reference to environmental issues either.

Since then, only soft law-based non-binding international documents have been adopted within the field of space law. While some of these have included a focus on planetary protection, the protection of the Earth's ecosystem remains their main focus.

The non-binding 2020 Principles for Cooperation in the Civil Exploration and Use of the Moon, Mars, Comets, and Asteroids for Peaceful Purposes (hereinafter: Artemis Accords),[17] represents an increasingly promising soft law interstate commitment which addresses the preservation of the heritage of outer space. Finally, the signatories of the Artemis Accords dealt with the protection of the planetary system by the inclusion of this preservation commitment. However, Section 9 of the Artemis Accords applies to man-made outer space heritage ("historically significant human or robotic landing sites, artifacts, spacecraft, and other evidence of activity on celestial bodies"), Section 10 echoes the classical environmental protection wording of legal instruments by adding that

[17] As for the Artemis Accords see Bartóki-Gönczy – Nagy 2023: 888–898.

> "the Signatories emphasize that the extraction and utilization of space resources, including any recovery from the surface or subsurface of the Moon, Mars, comets, or asteroids, should be executed in a manner that complies with the Outer Space Treaty and in support of safe and sustainable space activities. The Signatories affirm that the extraction of space resources does not inherently constitute national appropriation under Article II of the Outer Space Treaty".

In recent years, the enormous increase in the amount of space debris and the necessity of mitigating this problem have basically determined the environmental aspects of regulations on outer space and the drafting of relevant documents (although all of them are soft law measures).[18] The regionally-focused 2004 European Code of Conduct for Space Debris Mitigation prescribes that each space project should establish a space debris mitigation plan. It stipulates that during the tasks associated with the identification and definition of space debris, a space project should determine the "potential harm at the Earth's surface or damage to the environment caused by the re-entry of its product" as well as ensuring that in the re-entry phase, no harmful contamination is caused to Earth.

Although the common rules did not directly refer to the explicit protection of the ecosystem of the planetary system (outside the Earth), the regulation on space debris implicitly does not solely apply to the Earth's ecosystem but also to outer space.[19] These rules have spread widely to the relevant parts of space policies and strategies since then.[20]

18 See the 2007 Space Debris Mitigation Guidelines and 2018 Guidelines for the Long-term Sustainability of Outer Space Activities. On the importance of the long-term sustainability guidelines in the future of outer space see Martinez 2023: 41–58; Bittencourt Neto 2023: 93–112; Soucek–Tapio 2023: 211–228.

19 See e.g. International Telecommunication Union (ITU) 2010 Recommendation ITU-R S.1003-2 on the environmental protection of the geostationary satellite orbit; the European Space Agency's Clean Space Initiative of 2012; UNISPACE 50+ Conference, the UN General Assembly adopted by resolution 73/6 of 26 October 2018 the Declaration entitled "Fiftieth Anniversary of the First United Nations Conference on the Peaceful Uses and Exploration of Outer Space: Space as an Engine for Sustainable Development"; Regulation (EU) No 2021/696 establishing the EU Space Programme.

20 For instance, see Hungary's Space Strategy, 2021.

Beyond the space debris mitigation initiatives, in terms of the ecological protection of outer space, it should be noted that the (also non-binding) 2014 Draft International Code of Conduct for Outer Space Activities highlights the protection of the sustainability of outer space. Meanwhile, although it is also not a legally binding document, it is worth mentioning that the forthcoming Volume II of the prestigious McGill Manual will definitely contain Rules with Commentaries on the 'Protection of the Environment'.

It can thus be surmised that space law instruments have only sporadically dealt with the question of planetary protection, or at least with the protection of low Earth orbit or the geostationary Equatorial orbit.

One of the pioneering researchers of the ecological protection of outer space, Mark Williamson stated that while the natural space environment clearly needs to be protected, the substantial question arises "'to what extent should we protect the space environment?' Should we regulate its use to protect it for future generations, or should we simply continue the laissez faire attitude of previous generations?"[21] In another article by Williamson (from 2002) he emphasises five steps for the protection of the space environment, including:

– the protection of Earth orbits as a commercial and scientific resource by formalising debris mitigation measures
– the protection of planetary surfaces to preserve their environments for future scientific study
– the protection of planetary surfaces to preserve possible indigenous life forms
– the protection of historic exploration sites on the Moon and other planetary bodies
– the protection of geological formations and other natural features of planetary surfaces for the enjoyment and edification of future generations[22]

[21] Williamson 2003: 48.
[22] Williamson 2002.

In 2023, under the aegis of the Committee on the Peaceful Uses of Outer Space several delegations made commitments to preserve outer space and ensure the sustainability of outer space activities. Furthermore, they emphasised the importance of the sustainability of space resources as well as expressing that it was important to conduct a study of the Moon and other celestial bodies to determine whether the exploitation of space resources would adversely affect the space environment.[23]

Furthermore, NGOs and green stakeholders are also eager to adopt "softer than soft law" declarations, which do not have any binding effects, but which can clearly articulate the solid opinion of certain parts of the public discourse as they try to influence the ecologically sensitive and conscious minds of our contemporary society.[24]

CONCLUSION

If the rules and obligations of sustainability on Earth are unclear and difficult to enforce, the sustainability of the unlimited, universal and less-known space environment poses regulation challenges that are even less clearly delineated. The most extensively studied aspect of this, the issue of space debris is clearly a crucial aspect of the protection of the ecological conditions of outer space. However, there is still no legally binding definition of space debris within the international agreements. In sum, it can be concluded that neither the soft law-based general rules of international (environmental) law, nor the more specific hard and soft law measures of international space law contain definite rules on planetary protection with detailed provisions. At the same time, however, even soft law mechanisms can be implemented into the domestic legal systems, and the majority of space law measures should be interpreted in accordance with international law, so the spacefaring states have taken more than enough legal measures to protect the ecology of the outer space. Therefore, the hypothetical

[23] Report of the Legal Subcommittee on its sixty-second session, 2023.

[24] 2021 Declaration of the Rights of the Moon.

regime of international environmental space law compounds the variety of space law norms, the rapidly unfolding environmental standards (of hard and customary nature) as well as international law measures for the peaceful use of global commons and the prohibition of certain weapons. For the time being, this complex regime already involves an enormous number of legal measures which cannot totally be derogated by the states.

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Space Technology and Environmental Harm: The Role of Astro-Green Criminology

INTRODUCTION

It has become clear that alongside new opportunities, New Space has brought numerous new challenges, opening up a wide discussion regarding the long-term sustainability of the use and exploration of outer space. In the early phase of space law developments, which included the drafting of the main space treaties, sustainability and preservation of outer space environment were not seen as a priority.[1] It is therefore not surprising that they made little progress towards achieving sustainability. Not only did many of these provisions lack effective enforcement, but their broadness and lack of concretisation allowed for several (sometimes even contradictory) interpretations, posing difficulties in defining which activities are compliant with the legal framework, and which, on the other hand, are unlawful. Researchers have long recognised the danger of these legal shortcomings, and have called for the creation of a new discipline – Astro-Green Criminology, that would expand the lenses through which most of the legal research in this area is currently carried out, by including consideration of the question of the *harmfulness* of certain space activities, and not just their *unlawfulness*.[2] This could have important implications for the further development of space law in the direction of making more harmful activities explicitly unlawful. At the same time, Astro-Green Criminology would offer an opportunity to thoroughly address some basic philosophical questions that are crucial for the determination of the future legal framework, such as:

[1] Deva Prasad 2019: 166.
[2] Takemura 2019; Lampkin 2020.

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"What is and what should be the purpose of human activity in outer space in the future?"[3] A legal framework developed in such a way would consequently enjoy a higher level of legitimacy and would be more aligned with the interests of all humankind.

In the first part of this Chapter I elaborate briefly on the emergence of New Space and its relation and contribution to threats to sustainability in the form of environmental harm. In the second part I describe the development of the discipline of Astro-Green Criminology, which was based on numerous calls for the expansion of criminological research beyond the scope of what legislators defined as "criminal" or "unlawful", to include activities that are not criminalised or otherwise prohibited by the law, yet which are able to produce extremely harmful effects. In the third part I outline some of the shortcomings of the existing legal framework and then demonstrate how developing the field of Astro-Green Criminology can complement the current efforts to amend the legal framework by providing new perspectives, methodology and insights on that topic. I conclude with some remarks outlining the perspectives for future research.

ENVIRONMENTAL HARM CAUSED BY SPACE TECHNOLOGY, THE EMERGENCE OF NEW SPACE AND THE PRESSING ISSUE OF THE SUSTAINABILITY OF SPACE ACTIVITY

The deployment of space technology has been, since its beginnings in the 1950s, accompanied by great enthusiasm and hope, as it led to unimaginable discoveries and possibilities that have enriched scientific, technical and social development.[4]

[3] Lampkin 2020: 250.

[4] The most notable events at the beginning of the space age, namely, Sputnik I becoming the first successfully launched satellite, Yuri Gagarin becoming the first person in outer space and the Apollo 11 successfully landing on the Moon with Neil Armstrong being the first human ever to step on its surface, have been highly publicised, used for the promotion of respective governments, and later on incorporated into the national spirit, ideology and

Despite its numerous benefits, however, this development simultaneously resulted in various forms of environmental harm.[5] Environmental damage in outer space is caused by several different forms of contamination, including,[6] but not limited to radiological contamination through nuclear experiments,[7] physical contamination through the proliferation of numerous space objects and space debris,[8] chemical contamination through rocket gas and fuel emissions,[9] and recently even the threat of biological contamination of outer space with terrestrial organisms.[10] What was perhaps once easily overlooked, as it was overshadowed by the great enthusiasm surrounding space technology, has now become impossible to ignore: environmental harm, caused by this technology, has drastically increased in the last 50 years and nowadays poses a severe risk to humanity as well as to the future of space exploration.[11]

According to a study conducted by the European Space Policy Institute (ESPI), the image of the space sector has been drastically transformed in recent years. The main reason for this change are the new entrants to the space sector, which are using new processes, business models and solutions, challenging the formerly prevalent approaches to space programmes.[12] This trend marks the transition from the old "slow, bureaucratic, government-directed, and completely top-down" space regime, to a situation that has yet to be precisely defined but which is often referred to as 'New Space'.[13] While the distinction between the previous situation and the current one is perhaps not so clear as sometimes

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culture of both the USSR and the USA, their influence extending far beyond their borders. See, for example, Siddiqi 2010: 426–427; Shreve 2003: 69–74.

5 Gaston et al. 2023: 290; Ryan et al. 2022.

6 For more on this see Qizhi 1988.

7 Such tests resulted in electromagnetic pulses and dangerous debris. Yan 2023; Dupont 2004: 100–105. On the general negative environmental effects of nuclear tests see Prăvălie 2014.

8 Stubbe 2018: 3; Tallis 2014: 86–88.

9 Ross–Vedda 2018: 2–5; Ryan et al. 2022.

10 Rettberg et al. 2019.

11 See Hamilton 2022; Kellman 2014.

12 ESPI 2017: 3.

13 ESPI 2017: 1.

presented, it cannot be denied that the space sector has undergone some drastic changes in the recent past and has been transformed by numerous trends, by which I mean large-scale shifts in various areas of the global arena of space activities. Besides the increasing number of private actors in the space sector (both established companies and new startups), other trends defining New Space and differentiating it from the old system are, for example, the increasing number of spacefaring nations, innovative public procurement and support schemes, new industrial approaches, disruptive market solutions and others.[14]

New Space has brought new challenges, that now coexist with all the unresolved issues from mankind's earlier ventures in space, which is perhaps most worrying in terms of the environmental harm caused by space activities, posing a severe threat to their long-term sustainability. While some level of harm is inevitable, it can be avoided, or at least to some extent significantly reduced, through cautious mission planning. However, the increased involvement of private actors in space activities has seen a greater emphasis on private interests (usually in a form of economic benefits) over the long-term interests of equity and sustainability.

The 2019 accident of the Israeli Beresheet rocket can serve as an important example in this regard. The incident was widely described as posing a threat of biological contamination of the Moon, as it broke down and crashed uncontrollably onto the lunar surface while carrying a cargo containing samples of human DNA as well as thousands of tardigrades – microscopic animals that are resilient to extreme habitats.[15] The concern has been raised that the tardigrades would survive the crash and would contaminate the lunar environment, arbitrarily interfering with the future of outer space.[16] The criticism raised with regard to that event were that the Beresheet program was prioritising commercial interests over environmental safety and sustainability. The programme was described as a commercial initiative and the decision to include tardigrades was claimed

[14] ESPI 2017: 2; Denis et al. 2020: 433.

[15] Oberhaus 2019.

[16] Oberhaus 2019.

to be an undocumented[17] private decision which the launching state was not aware of.[18] It has been further alleged that the program used certain components of questionable quality, which were "relatively inexpensive" and "had not been tested in space" prior to the mission.[19] Due to one of the main trends of New Space, namely, the increasing involvement of non-state actors in outer space, concerns are growing about the sustainability of space activities and the environmental protection of space being jeopardised by an increasing prioritisation of commercial interests.

THE EMERGING FIELD OF ASTRO-GREEN CRIMINOLOGY AS A RESPONSE TO THE CHALLENGES POSED BY NEW SPACE

In this part I will briefly present the development of criminological research in the last few decades, as a response to emerging social challenges. Firstly, I will discuss the expansion of criminology beyond the subject of *criminal law* and secondly the expansion of the criminological gaze *beyond our planet.*

Criminology beyond criminal law

For almost a century, theoreticians have argued that Criminology must look beyond its traditional subject of examination – criminality, as defined by criminal law. The development of critical criminology encompasses a set of new perspectives in the field, based mainly on the rejection of the official (i.e. the legislator's) definition of crime as a self-evident and exclusive object of criminological study.[20] Instead, they recognise that deviant behaviour which

[17] The fact that the state allegedly did not know about such a risky private decision that could potentially result in a breach of space treaties opens an important question regarding the extent of state responsibility for private conduct, as described in further detail in Gailhofer–Scherf 2022; Chirwa 2004.

[18] Cirkovic 2022: 337.

[19] Nevo 2020.

[20] Sykes 1974: 207; Meier 1977: 462–464.

harms society is much broader than this narrow official set of criminalised acts, which are designed in accordance with the interests and values of the more powerful part of the population.[21] Based on this recognition, that criminal law does not sufficiently address deviance in its entirety, critical criminological theories call for a broader consideration of these damaging phenomena, often defined through the notion of social harm, irrespective of its (criminal) legal status.[22]

Social harm does not yet have a universally accepted definition, but is most often understood as a set of harmful effects preventing people from meeting their needs.[23] It remains a matter of dispute whether the subject of social harm should be tackled within the scope of (critical) criminology, or by another young scientific discipline: zemiology, but it is becoming more and more clear that this broader approach brings significant advantages to the scientific examination of harmful behaviours.[24] The first expansion of criminological research that is relevant for this article is therefore the shift in focus from the notion of *crime* towards a broader term of *social harm*.

Based on a similar premise, another criminological discipline has emerged: green criminology. Building upon the theory advocating the expansion of the criminological interest to social harm, green criminology has more recently focused its attention on the environmental aspect, trying to seek ways of expanding regulatory frameworks so as to prevent or mitigate avoidable and avertable *environmental* harms.[25] The main concerns of green criminology are thus environmental crimes, but on a broader scale it also addresses other threats to environmental rights, ecological justice, the exploitation of natural resources and their relation to power structures within society.[26]

21 Sutherland 1983; Hillyard–Tombs 2004: 13; Curtis 2003: 147–149.
22 Tombs 2018; Paoli–Greenfield 2018; McGregor 2019: 352.
23 Tombs 2018; Copson 2011.
24 Felices-Luna 2010: 252.
25 See Lynch 1990: 3–4; Boukli–Kotsakis 2023.
26 White 2008: 170–171; White–Heckenberg 2011: 95–98; Boukli–Kotsakis 2023.

Criminology beyond our planet Earth

Astro-Green Criminology is a newborn scientific discipline, built upon numerous endeavours mentioned in the previous sections, all of which recognised that criminology must expand its focus from criminalised activities to also include activities that are non-criminalised, but which are equally or even more harmful. In line with the approach taken by green criminology, it focuses predominantly on environmental harm. In 2019, Takemura Noriyoshi proposed what he called "a new perspective against space capitalism", relying on a premise that the new space economy is indeed the pathway to a new era for humankind, but if done incorrectly, repeating the mistakes human civilisation has made on Earth while subjecting its environment to extreme exploitation and pollution, the longer-term sustainability of our existence will be jeopardised.[27] He proposed the establishment of a new discipline named Astro-Green Criminology, as a necessary research tool for ensuring that space exploration and space exploitation are conducted in an environmentally and ecologically safe and sustainable manner.[28] In the scope of his proposal, Takemura exposes a blind spot in the perspective of space exploration planning and its regulation: the absence of a comprehensive discussion regarding some important preliminary (eco) philosophical questions, such as: What are the legitimate purposes of human space exploration?; Does outer space, including the celestial bodies thereof, have any intrinsic value in and of itself?; Are humans justified in expanding their habitat outside of our initial planet?; What is a just distribution of benefits received from the space exploration?; and so on.[29] Without answering these questions, the lack of philosophical basis for the current legal framework and the actual activities being performed within it will result in both their legitimacy and their sustainability being undermined.

27 Takemura 2019: 8.
28 Takemura 2019: 15.
29 Takemura 2019; elaborated upon by Lampkin 2020: 250.

Building upon Takemura's call for the establishment of a new discipline, one year later Lampkin conceptualised and attempted to legitimise the development of Astro-Green Criminology by demonstrating its capacity to build upon several other theoretical approaches (including ecophilosophy), as well as its ability to shed light on some overlooked concepts related to space exploration.[30] Most importantly, he mapped[31] its terrain of research, focusing on the (environmental) issues, including the problem of space debris in Lower Earth Orbit (LEO), the extraction of minerals and energy resources from extraterrestrial bodies, emissions stemming from launching and operating space objects, the endangerment of heritage sites of cultural significance (such as the 1969 Apollo 11 landing site on the lunar surface), as well as future usages of outer space such as space travel/tourism[32] and space colonisation.[33] He suggests that astro-criminological research should tackle not only law-breaking and criminal actions in outer space, but also harmful activities in a broader sense, as well as the aspect of the victims of space-related crimes and harms.[34] Examples of potential research into space crimes and harms are: research on the power relations of and between subjects engaged in the exploration and use of outer space, unfair competition, the abuse of rights, intent or negligence in the creation of harms, the legitimacy of space operations, the democratic deficit in the regulatory framework of space activities due to the lack of participation of (both global and national) civil society, the philosophical basis for future space operations, the lack of enforcement mechanisms for noncompliance with the law, and many others.

30 Lampkin 2020: 239, 249–251.
31 His mapping could later on be expanded as space activities will progress and as new challenges will probably arise.
32 In this regard, the existing lack of effective and comprehensive space traffic management rules needs to be emphasised.
33 Lampkin 2020: 243.
34 Lampkin 2020: 240.

Addressing the shortcomings of the existing legal framework

The legal framework governing space activities is extremely diverse – consisting of international treaties,[35] customary international rules[36] which are often indicated by widely-accepted UN resolutions and other documents, soft law regulations,[37] policies,[38] national legislation[39] and *sui generis*[40] acts. For many decades, the United Nations Committee on the Peaceful Uses of Outer Space (hereinafter UN COPUOS) has been the leading body in drafting space legislation, following a multilateral process. However, this has changed

[35] The most known treaties governing outer space activities are: the 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (the Outer Space Treaty); the 1968 Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (the Rescue Agreement); the 1972 Convention on International Liability for Damage Caused by Space Objects (the Liability Convention); the Convention on Registration of Objects Launched into Outer Space (Registration Convention). Often, the 1979 Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (Moon Agreement) is listed as one of them, however, it must be noted that due to a very small number of states parties, its relevance has been put to question.

[36] Due to the high number of states parties to it, as well as a strong international support for its preceding resolutions adopted by the United Nations General Assembly, it has been claimed that most, if not all provisions of Outer Space Treaty are to be considered customary international law. See Jakhu–Freeland 2016: 3. Besides that, rules of customary international law can apply by means of Article III of the Outer Space Treaty, as explained in the text below.

[37] By this category I mean an alternative to international binding legal documents (such as the aforementioned treaties) – non-binding legal principles aiming to establish standards and best practices for space activities. These are, for example, recommendations, guidelines and technical standards, adopted by international organisations or other bodies, that are not legally binding but operate on a voluntary basis, such as the Space Debris Mitigation Guidelines (see below). See Byrd 2022: 830–831.

[38] Several states have adopted space policies, setting out the main goals and ambition for the following decades. See, for example, the evolution of the U.S. space policy, as described by Raghuvanshi 2023.

[39] Several states have adopted specific national laws to regulate space activities. For more, see the chapter on national legislation below.

[40] By *sui generis* acts I mean the documents with disputed or unclear legal relevance, such as the Artemis Accords.

in recent years. While in the second half of the last century it was indeed able to reconcile the interests of different states and to lay, on the basis of certain ideological or philosophical considerations, a solid foundation for space law by adopting several legally binding mechanisms, it is failing to do so today for a variety of reasons. A lack or even total absence of important factors such as political will, consensus between states, formal input and discussions with private sector precludes it from adopting new space treaties and amending existing ones, and by limiting its role to creation of soft law mechanisms, this situation put its leadership in the law-making process in jeopardy.[41]

On the other hand, the advent of New Space has seen the emergence of new ways of *sui generis* regulation, sometimes even as a "side-effect" of particular space missions. A good example of the latter is the Artemis Accords, a set of principles aimed at enhancing international cooperation on future lunar activities through a set of bilateral agreements between the United States and other partner nations.[42] Even though in its own terms, the Accords are merely a political commitment, several commentators and critics have warned that their true purpose might be to establish a new interpretation of international space law, favouring commercial and private interests.[43] If that is indeed the case, the Accords would establish a new way of legislating on space, bypassing or even replacing the traditional multilateral law-making process in the UN COPUOS.[44] This could become problematic because of the concern that such agreements, concluded in private negotiations behind closed doors are lacking the type of transparent discussion that can balance different interests, examine power relations and resolve ethical and philosophical dilemmas regarding their content.[45]

41 See Kendall–Brachet 2023; Peter 2021.

42 NASA 2020.

43 Cogan 2023: 133–134; Byrd 2022: 805–806.

44 Nelson 2020: 4–5; Peter 2021.

45 It could be argued that this new way of legislating would be done in a more time-efficient manner when compared to the traditional law-making process. However, there exists a very realistic threat that this would be achieved on the cost of its transparency and legitimacy.

Based on the examination of the current situation, it can be anticipated that private (and other) entities will continue to engage in space activities and strive to go beyond the current technological limitations with or without an effective legal framework.[46] In order to ensure that space activities will be conducted in a sustainable manner despite the challenges brought by New Space, the current legal framework will have to be amended accordingly. Whether this takes place through the traditional route within the UN COPUOS or in some alternative way, in order to ensure sustainability such amendments will have to find a balance between different and even contradictory interests. Furthermore, they will have to be based on a stronger ideological foundation, resulting from a thorough discussion of (eco)philosophical issues connected to such topics as the intrinsic value of outer space, justifications for human expansion of their habitat beyond our home planet, how to ensure a just distribution of benefits received from the space exploration, and others.[47] After such an ideological basis is established, the discussion could move towards more concrete legal questions: How is the concept of sustainability understood amongst multiple players in the field, including both those spacefaring nations with a long tradition of space activity and the states that have only recently joined this category, private actors, non-governmental organisations, and finally, civil society? How should the burden of ensuring sustainability be fairly distributed between them? Which legal areas and legal rules show the greatest potential for ensuring that sustainability is continuously strived for, and what are their current shortcomings?

In the process of answering these questions, Astro-Green Criminology can play an important role. It can provide a research field in which the ideological basis of (eco)philosophy can effectively be translated into law, and can, with its harm-oriented approach, assess the effectiveness of particular legal solutions in mitigating harm.[48] In the following two parts of this chapter, I will highlight some of the shortcomings, caused or enhanced by certain

[46] Byrd 2022: 839–840.

[47] Takemura 2019; elaborated upon by Lampkin 2020: 250.

[48] Lampkin 2020.

New Space trends, of particular legal mechanisms when it comes to ensuring the sustainability of present and future space activities, and demonstrate how the perspective of Astro-Green Criminology can play a concrete role in addressing these weaknesses.

Lack of concretisation and effective implementation of the main principles of international space law enshrined in the Outer Space Treaty

The Outer Space Treaty (OST) laid important foundations for all future documents on space law, as it set out the basic principles governing the activities in outer space. As an international treaty, however, it is only binding on the states that are parties to it, and even though it has been established[49] that most of its provisions represent customary international law and are thus binding upon all states, they are not (yet)[50] directly[51] binding on private actors. Despite the fact that the reach of the OST is for this reason limited, in the following section I will examine some of its provisions which are relevant from the perspective of ensuring the sustainability of space activities. I will

49 Jakhu–Freeland 2016: 3.

50 It has been claimed that private actors are in certain cases subjects to international law; a general consensus has not yet been reached on this view. See Gailhofer–Scherf 2022; Chirwa 2004.

51 It could be argued that private actors are somehow *indirectly* bound by the OST through its Article VI, which provides that states bear international responsibility for national space activities, including the activities of private actors. However, the effect of this provision is currently disputed, as there exist two different interpretations of the nature of the obligation therein. According to the first view, Article VI regulates merely primary obligations of states to supervise and authorise space activities, which are then fulfilled when states follow through with adopting measures establishing authorisation and supervision procedures, but according to a second, stricter view, Article VI represents a *lex specialis* rule to secondary rules of state responsibility, causing a direct attribution of private activities to appropriate states. See Ramuš Cvetkovič 2021: 19–20. It can therefore be concluded for now that the role of states in ensuring that private actors conduct their activities in accordance with the OST will have to be further clarified in the future.

demonstrate that sustainability, despite not being specifically mentioned in the OST, is not completely overlooked by it, as it can be implicitly found in many of its principles, although in order to be fully implemented in practice, it would require concretisation[52] and effective enforcement.

The starting point of this analysis is Article I of the OST, which dictates that outer space must be free for exploration and use by all states without discrimination of any kind, on the basis of equality and in accordance with international law. As established at the very beginning of the OST, this commitment to the freedom of exploration and use of outer space is thus one of the main principles of international space law. It simultaneously consists of two interrelated notions – a right and an obligation. Firstly, states have the right to freely explore and use outer space, and secondly, by doing so, they are also obliged to exercise their freedom in a way that does not impair the freedom of other states, as only in this way can the freedom principle be fully respected.[53] Several authors have identified an intriguing potential link between this freedom and the principle of sustainability, as only by ensuring that space activities are carried out in a sustainable manner can the freedom to further explore and use outer space be preserved.[54] Unsustainable practices, such as those which cause significant environmental harm that is difficult or impossible to undo, may thus pose a violation to Article I.

The first shortcoming of this freedom, however, is that the obligation not to impair the freedom of other states is not ensured by a direct enforcement mechanism.[55] The reason for this is not only the general absence of effective

[52] Some of the terms in the OST can be concretised in the process of their interpretation in accordance with the Vienna Convention on the Law of Treaties (VCLT). However, I argue here that while such a process is indeed extremely helpful for providing some clarity on some of the principles enshrined in the OST, especially when *ex post* assessing whether certain activity was in compliance with the OST, it is difficult to expect that one would rely solely on interpretation in *ex ante* planning of their activities. This is why more concrete rules need to be adopted, in order to guide the activities in the right direction from the start.

[53] See De Man – Munters 2018. See also Aganaba-Jeanty 2016: 5; Doucet 2019: 145.

[54] Palmroth et al. 2021.

[55] Doucet 2019: 145.

enforcement mechanisms of international law,[56] but also that no concrete threshold is provided for determining what kind of harmful effect constitutes an impairment of this freedom, and therefore what kind of activities (if any) are inconsistent with it.[57] It would be reasonable to suggest that this dilemma might be resolved by applying other principles of international law, such as the principle of proportionality. While Article III of the OST states that States "shall carry on activities in the exploration and use of outer space, including the moon and other celestial bodies, in accordance with international law", it remains a matter of dispute whether this means the application of international law in toto or merely the application of certain international principles that are in line with the legal regime and the nature of outer space.[58] Therefore, it is not entirely clear which principles and rules of international law can actually bring about the concretisation of Article I of the OST.

However, Article I needs to be read together with the rest of the OST. In this regard, Article IX of the OST carries important weight, as it provides guidance on certain limitations on space activities that are necessary in order to preserve the freedom enshrined in Article I.[59] Namely, Article IX stipulates that when conducting exploration of outer space, states must act so as to avoid its harmful contamination or the occurrence of adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial

56 For more about difficulties of enforcement of international law see KATSELLI PROUKAKI 2009.

57 It is not clear whether activities that may produce excessive amount of space debris, such as megaconstellations or ASAT tests have already reached the threshold of violation of Article I. Larsen argues that it can be deduced from the language of Article I that the use of outer space must be conducted in a way that enables continuous scientific exploration aimed at a better understanding of the universe. LARSEN 2021: 547. Based on his argument a claim could be made that the minimum threshold for the activity to be in compliance with Article I is that it does not impair scientific exploration.

58 RIBBELINK 2009: 67.

59 Gupta and Agasti claim that the purpose of Article IX is primarily to ensure the free exploration of outer space for all countries. GUPTA–AGASTI 2022: 10–11.

matter. Moreover, it obliges states to conduct international consultations in cases when they have reason to believe that an activity or experiment planned by them or their nationals in outer space would cause potentially 'harmful interference' with the activities of other states in the peaceful exploration and use of outer space. By addressing this threat, Article IX contributes to defining the threshold of potentially unlawful harm, by introducing the terms "harmful contamination" of outer space, "adverse changes in the environment of the Earth" due to contamination from outer space and "harmful interference" with other space activities. The shortcoming, however, is that these terms are not further concretised and thus remain open for interpretation.

It is disputed whether certain activities resulting in environmental harm, such as space object collisions, ASAT tests, or the mining of space resources are or would be considered a violation of these principles.[60] In order to establish that a certain activity is not in compliance with Articles I or IX of the OST, its scope and content needs to be clearly defined, including the threshold of harm required to be reached in order to be marked as a breach. While some significant efforts[61] have already been made to find more concrete definitions, and those efforts are extremely welcome and important, such an approach is not the only way. And since it can be reasonably estimated, based on the difficulties in the law-making process in UN COPUOS, that these efforts are not likely to soon be translated into binding international legal rules, ways of seeking alternative approaches to ensuring sustainability are needed.

For that reason, an alternative, harm-oriented perspective, of the kind provided by Astro-Green Criminology could be valuable, as it would move beyond asking the question "what kind of harm is required for an activity to

60 See, for example, articles elaborating upon the issue of whether ASAT tests are prohibited under the current legal framework, such as Strobeyko 2019; Koplow 2009.

61 Including, but definitely not limited to, Pershing 2019; Listner 2022; Cheney et al. 2020.

be considered legally relevant[62] or unlawful?"[63] to instead asking "what kind of unlawfulness should be ascribed to the perpetrated harm?".[64] Astro-green criminological research would investigate what kind of legal responses are appropriate for the level of harm caused by a particular activity – administrative sanction, international responsibility or civil liability – and whether that level of harm indicates that the activity should be criminalised or defined as unlawful in another way. Furthermore, through the use of the methodology of criminological research, an evaluation of the effectiveness of such individual legal responses and sanctions could be conducted. Astro-Green Criminology can thus be seen as a bridge between factual evaluation and legal regulation, and it could contribute to determining the most appropriate direction of legal regulation. Lastly, it can also be applied inside the legal discipline, as it can help to define the level of threshold needed for proving that there has been a violation of Articles I or IX of the OST.

Another important provision of the OST contributing to ensuring the sustainability of outer space exploration and use is Article II, which prohibits national appropriation of outer space, including the Moon and other celestial bodies, by claims of sovereignty, by means of use or occupation, or by any other means. Several states have claimed that the prohibition of appropriation does

[62] By 'legally relevant' harm I mean harm that is able to provoke some kind of legal consequences. An example of this would be determining, for example, whether a certain harm falls under the definition of "damage" recoverable under the Liability Convention [Article I(a) defines damage as "loss of life, personal injury or other impairment of health; or loss of or damage to property of States or of persons, natural or juridical, or property of international intergovernmental organizations"]. As can be observed, many examples of environmental harm, not directly resulting in aforementioned cases of damage, fall out of its scope.

[63] By 'unlawful' harm I mean harm that is legally obliged to be prevented or avoided, such as 'harmful contamination' mentioned in Article IX of the OST, or 'significant harm' threshold as defined by case law regarding customary no harm principle.

[64] Here, the word 'harm' is to be understood outside of the existing legal definitions. This does not mean that the two categories will not sometimes overlap – ideally, they should overlap to a great extent, but it predominantly means introducing to the research a broader category of harm, not limited by currently established legal thresholds.

not extend to space resources, but only concerns territorial claims, and have thus, based on such argumentation, decided to adopt legislation allowing their private companies to extract and appropriate the resources mined in outer space.[65] The Artemis Accords, a recent document issued for the purposes of the NASA-led Artemis space mission, even contain a provision stating that the extraction of space resources does not inherently constitute national appropriation under Article II.[66] These facts suggest that despite the prohibition of national appropriation contained in Article II of the OST, certain activities aimed at extraction and the consequent appropriation of space resources could occur in the future. Many experts, however, have warned that such activities could potentially produce harmful effects.[67] From the perspective of sustainability, more detailed regulation, especially on an international level, is needed.[68]

Before such legislation can be prepared, however, a consensus regarding the legitimacy of such activities needs to be reached. This can be achieved through the formulation of an ideological basis built upon the discussion about the question of whether and to what extent humankind can interfere in outer space and which aspects should be protected and preserved for future generations or life beyond planet Earth. This is a question of ethics and could be discussed within the scope of (eco)philosophy. Astro-Green Criminology can build on that discussion and, based on its conclusions, could evaluate whether an extraction of space resources would represent environmental harm beyond an acceptable level, or in other words, it can help to determine what kind of extraction of resources (if any) can be deemed sustainable. On that basis, it can

65 The states which currently have in place such legislation are: the USA (see U.S. Commercial Space Launch Competitiveness Act), Luxembourg (see Law of 20 July 2017 on the exploration and use of space resources), Japan (see Act 83 of 2021 on the Promotion of Business Activities for the Exploration and Development of Space Resources) and the United Arab Emirates (see their Federal Law No. 12 of 2019). For more on the argumentation regarding the complexity of such actions with Article II of the OST see Wrench 2019: 440–444; Fecht 2015.

66 NASA 2020: Section 10.

67 De Zwart et al. 2023: 156; Xu 2020.

68 Hofmann–Bergamasco 2020: 6.

suggest paths forward for more concrete legal regulation, containing specific safeguards aimed at ensuring the sustainability of space activities and preventing limitless extraction according to the "first come, first serve" principle.

Even though the OST is binding on its states parties, and by means of its customary nature also on other states, it also has a certain relevance for the activities of non-state actors. Article VI of the OST dictates that states bear international responsibility for all national activities in outer space, whether such activities are carried out by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the OST. Furthermore, it stipulates that the activities of non-governmental entities in outer space require authorisation and continuing supervision by the appropriate state. One way of implementing this obligation by the states is to draft and adopt appropriate national legislation to establish the procedures for the authorisation and continuous supervision of private space activities. Some states parties have already done this, but many have not.

States may often, however, find themselves in a difficult situation where they are forced to find a fine balance between different and often contradicting interests. Namely, on the one hand, they need to fulfil certain requirements stemming from the OST and other sources of law binding upon them, including rules aimed at the prevention of environmental harm and the protection of the long-term sustainability of space activities, while on the other hand they are responsible for safeguarding their own economy, which means protecting its ability to attract foreign investments and ensuring the competitiveness of their private actors in the global space sector.[69] Astro-Green Criminology can enable research aimed at identifying and evaluating the power relations of various stakeholders, as well as determining the level of unacceptable environmental harm and the level of diligence required when handling certain space activities that should not be overridden by private interests.

Article VII of the OST and the subsequent international Liability Convention (LIAB) establish that launching states are liable for certain damages

69 See, for example, LINDEN 2016.

caused by their space objects. Articles II and III of the LIAB determine further that liability is absolute if the damage is caused on Earth or to an aircraft in flight, and that it is fault-based if the damage is caused in outer space. Despite the wide acceptance of these provisions, they have not been widely applied in practice. First, there are frequently factual difficulties in proving which space object (or a part thereof) was the one causing the damage, and consequently causality cannot be established.[70] There are numerous pieces of space debris in lower Earth orbit, many of which are smaller than 1 cm. Second, neither Article VII of the OST nor the LIAB prescribe any guidance on how to establish fault, leaving the determination of this to an interpretation of a due diligence standard in accordance with several technical guidelines and other documents.[71]

Regarding liability, Astro-Green Criminology can offer an additional perspective on the aspects of fault, namely, intent, negligence and the lack of due diligence regarding the harmful damage caused by a space object. Based on such analysis, it can evaluate which level of fault would need to be criminalised or which is already sufficient to invoke a legal response.

Difficulties in enforcement of soft law mechanisms

Despite the existence of several soft law mechanisms aimed at ensuring the sustainability of space activities, the most relevant for the topic at hand are the UN COPUOS Guidelines for the Long-term Sustainability of Outer Space Activities (hereinafter: LTS Guidelines).[72] The Working Group tasked with drafting these guidelines has built on existing initiatives and the work of other bodies, in order to bring them together and provide a consolidated set of voluntary best practice guidelines that could be applied by all relevant stakeholders, from States to private sector entities, in order to enhance the long-term sustainability of human activities in outer space.[73] The LTS guidelines

70 Lampertius 1992: 448, 445; Dennerley 2018: 284; Pedrazzi 2008.
71 Dennerley 2018: 291–301.
72 UNOOSA 2021.
73 Martinez 2021: 99.

recognise that the proliferation of space debris, the complexity of space operations and the emergence of large satellite constellations are posing a threat to sustainability. In this sense these guidelines go further than the aforementioned OST principles, as instead of abstract formulations the guidelines recognise concrete risks that have emerged in recent years. Accordingly, the guidelines call for the adoption, revision and amendment of national regulatory frameworks adopted under the obligations set out in Article VI of the OST, with the aim of listing sustainability as one of the primary goals of space legislation (see guideline A.1). Particular emphasis is given to the aim of minimising the impacts of human activities on Earth as well as on the outer space environment (see guideline A.2). The LTS Guidelines reaffirm some previously existing soft law documents, such as the ISO technical standard and the Space Debris Mitigation Guidelines (hereinafter: SDMG)[74] (see, for example, guidelines A.2 and B.7).

The SDMG is another soft law mechanism of great importance for sustainability. Recognising the dangers posed to environment, human life and property by the increasing amount of space debris, they aimed to limit the quantity of debris released through normal operations (see guideline 1), minimising the potential risk of break-ups (see guideline 2), limiting the chances of accidental collisions in orbit (see guideline 3), avoiding the intentional destruction of space objects and other harmful activities (guideline 4), etc. Moreover, the SMDG is not the only initiative aimed at minimising debris. The most recent document addressing this problem was issued by the European Space Agency (ESA). Entitled *Zero Debris Charter,* the document aims at strengthening the endeavours of the ESA member states to stop generating space debris by 2030, by recommending actions such as the avoidance of the intentional generation of space debris, the anticipation and mitigation of its adverse impacts, and others.[75]

However, the reach of these soft law mechanisms is limited. The main problem with them is the lack of enforcement, as they often specifically state that they do not create any new legal obligations on states, or the language used contains non-obligatory terms such as *inviting, welcoming* and *encouraging* the

[74] UNOOSA 2010.
[75] ESA 2023.

implementation of the content. This means that not only do space actors lack the equal capability to implement them, but there is also no explicit requirement for their implementation, as compliance with such mechanisms is voluntary.[76] Nevertheless, they might gain a legally binding character when incorporated into national legislations (see the next sub-section).[77]

The main importance of soft law mechanisms is thus the concretisation of existing legal principles and the acknowledgement of certain issues stemming from the emergence of New Space. However, these mechanisms alone cannot be the overreaching solution, and they need to be translated into more concrete, directly enforceable legal rules. This is another example of an area where Astro-Green Criminology could play an important role. By shifting the focus from the study of unlawfulness to the study of harmfulness, it decreases the significance of the fact that these guidelines do not have direct binding legal effect. Instead, the focus shifts to their content, which is oriented towards harm prevention. Demonstrating the value of such guidelines in ensuring sustainability, Astro-Green Criminology can thus provide arguments for increasing their legal value – either through transposing them into national legislation or adopting a binding international treaty of such content.

Lack, incoherency and broadness of national legislation

An important part of the legal framework governing space activities is national legislation of space-active states, by means of which states carry out and concretise their obligations under the OST and other international treaties, as well as implementing certain soft law mechanisms. However, it must be noted that not all of them have actually done so in practice. There are approximately 70 space-active states, and of those only slightly over half have put in place some kind of national legislation on space activities.[78] The first shortcoming of the legal framework on a national level is the absence of space legislation in

[76] Martinez 2021: 103.
[77] Martinez 2021: 102.
[78] See HDI Global 2022; UNOOSA 2023.

a significant number of space-active states. Several differences can be observed between the existing national laws of space-active states, despite the existence of a Model Law on national space legislation issued by the International Law Association (ILA), which includes standardised provisions regarding the authorisation and supervision of national space activities, including those conducted by private actors, the operation, transfer and termination of such activities, compensation for damages, environmental[79] protection, etc.[80]

Very few national laws make direct reference to sustainability. Some of them list environmental protection as a condition for receiving a licence (for example Australia,[81] Austria,[82] Belgium,[83] Denmark,[84] Finland,[85] Slovenia,[86] the USA[87] and several others) or a reason for its withdrawal (Luxembourg[88]) or refer to

79 Article 4 of the ILA Model Law states that one of the conditions for authorisation is that the activity does not cause environmental damage to the Earth and to outer space, and that it is carried out in such a way as to mitigate to the greatest possible extent any potential space debris. Furthermore, the obligation to conduct environmental impact assessment is enshrined in its Article 7.

80 Hobe 2013.

81 Article 18 of the Space Activities Act 1998, No. 123, 1998 (as amended, taking into account amendments up to Act No. 8 of 2010) (Australia).

82 Article 4 of the Federal Law on the Authorisation of Space Activities and the Establishment of a National Registry (Outer Space Act), BGBl. I No. 132/2011 (Austria).

83 See Article 5 of the Law of 17 September 2005 on the Activities of Launching, Flight Operation or Guidance of Space Objects (consolidated text as revised by the Law of 1 December 2013 [B.O.J. of 15 January 2014]) and then the Royal Decree implementing certain provisions of the Law of 17 September 2005 on the activities of the launching, flight operations and guidance of space objects form the legal basis of the regulation of space activities (Belgium).

84 Part 3 of the Outer Space Act (Act 409 of 11 May 2016) (Denmark).

85 Section 5 of the Act on Space Activities (63/2018) (Finland).

86 Articles 4 and 5 of the Space Activities Act, Official Gazette of the Republic of Slovenia, 43/22 (Slovenia).

87 Title 51 Section 4(3)(a) of the U.S. Commercial Space Launch Competitiveness Act 2015 (Public Law No. 114-90) (USA). This Act also dictates that environmental impacts of launch activities must furthermore be considered as mandated by the specifically referenced National Environmental Policy Act (NEPA) (see Title 14, Chapter III, Parts 415.31 and 415.33).

88 Article 9 of the Law of 15 December 2020 relating to space activities (Luxembourg).

the environmental aspect in some other way (for example Kazakhstan[89] or the U.K.[90]), but most of them do not mention environmental aspects explicitly. It can be observed from this that legislations differ significantly in how and to what extent they follow and transpose non-binding soft law guidelines. Some states decide to transpose the international documents in their entirety, as for example Austria[91] and Slovenia,[92] which transposed SDMG into their laws, thereby according a legally binding nature to their provisions.

The uncoordinated and unharmonised national legislative approaches, resulting in varying national legislative frameworks, may become problematic for the long-term safety and sustainability of space activities. More specifically, if some of these national frameworks will be more beneficial to private actors (for example by setting fewer requirements for the granting and continuation of authorisation), there will be strong incentive for private entities to move to that jurisdiction *(forum shopping).*[93] In order to protect their economies, other states will be pressured to lower their standards to match that regime, and that wish to obtain such short-term benefits could result in a spiralling "race to the

89 See the Law of the Republic of Kazakhstan on Space Activities, 6 January 2012 No. 528-IV (Kazakhstan). Article 3 mentions a principle of compensation for damage done to the environment, while Article 27 is concerned with the safety of space activities.

90 The Secretary of State *may* consider the environmental aspect when deciding upon a licence authorising a space activity. See Article 5 of the Outer Space Act of 1968 (UK).

91 See Article 5 of the Federal Law on the Authorisation of Space Activities and the Establishment of a National Registry (Outer Space Act), BGBl. I No. 132/2011 (Austria), which demands compliance with "state of the art and in due consideration of the internationally recognised guidelines for the mitigation of space debris".

92 Article 5 of the Space Activities Act, Official Gazette of the Republic of Slovenia, 43/22 (Slovenia) states that space activities must "envisage measures for limiting the generation of space debris in accordance with the applicable UN Space Debris Mitigation Guidelines and for limiting adverse environmental effects on Earth or in outer space or adverse changes in the atmosphere".

93 Doucet 2019: 145.

bottom"[94] in which sustainability will draw the shortest straw.[95] The role of Astro-Green Criminology would be to point out such potentially dangerous trends, and to expose certain unsustainable practices. Criminological research and its methodology could provide important insights into whether states effectively exercise their obligation to authorise and supervise space activities, and whether this is done indiscriminately and impartially, and in a detailed and comprehensive way. This is especially important, as it has already been observed that the denial of social harm is a very frequent occurrence, and part of a wider culture perpetuating harm, using techniques such as "state–corporate gaslighting" – a tactic by which state authorities and corporate representatives deny the existence of pollution produced by a particular activity and its harmful effect on humans and/or environment.[96]

National laws provide for various sets of sanctions for violations of their provisions. Most of these take the form of monetary sanctions, usually a monetary fine defined on the basis of the type of offence as well as considering whether a perpetrator is a natural or a legal person.[97] Some of them include the option of a prison sentence, usually up to 1 year of imprisonment, sometimes more.[98] Research in the field of Astro-Green Criminology can examine the effectiveness of various sanctions, suggesting further improvements in the area. In particular, by deploying criminological methods, it can use various avenues

[94] It must be noted that Article VI of the OST could play an important role in mitigating this effect, as the direct responsibility of states for the conduct of their private actors could motivate states to adopt stricter regulation. However, since it is not clear whether Article VI of the OST in fact entails the direct attributability (and thus responsibility) of the conduct of private actors to the relevant states (see Gailhofer–Scherf 2022; Chirwa 2004), such lack of clarity regarding the nature of Article VI can negatively affect the aforementioned motivation of states.

[95] Doucet 2019: 145.

[96] Boukli–Kotsakis 2023.

[97] See, for example, Article 19 of the Law of 17 September 2005 on the Activities of Launching, Flight Operation or Guidance of Space Objects (consolidated text as revised by the Law of 1 December 2013 (B.O.J. of 15 January 2014) (Belgium).

[98] Article 14 of the Law of 15 December, 2020 relating to space activities (Luxembourg), for example, sets the limit for imprisonment sanction up to 5 years.

to analyse the effectiveness of sanctions from the perspective of the offender (this is a penological perspective, evaluating the effectiveness of different approaches, such as liability, monetary fine, prison sentence, etc.), as well as from the perspective of the victim (victimological perspective, evaluating the promptness and the appropriateness of the compensation received).

Lastly, the problems arising in the wake of New Space will also require new ways of legitimising space activities. As sustainability is surely an important part thereof, other methods will need to be deployed in this area. Anglada-Escudé, for example, strongly advocates more civic participation through greater inclusion of various social stakeholders, such as civil society representatives, as well as the broader public.[99] Astro-Green Criminology can examine whether the legal frameworks created enjoy democratic legitimacy amongst the population.

CONCLUSION: THE ROLE OF ASTRO-GREEN CRIMINOLOGY IN FUTURE REGULATION OF SPACE ACTIVITIES

The brief legal analysis of space law conducted in this Chapter, which is not in any way conclusive and overreaching, but rather demonstrative, has exposed numerous shortcomings which are making space law in a large part ineffective in the face of the rapid proliferation of challenges arising from New Space. This is the reality of the situation, and this reality demands that we start looking for additional new ways and perspectives of tackling this issue.

In this endeavour, Astro-Green Criminology can play a significant role by shifting the perspective from a strict legal analysis, focused on 'what is compliant with the existing legal framework and what is not?', towards asking 'what is harmful and how should it therefore be appropriately regulated?'. In that way, starting from the bottom up (from the factual analysis to the creation of legal framework), the examination of harms can be conducted without being subject to the limitations inherent to the examination of the legal framework. In other

99 Anglada-Escudé 2022: 1360.

words – an examination of harm can be conducted thoroughly, without first having to prove that such harm indeed reaches the threshold which is required for it to be considered 'unlawful'. This does not mean that the analysis of harm is separated from the analysis of the applicable legal framework. On the contrary, identifying deviant behaviours that are harmful, but which are not yet criminalised or otherwise legally regulated, can serve as an important basis both for the modification of existing law and for the creation of future political and legal responses.

Furthermore, Astro-Green Criminology could provide an important forum for further discussions regarding the future of space law, as the shortcomings of the current legal systems are not purely issues of law, but are the product of an ideological background and lack thereof, as well as a result of numerous relations of power and interests, and must be regarded and examined as such. This means exposing the complex power relations between space players and the legislator, including the conflicts of interest that may exist within the law-making processes.

Moreover, building upon the findings of (eco)philosophy, criminological research can provide answers to the necessary preliminary questions of why and how space exploration should be conducted, and thus begin to address the striking absence of a concrete theoretical and ethical background in current and especially in planned space activities, such as space tourism, space mining and space colonisation.

The criminological analysis of harm can pave the way towards better and possibly stricter legal regulation of space. This entails not only international law, but also national administrative proceedings, liability claims, and, in some cases, also criminal law. Astro-Green Criminology can deploy the methodology used in criminological research to assess the effectiveness of these legal approaches. A comprehensive legal framework with effective sanctioning ability is the only way to ensure that space activities are carried out in a sustainable manner. Previously, most of the regulatory framework of space law, especially the documents adopted in the first thirty years of the space activities, was not drafted with sustainability in mind. Sustainability was often merely an afterthought in both space exploration and the development of space legislation.[100] The current situation, however, with the increasingly overcrowded Lower Earth Orbit (LEO), the enormous amount of space pollution and the growing number of space players and planned missions, demands a shift in perspective towards a more sustainable way of law-making.

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[100] DHOPADE et al. 2023.

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Diána Daczi

Megaconstellations: Crowded, Contentious and Competitive

INTRODUCTION

The rise of megaconstellations has set a new precedent in orbital congestion, simply as a result of the increased number of satellites involved. According to the United Nations Office for Outer Space Affairs, since the launch of Sputnik 1, 17,263 objects have been launched into space,[1] of which 11,330[2] individual satellites were orbiting the Earth at the end of June 2023, representing a 37.94% increase since January 2022. Although we have become accustomed to the novelties of space communication, until now it was characterised by a steady development. Now, however, its pace has changed: until 2020 only 10,308 were launched, but the last 3 years has seen a further 6,995 objects launched, which means 40.29% of all objects in this period. Most of these objects are communication satellites, which are deployed in increasingly connected systems in low Earth orbit (LEO).

Although the rapid development of the LEO constellation has contributed to numerous human activities, such as communication, navigation, remote sensing, the deployment of these constellations has strained not only the limited natural resource of frequencies, but also the scarce resource of orbits. The deployment of these constellations is an issue of regulation and meticulous planning.

International discussions are ongoing on space debris and space traffic management, but less is known about the other thorny problem raised by these constellations: interference. The LEO constellations possess the characteristics

[1] Our World in Data s. a.

[2] Pixalytics 2023.

DOI: https://doi.org/10.36250/01208_13

of other, better known geostationary satellite constellations, including a wide range of distribution and an enormous scale. While the development of these constellations is bringing revolutionary changes to the progress of the global space industry, the problem with these satellites takes us back to the basics of telecommunication: not to cause harmful interference to another radio system.

The problem of interference is not specific to satellites, it is omnipresent in every radio system, although satellites might suffer more from such disturbance, whether intentional or not. The electromagnetic field provides two windows to Space or from Space to Earth: one is light, the other radio waves. Only a certain length of radio waves can pierce through the atmosphere of the Earth: from 2 GHz to 40 GHz, which means that only this rather narrow bandwidth facilitates the communication between all satellites and other human made space objects (i.e. space probes, rockets) and the Earth or indeed the Universe.

Before investigating the problems of LEO satellites, it is important to understand the international mechanisms that allow the peaceful coexistence of different systems: the international frequency coordination of the International Telecommunications Union (ITU).[3]

WHAT IS FREQUENCY COORDINATION?

Frequency coordination is a procedure carried out by operators via their respective administrations to avoid potential harmful interference between new and existing wireless systems, stations or applications. The procedure is applicable to all radio systems, providing there is a possibility of an impact that extends beyond national borders. Article IX of the Outer Space Treaty[4] requires international consultations in cases when potential outer space activities or an experiment planned by a State or its nationals might cause harmful

[3] The International Telecommunication Union (ITU) website: https://www.itu.int.

[4] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, 1967.

interference. It should also be noted that the ITU coordination procedures for objects launched into space preceded the Outer Space Treaty, as these procedures were introduced as early as 1963.

The purpose of the coordination:

a) enabling the effective operation of existing radio stations or systems, as well as any new stations or systems
b) the recognition of this new station or system, i.e. protection against harmful interference of stations or systems to be installed in the future

Since the beginning of the space age, the ITU has identified the needs of the space sector and from 1959 onwards it has provided the spectrum requirements for the growing space industry. The ITU is a specialised agency in the UN system, consisting of representatives of the signatory Member States along with representatives of academia and private sector, thus provides a synergistic approach to the studies and proposals which are discussed and adopted in various forums.

It is universally acknowledged that the most elaborate and detailed form of the regulation of space activities concerns space communication. As part of telecommunication, space communication is regulated within the framework of the International Telecommunications Union (ITU). The most important document in this field is the Radio Regulation,[5] an international treaty governing, among other matters, the use of the radio spectrum, the procedures for obtaining access to spectrum and orbit resources, and the recording of these in the Master International Frequency Register – MIFR).[6] The aim of this legal framework is to govern the allocation of these resources among potential users, the provision coordination mechanisms among users to avoid conflict, and the protection of orbital resources from detrimental activities.

It is important to note that Member States are represented in these procedures by their appointed national administrations, which may be either

[5] *Radio Regulations* 2020.
[6] *Rules of Procedure* 2021.

a ministry, a government department or a national regulator, which is armed with all the instruments necessary for implementing the obligations set out in the ITU documents.

The orbital position of a satellite determines the area where its signals reach the Earth and affects the technological possibilities of the satellite service. Until the second half of the 2000s, satellites operated mostly in a geostationary orbit, an altitude of approximately 35,800 km in the plane of the equator. At this altitude, each satellite rotates around the Earth's axis once every 24 hours and thus appears to remain stationary above a fixed point on the Earth. This remains the scarcest orbital resource.

From the 2000s onwards, however, technological developments have brought a new era for satellites, enabling communications satellites to operate from low Earth orbit. This orbit – which is between 500 and 2,000 km altitude from the Earth – provides low latency by the use of smaller communication satellites. However, from this orbit the coverage of each satellite is limited, so a network of several satellites or "constellation" is needed to ensure continuous service.

Deploying satellites into orbit represents a limitation, since it is only possible to obtain the right to use satellite positions and the associated frequencies within the institutional framework defined by an international convention – in favour of the requesting state. The state transfers this right to an organisation or company if it is entitled to it through its own national licensing procedures. By launching the satellite, this organisation or company performs space activities, which may be implemented under continuing state supervision in accordance with Article VI of the Outer Space Treaty.

Temporary use of the spectrum is implied by the deployment of the satellites into orbit, i.e. for a period equal to the life of the satellite – either on the basis of *a priori* plans or within the framework of a coordination procedure aimed at the international negotiation of frequency use, with the state that initiated the procedure receiving the right to use the given orbit and the orbit being granted to an organisation or a company – mostly an entity under the state's jurisdiction – by the national authority. The procedure is carried out by the ITU together with the communications administrations of the countries concerned. The satellite systems included in the *a priori* plans are the positions in the geostationary orbit assigned to each country and the corresponding frequencies, which can only be owned by the given state. These states can send a satellite to that position at their discretion, either by means of their own (national) operators or leased to an operator registered to another country.

As noted earlier, frequency and satellite orbits are precious, scarce and limited natural resources, which led to two major mechanisms being developed and implemented for sharing orbital and frequency resources:

a) *a priori* planning procedures
b) the first come, first served coordination procedures

The BSS (Broadcast Satellite)[7] and FSS (Fixed Satellite) Plans[8] were created to prevent the depletion of satellite positions. These plans provide each country with an opportunity in a specific frequency range to implement a satellite service covering the country in the future without having to ask for the consent of other countries. The planned frequency bands are those which countries can use for their own satellites. The problem with these plans is that they focus on satellites in geostationary orbit, since they were developed in the 1980s and based on the technology of that time.

The rest of the satellite orbits – orbital slots or planes – are allocated by coordination procedures, where latecomers have to consider the requirements of the first filed satellite network. The coordination procedure is a mandatory process of negotiation between national administrations and the ITU. The goal is to achieve the most efficient use of the orbit and spectrum resources through a controlled interference environment in which satellite networks can operate and meet requirements that include the provision of GSO networks in all services and frequency bands and non-GSO networks in certain frequency bands.

Although satellite frequencies are allocated globally, differences exist in the three regions of the ITU concerning frequency allocation. Article IV Section 5 of the Radio Regulations contains the frequency allocation table, which defines

7 *Radio Regulations* 2020: Appendix 30.
8 *Radio Regulations* 2020: Appendix 30B.

for each frequency band which radiocommunication services are allocated for which purpose in all three ITU regions. (For the purpose of radio frequency allocation, point 5.2 of the Radio Regulations divides the World into three regions: Region I: Europe, Africa and Russia; Region II: the Americas; and Region III: Iran, Pakistan, India, China and East Asia, Australia, New Zealand and the Pacific Islands south of the Equator.) While the ITU member states may differ in their own frequency allocation tables from those contained in the table of the International Radio Regulations, they may not thereby cause harmful interference to another ITU member state, which applies the allocation according to the Radio Regulations.

The Radio Regulations define the uses of individual frequency bands that receive international recognition. Within each frequency band, radio telecommunications services are divided into 'primary' and 'secondary', either globally or regionally. By definition, stations falling in the secondary service category may not cause harmful interference to existing or future stations of the primary service, and may not claim protection against harmful interference caused by these stations (Radio Regulations, Article 5.30).

The Radio Regulations specifies procedures by which a satellite network's frequency assignments can be registered and submitted by its national administration, and hence to the ITU to obtain international recognition of the radio system. Through these procedures all national administrations belonging to the ITU are informed of the use of the frequency assignments, while ensuring that they are taken into account in any future planning conducted at the national, regional or international level. Importantly, ITU registers the frequency assignments of a radio system along with the position of the station – whether it is terrestrial or satellite/space station – and provides information to the administrations affected by the service area.

It is also important to note that the ITU does not authorise the use of frequencies, but registers the allocated frequencies and the associated satellite orbits in order to avoid interference, the authorisation of frequency use and the supervision of the service provider are the responsibility of the national authorities, mostly the national administrations.

The powers of the national authorities vary, but they are uniform in that they regulate the method of awarding the right to use frequencies based on technical aspects, which can range from an individual licence to auctions (tender or concession).[9] The states have devices corresponding to their own legal system regarding each frequency, which is typically state property (in some cases the property of the king or queen), while the allocation of satellite orbits also follows a similar principle, although all states prioritise uninterrupted cooperation during use. Most spacefaring countries opted for individual licences on the principle "first come, first served", as in the U.S., the U.K., Luxembourg or France, while Brazil and Mexico use auctions to award licences.

WHAT IS THE PROBLEM WITH MEGACONSTELLATIONS? INTERFERENCE, OVERFILING, RADIO ASTRONOMY

A major source of potential problems for current satellite systems is that the radio spectrum the LEO constellations wish to use is already in use by existing geostationary (GEO) satellites. Consequently, a situation may arise in which a constellation of satellites orbiting the Earth in low Earth orbit (LEO) fly through the beam of a GEO satellite and the transmission occurs on the same frequency, thus causing interference to users on the ground underneath. Considering the shape of the Earth, this is only an issue when the LEO satellites are relatively close to the equator. Nevertheless, LEO satellites are in inclined orbits and thus cross the equator twice on each orbit, and the orbit period, mainly depending on the altitude, varies in the range of 90–120 minutes, so this remains a problem.[10] In addition, most of the LEO – and also high Earth orbit (HEO) – constellations consist of 3 to 5 satellites using the same orbital plane, so interference can potentially occur more frequently.

However, existing GEO systems are not the only potential sources of radio frequency contention. As the number of megaconstellation satellites grows,

9 Nordicity 2010.

10 Eves 2021.

there is an increasing probability that they will interfere with each other. It should be reasonably clear that, even from LEO, hundreds or even thousands of satellites are not needed simply to provide users with a line of sight to a satellite. The reason why the megaconstellations are so large is that each satellite is only designed to provide services in a relatively small region immediately beneath its ground track. The sizes of these satellites' service areas (footprints) also dictate the range of angles in which the user terminals must operate in order to maintain contact with the constellation. Table 1 shows the largest satellite constellations – operating (first figure) or filed (second figure) – with their altitude and the frequency band used.

Table 1

The largest satellite constellations

Name	Number of satellites	Orbital altitude	Band
Starlink	5,399/42,000	340, 550–570 km	Ku, Ka, E
OneWeb	636/648	1,200 km	Ku
Telesat Canada	3/198	1,000 km	Ka
Swarm	189/150	500–550 km	VHF, UHF
Kuiper	2/3,236	590–630 km	Ka
Guowang (China)	0/12,992	150–300 km	Q, V, Ka
Cinnamon (Rwanda)	0/337,320	500–700 km	Ku, Ka

Source: Compiled by the author.

The sheer number of these constellations creates serious safety and long-term sustainability challenges to the use of low Earth orbit. According to the ITU's database, permits for more than 300 constellations representing over one million satellites were filed between 1 January 2017 and 31 December 2022. Among these 300 constellations, more than 90 comprise over 1,000 satellites each, with the largest single filing, Cinnamon-937 involving 337,320 satellites.[11] Congestion in LEO orbit might lead to the potential collision of the satellites

11 FALLE et al. 2023: 150–152.

of the various systems, which may cause a significant increase of space debris. As approximately 89% of the active satellites are located in LEO,[12] and the majority operate at orbits lower than 1,000 km, there is a high probability of collision. Nevertheless, the details of the problems of space debris or space sustainability are not the topic of this paper.

It is likely, however, that these constellations may not be launched, or at least not as they are planned. There are many reasons why satellite projects may not come to realisation. Apart from funding problems, development and planning issues and the lack of governmental support are the major ones. Filings to the ITU can also be a calculated move on the part of companies or governments, either to attract investors or to later be able to sell orbital rights, or simply "spectrum warehousing", in order to use these permits later if customer demand increases. Overfiling is a recognised problem, and the space industry has already developed practices to provide spectrum warehousing by splitting their satellite constellations between multiple administrations and multiple filings. For example, SpaceX's Starlink Gen2 constellation was submitted across approximately 22 filings, by three administrations – Norway, Germany, the United States and recently Tonga.[13]

Since different nations have different approaches to and regulations for ITU filings, naturally, the companies prefer to consider all the factors that could provide them with a favourable regulatory environment, in a similar way to flag of convenience in the maritime sphere. Small nations provide registration as required by international law, but their national law includes the bare minimum and is hardly ever enforced, while, as ITU Member States, the accessibility of the ITU's processes for securing radio frequency spectrum offers nations a way into the fast-growing high-tech sector. To counteract overfiling, administrative measures were adopted at the ITU's World Radio Conferences during the last 25 years. To reduce speculative filings, due diligence rules were established in 1997 (RES 49),[14] which require notifying administrations to submit information

[12] Union of Concerned Scientists 2023.

[13] Falle et al. 2023: 150–152.

[14] *Radio Regulations* 2020.

such as the planned spacecraft manufacturer and the launch provider to the ITU. Another administrative measure was adopted in 2019, the "milestones" approach, where operators must launch 10% of their constellation within two years, 50% in five years and 100% within seven years after the initial filing. If they fail to launch enough satellites before these deadlines or fail to finish the constellation within seven years, their spectrum rights are limited proportionally to the number deployed before the allotted time ran out.

The negative effect of these constellations on radio astronomy is also a source of concern for scientists. Various instruments have been implemented to protect the radio telescopes, which are mostly passive antennas, thus being subject to the Radio Regulation. The ITU's World Radio Conference in 2019 adopted a resolution stating that megaconstellation satellites must be equipped with filters that specifically aim to protect the radio telescopes which operate in the frequency range from 10.6 to 10.7 GHz. Undoubtedly, it is hoped that the active transmissions from satellites can be managed, although, a rather more contentious issue is the possibility that the increased quantity of megaconstellation hardware in Earth orbit will cause inadvertent interference simply by being deployed in the orbit. An experiment performed by the Murchison radio telescope array in Australia has demonstrated[15] that terrestrial radio signals (including FM radio stations) can be detected by reflection from objects in LEO. While admittedly the target object in the Australian experiment was the International Space Station (ISS), which is by far the largest man-made object in space, the implications of this are serious because it raises an important question, namely, is there a place on Earth which is radio quiet?

Apart from the potential problems arising in the radio frequency domain, the megaconstellations are also creating issues at optical wavelengths. One issue that has received extensive coverage is the fact that Starlink's satellites are creating "artifacts in astronomical observations".[16] The company recognised

15 Tingay et al. 2020.

16 Rawls 2023.

this issue and sought to address it by conducting experiments to reduce the reflectivity of the satellites' antennas, installing sun-visors to shade highly reflective components and changing the attitude of their satellites in the orbit-raising phase of the mission. Paradoxically, one of the more effective measures taken is the lowering of the orbital altitude, since this reduces the amount of time that the satellites spend in twilight conditions (where the ground is in darkness but the satellites are still illuminated by the Sun). This also addresses the problem that arises for astronomers searching for near-Earth objects, as reducing the time megaconstellations spend in twilight will enable more efficient searches for these targets.

Another serious concern is the influence of megaconstellations on global space activities. The megaconstellations in LEO form a high-density 'space grid' in the near-Earth space, which tightly wraps the Earth in multiple layers, causing these orbital zones to become more crowded. As the number of LEO satellites has grown dramatically, the risk of collision has grown, significantly reducing the extent of global safety launch windows. Potential collisions may have disastrous consequences, leading to the eventual collapse of the space environment.

THE DILEMMA OF LEO SYSTEMS

The question arises, why is LEO orbit so important, and why do so many new space operators opt to place their equipment in this orbit?

The answer lies in the efficiency of the satellite networks, which makes these orbital planes so precious. As the performance of a satellite network depends on the orbit the satellite is deployed in, the distance from the Earth affects the capabilities of the satellite. Although satellite networks in LEO orbit require the most satellites to build up a constellation and the area covered by a single satellite is relatively small, the system as a whole provides a very low latency

(~50 m/s) compared to satellites in GEO (~700 m/s) or MEO (~150 m/s) as well as offering coverage of the polar areas, where the GEO satellites may have limited or no line of sight.[17]

The distance to orbit is also a determining factor of the most important variables of commercial satellites: the cost of launch. In case of GEO satellites, the launch cost comprises more than one third of the total cost of the satellite, while LEO satellites are smaller, lighter, and the cost of launch per satellite is lower. On second glance, however, it becomes clear that this may not be the case for the whole constellation, which may comprise hundreds or even thousands of satellites to allow it to provide uninterrupted service. When compared with a GEO satellite with an active service life of 20 years, the cost to deploy a LEO satellite system is significantly higher, almost tenfold. As LEO satellites have a shorter operational lifespan, typically from three to five years, they therefore need more frequent replacement, and also require more complex tracking and control systems, thus, from this perspective these constellations might seem less attractive.

As for the frequency bands, most LEO systems use Ka (12–18 GHz), K (18–26.5 GHz) and Ku bands (26.5–40 GHz), as these bands are the most advanced in technology. Very low latency is a unique characteristic of LEO constellations, which supports real time communications, not just in voice and data services, but also broadband internet access in remote or rural areas, offering global coverage.

Data collection is the main focus of the Earth observation applications, which also operate in low Earth orbit. The high-resolution images and extensive data provided by these satellites are invaluable for weather prediction and for studying climate change as well as disaster response to recovery efforts. These capabilities of LEO satellites are an invaluable asset for surveillance and reconnaissance, together with satellite navigation and positioning, as well as for agriculture and forestry.

[17] Digital Regulation Platform 2023.

ECONOMIC CONSIDERATIONS OF OPERATORS

The continuous development of space technologies made the emergence of space communications possible, and by the late 1980s the first private satellite operators, including PanAmSat and SES, were already competing with established market players operating in the form of intergovernmental organisations. The liberalisation of the communications market by the late 1990s led to the privatisation of most intergovernmental satellite organisations and marked the beginning of the commercial use of outer space.

However, this did not mean that the state's role in the use of space ceased, but rather that the centre of gravity shifted: while previously the state actors determined the direction and methods of space research and use, from the 1990s, certain areas of space research and some – in particular, non-civilian – uses remained in the hands of the states while commercial use became free under strong state control in a large proportion of the world, which led to the emergence of global service providers.

The consequences of the state's involvement in the background can be very serious for the state's sovereignty. On the one hand, the technological knowledge acquired puts each company or group of companies in a monopoly position, and thus defence investments become completely vulnerable to these companies. The advance of artificial intelligence shows that technology-developing companies with strong capital are already determining the evolution of the market, with no state having any influence on the price and distribution of their products and developments, which puts state customers in a vulnerable position. On the other hand, the basic interest of companies is profit maximisation, not loyalty, so it can easily happen that opponents have the same military equipment at their disposal. The third and last consequence to be mentioned is that multinational companies dominate the global market. Their size and influence are greater than the capabilities of a small or medium-sized country, and they are also able to represent their interests more effectively. Currently, multinational companies prefer to enforce their interests through individual countries, but it is expected that these companies will realise the potential of their political influence related to their financial capabilities, and many consider that it is only a question of time before they act openly to assert their interests.

The situation is more nuanced by the fact that multinational companies, applying the practice of "forum shopping", settle in the territories of states in which entering the market is subject to predictable conditions, the risk of their investment is not too high, and the regulations of the given state do not demand too much of their income. In the satellite sector, following the communications liberalisation of the 1990s, this process only accelerated. As noted earlier, this trend is supported by the ITU's processes for frequency filings, where the flag of convenience is becoming more easier to access via the procedures of national administrations.

Based on all of this, the market role of multinational companies raises serious questions of sovereignty and security policy, especially if the company's products involve key military technology or the multinational company provides a service that is vital for the protection of the state's security.

Although multinational companies are not completely global and cannot be understood without considering the country where their headquarters are located, they can nevertheless represent a significant force within the given country. The obligations of multinational companies are determined by the internal legal framework of the state where their headquarters are located, but due to their size and activity, a rapid change of circumstances, i.e. a change of the state of their headquarters, is not possible in practice. Due to their size alone, multinational companies have a clear financial, economic and even political influence on the states in which their headquarters or even their subsidiaries and branches operate. This assumes that the multinational company's settlement in the given state was preceded by the consent of the home state, and that the multinational company recognises the sovereignty of the given state over itself. However, this does not entail absolute control over the entire activity of the multinational company, as it is possible to control only certain activities related to the given state.

Nevertheless, in order to preserve their sovereignty and enforce their security policy goals, states pursue and will continue to pursue policies that satisfy the needs of multinational companies, if they have products and services that are important to them. In connection with the space race, it can be stated that the satellite sector is mostly the domain of multinational companies that have served the security policy interests of a state almost since their foundation and which sell their capacities above that on the global market. Since there are no binding operating standards to it, the space race is also intensifying due to the rapid development of technology. Moreover, the states participating in the conquest and use of outer space act according to the ancient and overriding state interest (raison d'état) in order to protect their sovereignty.

REGULATORY CHALLENGE

In the field of satellite communication, the youngest of the communication sectors, a global market has thus apparently been established, and access to technology, development and innovation significantly influence the competition in this global market.

The global market for satellite communications cannot be managed within the framework of current international trade cooperation which was defined in the early 1990s. The general principles of competition regulation and the special principles regarding electronic communications, as well as the basic principles for the reasonable, efficient and economical use of frequency and satellite orbit appearing in the ITU system determine the frameworks that must also be followed in the regulation of space communications, although, this is not possible without the existence of an international organisation with appropriate powers.

Satellite communication operates in an international market that aims to provide end users with a low-cost, unified communication option capable of covering a region or the entire Earth. Unlike terrestrial networks, satellites can provide service almost everywhere: in both urban and rural, congested or sparsely populated areas alike.

Many functions that guarantee and protect the interests of the licencing state or the customers are difficult or impossible to implement in the case of a global service provider. Although the licensing state must request territorial consent from the relevant state for purposes of frequency coordination, it does not mean that the satellite will actually provide any service in the consenting state. The provision of electronic communication services in the territory of the EU is subject to notification, and many consumer protection and data protection rules are connected to this. In the absence of notification, the authority supervising the service is unable to enforce the provisions established to protect its own citizens, even in case of a global service notification, as national rules can only be enforced based on the high degree of cooperation of the service provider.

This uniformity also constitutes the principal regulatory challenge, since satellite service providers need uniform rules to apply in the area covered by the satellite, but the services are based on licences issued by individual states and on the frequency they provide. Although regional regulatory forums operate, such as the European Conference of Postal and Telecommunication Administrations (CEPT) which facilitates harmonised policies, strategies and standards, or the Inter-American Telecommunication Commission (CITEL) which recommends framework regulation for certain technologies, the implementation of these instruments still lies in the hands of the member states of these regional organisations.

It is universally acknowledged that the satellite industry is one of the most dynamically developing sectors in today's economies, providing innovative technology and new services. However, market access is dependent upon an understanding of the regulatory landscape. As states have the authority to establish their own national rules for the use of the frequency spectrum, they are obliged to manage the spectrum in a way that is rational, economical and fair,[18] while taking a vast number of measures to serve their national interests.

[18] ITU Constitution 2022: Article 44.2 (196).

The existing licencing processes are designed for traditional satellite services, and may not be suitable for the deployment of more innovative services within shorter timeframes. As mentioned earlier, the spectrum allocation processes are not globally harmonised, which means that deploying a new globally reachable satellite system is complicated by the different regional regulations involved. Efficiently managing spectrum usage while avoiding interference is also crucial, not just between satellite networks, but also between satellite and terrestrial networks, as in lower frequencies the usage may overlap.

FUTURE TRENDS

Emerging technologies and trends define the future of global communication, especially in the satellite sector. As 5G technologies reshaped communication, the seamless integration between ground and space networks became a reality. Integrated hybrid systems have the advantages of both systems: they have high capacity and low latency, similarly to terrestrial systems, while offering the global coverage of satellite systems. This technological breakthrough is transforming the face of terrestrial communication networks today.

A powerful synergy of complex communication systems is provided by "multi-orbit" satellites and terrestrial networks, that can satisfy the changing consumer habits, which – with the increasing demands of consumers for continuous "online" presence and services "on-demand" – lead in the direction of the convergence of the sectors of the telecommunications industry.

Multi-orbit satellite systems are changing the global satellite market, as GEO satellite operators combine with MEO or LEO operators to diversify their services. The use of multiple orbits enables operators to optimise their performance across different networks. With GEO satellites offering high capacity, MEO and LEO satellites providing low latency and global coverage, the demands of end users for reliable service, cost effectiveness and high speed are best served. The mergers and collaborations taking place on the global market show that established operators are opting to deploy multi-layer satellite systems, either by building their own constellations (like Telesat[19] or SES[20]), or by merging their capacities (like Eutelsat-OneWeb[21] or Viasat-Inmarsat[22]). Apart from the mergers and collaborations of the satellite operators, the traditional telco companies[23] are also reaching out to complementing satellite networks, since the fibre technology is widely available at densely populated areas, whereas satellites services do not have the capacity to provide that level of service, and fibre is not an option for most rural or strongly segmented areas.

The merger of satellite operators is a complex process that involves various legal, regulatory, financial and operational considerations. Mergers in the communication industry often, particularly in the satellite sector, require regulatory approval from relevant authorities, to ensure that the consolidation does not result in anti-competitive behaviour, and that it complies with national and international regulations. Regulatory bodies may assess the impact of the merger on market competition, pricing and overall industry dynamics, while also scrutinising satellite operator mergers from a national security perspective. If the satellite services are critical for national infrastructure or defence, the regulatory authorities may assess the potential impact of a merger on national security before granting approval.

Consolidations and mergers often involve streamlining operations, eliminating redundancies, and improving the overall efficiency of a company, which can lead to a more agile and cost-effective organisation capable of responding to market dynamics more effectively. Moreover, merged companies may have extra resources available to invest in research and development, fostering innovation and the integration of advanced technologies, and resulting in the development of more capable and competitive satellite systems.

19 Dalvi 2023.
20 SES 2023.
21 Rainbow 2023.
22 Jewett 2023.
23 Wood 2023.

Another benefit of mergers in the satellite sector is that merged satellite operators may be able to optimise their use of spectrum and orbital slots, potentially leading to more efficient utilisation of resources. This optimisation can be important in addressing the growing demand for satellite services and mitigating concerns about orbital debris.

Although these rapid technological developments have facilitated a reduction in satellite operational costs and made satellite communication more widely available, reaching profitability in the short term remains a challenge, since launching and operating a satellite network is an extremely capital-intensive investment. For this reason, the market demands for high-bandwidth, low-latency networks to satisfy customer needs may best be met via multiple solutions provided by multilayer networks. The most rapidly technologically developing companies are mostly small and thus lacking funds, while established operators are searching for new methods and new markets to maintain profitability. All these circumstances strongly suggest that the consolidation of the satellite communication sector is inevitable.

Apart from the market consolidation of the satellite operators, the advancement of technologies contributes to the changes of production and usage of equipment. Advancing technologies for user terminals contribute to decreases in cost, while miniaturisation has led to smaller, more efficient terminals with higher performance. As developers aim to create more user-friendly, customer-oriented solutions, self-installing equipment and terminals are taking over, further reducing costs by eliminating the need for professional installation and maintenance. However, this scenario will influence the existing regulatory framework and its implementation, as this increase in the amount of equipment and terminals leads to the expansion of spectrum demands, causing further congestion in the limited frequency bands and increasing the possibility of interference. As equipment and terminals for satellite communication are not in all cases exempted from licencing in the state where they are used, the sheer number of these devices can lead to lingering licencing processes, which also implicates that regulators will have to reshape their licencing procedures.

CONCLUSION

While it is important to emphasise that the management of satellite radio frequencies cannot be separated from the electronic communication system, as it is an integral part of it, due to its global nature, some aspects of this management require regulation that is independent of sovereign states. The independent regulatory demands involve special requirements for a new communications sector, which is not related to telephone and broadcasting services and does not necessarily mean a competitive market for national companies, but instead a complex system of global service providers. These systems cover the entire range of ICT services, in addition to providing both the infrastructure and the device or terminal for the users.

Multiple stakeholders and international operators are challenging the borders of the current regulatory landscape, a landscape in which regulators have to perform a delicate balancing act between protecting the incumbent services and operators while at the same time supporting technological advancements. Maintaining technology-neutral policies and goals, while converging towards a certain level of regional harmonisation to foster innovation, while at the same time ensuring efficient spectrum use gives regulators a thought-provoking and unique opportunity to develop new approaches.

The more congested the orbital planes around the Earth become, the more forward-thinking regulation will be necessary to ensure seamless, uninterrupted service. With the accessibility of myriads of LEO satellites and the technological innovation they represent, the regulatory landscape goes beyond technological aspects and encompasses new issues such as safety, security, privacy and regional harmonisation. This complex regulatory challenge cannot be faced by the regulators alone. Synergies need to be created and maintained between stakeholders at all levels, since space is a global commons. Developing and harmonising regulations across different countries and regions is a challenge that needs to be overcome to ensure the responsible use of space resources, balancing the interests of various stakeholders, ensuring equitable access and avoiding harmful interference.

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Space Resource Activities and the New Space Age: Current International Legal Framework and Preparing for the Future

INTRODUCTION

Humans have been gazing into space since the beginning of time. In fact, in some ways, our space activities began long before the V2 rockets flew or the launch of Sputnik 1. The first stage of those activities (Space 1.0) was marked by astrology and astronomy, with Space 2.0 being the phase of the space race between the U.S. and USSR.

With the ending of the Cold War, the age of international cooperation began, and the symbol of this new phase (Space 3.0) is naturally the ISS.[1] The next and most recent stage, which is either named Space 4.0 or, under its more common name, New Space is seen as representing a paradigm shift in human space activities.

Although it might be a "misleading expression" (mostly because New Space developed from Old Space),[2] the term New Space has been widely used to describe the current stage of space activities. New Space is characterised by the ever-growing presence of private actors in space (both in terms of active players and passive investors) with a focus on commercialisation, which is sometimes (perhaps wrongly) referred to as the "democratisation of space". New needs (more connectivity, IoT, etc.), new approaches (supply chain disruptions), new

1 ESA 2016.

2 Denis et al. 2020: 432–433.

DOI: https://doi.org/10.36250/01208_14

markets (some of them still just a possibility, such as ISRU – *In-Situ Resource Utilisation*), are the hallmarks of the New Space age.[3]

At the same time, space law has developed over several stages which have reflected the evolution of space activities. The first phase took place in the period before the main space treaties, and after the establishment of the COPUOS, with the Legal Principles Declaration being its main expression. The second phase was that of the major space treaties, while the third phase can be regarded as a soft law era, with non-legally binding declarations emanating from the COPUOS. To some extent, this phase is still ongoing.[4]

Frans von der Dunk has suggested that a fourth stage (or layer, given that some marks of this stage were developed and achieved during the second and third phases) of space law has begun. This layer represents a sort of movement beyond the core of international space law, whose development comes from the UN as a representation of international cooperation, towards a global state of what is space law today. It includes the specific regimes of some sectors which followed the development of space activities and the use of space for terrestrial applications, such as the EUMETSAT Convention or certain bilateral agreements. This phase also reflects the idea of the shift towards private participation and commercial activities.[5]

Be that as it may, one relevant question that can be asked is: for how long will the New Space age last? At the same time: will space resource activities even take place in the New Space age? Are they permitted by the existing *corpus juris spatialis*? And if so, do we have an adequate framework to address this issue? Answering only the two latter questions is the aim of this work, but it may still be worth briefly addressing the others below.

Certainly, space resource activities are part of the human future. Some of them, like mining water ice in asteroids may technically be possible already, considering the current stage of technological development.[6] It is also

3 Denis et al. 2020: 434.

4 Von der Dunk 2015: 38–43.

5 For a larger overview of this fourth phase see von der Dunk 2015: 106–125.

6 Cheney 2019: 120.

expected that at least within 20 to 30 years we could see the development of some other resource extraction activities, although it seems more likely that they will be more along the lines of prospecting than the actual exploitation and commercialisation of space resources.[7]

Even considering that the initial ventures which generated the hype around space resources have shifted their focus, there are still projects for exploiting resources in space.[8] Despite the current low level of these activities, with only a reasonable likelihood of prospecting in the near future, it is still necessary to discuss the regulation of space resource activities, and this is something that is definitely taking place in the New Space age.[9] In fact, discussions are already undergoing in the COPUOS, with the creation of a Working Group on Legal Aspects of Space Resource Activities marking an important step.[10]

As such, if we are to prepare for the future it is highly relevant to understand what the current *corpus juris spatialis* says about the subject and to consider how to contribute to the discussion. I will begin by addressing the current international framework, with a focus on the two most relevant treaties for the issue of space resource activities: the 1967 Outer Space Treaty (OST)[11] and the 1979 Moon Agreement (MA).[12] This is the core of this work and aims to determine whether space resource activities are permitted and how existing rules affect them.

Subsequently, it is important to look at some proposals and approaches with a particular focus on the Artemis Accords and the Hague Building Blocks. I will also consider the issue of national legislation. I will conclude with an overall

7 Cheney 2019: 137; Xu–Su 2022.

8 Hofmann–Bergamasco 2020: 2.

9 Cheney 2019: 121.

10 Report of the Legal Subcommittee on its sixtieth session, held in Vienna from 31 May to 11 June 2021, para. 255, 33. U.N. Doc. A/AC.105/1243, 2021.

11 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, opened for signature on 27 January 1967 and entered into force on 10 October 1967, 610 U.N.T.S. 205.

12 Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, opened for signature on 18 December 1979 and entered into force on 11 July 1984, 1363 U.N.T.S. 3.

assessment of the current state of affairs regarding space resource exploitation and with some general suggestions for what needs to be improved in the current framework and how we must proceed in order to prepare for the future of space resource activities.

THE CURRENT INTERNATIONAL LEGAL FRAMEWORK: THE OUTER SPACE TREATY AND THE MOON AGREEMENT

The first point to note is that there is no specific legal framework in place addressing the issue of space resource exploitation activities, at least not one regulating it in any detail, and which has been widely ratified. Although the Moon Agreement was drafted with the purpose of addressing the exploitation of resources in space,[13] the fact that it only has 17 ratifications[14] hinders its applicability and effectiveness on a global level.

In fact, if one were to start by addressing concepts and definitions, one would quickly notice the absence of the terms *space resources* or *space resource activities* from any of the five international treaties regulating activities in outer space. There is, however, a mention of them in both the preamble and Article 11 of the MA, where reference is made to "the natural resources of the Moon and celestial bodies".

One has to look to other sources to find definitions of such resources or their exploitation. For instance, despite not being an international legal agreement, the Hague Building Blocks on Space Resource Activities do offer a definition of space resources which seems to have gathered some support. According to these guidelines, a space resource is "an extractable and/or recoverable abiotic resource

13 This is recognised in the preamble of the treaty where it is written that the drafters took into account "the benefits which may be derived from the exploitation of the natural resources of the Moon and other celestial bodies".

14 It previously had 18 ratifications; Saudi Arabia's withdrawal produced effect in January 2024. Status of International Agreements relating to activities in outer space as at 1 January 2023, U.N. Doc. A/AC.105/C.2/2023/CRP.3, 12.

in situ in outer space".[15] In the note to this definition, the Hague Working Group specified that it includes mineral and volatile materials (and water) but excludes satellite orbits, the radio spectrum (both already addressed by the ITU regime, although in the latter case mostly the GSO) and solar energy.

This definition reflects those previously subscribed to by two of the four countries with national legislation on space resource activities: the U.S. and Luxembourg. The U.S. Code has enshrined this concept, complemented with a separate definition of the term *asteroid resource* which are space resources "found on or within a single asteroid".[16] Luxembourg affirmed the American position, and despite its national law not containing any definition, the explanatory statement provided to the draft law claims that this is a common meaning of the term.[17]

However, unlike the absence of a concept of space resources, the fact that any definition of *space resource activities* is missing in the space law treaties does create some doubts regarding their possibility. Here too, the Hague Building Blocks can provide some help in defining the concept, which they describe as activities undertaken to search for, recover or extract space resources (including the construction and operation of associated systems).[18]

However, despite this clarification, when it comes to the core space treaties, questions about space resource activities remain, especially about their legality. The Outer Space Treaty, due to its general nature and principles, applies to all human space activities and provides some answers on this matter. Additionally, and even considering its low number of ratifications, discussing the Moon Agreement is still highly relevant, if anything, because it will always reflect the result of a certain period of negotiations in the COPUOS. At the same time, it provides clarifications pertaining to the exploitation of space resources and

15 Bittencourt Neto et al. 2020: 8.
16 U.S. Code § 51301(1).
17 Government of the Grand Duchy of Luxembourg 2016: 1.
18 Bittencourt Neto et al. 2020: 8.

it is binding for its States Parties, with the possibility of it still being used as the basis for international discussions.[19] As such, both treaties are addressed below.

The Outer Space Treaty

The first article of the Outer Space Treaty enshrines what are usually called the three "space freedoms":[20] the freedom of use and exploration of outer space (which includes the Moon and other celestial bodies), the freedom of access to all areas of celestial bodies and the freedom of scientific investigation. Most scholars agree that it is precisely under the freedom of use of outer space that space resource activities are permitted. Indeed, despite not being specifically envisioned at the time of drafting the OST, it is now generally agreed that the use of outer space includes commercial activities, which in turn include the exploitation of space resources.[21]

However, this is not to suggest that there are no divergent opinions. Contrarily, it has been argued that, due to the prohibition of appropriation, the exploitation of space resources is also prohibited.[22] This view considers that such exploitation is itself a form of appropriation.[23] Nonetheless, whilst consuming a celestial body in its entirety to the point of extinction would be considered appropriation,[24] space resource activities do not require the appropriation of outer space, including celestial bodies, or of the resources *in situ*.[25] Given the lack of the express prohibition of space resource exploitation activities, it seems both logical and in accordance with international law to interpret the freedom of use of outer space in such a manner that it allows them.[26]

19 Su 2017: 994.
20 Soucek 2016: 24.
21 Hobe 2017: 195; von der Dunk 57.
22 Hofmann–Bergamasco 2020: 2–3.
23 Soucek 2011: 294.
24 Su 2017: 1006.
25 Hofmann–Bergamasco 2020: 3.
26 In this aspect I am not only alluding to the Lotus principle, but also to the idea that the purpose of the Outer Space Treaty does not seem to be excluding these activities from being

It is also important to notice two other aspects from Article I that might affect the freedom of use of outer space and whatever might be considered as such. First, this freedom is considered to be the *province of all humankind*. Secondly, the use and exploration of outer space has to be carried out for the benefit of and in the interest of all countries. Both terms are more than just political expressions and have specific legal meanings and consequences.

The choice of the wording "province of all [hu]mankind" has (understandably) sparked some debate as to whether this means the same as the *common heritage of humankind*. However, they represent fundamentally different approaches. The province of all humankind reflects the traditional *res communis* principle, meaning that States can engage in the unilateral exploitation of space resources, but must respect the legal obligations they are subjected to.[27] As such, all States can unilaterally conduct space resource activities, as long as they have the necessary means to do so, and respect the existing limitations on that freedom. This alludes to formal equality, since those States that do not have the capacity to perform such activities will not be able to conduct them, despite being allowed to.[28]

In this regard, it is important to understand how the *common benefits clause* has the potential to limit the freedom of use of outer space. While this clause is usually considered to entail a legal obligation despite its use of rather general language, it would be an exaggeration to claim that it amounts to a duty to share benefits and profit.[29] This follows precisely from that *res communis* approach since States are not required to facilitate the access of those without the capacity to perform resource activities. Still, some form of overall benefit needs to result from such space activities, and States must refrain from deeply jeopardising the interests of other States and from

pursued under such freedom. SS Lotus Case, PCIJ Ser. A, No. 10 (1927), 18. Moreover, Article 31 (1), Vienna Convention on the Law of Treaties, 23 May 1969, 1155 U.N.T.S. 331. This also seems to be the basis for the general position in favour of Article I OST allowing space resource activities. Su 2017: 1000.

27 Von der Dunk 2015: 57–58.

28 Van Hoof 1986: 55.

29 Soucek 2016: 25.

doing harm to them. The overall benefits of space activities have generally been interpreted in the sense of downstream applications and technology development, which benefits even non-spacefaring nations.[30]

An additional aspect of this issue is that the idea of common benefit is viewed from a utilitarian perspective.[31] Some activities will bring general benefits and yet negatively affect specific States. For instance, space resource activities might make a particular resource cheaper, which will affect the economies of countries exporting this resource – something that can be especially impactful in the fuel and energy sectors. As it is, it would seem that the general benefit will still have to prevail over that negative effect.[32] However, this has to be balanced on a case-by-case basis. If an emerging situation leads to monopolies and advantages for a group of States but seriously impairs the interests of others or leads to large scale inequalities to the point that the general benefit becomes questionable, this could constitute a violation of this clause.[33] This is something that has been addressed in the law of the sea, for instance, and measures of economic assistance may be taken to compensate the developing countries whose economies are affected by activities in the Area (i.e. the part of the seabed lying beyond national jurisdiction).[34]

The prohibition of national appropriation in Article II is highly relevant in the context of space resources and can be properly understood by taking a step-by-step approach. The first issue to be addressed pertains to the concrete meaning of the term "national appropriation" and what it entails for private ventures.

The use of the term *national* does not preclude the application of the prohibition of appropriation to private entities. This follows the same reasoning as Article VI of the OST, which specifies that States are responsible for their national activities in outer space. In this sense, national activities include those

30 Lyall–Larsen 2009: 64–65.
31 Su 2017: 1002.
32 Lintner 2016: 145.
33 Su 2017: 1003.
34 Section 7 (1), Agreement Relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea of 10 December 1982, 28 July 1994, 1836 U.N.T.S. 3.

undertaken by non-governmental entities.[35] Ultimately, this means that private undertakings or individuals cannot appropriate celestial bodies for themselves, or for the State, on its behalf (therefore preventing the repetition of scenarios of the colonial past such as those of the East and West India Companies).

Despite arguments for the desirability and convenience of companies acquiring property for exploiting and mining activities,[36] this is simply not permitted. To allow this would both defeat the purpose of the Outer Space Treaty and ignore the negotiation history in which most delegates favoured the position the treaty took.[37] This has also been reiterated by national courts in the U.S. and China.[38] Since the State is prohibited from acquiring ownership and sovereignty over outer space and celestial bodies, it cannot allow its citizens to do the same since it would not be able to adjudicate on such property.[39]

It is also not evident that allowing private entities to acquire land in outer space (and ownership of *in situ* resources) for commercial exploitation would be preferable. It can be argued that upholding Article II would lead to a safer and fairer space environment even as regards resource exploitation activities, as it prevents land grabbing, exclusive ownership and the monopolisation of certain areas or entire celestial bodies.[40] Moreover, if land ownership were permitted, matters could quickly escalate, as there would be competing claims, and the need to somehow enforce them on an unilateral basis could result in potential conflicts.

35 Jakhu–Freeland 2017: 240.
36 Lintner 2016: 145, 153.
37 Most of the delegations, including the American one, shared the opinion that space must remain free from exclusive property rights. Jakhu–Freeland 2017: 238–239. It is worth paying particular attention to the French and Belgian positions which considered that this prohibition prevented "the creation of titles to property in private law". The statements of their representatives can be consulted in UN. Doc A/AC.105/C.2/SR.71, Add.1, 4 August, 6–7, and UN. Doc. A/C.1/PV.1492, 17 December 1966, 31–40.
38 For instance the Nemitz case in the United States or the Moon plots case that came before Chinese national courts. Jakhu–Freeland 2017: 250–251.
39 Tennen 2016: 287. Also, Soucek 2011: 316.
40 Tennen 2016: 286.

Whilst this does not mean that sovereignty or property do not exist in outer space, the idea that in order to carry out space resource activities some form of land ownership is needed fails to understand the nature of such activities. By way of analogy, resource activities take place under the oceans in the Area without such need for ownership and the same can be said of space activities, given that the ITU allocates GSO orbital slots on an equitable basis but allows for their exclusive use until the end of the satellite's lifespan.[41] It is also worth recalling that governmental and non-governmental entities still own those space objects and States still have jurisdiction over them (according to Article VIII of the OST), while noting that such ownership and occupation does not grant them ownership of the allocated orbital slot.

The only guarantee that companies effectively need is the recognition of their "enterprise rights"[42] or "extraterrestrial exploitative rights",[43] which is basically guaranteeing non-interference with their activities and giving them some right of exploitation over a region, with subsequent recognition of ownership rights over extracted resources. Such rights can be protected through the establishment of an international legal regime and consolidated through authorisation and supervision (Article VI of the OST).[44]

Some discussions have pondered whether the prohibition of appropriation should apply to the smaller bodies of the Solar System. On this issue, the IAU has extended the scientific definition of the bodies in the Solar System which includes planets, dwarf planets and smaller bodies, to comprise most "asteroids, Trans-Neptunian Objects, comets, and other small bodies".[45] As such, given that the drafters of the OST were aware of the existence of smaller bodies and yet no exclusion of any sort was envisaged in this article, it seems that the prohibition of appropriation of celestial bodies is "all-encompassing".[46] Perhaps

41 Walter 2011: 506–507.
42 Tennen 2016: 285.
43 Jakhu–Freeland 2017: 260.
44 Tennen 2016: 291.
45 International Astronomical Union 2006.
46 Su 2017: 997.

it would be acceptable to amend the article or provide a legal definition that excludes tiny bodies or very small asteroids from the scope, but this would have to be agreed upon and negotiated at the international level to produce any effects.

It is also important to consider Article IX, even if only briefly, as space resource activities are also subject to its limitations. States have to conduct their activities with due regard to the corresponding interests of other States, whilst at the same time they must avoid the harmful contamination of celestial bodies. Article IX requires a certain standard of care and the prevention of harmful interference between space resource activities.[47] Whenever a State has reason to believe its activities may affect another State it will have to consult with it before proceeding with such activities, while potentially affected States can request consultations regarding them.

Similarly to what was mentioned above, this requirement to abstain from harmful interference and pay due regard to their corresponding interests is necessary to protect commercial ventures in space, and private endeavours are both protected by them and bound to respect them. At the same time, they have to respect environmental protection and cross-contamination rules, although it is still rather unclear exactly what environmental protection measures States will have to adopt on celestial bodies,[48] for which reason the adoption of an international regime is desirable.

Overall, it seems clear from the Outer Space Treaty that space resource activities are not prohibited, and, due to it reflecting the *res communis* approach to outer space, States may carry out such activities unilaterally, as long as they respect the limitations imposed by the norms of space law they are subject to. Considering the particular case of Article II, the absence of any reference to space resources or natural resources of celestial bodies is noticeable in this prohibition, which implies a difference in status. Indeed, considering the silence of the Outer Space Treaty on this topic, questions still remain concerning the appropriation of space resources *per se*.

47 Marchisio 2017: 570.

48 Soucek 2016: 29; Hofmann–Bergamasco 2020: 3–4.

Since there is no territorial sovereignty over celestial bodies, the ownership of *in situ* resources is also not possible, as that would amount to reserving an area for future use and occupancy, which is not permitted under the non-appropriation principle.[49] However, given that space resource activities are permitted and this includes the extraction of space resources, there are doubts as to the appropriation of extracted resources. It is precisely on this matter that the Moon Agreement clarifies the prohibition of appropriation.

Moon Agreement

According to Article 1 (1) of the Moon Agreement, the agreement also applies to other celestial bodies of the solar system, as long as no specific regimes or rules exist regarding them. The agreement was open for signature in 1979, but only entered into force in 1984. As mentioned earlier, it currently has 17 States Parties and 4 signatories. However, it is widely recognised that most of it is fairly non-problematic and the reason for the lack of substantial ratifications of it is its controversial Article 11 which also considers the celestial bodies and their natural resources to be the *common heritage of humankind* [Article 11 (1)].[50]

Indeed, negotiations hit a wall when addressing this provision, which stemmed from an Argentinian draft proposal,[51] since the USSR was concerned about the introduction of this principle as they perceived it would bring the issues of ownership and property rights to international space law. At the same time, there were concerns over the UNCLOS negotiations and issues such as the mandatory transfers of technology that some states were seeking to avoid seeing reflected in the Moon Agreement.[52]

To break this impasse a final Brazilian suggestion, advanced in 1979, tied the meaning of Common Heritage to the Moon Agreement specifically, which is why Article 11 (1) also mentions that the expression "common heritage

49 Lintner 2016.
50 Von der Dunk 2015: 99–103.
51 UN. Doc. A/AC.105/85, 3 July 1970, Annex II, 1–2.
52 Christol 1980a: 459; Gangale 2008: 10.

of humankind" is to be found in the Agreement, with Article 11 (5) being highlighted.[53] Although this produces no effect and does not bind States to ratify a treaty, the MA was approved by consensus without further objections.[54]

It is important to bear in mind the historical context of the negotiations of the Moon Agreement and the UNCLOS, both treaties which have enshrined the principle of the common heritage of humankind. Newly independent States were looking to overcome years of Western colonialism and break the West's hold on the world economy. The aim of these developing countries was to prevent the unilateral exploitation of the resources of the *global commons,* something promoted under the *res communis* regime. Common heritage of humankind is, in this respect, the legal principle used to pursue such a goal.[55]

The differences introduced by this principle involve the need for an international legal framework to regulate space resource activities (and therefore uphold the prohibition of unilateral activities in this realm), which may or may not require an international authority.[56] This principle also brings intergenerational equity and the accompanying equitable approach where even non-spacefaring nations need to see tangible benefits from space resource activities through benefit-sharing mechanisms.

These aspects can be found throughout the Moon Agreement, and not only in Article 11. For instance, in Article 4 (1), the due regard principle is extended to the "interests of present and future generations as well as to the need to promote higher standards of living and conditions of economic and social progress and development". The ideas of intergenerational equity and sustainable development are discernible in these lines, which makes the treaty so visionary for its time. Indeed, it was perhaps too visionary for its day.

53 This is according to Christol 1980a: 469. However, according to Cheng 1997: 367, Austria had proposed the idea in a working paper the previous year. The *ipsis verbis* suggestion adopted was that of Brazil, despite reflecting the same thought of the Austrian suggestion.

54 Christol 1980a.

55 In fact, both treaties were negotiated in a period marked by the New International Economic Order and the rise of influence of the Group of 77. Lee 2012: 219.

56 Noyes 2011: 450.

Of course, Article 11 is the most relevant provision of the MA for space resource activities. However, it is worth noting that Article 6 (2) allows States Parties to collect and remove samples as well as to make use of minerals and other substances to support their missions. The difference in scope of this article is that it is concerned only with scientific endeavours and not commercial resource activities, like Article 11. Even when it comes to scientific missions, the use of local resources to support them has to be done in an appropriate manner, which means that in those cases where a scientific mission might be investigating the feasibility of mining a resource, it still does not justify large exploitation ventures.[57]

As Leslie I. Tennen has written, Article 11 (3) makes an essential clarification, rather than a departure from the spirit of Article II of the OST.[58] It clarifies that, whilst the prohibition of appropriation applies to celestial bodies (their surface and subsurface) and resources *in situ,* extracted resources can be owned. In this regard, even those critics of the Moon Agreement (who usually characterise it as overly restrictive), use this clarification to defend the appropriation of extracted resources in a cherry-picking manner.[59]

Significantly, according to the MA, the exploitation of space resources has to be regulated under an international regime [Article 11 (5)]. The States Parties agreed to establish this regime only when such exploitation is about to become feasible.

Therefore, no regime is actually in place or was established in the treaty. What was agreed was a *pactum de negotiando,*[60] a compromise to negotiate such a regime in the future. At the same time, despite perceptions that the MA has created a *moratorium* on space resource activities, this is simply not true.[61] This issue was clearly agreed on, and addressed, during the negotiations of the treaty: to include the common heritage principle, it had to be agreed that no

57 Su 2017: 1005.
58 Tennen 2016: 290.
59 Lintner 2016: 149.
60 Cheng 1997: 161.
61 As it has been highlighted by Gangale 1980: 15–18.

moratorium on space resource exploitation would exist, unlike what happened with the Area in the law of the sea.[62] If anything, Article 11 (5) reinforces the need to actually begin space resource exploitation activities, as it is the only way of assessing their feasibility.[63] It seems to be implied that during the first prospecting stages of these activities, no regime has to be in force.

While this is so, the Moon Agreement has at least established some of the purposes that this regime should pursue: the orderly and safe development of space resources; their rational management; the expansion of the opportunities for their use; and the equitable sharing of benefits derived from them [Article 11 (7)]. It is regarding the latter purpose that the MA truly reflects the common heritage principle, as it is the most differentiating element of the document. Exactly what form the sharing of benefits has to take is still debatable, and it does not necessarily need to be financial.[64]

However, my assessment is that if the equitable sharing of benefits is interpreted similarly to the common benefits clause, therefore not bringing about any changes to what was envisioned in Article I of the OST,[65] then it would not reflect the true purpose of the common heritage principle. It needs to mark a clear contrast with the *res communis* regime and prevent a repetition of the mistakes of colonialism which have led to global asymmetries. The exploitation of such a system has created for some nations the conditions which have allowed them to be at the forefront of space activities.

As such, the change that is sought with the introduction of the common heritage of humankind and benefit-sharing requirements is something more tangible, which leads to global balance instead of increased tilting of the scales. Hence, the idea is to prevent the unilateral exploitation of space resources by only those with the capacity to do so and instead provide also to developing countries an equitable share of all benefits derived from them (which should also include financial benefits).

62 Christol 1980a: 469.
63 Gangale 2008: 15.
64 Jakhu et al. 2013: 398.
65 Cheng 1997: 380.

Sticking to a *res communis* approach, where the current spacefaring nations (including private ventures from those countries) would be able to pursue space resource activities unilaterally, therefore choosing the most convenient and profitable areas, would produce unfair results. This would mean demanding that once the rest of the world develops the technology to endeavour in such activities, they have to reach higher stages of that technological development than those required for the first spacefaring nations, as they would need to travel to farther celestial bodies or be confined to less profitable fields.

It seems, then, that the issue of the equitable sharing of benefits will remain contentious in discussions surrounding space resource activities. Whether it is connected to the Moon Agreement or not, any future framework negotiated at the international level will surely need to include a discussion of benefit-sharing.

Assessment of the current framework

It can be asserted that the current international legal framework does contain rules that apply to space resource activities, with the most relevant articles having been addressed above. At any rate, it is possible to ascertain from the Outer Space Treaty that these activities are allowed under the freedom of use of outer space.

At the same time, anyone carrying out these activities will always have to respect the prohibition of appropriation, which brings some concerns regarding the ownership of space resources. Whilst the prohibition of land ownership and of resources *in situ* seems clear, there is room for debate on the legality of owning extracted resources. However, besides this issue and some general calls to take care of the surrounding environment and the need to avoid harmfully interfering with the activities of other States resulting from Article IX, the Outer Space Treaty, naturally, does not create a clear framework for these activities.

On that matter, it is the Moon Agreement that brings greater clarity to the table. The main problem with it, besides the misconceptions perpetuated about it, is that it is only binding for ratifying States, and to some extent only to those which have actually signed it.[66] Without the Moon Agreement in the equation, the situation is worse, as the OST alone is certainly not enough to regulate the matter (nor was it ever its purpose). In this vein, there have been proposals to make the MA more attractive or to give concrete realisation to some of its aspects.

It has been suggested in this regard that a possible way to increase the attractiveness of the MA would be to get rid of the equitable sharing requirement and replace the CH principle by the *province of all humankind* approach.[67] Christol, on the other hand, has proposed a way of concretising the equitable benefit-sharing requirements, namely by providing profit-based payments to an international fund established to promote human development with particular attention to developing countries.[68]

Whilst the second proposal does follow the spirit of the Moon Agreement, the first line of thought is particularly problematic, as the implementation of those suggestions would ultimately lead to defeating the purpose of the negotiations of the treaty and would not reflect the historical context of the discussions.[69] Indeed, while I recognise and understand that this was not the intention behind the proposal, the *common heritage* principle implies a paradigm shift in international law, breaking from its colonial roots and the language of disempowerment and disfranchisement to a language that is more compliant with the intended universality of the project.[70]

Still, not all proposals and solutions put forth on the matter have been tied directly to the existing space treaties, or even discussed inside the COPUOS.

66 In that they have to abstain from jeopardising the objective of the treaty. Article 18 (a) Vienna Convention on the Law of Treaties, 23 May 1969, 1155 U.N.T.S. 331. However, considering the time span since countries such as France signed the MA, it is doubtful that they will ever do so and this may constitute sufficient proof of their unwillingness to sign it.

67 Williams 2002: 8.

68 Christol 1980b.

69 Williams 2002: 11.

70 For further developments of this idea see Koskenniemi 2011: 1–36; Eslava–Pahuja 2011: 121; Anghie 2010: 31.

Some of them have come from other forums or are simply the result of national legislation. As such, below, I address the Artemis Accords, the Hague Building Blocks (both the most relevant proposals at the international level), and the issue of national laws in a collective manner.

OTHER PROPOSALS OR SOLUTIONS: THE ARTEMIS ACCORDS, THE HAGUE BUILDING BLOCKS AND THE ISSUE OF NATIONAL LEGISLATION

The Artemis Accords[71]

The Artemis Accords is a set of political agreements (therefore non-legally binding) seeking to "enhance the governance of the civil exploration and use of outer space" through the "operational implementation of important obligations contained in the Outer Space Treaty and other instruments".[72] It is noteworthy that the Moon Agreement is, of course, not one of these instruments, since the USA does not consider this treaty to be "effective or necessary". Then again, the United States also do not consider space to be a *global commons,* which in itself can be seen as a problem.[73]

The scope of these Accords refers to activities taking place on the Moon, Mars, asteroids and comets, including the Lunar and Martian orbits, and the Lagrange points of the Earth–Moon system.[74] Not only do they mention space resources, but also they are not entirely novel in their content. In fact, many of its sections merely reflect existing norms of international space law, with the main points of discussion being section 9 (on outer space heritage, which is a novelty) section 10 (on space resources) and section 11 (on safety zones).[75]

71 NASA 2020.
72 Section 1, Artemis Accords.
73 Presidential Documents 2020.
74 Section 1, Artemis Accords.
75 Bartóki-Gönczy – Nagy 2023.

Section 10 recognises space resources as beneficial for humankind and asserts that their extraction, which according to the Signatories of the Artemis Accords does not constitute national appropriation, needs to be consistent with the Outer Space Treaty.

There are no further references to space resource activities than the above, although section 11 deals with the deconfliction of space activities through safety zones, something which was already called for in the Hague Building Blocks.[76] In the Artemis Accords they are defined as areas where "nominal operations of a relevant activity or an anomalous event could reasonably cause harmful interference".[77]

Safety zones have the potential to raise concerns when it comes to exclusive use and occupation and the prohibition of national appropriation. There are guidelines in the Accords regarding their duration, which is always deemed to be temporary, as the safety zone ends at the same time as the operation. However, depending on the duration of the operation (especially if said duration is not predetermined), this could lead to *de facto* occupation, therefore breaching Article II of the OST.[78]

How the Artemis Accords uphold Article II comes down to an issue of practice, and indeed these Accords seek to influence State practice in order to generate customary norms in the long run. As I have argued before, whilst not particularly conflicting with the OST (and even the MA), the Artemis approach is problematic both in departing from the COPUOS as the main forum of decision, which leads to a risk of the increasing fragmentation of international law, and because of the underlying American legislation, which will be discussed below.[79] Overall, the main problem is that section 10 can be

76 Bittencourt Neto et al. 2020: 65.

77 Section 11 (7), Artemis Accords.

78 Whilst the focus on this work has been mostly on the prohibition of appropriation, it can still be argued that space resource activities have the potential to "collide" with the freedom of access to all areas of celestial bodies guaranteed under Article I of the OST. In light of that, a future framework also has to weight this occupation against that freedom.

79 Marques de Azevedo 2023.

contested by other States which favour a different interpretation, which would lead to difficulties when it comes to recognising the legality of some operations.

Indeed, the U.S. seek to promote their interpretation of international space law through the Accords. Moreover, while once again recognising that the Artemis Accords are ostensibly merely political agreements, they are overly vague about the possibility of space resource activities and offer no other concrete measures besides safety zones to facilitate their governance.

The Hague Building Blocks for the Development of an International Framework for the Governance of Space Resource Activities

The Hague Buildings Blocks are a debated solution from a group of experts and multi-stakeholders which was submitted to the COPUOS as a Working Paper by the Netherlands and Luxembourg.[80] The Hague BBs follow the principle of *adaptive governance* where the regulation of space resource activities would be carried out incrementally, assessing the appropriate time to do so, and reflecting the technological and scientific developments available.[81]

Whilst assessing the Hague Building Blocks in full would require a work of its own, it can be stated that their approach to the ownership of space resources reflects the idea of enterprise rights already mentioned, albeit with certain differences. Operators would first be attributed *priority rights,* and then *resource rights* over the extracted resources (building blocks 7 and 8).[82] It is then recognised that only the ownership of *extracted* resources can be obtained in outer space, which reflects the same rationale as the Moon Agreement. The Hague BBs suggest that these resource rights can be recognised through national legislation, via bilateral or multilateral agreements, yet their mutual recognition between States has to be enabled.

80 Building blocks for the development of an international framework on space resource activities, U.N. Doc. A/AC.105/C.2/L.315.

81 Bittencourt Neto et al. 2020: 9; Xu–Su 2022.

82 Bittencourt Neto et al. 2020: 10.

Despite the BBs not mentioning to whom the priority rights would be allocated, they recognise the need for an international registry to ensure their recognition and stipulate that they would last only for a fixed period of time and within a maximum area. Their attribution and duration would be determined considering the circumstances of the proposed activity.

The problem with this approach is that a first come, first served solution will not safeguard the interests of developing countries. This was recognised by the Hague Working Group itself, but still this was deemed to be the most appropriate method in the initial stages.[83] Two points are worth making in this regard: first, when it comes to the ITU, this same method was agreed upon internationally so the same process would have to exist for space resource activities to achieve the same level of legitimacy;[84] secondly, to safeguard the rights of operators to exploit a certain area, they do not necessarily have to be attributed on a first come, first served basis. Instead, the merits of the proposed activity can be evaluated and weighted; therefore, instead of priority rights, the designation of exploitative rights would have been preferable.

At the same time, despite allusions to the desirability of benefit-sharing mechanisms, the Hague Building Blocks do not directly call for mandatory monetary benefit-sharing, which is its most tangible form. As such, despite reflecting an approach which is in some respects similar to the MA, this international framework could still result in the same increase in inequalities in practice.

Even so, overall, the Hague Building Blocks are a worthy initiative and indeed they would form an interesting initial basis for negotiations in the COPUOS (in the event that the Moon Agreement ends up being set aside as a preferable basis). For initial space resource activities, such as prospecting, a common understanding seems enough. However, in the long term, an international, legally binding agreement will be necessary to ensure the enforcement of ownership and the settlement of disputes that can arise in this context.

83 Bittencourt Neto et al. 2020: 49.

84 Tronchetti 2014: 194–195.

The issue of national legislations dealing with space resources

In recent years, some countries have decided to unilaterally adopt legislation pertaining to space resources, a development which has raised some questions. In this field, the U.S. was the pioneer with Title IV (Space Resource Exploration and Utilization Act or SREU Act) of the 2015 U.S. Commercial Space Launch Competitiveness Act. They were to be followed by Luxembourg, the UAE and Japan, who introduced their own national legislation on space resource activities.

Despite some differences between them, all these national laws permit the ownership of space resources. For Luxembourg, clarification of this can be found in the first article of its Law of 20 July 2017 on the Exploration and Use of Space Resources where it is stated: "Space resources are capable of being owned."[85] Similarly, the UAE Federal Law No. 12 of 2019 looks to regulate, among other areas, space resource exploration and extraction activities, allowing permits for the "acquisition, purchase, sale, trade, transportation [and] storage" of space resources.[86]

Japan joined this group only recently with its Act on the Promotion of Business Activities Related to the Exploration and Development of Space Resources, adopted in 2021. The act allows private persons, licenced by Japan, to own extracted resources according to their approved business activity plan.[87] As it was the precursor of these pieces of legislation, the American SREU Act will be the main subject of the following analysis.

85 Article 1, Loi du 20 juillet 2017 sur l'exploration et l'utilisation des ressources de l'espace, English translation available at https://space-agency.public.lu/en/agency/legal-framework/law_space_resources_english_translation.html.

86 This is according to the joint reading of Article 4 (i) and (j) with Article 18 of Federal Law No. 12 of 2019 on the Regulation of the Space Sector.

87 Japan has not released an official English translation. One is available at https://www.japaneselawtranslation.go.jp/en/laws/view/4332/en. Still, it has provided an overview of its Space Resources Act.

The SREU Act contains the following assertion:

> "A U.S. citizen engaged in commercial recovery of an asteroid resource or a space resource shall be entitled to any asteroid resource or space resource obtained, including to possess, own, transport, use, and sell it according to applicable law, including U.S. international obligations."[88]

The major question arising from this approach is whether the United States grants itself territorial jurisdiction in order to grant its citizens the property rights over the resources obtained.[89] If so, then it would be a clear violation of Article II of the Outer Space Treaty. On the other hand, it could be said that this Act is doing nothing more than recognising the ownership rights that American citizens and companies will have over the extracted resources. In fact, the same sentence mentions that the applicable law includes the U.S. international obligations. Additionally, the following section of the act underlines that no jurisdiction, sovereignty, or ownership of celestial bodies is asserted.

Of course, it is not enough for the U.S. legislation to assert that it does not claim such ownership for the legislation itself not to amount to it. Even so it can be construed that the U.S. are recognising property rights merely over extracted resources, not over space "real estate". At the same time, it is difficult to understand how the United States can affirm anything in this matter, when the international obligations that are applicable to the issue at hand and to which the country itself is subject are still the object of differing interpretations.[90] Once again, this is not a problem of the American legislation only, as the other national laws mentioned all set out from the same understanding.[91]

88 Section 402 of Public Law No. 114-90 of 25 November 2015, also known as the U.S. Commercial Space Launch Competitiveness Act.

89 Cheney 2019: 114.

90 De Man 2017: 14.

91 In the case of the Luxembourgish, as seen, the recognition of ownership is general, not necessarily tied down to activities of the companies it authorises (Article 1, Loi du 20 juillet 2017 sur l'exploration et l'utilisation des ressources de l'espace).

This highlights the limitations that such unilateral approaches have: since the recognition of property rights of extracted resources is done under national law, but States have no territorial jurisdiction over celestial bodies, it does not mean that mutual recognition of these rights is assured from the get-go.[92] At the same time, competing claims can arise, which may lead to increased costs of activities if we factor in the settlement procedures that will be necessary to solve the issue. These are some of the risks (alongside the fragmentation and undermining of international space law) of departing from the multilateral approach. As such, an international regime represents a better option, especially because it will be easier to enforce with fewer costs.[93]

Moreover, one problem with such unilateral approaches and national laws is that, whilst alluding to or implying general ideas of common benefits, they do not actually establish mechanisms to achieve said benefits, not even for the populations of the States approving them. Instead, they favour the privatisation of profits with the socialisation of costs, using the State as a sponsor.[94]

MOVING FORWARD AND PREPARING FOR THE FUTURE: SOME THOUGHTS AND SUGGESTIONS

From all of the above, it is possible to understand that whilst the existing *corpus juris spatialis* provides some answers, the current legal framework (especially if the Moon Agreement is disregarded) does not provide enough legal certainty for space resource exploitation in the future. Even though the Outer Space Treaty allows space resource activities under the freedom of use, this is still debated at the international level. At the same time, if it were not for the clarification provided in the Moon Agreement, the possibility of ownership of extracted resources would be much more arguable.

[92] Cheney 2019: 115.
[93] Cheney 2019: 115–131.
[94] Feichtner 2019: 272.

As such, the first step, moving forward, is to reach a common understanding regarding the existing international framework and the interpretation of some of its provisions and their effects upon space resource activities. The fact that the issue is being discussed in the COPUOS is a very promising start, but these discussions must achieve concrete results.

During the initial stages of these activities, especially considering that *in situ* prospecting has not even started, this common understanding will suffice. The principle of adaptive governance and the approaches which make use of it, such as the Hague Building Blocks, can be helpful as they provide a sound basis for further development of an international framework.

In the long run, however, an internationally binding regime is both desirable and will prove necessary. The issue cannot be left to unilateral approaches or national legislation alone, as this is not enough to guarantee the effective enforcement and mutual recognition of ownership of extracted space resources. Only an international regime can guarantee a higher degree of legitimacy and lower the risks of a tragedy of the commons and environmental problems.[95]

If the issue is left for national legislation to develop the necessary provisions, lack of international coordination and the promotion of *laissez faire* competition with the ensuing resource-grabbing race could soon prove troublesome. Moreover, private ventures could be incentivised to only choose those States with the more appealing regulations (instead of those requiring higher standards of care, for instance) which can lead to some States acting as a *flag of convenience* and create a *race to the bottom*.[96] This can be problematic especially if the required environmental protection standards differ from State to State. At the global level, this approach is more likely to lead to increased unfairness and the neglect of intergenerational concerns.

95 The idea of permitting unilateral exploitation of a global commons (which can be used by all) can lead to everybody using it for private interests and no one protecting it for common interests, therefore effectively depleting the resources of the commons, which would result in the worst outcome for all.

96 Su 2017: 1007, 1008.

States should avoid pursuing unilateral ventures in certain matters to prevent the further fragmentation of international space law and so as not to undermine the role of the COPUOS. Additionally, an internationally negotiated solution already exists, which guarantees an equitable approach and addresses intergenerational concerns: the Moon Agreement. It is clear, however, that the current commercial and political situation globally might prevent the possibility of an international agreement, especially one as disputed as the MA.[97]

Still, controversial as it might be, to keep on promoting the idea that the Moon Agreement is detrimental to or represents a barrier to space resource activities is a pure work of science fiction. If there have been no commercial resource activities in space so far, this is the result of a lack of technological capacity, not a stifling regulatory environment. In that regard, if anything, the Moon Agreement provides more legal certainty since it was clearly drafted to address the issue of space resources and it clarifies the possibility of their ownership after extraction.

The common heritage principle is also not necessarily incompatible with commercial ventures.[98] In fact, if there is something that can be learned from the example of the UNCLOS, and its Implementation Agreement, it is that this principle can be adapted to a free market economy as well – albeit this does not mean it has to follow the same path – without a requirement to part ways with it.[99] While being a modified version, the general principle of common heritage of humankind remains in the law of the sea. It is perfectly conceivable for States to ratify the Moon Agreement and work on building upon its provisions, where they can make use of proposals such as the Hague Building Blocks, which reflect more recent perspectives.

When it comes to the equitable approach and the sharing of the benefits derived from space resources, this is a discussion that will take place either with or without the MA on the table. This is perhaps the most crucial point

[97] Xu–Su 2022.

[98] Christol 1980a: 454.

[99] Lee 2012: 252.

of debate that needs to be considered and a solution needs to be found based on mutual understanding.

From the point of view of non-spacefaring nations and developing countries it needs to be understood that without the major spacefaring nations, any international regime to regulate space resource activities will not work, given that they will be the ones carrying out such activities.[100] At the same time, major spacefaring nations need to understand that they need the international support of other countries when developing their space activities and that the mutual recognition of the ownership of extracted resources is essential. Without envisioning a regime that includes benefit-sharing mechanisms, they will not be able to obtain the support of these countries.[101]

Various types of benefit-sharing mechanisms have been proposed, which can be qualified as monetary, non-monetary and concerning the advancement of developing countries, with the latter options being the most likely to be adopted due to the current state of the international political economy.[102] Of course, aspects like the knowledge of space resources and the environment are beneficial, and measures such as capacity-building should be incentivised by an international regime, as this also provides tangible benefits.[103] However, financial benefit-sharing does not need to be discarded – and it must be stressed that it does not necessarily need to be mandatory.

Suggestions have been made on possible benefit-sharing regimes that can be established and which consider issues such as the type of resources exploited, the stage of development of these activities and the type of benefit shared.[104] Any discussion regarding the possibility of financial benefit-sharing will have to factor in the type of resources exploited, their use and value, as well as the stage of development of the space resource activities. As such, an international regime could consist of various different approaches accordingly.

[100] Cheney 2019.
[101] Xu–Su 2022.
[102] Xu–Su 2022.
[103] Xu–Su 2022.
[104] In this regard, I suggest a reading of Xu–Su 2022.

For instance, when it comes to prospecting activities, it would not make sense to require any financial contribution,[105] but in the long run and once exploitation has been well established and produces substantial profits, some form of financial profit sharing should be considered. Payments to an international fund based on the profit of these ventures would safeguard the loss of profit and help them adjust to market demands. Such an international fund could then finance sustainable development programmes, paying particular attention to the needs of developing countries. This is an issue that will have to be highly debated, as it is likely to encounter some resistance.

Another question connected to the equitable approach which needs to be discussed thoroughly concerns the attribution of exploitative rights. Any attribution of exploitative rights on celestial bodies (either by an international authority or not – an issue that also needs to be settled) which is on a first come, first served basis is likely to produce unequitable and unfair results. This is especially true if it is done without setting up any financial benefit-sharing measures or if there is no reservation of areas of equal value to be exploited by developing countries.[106]

As mentioned above, the goal of promoting equity through space activities is to avoid creating further asymmetries at the global level, as well as perpetuating a system of international law that protects those "structures of over-exploitation and unequal distribution that it is then called upon to fix".[107] The idea of *space for all humankind* offers the most recent opportunity to correct the mistakes of the past – a chance that must not be wasted. The aimed-for universality of the project of international law is riding on it.[108]

Any regulation of space resource activities must not depart from multilateralism and the possibility of reaching an international agreement. While

[105] Xu–Su 2022.
[106] Cheney 2019: 137.
[107] Feichtner 2019: 273.
[108] Eslava–Pahuja 2011: 121.

achieving results will still take some time, discussions aiming at promoting intergenerational equity, a fair regime and sustainable development will have to consider the questions mentioned above.

CONCLUSION

In this contribution I aimed to address the issue of the regulation of space resource activities. To achieve this, I first assessed the current *corpus juris spatialis,* focusing on the two treaties which are most relevant to the matter: the Outer Space Treaty and the Moon Agreement.

While it seems clear from both treaties that space resource activities are permitted and that the provisions on national ownership prohibit land and *in situ* resources ownership but allows the ownership of extracted resources, there are still some divergent opinions.[109] As such, a common understanding of the current international framework needs to be reached.

Recent years have seen new proposals and approaches to this topic such as the Artemis Accords, the Hague Building Blocks and even national laws. The latter approach is particularly problematic as "going it alone" can lead to a state of *laissez faire* competition which will result in resource-grabbing races, flag of convenience States and a race to the bottom, with the potential to create a tragedy of the commons.

It was recognised that initially, due to the current geopolitical circumstances, the prospecting stages of space resource activities can take place under a set of well-defined principles that represent a common understanding of the current core treaties and which follow the principle of adaptive governance. However, in the long term, an international regime is necessary to ensure enforcement, the effectiveness of measures, the mutual recognition of space resource rights and to better coordinate these activities. This prevents the fragmentation of

109 At the same time, the fact that ownership of extracted resources is permitted does not mean it is desirable or this is the path that we have to pursue. This is a discussion that was left out of this work.

international space law and avoids undermining the role of the COPUOS as a forum of discussion, that could be caused by further unilateral approaches.

This regime can vary in many aspects and in the last section of this work I discussed some of the difficulties which may arise and made suggestions about what needs to be addressed in the discussions to prepare the future regulation of space resource activities. A possible solution available to States is to ratify the Moon Agreement, since the common heritage principle does not represent a barrier to space resource activities, and then build upon its provisions, even making use of more recent proposals such as the Hague Building Blocks. At the same time, ratification is not absolutely necessary, and the Moon Agreement can be a basis for negotiations at the international level, also bringing to the table private actors in the field.

In any case, an international regime for the regulation of space resource activities will need to consider all sides. Major spacefaring nations need other countries to support their space resource activities and, in order to establish a successful international regime that achieves global application, developing countries need the adherence of the major spacefaring nations.

It is this author's view that this international regime needs to address issues of intergenerational equity and the distribution of resources and, therefore, the inclusion of benefit-sharing mechanisms needs to be contemplated. Whilst there are other possibilities besides financial benefit-sharing, this option still needs to be considered, even if it is not on a mandatory basis. After exploitation activities are well-established, States should consider making profit-based payments to an international fund that will finance sustainable development programmes, taking into account the needs of developing countries.

Promoting intergenerational equity through a regime for the regulation of space resource activities is an approach that seeks to avoid repeating mistakes from our past. Although this will take some time, the results we achieve during this process will be essential in dictating if we reach the goal of space for all humankind.

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Katja Grünfeld

Space Settlements: An Age of Civilisation Building?

Introduction: Plans in the Making

Humanity has gazed at the stars for millennia, marvelling and wondering at the secrets they hold and what life among them would be like. An abundance of artwork, literary works and films are testament to the popular fascination with the prospect of human existence in outer space.[1] The wealth of governmental studies and policy papers, scientific works and architectural designs related to space exploration demonstrate the intent to see it become reality.[2]

In 1969, a first step towards this dream was made as millions worldwide watched Neil Armstrong take his "small step for man, giant leap for mankind" following Apollo 11's historic touchdown in the Sea of Tranquility on the Earth's Moon.[3] Subsequently, twelve humans walked on the Moon on six Apollo Missions between 1969 and 1972, gathering lunar soil samples for scientific studies, before humanity withdrew from the Moon.[4] Now humanity is primed to return to the Moon and even travel beyond it to the Red Planet, Mars. The famous Artemis project, named for Apollo's twin sister in Greek Mythology, initiated by the USA in cooperation with partner states and agencies, such as the European Space Agency (hereinafter: ESA), saw its first

1 See for example Clarke 1968; Verne 1865; *2001: Space Odyssey* 1968; De Bergerac 1650.

2 Examples include NASA 1977; Oberth 1958; Noordung 1995; von Braun 1952. See also Grünfeld–Hobe 2022: 401–417.

3 For more see Whitehouse 2019; Loff 2015.

4 See for example Heiken–Jones 2007.

DOI: https://doi.org/10.36250/01208_15

milestone in November 2022 with the successful maiden flight of the unmanned Artemis I.[5] To facilitate its journey as well as the push for Mars, the orbital space station Gateway is under development, that, subject to successful testing, will be placed in the Moon's orbit to serve as a stop-over point for incoming spacecraft, offering refuelling and other necessary services.[6] This is expected to be of vital assistance to deep space travel as the most arduous part of any space travel is escaping and entering a celestial body's gravitational field.[7]

ESA will join the American National Aeronautics and Space Administration (hereinafter: NASA) on its Artemis mission and establish the first Moon Village on the lunar surface.[8] Meanwhile, China is busy researching all aspects required to establish its first lunar base,[9] a project on which it intends to cooperate with Russia.[10] India is also planning on sending its first astronaut to space and then to the Moon.[11] Looking beyond the Artemis mission, the USA furthermore plan to land the first astronaut on Mars.[12] The United Arab Emirates is planning a full scale Martian settlement in 2117.[13] Non-State entities (hereinafter: NSE) also have their sights on celestial bodies, as the Moon Village Association,[14] the Mars Society[15] and various space resource mining companies may require the support of settlements for their endeavours,[16] and most notably the influential and successful commercial space services provider SpaceX is developing a super heavy rocket named Starship to carry the first humans to Mars by 2030.[17]

5 For more information on Artemis see NASA 2023a.
6 NASA 2023b.
7 For an explanation of space travel see Noordung 1995: 3–72, 128–132.
8 ESA 2016; ESA 2023.
9 Singer–Corbett 2023.
10 Bensaid 2023.
11 Kumar–Mashal 2023.
12 National Aeronautics and Space Administration Transition Authorisation Act of 2017.
13 UAE s. a.
14 Moon Village Association s. a.
15 The Mars Society s. a.
16 Petrova 2022.
17 SpaceX s. a.

Whether the human venture into outer space to establish permanent human presence there will be called "space colonisation" or the more politically neutral sounding "space settlement", in an attempt to distinguish humanity venturing into the Cosmos from the colonisation history of previous centuries,[18] little doubt remains that as soon as technology permits, permanent human presence in outer space will be established. Before this happens, however, a legal framework should be established, for where at least two people live, laws must exist to regulate their interactions and property, to dictate the musts and must-nots, and to resolve conflicts when these arrive, thus preventing bloodshed and enabling people to co-exist.[19] Therefore, the law must precede humanity into the final frontier since the potential for conflict during humanity's race for resources and outer space's potential for military domination and warring efforts are well established.[20]

This chapter will, therefore, provide an overview of the methods and instruments humanity has already employed to regulate human activities in outer space and their contents, which have mostly taken the form of international agreements. In this manner, it will attempt to show what legal instruments are likely to emerge in the current age of leaving the Earth and in the coming age of space settlement, as well as proposing what questions and content these instruments should address.

THE EVOLUTION OF SPACE LAW AND THE NECESSITY FOR AN AGREEMENT ON SPACE SETTLEMENT

The evolution of space law began with the launch of the first artificial satellite, Sputnik 1 in 1957, followed by the establishment of the United Nations Committee on the Peaceful Uses of Outer Space (hereinafter: UN COPUOS) tasked

18 Blount 2021: 187–203.
19 Shaw 2017: 1–51; Crawford 2019: 3–18.
20 Lay–Taubenfeld 1972; Noordung 1995: 122–123.

with drafting legislative principles for outer space.[21] Following an arduous process, in 1967 the fundamental Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies,[22] known as the Outer Space Treaty for short (hereinafter: OST), was adopted, and ratified as of November 2023 by 114 States worldwide, including all spacefaring nations.[23] It codified that the outer space is an area beyond national jurisdiction, akin to the high seas, where every State has the freedom of exploration and use, which shall be carried out in accordance with international law and for the benefit of all, for outer space is the province of all mankind,[24] possibly *res communis.*[25] As indicated, the OST is State-oriented, binding States and decreeing that activities of the NSE shall be the responsibility of the appropriate State.[26] This heralds the *first conclusion* that any space settlement agreement should be international. To clarify, the term *international* in this context relates to interstate agreements and relations, with international law denoting a legal system regulating the relations between nation states as the primary subjects and at the same time creators of international law.[27]

The first conclusion can be supported by subsequent practice. The OST provisions were drafted as broad and general principles rather than specific detailed rules.[28] The treaty was therefore quickly followed by four other international agreements concretising select aspects of the OST, such as assistance to astronauts, liability in cases of damage by space objects, registration of space objects and the legal regime for the Moon (and other celestial bodies), in the 1968 Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space or Rescue Agreement for

21 Lachs 2010: 27–39.
22 United Nations, *Treaty Series,* 610(8843).
23 See for example Rome 2023.
24 Lachs 2010: 42–46; Freeland–Jakhu 2009: 44–64.
25 Hobe 2023: 77.
26 Hobe et al. 2009.
27 Shaw 2017: 1–2.
28 Sancin et al. 2021: 7–9.

short (hereinafter: RA), the 1972 Convention on International Liability for Damage Caused by Space Objects, abbreviated as the Liability Convention (hereinafter: LIAB), the 1974 Convention on Registration of Objects Launched into Outer Space, or the Registration Convention (hereinafter: REG), and the 1979 Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, commonly called the Moon Agreement (hereinafter: MOON), respectively.[29]

This era of space treaty-making is recognised as the first phase of space law-making with the MOON signalling the end of the hard law (legally binding instruments) era, which was followed by two phases of creating soft law instruments (generally understood as legally non-binding instruments).[30] These two consecutive phases were marked (mainly) by the United Nations General Assembly (hereinafter: UNGA) Resolutions developing specific topics of space law, for example direct television broadcasting, remote sensing and nuclear power sources in outer space in the second phase (1982–1996),[31] and interpreting existing principles and concepts entailed in the existing space law treaties in the third phase (1996–ongoing).[32] During the latter third phase, additional instruments regarding recognised globally important issues were developed and adopted, such as the Inter-Agency Space Debris Coordination Committee's 2002 Space Debris Mitigation Guidelines (hereinafter: SDMG), International Law Association's 2013 Model Law for National Space Legislation,[33] and the 2018 Long-Term Sustainability Guidelines (hereinafter: LTS).[34] This indicates that projects that are of interest to all have been subject to international regulation.

29 For an in-depth study of the Treaties see generally Hobe et al. 2009; Hobe et al. 2013; Böckstiegel 1991.

30 Hobe 2023: 58–68.

31 Examples include UNGA Res. 37/92 (10.12.1982); UNGA Res. 41/65 (3.12.1986); UNGA Res. 47/68 (14.12.1992). For an in-depth analysis see Hobe et al. 2015.

32 Examples include UNGA Res. 51/122 (13.12.1996). See Hobe 2023: 58–68.

33 U.N. Doc. A/RES?68/74 (2013).

34 UNOOSA 2010; UNOOSA 2021.

Equally, for example, the establishment of international and regional organisations, such as the International Telecommunications Union (hereinafter: ITU) (1865), the ESA (1957), INTELSAT/ITSO (1964), INTERSPUTNIK (1971), IMSO/INMARSAT (1976–1979), EUTELSAT (1977), EUMETSAT (1986), the Latin American and Caribbean Space Agency (2021), the African Space Agency (2023) and others have been subject to international legislation, albeit normally hard law instruments, such as the ITU Convention, the ESA Convention etc., rather than soft law instruments as in the case of the SDGM and LTS.[35]

The illuminated practice then confirms the use of international instruments for the evolution of global issues facing all space users, including an indication that newer instruments are more often soft law in nature. This furthermore echoes the *second conclusion,* that space settlement should be subject to a space settlement specific international agreement concretising the basic principles outlined in the OST.

After all, while calls to amend the OST have persisted as space technology has evolved and given rise to unprecedented activities, any real attempts to amend the OST have been avoided for fear of opening a Pandora's Box.[36] Namely, the OST was developed as a compromise during the Cold War in an era of treaty-making, in order to prevent an arms race in outer space.[37] This resulted in the wide and general formulation of its foundational provisions and on the one hand permits the OST to remain a living document, up to date and able to encompass the newest technologies, while on the other hand, renders it potentially insufficient and requiring concretisation for real-life operational use.[38] The enduring promises of high returns, the critical role of space technology in contemporary society and the subsequent possibilities for military and political domination of space developed States over non-space

35 Sancin et al. 2021: 7–15.

36 Tobias 2005: 299–318.

37 See generally Hobe et al. 2009.

38 Sancin et al. 2021: 7–9.

States,[39] make it imperative to keep the OST in power, thus avoiding a potential legal void, and keeping outer space from becoming a war zone.[40] However, it is perhaps precisely due to its general and foundational character, that the OST is an appropriate starting point, and should form the basis of a space settlement specific international agreement,[41] thus preventing space settlement from becoming a breeding ground for conflict and war. As demonstrated, then, additional instruments of concretisation have historically been employed to further evolve space law while retaining the OST as a foundation. Thus, space settlement, as a novel space activity not directly addressed by the OST, should likewise be subject to a new space settlement specific international agreement.

To determine finally the legal nature of any such agreement, however, a further glance at the regulation of international projects may prove useful. Projects such as the development and operation of orbital space stations, which are the closest approximation to space settlement activities to date, have historically been regulated by a combination of hard law and soft law instruments. While some space stations were launched and operated by single states and thus subject to national regulation,[42] the larger manned space station projects have included two or more cooperating States, in part due to the high costs involved.[43] One such long lasting space station was the Soviet Mir Station, which under Phase One, the Shuttle–Mir Programme, hosted astronauts (following the Russian wording *cosmonauts*) of various nationalities, including ESA astronauts.[44] Phase two of the project eventually led to the mammoth International Space Station (hereinafter: ISS) project for which Memoranda of Understanding (hereinafter: MOUs) between fifteen partners (States represeted by national

39 Noordung 1995: 122; see generally Lay–Taubenfeld 1972.
40 Miller 2020: 59–66.
41 Hobe 1997: 135–143.
42 Even if a space settlement would be a single State affair, the following space law analysis as well as the incident between SpaceX satellite Starlink and the Chinese Space Station (see Lan 2022) show that every space settlement will require a level of international cooperation, thus mandating an international agreement.
43 Harland–Catchpole 2002.
44 ESA 2001.

space agencies) and an intergovernmental agreement (hereinafter: ISS IGA) were formulated.[45] The legal nature of the MOUs is somewhat unclear, with some regarding them as an interstate gentleman's agreement.[46] Nonetheless, the IGA is an international hard law instrument,[47] signalling the use of both hard and soft law instruments in the establishment and operation of the mammoth cooperation project, the ISS. The IGA reconfirmed the OST's leading principles, including the exercise of jurisdiction and control of the State that registers a certain object in its national registry,[48] *in effect* leading to the applicability of national laws of the registering State,[49] for example regarding intellectual property[50] or criminal jurisdiction questions,[51] within a State's registered modules and over any personnel in it or else on the ISS that are its nationals.[52]

Certainly, some aspects of space regulation, such as the supervision of private actors have often been left to national legislators, in part due to the State-oriented nature of the OST, as for example Article VI of the OST, which mandates that States shall bear international responsibility for national space activities, whether carried on by governmental or non-governmental entities, and will authorise and supervise the activities of the latter, ensuring their compliance with the OST.[53] This prompted the development and emergence of national space legislation, the extent of which the United Nations Office for Outer Space Affairs currently evaluates at around 40 to 50 national acts (with some type of reference to space activity),[54] out of 80 to 90 States that are active in space.[55] However, only around 24 are considered to have concrete norms on authorisation and supervision of NSE space activity and can thus

45 NASA 2023f; Uri 2021.
46 Lyall–Larsen 2009: 38–39.
47 UN COPUOS 2013.
48 OST, Article VIII.
49 Schmidt-Tedd – Mick 2009: 146–168.
50 ISS IGA, Article 21.
51 ISS IGA, Article 22.
52 ISS IGA, Article 5.
53 Gerhard 2009: 103–125.
54 See UNOOSA 2023.
55 See, for example, UNOOSA s. a.; Rome 2023.

be regarded as having comprehensive national space laws in place (for example USA, Russia, the U.K., Japan and France).[56] The majority of private space activities seem to be undertaken in the USA, some European states, Canada, Japan and Russia.[57] The global space industry is currently valued at more than five billion U.S. Dollars, with the amount of investment and revenue expected to rise.[58] The expansion of private space activity has been largely credited to the evolution of small satellites, often termed *smallsats,* and the consequent reduction in launch costs.[59] This rising participation in space activities and the reliance of States on space NSE (for example, SpaceX and Ariane Space are providing launch services to the USA and ESA respectively),[60] illustrates the *third conclusion* that national space laws will (at least for the moment) continue to play an ever-growing role in the regulation of space activities.

Returning, however, to the question of the legal nature of an international settlement agreement, the *final conclusion* seems to be that it remains, for the moment, unclear whether the agreement shall take the form of a hard or soft law instrument. While the ISS has employed both, the final instrument to be presented is the Artemis Accords. In a renewed space race, in this modern era for space resources and settlement, the USA developed the Artemis Accords, a set of guiding principles for lunar and deep space exploration.[61] Determined to be a political agreement in Section 1,[62] the Accords seem to be a soft law instrument,[63] quickly gaining State signatories (37 as of April 2024), but still missing two of the main space powers, namely Russia and China who have shunned the agreement, calling it *inter alia* USA's colonisation attempt.[64]

56 Hobe 2023: 131–138.
57 Rome 2023.
58 Grush et al. 2023.
59 Larsen 2018: 481.
60 Markets and Markets 2022.
61 Einhorn 2022; Jamasmie 2021.
62 Artemis Accords 2020, Section 1.
63 De Zwart 2021: 68–69, 76–77.
64 Einhorn 2022; Jamasmie 2021.

For the foregoing reasons, *summarising in one sentence with three points:* entering the space settlement era, humanity requires a new *international* space settlement *specific agreement,* either in the form of a *soft or hard law* instrument. International agreement because humanity ventures into an area beyond national jurisdiction and sovereignty, a "province of mankind", as the endeavour is certain to include multiple States and their national NSE,[65] and as existing space law is State oriented. A new specific agreement, because the OST is a treaty on principles employing broad and general language, which permits it to encompass the newest technologies, but at the same time renders it in need of concretisation. For this reason, it is, however, an appropriate starting point and should form the basis of a new space settlement specific agreement.[66] Whether a space settlement agreement will take the form of an international hard or soft law instrument is for the moment unclear. The older ISS IGA, regulating the current human presence in outer space, and similar instruments (for example the ITU Convention), indicate the possible use of a hard law instrument,[67] while the most recent Artemis Accords and other newer instruments developing space law answers to global issues (e.g. SDGM and LTS) point toward a preference for soft law instruments.[68] There are advantages and disadvantages to both. Hard law instruments are legally binding on its Parties, but cumbersome to alter, while soft law instruments are easier to modify, but at all times rely on the Parties free will to carry out its provisions without threatening any kind consequence when failing to do so, except perhaps the political pressure from other Parties.[69] Both aspects, adherence and possibility of modification, will be important at the eve of a new era of human existence. Whichever form it takes, any agreement adopted should be honoured in good faith by its parties; the content of such an agreement will be examined in the next section.

65 See for example von der Dunk 2020: 78–89.
66 Hobe 1997: 143.
67 Chatzipanagiotis – Moro-Aguilar 2014: 11.
68 De Zwart 2021: 76–77.
69 Bosi 2021; Shaffer–Pollack 2009. See also Tarelli 2009.

LEAVING THE CRADLE

Soviet space engineer Tsiolkovsky stated that the Earth is the cradle of humanity, but that humanity cannot stay in the cradle forever, for in its pursuit of light and space, man will conquer the solar system.[70] To regulate this conquest the nations of the world codified several all-important principles of space exploration and use in the OST,[71] applicable to all human activities in outer space, including on the Moon and other celestial bodies.[72] It stipulates *inter alia* that exploration and use are to be free to all States without discrimination and are to be the province of all mankind, done for the benefit of all countries, for peaceful purposes, in accordance with international law, without causing harmful contamination or interference.[73] Outer space itself, including the Moon and other celestial bodies, is not subject to national appropriation,[74] including by private individuals and enterprises,[75] which shall in turn require the authorisation of and supervision by the appropriate State before undertaking any space activity,[76] as only States are internationally responsible for national space activities and liable for any damage caused by launched objects.[77] While this means that outer space is not subject to any one State's sovereign authority (e.g. sovereignty), launched objects retain the jurisdiction of the State that registered them in their national registry, and thereby attain a quasi-territorial status akin to ships or aircraft.[78] Jurisdiction, as the legal authority of a State to affect persons, property and circumstances within its territory, in effect creates sovereignty of the registering State in its registered objects.[79] It therefore

70 Tsiolkovsky 1928.
71 Lachs 2010: 125–135.
72 For a discussion on the term *celestial bodies* see Vitt 1989: 132–139; Hobe 2023: 1.
73 OST, Articles I, III, IV, IX.
74 OST, Article II.
75 Freeland–Jakhu 2009: 44–64.
76 OST, Article VI. For more see Gerhard 2009: 106–123.
77 OST, Articles VI, VII.
78 Cheng 1997: 467.
79 Schmidt-Tedd – Mick 2009: 156; Cheng 1997: 467.

means that space settlers, their rights and duties, their behaviour and any transgressions that may occur, will likely be regulated by national laws of the State that registered the module in which the settlers will be working and living, or by personal jurisdiction, e.g. nationality.[80] Finally, while orbits may be populated by military satellites in as long as no nuclear weapons or weapons of mass destruction are placed there, on the Moon and other celestial bodies, any type of military activity is forbidden.[81] Information must be shared and mutual cooperation is encouraged at various turns.[82] These are the fundamental principles of space law.

Proceeding into an era of space settlement, several factors may determine the further evolution of space law. The above indicated topics, will certainly require addressing, with some likely proving unproblematic. Judging from doctrine and practice, the requirements that all activities of the settlement will have to be in accordance with international law, for exclusively peaceful purposes with any military activity or testing of weapons on celestial bodies forbidden, with NSE activity requiring authorisation and supervision by the appropriate State, and the details of everyday life likely regulated by national legislation applicable through invocation of Article VIII of the OST, do not seem disputed (at least not at present). While dispute settlement remains an open topic, the lack of concrete rules does not seem to have negatively impacted State practice.[83] Some other aspects, pertaining mainly to desired new activities currently still in the planning stage, however, require analysis. Among these positioning of settlements and their coordination, the question of space resource extraction and environmental protection can be raised, as well.

80 Hobe 1997: 138–139. For the effects of Article VIII of the OST see Schmidt-Tedd – Mick 2009: 146–169.
81 OST, Article IV; Schrogl–Neumann 2009: 70–93.
82 OST, Articles I, III, V, IX, X, XI, XII.
83 See for example Goh 2007; Hobe 2023: 209–221; Vincenzo 2023.

POSITIONING OF SETTLEMENTS

With regard to the positioning of settlements it is worth mentioning that Article I of the OST decrees that the exploration and use of outer space, including the Moon and other celestial bodies, shall be carried out for the benefit of and in the interest of all countries, and that space shall be the province of all mankind, and free for exploration and use by all States. This in essence means that exploration (finding out whether use is possible and the discovery of areas appropriate for use) and use (commercial and non-commercial utilisation) of outer space, including celestial bodies, is free to all States with very few limitations.[84] For example, the requirement to benefit all, which read together with the prohibition of national appropriation of outer space from Article II of the OST, likely determines outer space as a *res communis,* indicating that outer space may not be used to the sole advantage of only one enterprise or State.[85] This, in essence, means that any settlement will need to be beneficial to all. Historically, the benefits requirement has been satisfied by the spacefaring party contributing to humanity's knowledge, by making available data such as remote sensing data or satellite navigation, etc.[86] The benefits requirement might then be satisfied even by the sheer existence of a settlement and its activities as far as the results are shared in accordance with, for example, Article XI of the OST, and scientific research is furthering humanity's collective knowledge.

Article I of the OST concludes that there shall be free access to all areas of celestial bodies. This more concrete decree might prove more difficult to satisfy.[87] The reason for this is that space objects, such as space station modules, are, unlike outer space itself, subject to the jurisdiction, and thus the legal authority and sovereignty of the State that registers the object in its national registry.[88] Jurisdiction, as a central aspect of sovereignty, guarantees the State

[84] Hobe 2009: 25–43; Hobe 2023: 77.
[85] Hobe 2023: 77; Hobe 2009: 25–43.
[86] Salmeri 2020: 110–111; Hobe 2009: 25–43.
[87] Von der Dunk 2020: 77–89.
[88] Schmidt-Tedd – Mick 2009: 146–168; Lafferranderie 2005: 231.

the right to require that any other State refrain from unauthorised actions and interference with its object.[89] For this reason some authors take the view that jurisdiction is (almost) absolute,[90] as the importance of State sovereignty to the existing international legal order has been highlighted by the International Court of Justice consititently in its jurisprudence.[91] Others, however, view the jurisdiction granted by Article VIII of the OST as simply the gateway to the application of national legislation to perform supervision in accordance with Article VI of the OST, and as such not absolute.[92] Current satellite practice indicates a possible preference for the former interpretation.[93] This could pose a potential danger to the freedom of access to all areas as States could deny access to an existing installation taking over a certain surface area, and thereby to that area of celestial body as well.

Nonetheless, while in principle access to all areas must be granted,[94] (as well as access to celestial space stations for visits from representatives of other State Parties),[95] no concrete practice exists in the absence of a celestial space station. One possibility to guarantee access to all areas of celestial bodies without harming jurisdiction (e.g. State sovereignty) would be by designing mobile settlements e.g. modules capable of moving to another area of a celestial body. Some designs have already been proposed, which envisage space stations on wheels or crawlers.[96] A second possibility, perhaps hinted at by Articles I, IX, X and XI of the OST, which mandate in various aspects international cooperation in the exploration and use of outer space,[97] could be the incorporation of cooperation

89 Lachs 2010: 65–75; Vereshchetin 1981: 31; Chung 2019: 31–47; International Court of Justice 1986.

90 Chung 2019: 38; Lachs 2010: 69; Cheng 1997: 72, 86.

91 See, for example, International Court of Justice 1986; International Court of Justice 1949.

92 Hobe 1997: 135–141. See also Vereshchetin 1981: 31.

93 See, for example, Chung 2019; Sancin et al. 2021.

94 Lachs 2010: 45.

95 Smith 2009: 207–215.

96 See, for example, Cohen 2004.

97 See generally Hobe et al. 2009.

provisions into the space settlement agreement.[98] For example, Article XII of the OST mandates that all stations on celestial bodies are required to facilitate access to representatives of other State Parties subject to prior notification and on a basis of reciprocity. This has not been tested yet in practice and the language leaves various interpretations possible (e.g. *visit* is commonly understood a stay of a short duration,[99] and thus not the act of settling, which is commonly taken to mean the act of settlers or astronauts accessing a certain area for purposes of exploring or using the surface of the celestial body beneath the settlement base[100]), with a doctrine indicating that the idea behind it was to guarantee a minimal degree of oversight over the activities of States, rather than facilitating access to all areas of celestial bodies.[101] However, a similar provision might be developed and incorporated into a space settlement agreement, giving due consideration to the sensitive question of jurisdiction granted by Article VIII of the OST, ensuring that any access is authorised by the registering State and it is thus not a violation of international law, e.g. a self-imposed limitation on its own access, which would be likely to require consideration of State interests to determine how this access is to be authorised and granted without aggravating the registering State and its activities. A third option, more in line with the non-absolute interpretation of jurisdiction, would be a type of functional jurisdiction, which would guarantee that an object, in this case settlement elements, are actively in use and possess only as much surface area as necessary to facilitate the function.[102]

Whichever avenue is chosen, (in theory at least) any settlement agreement should incorporate provisions that ensure that settlements are generally beneficial and do not obstruct free access to all areas of celestial bodies through either mobile design, provisions on permitting (authorised) access to the surface area or a type of functional jurisdiction.

98 For a possible evolution of a right to join the settlement as a manner of maintaining multi-State settlements see von der Dunk 2020: 88.

99 Smith 2009: 207–215; see also, for example, Cambridge Dictionary s. a.

100 See, for example, Hobe 1997; von der Dunk 2020; Blount 2021; Grünfeld 2024.

101 Smith 2009: 207–215.

102 Gorove 1969: 352; von der Dunk 2020: 86.

EXPLOITATION OF SPACE RESOURCES

A further consideration is the hotly debated question of space resources. Article II of the OST dictates that "outer space, including the Moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means". The OST does not further define the terms employed in the Article, leaving the question of resource extraction and appropriation ambiguous.[103] For example, the term "by any other means" could be interpreted as a prohibition on the extraction and appropriation of resources as a *de facto* appropriation of a celestial body bit by bit.[104] However, an overly strict interpretation of Article II might negate the freedom of use from Article I of the OST.[105]

Historically, resources have been a hotbed of interstate conflict,[106] and the use of space resources, for example frozen water or Helium-3, is likely to be critical to the survival and self-sustainability of any human settlement.[107] Should the use of such resources prove critical to safeguarding human lives, it may be possible to argue that such use must be permitted pursuant to universal human rights, such as the fundamental right to life, which is the precondition for the enjoyment of all other human rights.[108] Therefore, the use of resources for survival of a settlement may not in itself present a serious issue as long as they are used proportionally and this use does not damage or endanger the surface and existence of the celestial body.[109]

The use of resources for commercial purposes, however, is in any case more controversial. The question of whether it could be argued that the commercial utilisation of resources will be necessary for the economic survival of the settlements may become a serious question further down the line as self-sustainability

[103] Hobe 2023: 72; Lyall–Larsen 2009: 171; Freeland–Jakhu 2009: 59–60.
[104] Sancin et al. 2021; Freeland–Jakhu 2009: 53.
[105] Gorove 1969: 352; Hobe 2023: 167.
[106] United Nations s. a.
[107] Zubrin 2011; Kulcinski 1989: 168.
[108] HRC, CCPR/C/GC/36 (2019).
[109] Gorove 1969: 353.

becomes a topic of discussion.[110] When settlements are initially established, it is likely that they will be highly dependent on support from Earth.[111] The commercial use of space resources is evaluated as a highly profitable prospect as, for example, Helium-3, a scarce resource on Earth, may exist in abundance in outer space, for instance on Earth's Moon in the Sea of Tranquility, around 800 tons are estimated to exist, a single ton of which could create enough water for 45,000 people while 25 tons would be enough to provide a yearly energy supply to all U.S. citizens.[112]

While the economic use of outer space is permitted under Article I of the OST, the question of resources is becoming more relevant to Article II of the OST,[113] and concerns whether space resources constitute a celestial body itself or part theoreof.[114] It is certain that national appropriation covers appropriation, e.g. ownership over the surface of celestial bodies and any orbital position,[115] including private appropriation of these.[116] However, the OST does not address the topic of resources directly (or in any detail) and therefore leaves the question of their appropriation ambiguous.[117] The argumentation against resource appropriation maintains that resources are part of celestial bodies, and the incorporation of phrases "by means of use" and "by any other means" into the OST as general phrases intended to encompass any further means of appropriation that may become feasible in the future thus cover resource appropriation.[118] The argumentation in favour of resource appropriation has relied on the Lotus Principle, which dictates that any act which is not explicitly prohibited to sovereign states, is permitted.[119] As this relates to Article II of the

110 See generally OECD 2011; Pistor – De Shutter 2016.
111 Cockell 2019: 1–26.
112 Lee 2012: 52; Kulcinski 1989: 168.
113 Hobe 2023: 71–76.
114 See also Vitt 1989.
115 Freeland–Jakhu 2009: 44–64.
116 Hobe 2023: 71–76, 165–174; Freeland–Jakhu 2009: 44–64. See also Nemitz v. U.S. 2004; Lunar Embassy to China 2005. See also UNOOSA 1967.
117 Tronchetti 2009: 20; Hobe 2023: 71–76, 165–174.
118 Freeland–Jakhu 2009: 54.
119 The S.S. Lotus: 18–19. For more see Crawford 2019: 462.

OST, it amounts to the wording being formulated too broadly and too vaguely to amount to a prohibition.[120] Presently, several factors indicate the law might develop to permit space resource extraction and appropriation.

Firstly, the last space law treaty, the MOON in Article 11, Paragraph 3 specifically distinguishes between resources in place ("in situ") and resources not in place, furthermore stipulating in Paragraphs 5–7 that resource exploitation shall be governed by an international regime on benefit-sharing, incorporating certain elements that are outlined, such as equity. Therefore, the MOON seems to permit space resource exploitation as long as an international agreement regarding the exploitation of space resources is established, although as no such agreement exists to date, the MOON places a moratorium on space resource activities.[121] However, considering the MOON has very few State Parties, which undermines its legal authority in practice,[122] and that under the 1969 Vienna Convention on the Law of Treaties newer agreements may be used as an interpretational tool, only if it binds both disputing Parties,[123] it becomes questionable how much authority and clarity the MOON can provide.

Secondly, several documents have addressed the exploitation of space resources, *inter alia* the Hague Building Blocks,[124] the Position Paper of the International Institute of Space Law[125] and the Artemis Accords.[126] Furthermore, in 2015 the USA became the first country to pass national legislation, granting its citizens the rights to extract and own space resources. In 2017, Luxembourg joined this "club" and most recently the United Arab Emirates and Japan followed. While the validity of these laws may be debated,[127] it is nonetheless the practice of these four States indicating possible evolution of future laws.[128]

120 Hobe 2023: 167.
121 Lee 2012: 274; Hobe 2023: 170; Čeferin 2018: 23.
122 Bini 2008: 1–7.
123 VCLT, Article 31.
124 The Hague International Space Resources Governance Working Group 2019.
125 International Institute of Space Law 2015.
126 Artemis Accords 2020, Section 10.
127 Hobe 2023: 172.
128 Force 2013.

Thirdly, practice indicates the desire to mine space resources, for example, a myriad of existing NSE are gearing to begin space mining operations, defying financing and investment issues,[129] leading States worldwide to establish the United Nations Working Group on Legal Aspects of Space Resource Activities to examine and propose a legal framework.[130]

It may therefore come to pass that space resource extraction and exploitation will be permitted when the requisite technology becomes available and the endeavour viable.[131] The permissiability of using resources for the survival of a settlement seems less in doubt in light of the right to life and free space exploration and use. The use of resources for commercial purposes is less clear-cut, and more controversial, although as we have seen there is at the very least an enduring desire to lobby for its permission. In any case, the OST at this instance seems too vague to amount to either a clear prohibition or permission of space resource exploitation, and therefore further developments of the legal position, perhaps through a new treaty on space mining or through resources provisions within a space settlement agreement will be required.[132]

ENVIRONMENTAL PROTECTION

Space debris (or space junk), commonly understood as non-functional man-made objects and parts thereof (which remain in space),[133] is one of the most pressing issues of space exploration, threatening not only the space environment, but also the safety of active space objects and consequently the future of space activity.[134] Article IX of the OST sets a general obligation on states that the exploration and use of outer space, including the Moon and other celestial

[129] Petrova 2022.
[130] UN COPUOS 2021.
[131] Masson-Zwaan – Richards 2015.
[132] See Hobe 2023: 165–174.
[133] SDMG, Guideline 1.
[134] Chung 2019; Jakhu 2012; Freeland 2021.

bodies, should be conducted in such a manner as to avoid their harmful contamination and stipulates that State Parties shall, when necessary, adopt appropriate measures for this purpose. While the majority of experts agree that harmful contamination includes forward and back contamination by space debris,[135] the OST does not define harmful contamination, mandate specific conduct or prescribe consequences of not meeting these obligations, and as such, while it in principle provides for environmentally responsible behaviour, it is too general to amount to a specific obligation, rendering the Article weak in practice.[136]

It may be helpful to draw upon international environmental law (hereinafter: IEL) applicable to outer space through Article III of the OST, although the IEL principles most often called upon, such as the sustainability principle or the no-harm principle likewise lack concretisation and oblige states only to vaguely defined general goals.[137] Even such principles as common, but differentiated responsibilities seem disputed, not only in practice on earth, but also as applied to outer space in particular, as some argue against the application of such principles to ultra-hazardous activities.[138] The main issue seems to be, not the lack of principally applicable international law provisions, but the lack of clear and concrete obligations stemming from these. Despite an ever-growing sense of urgency when it comes to addressing orbital debris and protecting critical satellite services,[139] environmental protection of outer space still seems to be in its infancy in this regard. It therefore hardly seems likely that more attention will be paid to the celestial environment, which will not be of such critical importance to Earth population as Earth's orbits. However, given the static nature of the celestial environment, it is imperative to foresee such environmental protection before the celestial environment is polluted beyond

[135] Viikari 2008: 31–45.
[136] Marchisio 2009: 169–183; Hobe 2023: 93–95.
[137] For an in-depth analysis see Viikari 2008: 119–207.
[138] Viikari 2008: 178–184.
[139] Hollingham 2013.

repair and any future human settlements are placed in jeopardy.[140] While the general obligation seems to have been established in the OST, the Rio Declaration and other IEL documents and customs, greater clarity is required, which may be achieved in a specific space settlement agreement.

In practice, many States freely adopt measures at a national level to mitigate and remediate orbital space debris, including efforts to develop collision avoidance measures (including by appropriate mission design) and space traffic management system(s).[141] While some states have adopted these measures in their national laws or have at least adopted references to maintaining and safeguarding the space environment, not all have done so. Most states still do not have comprehensive national legislation in place that would regulate also space debris.[142] At the same time, however, some soft law documents have been adopted at international level such as the SDGM and the LTS. The questions of sustainability and space debris are raised at the UN COPUOS discussion table every year and are incorporated into its legal as well as technical reports. While all of this indicates awareness, and in the case of national legislation (at least to a degree) binds the NSE, it still does not obligate states to any concrete actions or guarantee they will take environmental action when building settlements.[143]

The problem of orbital debris is also relevant to space settlements on celestial bodies, particularly the Earth's Moon which has, for example, seen incoming debris strike its surface on more than one occasion.[144] Furthermore, unsuccessful landing attempts, such as that of the Bereshed spacecraft which carried tardigrades on board, have been another source of potential contaminants of the Moon's environment.[145] Moreover, space settlements may themselves represent a potential source of environmental pollution. For example, one problem that may be anticipated is how to deal with the by-products of space resource

140 Thompson 2023.
141 See, for example, Froehlich 2019; ILWR 2023; EUSTM 2023.
142 Hobe 2023: 134–135.
143 See generally Hobe 2023: 93–107; Viikari 2008; Stubbe 2018.
144 Gough 2022.
145 Oberhaus 2019.

mining.[146] The national space act provisions granting the right to space resource extraction and appropriation, do not seem to address environmental protection under the same provision, but instead leave this aspect to the remaining legal framework. Another problem that will certainly arise is that of waste disposal. The Apollo missions, for example, left a considerable amount of items on the Moon, including bags of human waste, discarded equipment, personal items such as photographs, etc.[147] Finally, the possibility of an abandoned facility is a further cause for concern, not only from an environmental perspective, but also in terms of access rights to the area of celestial body it encompasses, partially discussed above. This is due to the fact that the jurisdiction granted by Article VIII of the OST is not dependent on the functionality of an object, meaning that even space debris remains under a state's jurisdiction.[148]

In maritime law, installations may involve the abandonment of jurisdiction.[149] By comparison, the OST indicates the intention of the drafters that jurisdiction and the resulting liability for space objects cannot be abandoned, in order to protect potential victims of space activity.[150] This, however, then prevents any unilateral action on the part of third states, in other words, even a *de facto* abandoned celestial facility would retain the jurisdiction of the registering State, and its removal would thus be subject to authorisation by the registering State. In this manner, not only might environmental protection be impacted through the decay of the installation but, if it is left unattended, it could present a *de facto* avenue of appropriating whole areas of celestial bodies.[151] For example, even the safety zones proposed by the Artemis Accords have been equated by China to a way of circumventing the prohibition of national appropriation under Article II of the OST.[152]

146 Hofmann–Bergamasco 2020.

147 Royal Museums Greenwich s. a.

148 Lyayll–Larsen 2009: 67; Schmidt-Tedd – Mick 2009: 154. See also UNOOSA s. a.; U.N. Doc. A/AC.105/C.1/2012/CRP,16 (2011).

149 UN Convention on the Law of the Sea 1994, Article 69; I.M.O. Res. A.672(16) 1989.

150 Lyayll–Larsen 2009: 67.

151 Sancin et al. 2021: 22–25.

152 Einhorn 2022; Jamasmie 2021.

A possible solution would be to establish concrete norms on the issue, for example the discussed functional jurisdiction, e.g. mandating that a facility only uses as much surface and only for as long as necessary and in active use.[153] By analogy, such regimes are already in force on the seas. For example, installations in the Exclusive Economic Zone must be removed as soon as they are not functional anymore, as these would otherwise lead to pollution and hinder free navigation.[154] Similarly, in geostationary orbit, which is considered a limited natural resource, orbital slots may be occupied only by functional spacecraft.[155] Even the SDGM indicate that only active spacecraft should populate the most useful Earth orbits.[156]

In conclusion, there is a need for clear provisions not only on the general environmental protection of outer space, including celestial bodies, but also addressing the issues of incoming space debris, debris left behind by unsuccessful landings and missions, human waste during the operation of a space settlement, the maintenance of settlements and the issue of disused installations that remain under the jurisdiction of the registering State, about which topics, maritime practice might be a helpful resource.

AN AGE OF CIVILISATION BUILDING

Logically, once the first few settlements have been erected, these are likely to grow as the number of settlers increases and the activities conducted in them diversifies. For example, the first orbital space station Salyut 1 launched in April 1971, spanned 20 metres and was occupied by six people before it ended its operation after 175 days in orbit.[157] The current International Space Station has been operational since November 1998, has a span of 109 metres

[153] Gorove 1969: 352.
[154] UN Convention on the Law of the Sea 1994, Article 69; I.M.O. Res. A.672(16) 1989.
[155] Lee 2012: 179; Force 2013: 3.
[156] SDMG, Guidelines 6 and 7.
[157] Chladek 2017: 69–109; NASA 2023d.

and has been visited by more than 250 astronauts, between 7 and 13 at a time, for an average period of six months.[158] What may begin as a celestial research station akin to the proposed Moon Village, may therefore lead (eventually) to a new civilisation-building settlement.[159]

The points discussed above will present an issue in the short-term, in what could be termed the first phase of space settlement, preceding the establishment of the first permanent human settlement, and within the second phase during which the first few established settlements will need to coordinate their efforts, while the third, likely to evolve from the first two, will finally be the age of civilisation-building space settlements, which will raise new questions to be answered and regulated.[160] For example, work and life within celestial settlements, as human presence grows from short-duration to long-duration stays, may necessitate a fresh look at human rights (the right to water, the right to oxygen, the right to property, labour rights, reproductive rights, etc.).[161] It may require a re-evaluation of whether application of national laws of the registring State is still appropriate,[162] for example for criminal jurisdiction,[163] or intellectual property protection.[164] It may even raise questions of celestial democracy (or the lack thereof), given that life on celestial bodies will depend on a steady supply of oxygen and other supplies from Earth, on the safe refuge of space stations and other daily hardships imposed by the hostile environment of celestial bodies as currently only the Earth is considered to possess human-friendly natural conditions.[165] This may lead to questions of how celestial settlements are influencing the Earth and its population.[166] These hostile

158 NASA 2023e; NASA 2023c.
159 Miller 2020: 59–66.
160 For an analysis of the phases of space settling see Blount 2021: 189–197. For further discussions on space settlements see Froehlich 2021; Blount et al. 2020.
161 Hobe 1997: 142; von der Dunk 2020: 77–89; Blount 2021: 197.
162 Von der Dunk 2020: 77–89.
163 Hallet 2020.
164 Němcová 2021: 15–25.
165 Cockell 2019: 1–26; Blount 2021: 198–199.
166 Cockell 2019: 1–26.

natural conditions may in turn raise the question of the morphing identity of settlers, which is likely to result in questions of a new nationality, e.g. Martian or Lunar nationality.[167] Another issue which may emerge is that of ensuring continued access to Earth as a "right to return".[168] Moreover, the potential birth of children within these settlements will throw open a myriad of new questions as these children may never know Earth or even be able to return to Earth as a consequence of their bodies developing in lower gravity environments than that on Earth.[169] This may raise questions of ethics related to space settlement,[170] such as *inter alia* questions regarding terraforming.[171] It may even lead to questions of state-forming elements occurring.[172]

In the end, it is impossible at this juncture to predict all the questions that may be thrown up by space settlement.[173] The issues which arise will certainly be novel, bred by the circumstances and hardships that will face settlers and these will clearly require a new or amended space settlement regulatory framework. The success of the initial space settlement agreement may facilitate or hamper the civilisation-building phase and its regulatory framework.

CONCLUSION

In conclusion, many uncertainties shroud space settlement. Given the conflict potential and historical lessons learned, the adoption of an international agreement, whether as a hard law or more likely soft law instrument, addressing the most important points and reiterating the OST, will be necessary to avoid chaos. The formulation of the content of such an agreement is likely to be

167 Von der Dunk 2020: 77–89; Hobe 1997:142–143.
168 Schwartz 2021: 193–205.
169 Hobe 1997: 142–143.
170 Green 2021.
171 Beech et al. 2022.
172 Blount 2021: 197; Hobe 1997: 142–143; Vitt 1989: 139; Kyriakopoulos 2020: 181.
173 See, for example, discussions in Grünfeld 2024; de Waal Alberts – Martinez 2020; Masuda 2020.

similar to the ISS IGA, the OST and the Artemis Accords. In other words, it is likely to be formulated as a set of goals with details specified in national laws, which will be made applicable through the specification of Article VIII of the OST. Some topics are likely to be unproblematic such as the application of international law, the peaceful activities requirement, the application of national laws of the registering State within its registered objects, and State responsibility for the authorisation and supervision of non-governmental activity. Other topics that are addressed vaguely in the OST, but have since the OST's adoption been identified by practice as *hot topics,* are, however, likely to require concretisation or at least clarification as the age of space settlement draws near, such as for example the issues of benefit-sharing and access for all, space resource utilisation, environmental protection and dispute resolution.

These hot topics have been addressed in international legal documents in the form of principles, rather than concrete rules, resulting in some ambiguities. For example, the legality of space resource exploitation is debated and is now subject of discussion by the Working Group on Legal Aspects of Space Resource Activities. The issue of environmental protection is accepted in principle, without specifying any concrete obligations, which leads to widely varying approaches and even degrees of addressing the issue. Some States, for example, have regulated the issue nationally and are developing a number of programmes to address space pollution, while others have not enacted any legislation on the matter and are focusing instead on the development of their space industry. None of the national legislation granting private persons, including commercial NSEs, rights to the extraction and appropriation of space resources, have, for example, within those same provisions directly addressed the protection of the environment during space mining operations, which are likely to constitute a new, and potentially significant, source of pollution. Furthermore, while numerous provisions refer to international cooperation and even benefit-sharing, none of the provisions determine *in concreto* the manner or elements of such cooperation or benefit-sharing. With the OST mandating free access to all areas of celestial bodies, while simultaneously granting States jurisdiction over their registered objects, space stations will require either cooperation agreements granting access or factual mobility. Finally, as the topics discussed above, particularly space resource activity, have been evaluated as potential sources of conflict, dispute resolution methods should be determinable, to avoid a further source of conflict.

Finally, the issues presently confronting humanity as it enters the space settlement stage, are likely to characterise the first stage of space settlement and define its instruments, while experts predict that the establishment and success of the first permanent human settlements will open the doors to the second stage, which may in turn, as settlements are established and grow from a few astronauts to a few tens, to possibly hundreds of people, shift the attention from interstate relations to State–individual relations, bringing the issues of the status of settlers and their human rights to the forefront. Some upcoming issues have already been considered in doctrine, although in all likelihood only the coming of the age of space settlement will reveal the true nature and extent of the issues that it brings. Whatever the questions it throws up, answers to them will be required in the form of a regulatory framework as human societies have since the dawn of time been governed by a legal order which determines acceptable and non-acceptable behaviour. This may be done either through the emergence of new rights or the amendment of old ones. Should this usher in a new era of civilisation building, it remains to be seen whether humanity will repeat and reconstruct its Earthly realm elsewhere in the universe, with all its faults and flaws, or will we wipe the slate clean and begin anew?

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Part Four:
Security

Gábor Sulyok

The Final Front(ier): Self-Defence in Outer Space

INTRODUCTION

Humankind began to make use of airspace, outer space and cyberspace in the course of a single century. While the rapid development of science and technology has opened up unprecedented opportunities for human civilisation, it should not be forgotten that each of these three domains can be put to offensive and defensive military use. Nowadays, outer space is arguably the "most peaceful" of these domains, but this situation could easily change if the intensifying new space race takes an unfavourable turn. The headlines reveal increasing turmoil on the world stage. For example, SpaceX has provided vital technological support to Ukraine's self-defence by rapidly granting access to its Starlink megaconstellation service, but it also caused considerable controversy when its chief executive officer refused to activate the service over the Crimean peninsula, preventing Ukraine from launching a major drone strike on the Russian naval fleet, and limiting the legitimate freedom of action of the attacked state. There have also been reports of measures taken in self-defence in outer space for the first time, with the Israel Defense Forces' "Arrow/Hetz" missile defence system intercepting an incoming ballistic missile. Meanwhile, the United States is reportedly considering ways to compensate private companies in case their satellites being used for military purposes are targeted in an armed conflict.[1] For these reasons, the present chapter seeks to introduce and examine selected issues relating to the exercise of the right of individual or collective self-defence in outer space.

[1] Isaacson 2023; Mizokami–Roblin 2023; Erwin 2022.

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THE RIGHT OF INDIVIDUAL OR COLLECTIVE SELF-DEFENCE

Every legal system recognises the right of self-defence. The conditions and extent to which self-defence is permitted depends on the level of development of the legal system concerned. The actual role and importance of self-defence is inversely proportional to the degree of centralisation of the sanctions regime that ensures the effective enforcement of the provisions of the law.[2] The same holds true for contemporary international law, where the right of individual or collective self-defence has, after centuries of historical development, been recognised as one of the exceptions to the comprehensive, objective and peremptory prohibition of the threat or use of force.[3] The detailed rules are contained in the Charter of the United Nations (UN) and in customary international law. Article 51 of the UN Charter provides:

> "Nothing in the present Charter shall impair the inherent right of individual or collective self-defence if an armed attack occurs against a Member of the United Nations, until the Security Council has taken measures necessary to maintain international peace and security. Measures taken by Members in the exercise of this right of self-defence shall be immediately reported to the Security Council and shall not in any way affect the authority and responsibility of the Security Council under the present Charter to take at any time such action as it deems necessary in order to maintain or restore international peace and security."[4]

This is undoubtedly one of the most famous provisions of the UN Charter. Remarkably, the article was included in the treaty text at a rather late stage, during the San Francisco Conference. Previously, self-defence had been regarded as a right that all States took for granted and that could safely be omitted from treaties. U.S. Secretary of State Frank B. Kellogg had even famously stated: "That is an inherent right of every sovereign, as it is of every individual, and it

2 Bowett 1958: 3–4.
3 Charter of the United Nations, Article 2 (4).
4 Charter of the United Nations, Article 51.

is implicit in every treaty."[5] This approach permeated treaties on the limitation and prohibition of war concluded between the two world wars. However, with the advent of the prohibition of the threat or use of force, and the establishment of a new collective security organisation, the Latin American states wished to ensure that their regional system of mutual assistance based on the Act of Chapultepec would not be considered contrary to the UN Charter.[6]

The UN Charter recognises the right of individual or collective self-defence as an "inherent right", which can be interpreted as a reference either to natural law, state sovereignty or customary international law.[7] There is a strong case for the last of these interpretations. However, if the expression "inherent right" is understood to refer to the relevant rules of customary international law, which are not "impaired" by the provisions of the UN Charter, the question arises: How do the Charter-based and customary rights of individual or collective self-defence relate to each other? Keeping in mind that in traditional international law, the right of self-defence permitted, *inter alia,* pre-emptive strikes, the timeliness and importance of this question scarcely require further explanation. It should be noted that the International Court of Justice has consistently interpreted "inherent right" as a reference to the relevant rules of customary international law, the content of which is essentially identical to that of the UN Charter. Having said that, this parallelism does not imply an exact overlap between them or completely identical content.[8]

The "overture" of the exercise of the right of self-defence is an "armed attack". Since the UN Charter does not define the concept of armed attack, external and subsidiary sources of interpretation must be consulted in order to reveal the meaning of that term. Based on state practice and the relevant literature,

5 *Hearings Before the Committee on Foreign Relations, United States Senate, Seventieth Congress, Second Session on the General Pact for the Renunciation of War, signed at Paris August 27, 1928. December 7 and 11, 1928. Part 1.* 1928: 4.

6 Mori 2018: 219–223. See also, Final Act of the Inter-American Conference on Problems of War and Peace, Mexico City, 8 March 1945, 60 Stat. 1831, TIAS 1543.

7 Kajtár 2015: 62–72.

8 Military and Paramilitary Activities in and against Nicaragua (Nicaragua v. United States of America), Judgment of 27 June 1986, ICJ Reports 1986: 94.

it appears that two criteria, a quantitative and a qualitative element, must be met for an armed attack to occur: the quantitative element relates to the gravity and intensity of the armed attack, while the qualitative element relates to the perpetrator of the armed attack.[9] From a quantitative point of view, an armed attack is the gravest and most intensive form of the use of force and, as such, it is in a part–whole relationship with the concept of aggression. However, it is impossible to formulate a precise and universal yardstick, as each case must be assessed individually. It is conceivable that a singular act could surpass the gravity and intensity threshold, but it is equally conceivable that a series of attacks of lesser gravity constitutes an armed attack in accordance with the debated theory of "accumulation of events".[10] In some views, even placing territory at the disposal of another State may constitute an armed attack.[11] However, isolated violent acts of minor gravity cannot be considered armed attacks even when they result in the loss of life.[12] Nowadays, armed attacks can also be carried out in cyberspace.[13] It should be emphasised that the type of weapons used is irrelevant for the purposes of determining whether an armed attack occurred, and such an attack may even be committed by means that are normally not considered weapons.[14]

From a qualitative point of view, only conduct attributable to a State can be considered an armed attack.[15] Notwithstanding that scholarly consensus is lacking as to how such attributability is to be determined,[16] this should arguably

9 Kajtár 2015: 73.

10 Oil Platforms (Islamic Republic of Iran v. United States of America), Judgment of 6 November 2003, ICJ Reports 2003, 190–192; Armed Activities on the Territory of the Congo (Democratic Republic of the Congo v. Uganda), Judgment of 19 December 2005, ICJ Reports 2005, 219, 223.

11 Randelzhofer–Nolte 2012: 1414.

12 Eritrea–Ethiopia Claims Commission, Partial Award: Jus Ad Bellum–Ethiopia's Claims 1–8, Decision of 19 December 2005, RIAA Vol. XXVI, 465.

13 Schmitt 2017: 339, 341–343.

14 Zemanek 2012: 599.

15 Legal Consequences of the Construction of a Wall in the Occupied Palestinian Territory, Advisory Opinion of 9 July 2004, ICJ Reports 2004, 194.

16 Kajtár 2015: 173–219, 256–257.

be performed in accordance with the rules of international law concerning the responsibility of States. Similarly to an act of aggression, an armed attack can be carried out either directly or indirectly. In case of a direct armed attack, the act is carried out by a State, while an indirect armed attack is carried out by a person or a group of persons acting on the instructions of, or under the direction or control of a State.[17] There are divergent approaches as to the degree of control required over an attack for it to be attributable. The International Court of Justice requires "effective control",[18] while the International Criminal Tribunal for the former Yugoslavia, for the purposes of individual criminal responsibility, only required "overall control".[19] Furthermore, it is also matter of debate whether attacks carried out by non-state actors that are not attributable to any State can be considered armed attacks. This is perhaps the most important dilemma today concerning the right of self-defence. While it would stray from the present topic to engage in a detailed discussion of the related problems, it should be noted that the arguments in favour of self-defence against non-state actors do not appear to be entirely convincing. The same holds true for the so-called "unwilling or unable" doctrine.[20]

The UN Charter makes it clear that the victim of an armed attack is a State.[21] An armed attack may be carried out either in or against the territory of a State

17 Responsibility of States for Internationally Wrongful Acts, Article 8. In Yearbook of the International Law Commission, 2001. Vol. II. Part Two, U.N. Doc. A/CN.4/SER.A/2001/Add.1 (Part 2), 26.

18 Military and Paramilitary Activities in and against Nicaragua (Nicaragua v. United States of America), Judgment of 27 June 1986, ICJ Reports 1986: 64–65; Application of the Convention on the Prevention and Punishment of the Crime of Genocide (Bosnia and Herzegovina v. Serbia and Montenegro), Judgment of 26 February 2007, ICJ Reports 2007, 208–210.

19 Prosecutor v. Duško Tadić, Judgement of 15 July 1999, Case No. IT-94-1-A, 47–62.

20 Letter dated 23 September 2014 from the Permanent Representative of the United States of America to the United Nations addressed to the Secretary-General, U.N. Doc. S/2014/695.

21 The International Law Commission proposed that certain international organisations may also be placed in a situation of self-defence, but has not provided details as to how this may happen. Draft Articles on the Responsibility of International Organizations, Article 21. In Yearbook of the International Law Commission, 2011. Vol. II. Part Two, U.N. Doc. A/CN.4/SER.A/2011/Add.1 (Part 2), 40.

or, as the case may be, against persons or objects representing a State outside its territory.[22] The determination of whether an armed attack has occurred is primarily based on the subjective assessment of the attacked State, and the burden of proof also rests on that State.[23] If the furnishing of direct evidence is precluded by the sovereignty of another State, even "a more liberal recourse to inferences of fact and circumstantial evidence" may be sufficient.[24] Nevertheless, the attacking State and other members of the international community are also likely to present their respective appraisals of the situation based of their subjective assessments. The UN Security Council is arguably capable of making a credible and objective determination, but such a determination by the principal organ bearing primary responsibility for the maintenance of international peace and security is certainly not a prerequisite for the exercise of the right of self-defence. In addition, its findings unavoidably lag behind the assessments made by the States concerned, and any such action is subject to the veto power of the permanent members. In any case, a peculiar situation would arise if the council happened to find that, contrary to the claim of the victim, no armed attack had occurred.[25]

If an armed attack occurs, the attacked State is placed in a situation of self-defence, and may have recourse to force in order to repel the attack lawfully, without violating the prohibition on the threat or use of force. This is the traditional case of self-defence. Even though it is not explicitly mentioned in the UN Charter, the same holds true for interceptive/interceptory self-defence, that is, for the use of force to repel an armed attack that has been launched but which has not yet struck its target. However, the use of force in anticipatory self-defence is prohibited: neither pre-emptive actions against concrete and imminent threats, nor preventive actions against abstract and remote threats

22 Ruys 2010: 199–249.

23 Oil Platforms (Islamic Republic of Iran v. United States of America), Judgment of 6 November 2003, ICJ Reports 2003, 189.

24 The Corfu Channel Case (United Kingdom v. Albania), Judgment of 9 April 1949, ICJ Reports 1949, 18.

25 Kelsen 1951: 798–800, 803–804.

are permitted under current international law. Having said that, the international community would probably not condemn the unilateral use of force in extreme cases of pre-emptive self-defence when waiting for the actual launch of an imminent armed attack would be unexpectable and unreasonable.[26] In the absence of an armed attack having been launched or having occurred, the right of self-defence cannot be invoked and exercised. Hence, violent actions not amounting to an armed attack cannot be met with violence, and the victim must resort, as appropriate, to other international procedures or measures in the face of these.[27]

In spite of the protection of vital interests and its function as a circumstance precluding wrongfulness,[28] the exercise of the right of self-defence does not provide unlimited freedom of action. Some of its most important conditions, including necessity and proportionality, are governed by customary international law, and were embodied in traditional international law in the so-called "Webster formula".[29] Nowadays, measures taken in self-defence meet these requirements only if other reasonable and effective solutions are not available, and provided that force is used as a last resort with no intention of retaliation, punishment or prevention. Generally speaking, measures taken in self-defence must be proportionate to the gravity and intensity of the armed attack. The fulfilment of this requirement is notoriously difficult to assess, since the success of a defensive act always presupposes a degree of effectiveness that exceeds that of the attack.[30] Proportionality demands full respect for the law of armed conflicts. However, there are open questions in this regard. For example, it is impossible to reach a definitive conclusion as to whether the use of nuclear weapons is permissible in extreme circumstances of self-defence, in which the survival of a State is at stake.[31] Immediacy of action is occasionally mentioned as a third

26 Kajtár 2015: 98–102.
27 Randelzhofer–Nolte 2012: 1401–1403.
28 Responsibility of States for Internationally Wrongful Acts, Article 21.
29 *The Diplomatic and Official Papers of Daniel Webster* 1848: 132.
30 Greenwood 2012: 109.
31 Legality of the Threat or Use of Nuclear Weapons, Advisory Opinion of 8 July 1996, ICJ Reports 1996, 245, 263.

requirement, but a scholarly consensus is lacking in that regard. Nevertheless, the time factor is admittedly important, as the requirement of necessity also implies that measures taken in self-defence must follow the armed attack within a reasonable period of time.[32] Furthermore, the occurrence of a situation of self-defence and the taking of measures in the exercise of the right of self-defence must be immediately reported to the Security Council. This is a Charter-based obligation which does not exist in customary international law. Failure to report a defensive act does not affect the lawfulness of the exercise of the right of self-defence. However, the fulfilment of this obligation is an important testimony of the attacked State's assessment of the situation.[33]

The UN Charter assigns self-defence a temporary and complementary role. It permits the use of force in the exercise of the right of self-defence, but it does not in any way affect the primary responsibility of the Security Council for the maintenance of international peace and security.[34] For that reason, the exercise of the right of self-defence lasts only "until the Security Council has taken measures necessary to maintain international peace and security". The activation of the mechanism of collective security terminates the exercise of the right of self-defence, and replaces it by the actions of the organisation. However, it is not entirely clear who has the power to determine that the "necessary measures" have indeed been taken by the Security Council, and on what basis.[35] The justification for the right of self-defence also ends when the attacked State successfully repels the armed attack and restores the *status quo ante*. In practice, this is not always a self-evident or objective limitation. The restoration of the situation which prevailed prior to the armed attack and the successful repulsion of the attacker do not necessarily result in satisfactory conditions from a military and security point of view. Keeping that in mind, measures taken in self-defence may become excessive, and may constitute a violation of international law.

[32] Dinstein 2017: 252, 267, 287, 299.

[33] Military and Paramilitary Activities in and against Nicaragua (Nicaragua v. United States of America), Judgment of 27 June 1986, ICJ Reports 1986: 105.

[34] Charter of the United Nations, Article 24 (1) and (2).

[35] Kelsen 1951: 800–803.

The right of self-defence can be exercised either individually or collectively. The latter alternative, collective defence, has played an essential role ever since the dawn of history. It means that the attacked State is not left to its own devices against the attacker, but may request and receive external assistance to repel an armed attack.[36] This assistance includes military assistance insofar as it is provided in accordance with the requirements discussed above. Such assistance may be provided on the basis of a collective defensive arrangement concluded before an armed attack or based on an *ad hoc* arrangement concluded after an armed attack. Treaties providing for assistance in case of an armed attack transform the right of collective defence into an obligation.

THE MILITARY USE OF OUTER SPACE

The casual observer might be inclined to think that, by virtue of international law, outer space is an endless sea of quietude, which can be used exclusively for peaceful purposes. This perception should be nuanced. Indeed, the exploration, use and scientific investigation of outer space, having the status of *res communis* or global commons, may be freely pursued by all States on the basis of equality, must be pursued for the benefit and in the interest of all countries, and must be regarded as a common province of mankind. These activities must be conducted in accordance with international law, in the interest of international peace and security and international cooperation and understanding.[37] Nevertheless, space law does not provide a definition of "peaceful use". Initially, two divergent interpretations emerged, maintaining that it means either "non-military use" or "non-aggressive use".[38] Nowadays, there is little doubt that it should be

36 Military and Paramilitary Activities in and against Nicaragua (Nicaragua v. United States of America), Judgment of 27 June 1986, ICJ Reports 1986: 102–105.

37 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (hereinafter: Outer Space Treaty), London, Moscow, Washington, 27 January 1967, 610 UNTS 205, Articles I–III. See also, GA Res. 1962 (XVIII), 18 UN GAOR Suppl. No. 15 (A/5515), 15.

38 Cheng 1997: 513–516.

interpreted in the latter sense, and that military activities are not completely prohibited in outer space. The militarisation/passive military use of outer space is permitted, as shown by consistent state practice since the beginning of the space age. The weaponisation/active military use of outer space, on the other hand, is subject to strict limitations. The partial demilitarisation of outer space is primarily based on the Outer Space Treaty, the Moon Agreement and selected disarmament and arms control treaties.

The Outer Space Treaty provides that nuclear weapons or any other kinds of weapons of mass destruction may not be placed in orbit around the Earth, installed on celestial bodies, or stationed in outer space in any other manner.[39] This prohibition sought to preserve the doctrine of "mutual assured destruction", and prompted U.S. President Lyndon B. Johnson to the describe the treaty as "the most important arms control development since the limited test ban treaty of 1963".[40] The provision concerned was reaffirmed and expanded by the Moon Agreement. The latter agreement provides that nuclear weapons or any kinds of weapons of mass destruction may not be placed or used on or in the Moon or other celestial bodies in our Solar System, or placed in orbit around or on another trajectory to or around them.[41] However, these prohibitions do not apply to the testing or use of Earth-based weapons of mass destruction that temporarily enter and traverse outer space on their way to their intended targets, and arguably do not apply to weapons of mass destruction that do not complete at least one full orbit around our planet either. (There is no consensus on this latter point.[42]) The relevant weapons or weapon systems include, for example, ballistic missiles with nuclear warheads, fractional orbital bombardment systems and certain nuclear-capable hypersonic glide vehicles. Ballistic missiles are widely

39 Outer Space Treaty, Article IV. See also, GA Res. 1884 (XVIII), 18 UN GAOR Suppl. No. 15 (A/5515), 13.

40 President Johnson Hails U.N. Accord on Treaty Governing Exploration of Outer Space 1966: 952.

41 Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (hereinafter: Moon Agreement), New York, 5 December 1979, 1363 UNTS 3, Articles 1 (1)–(2) and 3 (3).

42 Schrogl–Neumann 2017: 309.

known and hardly require a detailed explanation: beyond a specific launch angle and range, a section of the trajectory of these missiles passes through outer space. Fractional orbital bombardment systems were developed to provide the capability to carry out a barely detectable, rapid and global nuclear strike through outer space from any direction. Here a nuclear warhead is placed in low Earth orbit, but is de-orbited and aimed at the target before it has completed a full orbit around the planet. Deployed during the Cold War, these weapon systems were subsequently banned and decommissioned. Hypersonic glide vehicles are advanced weapons systems, designed to perform a barely detectable and prompt global strike. Notwithstanding that these ultrafast, manoeuvrable vehicles may also pass through outer space and may carry a nuclear warhead, they are not placed in Earth orbit, and as such, are not prohibited by space law. Space law does not prohibit the testing or use of nuclear weapons either, insofar as these activities do not entail placement, installation or stationing in outer space, and do not affect the Moon or other celestial bodies. The testing and use of nuclear weapons in outer space is extremely dangerous. High-altitude nuclear tests, such as Starfish Prime and Test 184 of Project K, have shown that a nuclear explosion in outer space at the right altitude and with an appropriate yield would produce an artificial radiation belt and an electromagnetic pulse which could indiscriminately damage beyond repair or disable any unshielded electronic system on a continental scale and/or in low Earth orbit. Recently, concerns have been raised over a possible emergence of nuclear space weapons and a re-emergence of fractional orbital bombardment systems.

These shortcomings have been and are being remedied by various disarmament and arms control treaties: the use of nuclear weapons and other nuclear explosive devices is prohibited by the Treaty on the Prohibition of Nuclear Weapons,[43] nuclear test explosions beyond the limits of the atmosphere are prohibited by the Partial/Limited Test Ban Treaty and the Comprehensive

[43] Treaty on the Prohibition of Nuclear Weapons (TPNW), New York, 7 July 2017, I-56487, Article 1.

Nuclear Test Ban Treaty,[44] fractional orbital bombardment systems were prohibited, on a bilateral basis, by the Treaty on the Limitation of Strategic Offensive Arms and the Treaty on the Reduction and Limitation of Strategic Offensive Arms,[45] and are to be prohibited by the Draft Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects.[46] Of these, the Treaty on the Prohibition of Nuclear Weapons and the Partial/Limited Test Ban Treaty are the only treaties that are in force, since the Comprehensive Nuclear Test Ban Treaty has not entered into force yet, the bilateral arms control treaties have expired, and no progress has been made on the rather controversial draft treaty. The effectiveness of the prevailing legal regime is diminished by the fact that the nuclear weapon states and their close allies do not participate in the Treaty on the Prohibition of Nuclear Weapons. Selected ballistic missiles were banned by the Treaty on the Elimination of Intermediate-Range and Shorter-Range Missiles until its termination.[47] As for other types of weapons of mass destruction, chemical and biological weapons are totally prohibited,[48] while radiological weapons

44 Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water (Partial/Limited Test Ban Treaty, PTBT/LTBT), 480 UNTS 43, Moscow, 5 August 1963, Article I; Comprehensive Nuclear Test Ban Treaty, New York, 10 September 1996, Article I.

45 Treaty between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Strategic Offensive Arms (SALT II), Vienna, 18 June 1979, Articles VII (Second Common Understanding) and IX (1) (c); Treaty between the United States of America and the Union of Soviet Socialist Republics on the Reduction and Limitation of Strategic Offensive Arms (START I), Moscow, 31 July 1991, Article V (18) (c).

46 Draft Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects (PPWT), 12 June 2014, Doc. CD/1985, Article I (c) and II.

47 Treaty between the United States of America and the Union of Soviet Socialist Republics on the Elimination of Their Intermediate-Range and Shorter-Range Missiles (INF Treaty), Washington, 8 December 1987, 1657 UNTS 2, Article I.

48 Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare, Geneva, 17 June 1925, 94 LNTS 65; Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction, London, Moscow, Washington, 10 April 1972, 1015 UNTS 163, Articles I–IV; Convention on the

are yet to be prohibited by a dedicated treaty. In addition, the international community formulated a politically-binding International Code of Conduct against Ballistic Missile Proliferation.[49] It should be noted that if ballistic missiles or hypersonic glide vehicles carry conventional warheads, they should be treated as conventional weapons.

The Outer Space Treaty provides that the Moon and other celestial bodies can be used exclusively for peaceful purposes. This is a remarkable limitation. No military bases, installations or fortifications may be established on any of the celestial bodies under the terms of the treaty. Military manoeuvres and the testing of weapons on celestial bodies are likewise prohibited.[50] The Moon Agreement reaffirms and extends this prohibition by adding bans on any threat or use of force or any other hostile act or threat of hostile act on or using the Moon, or making such a threat in relation to the Earth, the Moon, spacecraft, spacecraft personnel or man-made space objects.[51] It should be recalled that the scope of the Moon Agreement covers all celestial bodies in our Solar System, unless separately governed. For these reasons, conventional weapons may not be placed on any celestial body.

The deployment and testing of conventional weapons, on the other hand, is allowed in Earth orbit and in the void of space. The Treaty on the Limitation of Anti-Ballistic Missile Systems had previously contained bilateral restrictions to that effect, but that agreement was terminated more than two decades ago.[52] Notwithstanding the fact that conventional weapons have not been deployed on a large scale in outer space, such weapons have actually been developed and/

Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on Their Destruction (with Annexes), Paris, 13 January 1993, 1974 UNTS 45, 1975 UNTS 3, Article I.

49 The Hague/International Code of Conduct against Ballistic Missile Proliferation, The Hague, 25 November 2002, U.N. Doc. A/57/724, Annex.

50 Outer Space Treaty, Article IV.

51 Moon Agreement, Articles 3 (1)–(2) and (4).

52 Treaty between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems (ABM Treaty), Moscow, 26 May 1972, 944 UNTS 13, Article V (1).

or have occasionally travelled beyond the limits of the atmosphere. Examples include the Rikhter R-23M space cannon and the TP-82/TOZ-82 SONAZ cosmonaut combination gun. In addition, certain secretive experimental spaceplanes and satellites, such as the Boeing X-37B OTV and the "Shenlong"/CSSHQ spaceplanes, or the Kosmos-2521 and Kosmos-2543 satellites, are also believed to have at least partly military purposes. However, the range of ideas that have been or are being pursued is much broader than this, and includes a number of offensive or defensive weapons or weapon systems: kinetic weapons (kill vehicles, projectile launchers, docking mechanisms, robotic arms, co-orbital anti-satellite missiles, rail guns, coil guns, chemical or paint spraying mechanisms, deflected meteoroids, hypervelocity rod bundles), directed energy weapons (sun gun/heliobeam, laser weapons, particle beam weapons, plasma weapons, high-energy microwave weapons, electromagnetic pulse weapons), electronic warfare (jamming, spoofing, meaconing, signal intrusion), cyber operations (data interception, data monitoring, data corruption, seizure of control) and manned military spaceplanes.[53] Famous experimental examples of the latter include the Boeing X-20 "Dyna-Soar" and the MiG-105 "Lapot". In addition, basically any manoeuvrable satellite can be used to cause kinetic destruction by direct impact. Satellites and space stations which can conduct passive military activities are also allowed. Numerous military and dual-use satellites perform surveillance, reconnaissance, intelligence, early warning, positioning, navigation, timing, communication and Earth observation missions. In the past, military space stations, launched within the framework of the Soviet "Almaz" programme, have also orbited our planet. It should be noted that the use of military personnel or any equipment or facility necessary for scientific research or any other peaceful purposes is also explicitly allowed.[54]

The provisions concerned do not prohibit conventional Earth-based weapons or weapon systems. The Draft Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects does not seek to prohibit such weapons or weapon systems either,

53 Preston et al. 2002.

54 Outer Space Treaty, Article IV; Moon Agreement, Article 3 (4).

an approach that has attracted a great deal of criticism, instead it would only prohibit their use for offensive purposes.[55] Nowadays, only a handful of States have direct ascent anti-satellite capabilities that have been demonstrated by their past and recent tests. The problem these capabilities pose should not be underestimated, as some of the destructive tests have resulted in large clouds of space debris. Even though these tests are not directly in breach of the military provisions of the Outer Space Treaty, they are extremely hard to reconcile with other provisions of that treaty or with the space debris mitigation standards. Destructive direct ascent anti-satellite missile tests constitute irresponsible behaviour in outer space,[56] and the UN General Assembly has urged all States to commit not to engage in such activities.[57] The number of countries that have declared a voluntary moratorium on such tests is continuously increasing,[58] and their efforts have received support from stakeholders in the industry.[59] However, there are other threats that also need to be addressed. For example, States or non-state actors can easily come into possession of the means necessary to direct electronic attacks or cyberattacks against satellites. By virtue of their location, these means are not in breach of the military provisions of the Outer Space Treaty, but they are also hard to reconcile with other provisions of that treaty or with the legal regime of the International Telecommunication Union.

The States concerned have hitherto refrained from deploying conventional weapons on a large scale in outer space, and seem to have been content with the passive military use thereof. However, the prevailing situation is susceptible to change at any moment in light of the intensifying new space race and the increasing need to safeguard the security of space objects. This possibility

55 Draft Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects, Article II.

56 GA Res. 75/36, 75 UN GAOR Suppl. No. 49 (A/75/49) (Vol. I), 238; Reducing Space Threats Through Norms, Rules and Principles of Responsible Behaviours. Report of the Secretary-General, 13 July 2021, U.N. Doc. A/76/77, 6, 8–9.

57 GA Res. 77/41, 77 UN GAOR Suppl. No. 49 (A/77/49) (Vol. I), 225.

58 Secure World Foundation 2023.

59 Space Industry Statement in Support of International Commitments Not to Conduct Destructive Anti-Satellite Testing, 14 November 2023.

is reflected in the military doctrines and strategies of the main players concerned.[60] The extreme dangers inherent in the weaponisation of outer space have, of course, been recognised by the international community, and the overwhelming majority of States have been urging the prevention of an arms race in outer space for decades, so far without any tangible results.[61]

INDIVIDUAL OR COLLECTIVE SELF-DEFENCE IN OUTER SPACE

Since the prohibition of the threat or use of force is universal and peremptory, the right of individual or collective self-defence, recognised as an exception to that prohibition, also applies in outer space, irrespective of the meaning attributed to the "peaceful use of outer space".[62] This is attested, *inter alia,* by the reference to the UN Charter in the Outer Space Treaty, by the reference to the UN Charter and the UN General Assembly's Friendly Relations Declaration in the Moon Agreement, and by the reference to the right of individual or collective self-defence in the European Union's (EU) Draft International Code of Conduct for Outer Space Activities and in the Draft Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects.[63]

Theoretically, the right of self-defence can be exercised anywhere in outer space, without territorial restrictions. This state of affairs could only be

[60] Bingen et al. 2023: 8–32.
[61] GA Res. 36/97C, 36 UN GAOR Suppl. No. 51 (A/36/51), 71; GA Res. 69/32, 69 UN GAOR Suppl. No. 49 (A/69/49) (Vol. I), 242, and subsequent resolutions. See also Lattmann 2017: 171–187.
[62] Lachs 2010: 98, Jakhu–Freeland 2022: 22.
[63] Outer Space Treaty, Article III; Moon Agreement, Article 2; Draft Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects, Article IV; Draft International Code of Conduct for Outer Space Activities, 31 March 2014, paras. 2. and 4.2. For the Friendly Relations Declaration, see GA Res. 2625 (XXV), 25 UN GAOR Suppl. No. 28 (A/8028), 121.

modified by a subsequent norm of general international law having a peremptory character.[64] However, if the provisions of the Outer Space Treaty and the Moon Agreement on the complete demilitarisation of celestial bodies are to be regarded as peremptory norms, an opinion which has indeed been expressed in the literature,[65] then self-defence can only be exercised with the modifications and territorial restrictions emanating therefrom. Furthermore, provisions on the territorial scope of collective defensive arrangements, such as the Inter-American Treaty of Reciprocal Assistance, the North Atlantic Treaty or the Collective Security Treaty,[66] are also of interest here. These treaties were formulated with an armed attack taking place on the Earth in mind; therefore, their application in the case of an armed attack in outer space may pose an interpretative challenge.[67] Nevertheless, these dogmatic considerations will certainly not keep members of these alliances from taking the necessary measures if the right of self-defence needs to be exercised in outer space. For example, the North Atlantic Treaty Organization has recognised outer space as a new operational domain, and has declared that attacks to, from, or within space could lead to the invocation of Article 5 of the North Atlantic Treaty.[68]

It is possible to identify five different scenarios, depending on the possible directions of attack, in which an armed attack involves outer space. An armed attack may be launched from the Earth against a target in outer space; from outer space against a target on the Earth, from outer space against a target in outer space; from the Earth through outer space against a target on the Earth; or from the Earth and/or outer space against targets on the Earth and in outer space simultaneously. While each scenario is conceivable or feasible, at

64 Vienna Convention on the Law of Treaties, Vienna, 23 May 1969, 1155 UNTS 331, Article 53.

65 E.g. Bourbonnière–Lee 2008: 878–880; Sachdeva 2017: 22–24, 26.

66 Inter-American Treaty of Reciprocal Assistance, Rio de Janeiro, 2 September 1947, 21 UNTS 77, Articles 3 (3), 4 and 6; North Atlantic Treaty, Washington, 4 April 1949, 34 UNTS 243, Articles 5–6; Treaty on Collective Security, Tashkent, 15 May 1992, 1894 UNTS 309, Articles 4 and 6.

67 E.g. Martin 2020: 33.

68 See London Declaration, 3–4 December 2019, NATO Press Release (2019) 115, para. 6; Brussels Summit Communiqué, 14 June 2021, NATO Press Release (2021) 086, para. 33.

present, an attack from the Earth through outer space against a target located on the Earth, or an attack from the Earth and/or outer space against targets located on the Earth and in outer space simultaneously seem to be the most likely. Presuming that the actors concerned are rational, an armed attack always seeks to bring about a change on our planet, in the world of States. Therefore, in the current situation, outer space is likely to remain a secondary theatre of operations, primarily used to deliver ballistic missiles or to neutralise the adversary's "force multipliers". However, the prevailing situation is susceptible to change with the intensification of the use of outer space.

If an armed attack is launched from outer space against a target on the Earth or from the Earth through outer space against a target on the Earth, there should be little difficulty in establishing the existence of the quantitative element of the armed attack: the gravity and intensity of the action should be assessed in the "traditional" way, in the light of the force used and/or the destruction caused, taking into account analogous historical experiences. It should be pointed out that an armed attack from the Earth through outer space against a target on the Earth is, regardless of its likelihood, the least relevant case from the perspective of space law, as the means used for the purposes of such attacks only traverse outer space without completing at least one full orbit around our planet. Such attacks are usually excluded from the notion of "space warfare". Furthermore, it should be noted that the use of military or dual-purpose satellites or space stations for passive military purposes cannot be considered an armed attack from outer space. Even if such space objects are used in support of an attack, their "force multiplying" role cannot be qualified as a kind of "aggravating circumstance". The passive support of space-based assets, in itself, does not make an armed attack more serious. On the contrary, precision strikes enabled by military satellites may even reduce the gravity and intensity of the use of force.

If an armed attack is launched from the Earth against a target in outer space, or from outer space against a target in outer space, a range of factors complicate the assessment of the gravity and intensity of the action. For example, many complex questions need to be answered regarding the space object that was attacked. What was the purpose and significance of the space object? Was it a military, civilian or dual-use space object? How many space objects were attacked? Can the space object be substituted? What is the value of the space object? Historical experiences, which could in other instances be used as an analogy, do not facilitate the answering of these questions. Universal benchmarks cannot be formulated either, but the following short remarks may provide guidelines for arriving at a correct assessment. First, the importance attributed to a space object is based on the subjective judgement of the parties, but the importance of certain space objects definitely outweighs that of others. Suffice it to recall the obvious differences between the importance of a single satellite in a megaconstellation providing a global internet service and an exquisite early warning satellite or a national or international space station. Second, similarly to terrestrial targets located outside the territory of a State, the military, civilian or dual-use nature of a space object should also be taken into account. Space objects used for exclusively civilian purposes raise particularly difficult questions. Which of these are the external manifestations of a State that, if attacked, may result in a situation of self-defence? Is there an analogy between an attack on a civilian space object and an attack on a civil aircraft or a merchant vessel? What are the implications of the attack on a civilian space object for the State? Third, the number of space objects attacked may also be important. The International Court of Justice has not excluded the possibility that the striking of a mine by a single warship could result in a situation of self-defence.[69] Hence, the destruction of or serious damage to a single space object, under certain circumstances, could also constitute an armed attack, although this appears to be an exceptional case. The greater the number of space objects attacked, the easier it is to prove that the quantitative element prevails.

However, this correlation is subject to a constraint: the greater the number of space objects performing a similar function, the lower the probability that the quantitative criterion prevails. For example, in case of megaconstellations consisting of hundreds or thousands of satellites, the level of destruction

[69] Oil Platforms (Islamic Republic of Iran v. United States of America), Judgment of 6 November 2003, ICJ Reports 2003, 195.

required to reach the gravity and intensity of an armed attack would be so high that the likelihood of actually achieving that level is rather low. Considerations of military necessity, cost effectiveness and rationality would probably be against such an attack. This also holds true for small satellites. Finally, the value of the space object attacked and the extent of damage caused should also be taken into account. The International Court of Justice, as has been noted, held that even an attack on a single warship could result in a situation of self-defence. This statement was made in the context of heavy structural damage caused by a sea mine to a U.S. Navy Oliver Hazard Perry-class guided missile frigate, the USS Samuel B. Roberts. No lives were lost in the incident, but several sailors were seriously injured. The crew managed to keep the ship afloat, and the vessel was subsequently repaired. Frigates of the Oliver Hazard Perry-class had been produced and commissioned in large numbers at a reasonable cost. The average unit cost of the class concerned, even taking inflation into account, is below the cost of some of today's exquisite military satellites.

The nature of acts capable of constituting an armed attack also requires scrutiny. Intentional destruction, damaging or disruption may evidently exhaust the concept of armed attack. This is attested, among others, by the Draft Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects. The draft treaty adds that acts carried out by a State at the express request of another State, on the basis of a special agreement, in order to discontinue the uncontrolled flight of space objects under the jurisdiction and/or control of the requesting State are not to be regarded as a use of force, and as such, as an armed attack.[70] While the destruction or damaging of an adversary's space objects may seem an obvious solution, the peculiarities of the space environment make such acts the least favourable methods of warfare. Destroying or damaging space objects would generate a staggering amount of space debris of various sizes, threatening the safety of space activities for various amounts of time. The higher the altitude, the longer a piece of space debris remains in orbit. If the destruction or damaging

70 Draft Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects, Article I (d).

of space objects had widespread, long-lasting or severe effects, it could even be considered an environmental modification technique prohibited by the law of armed conflicts, and could easily bring about the dreaded "Kessler syndrome": a catastrophic scenario where space debris generated by collisions in a crowded orbit leads to a self-sustaining cascade of collisions generating even more space debris.[71] Since space debris threatens a state's own objects just as much as it threatens hostile and third party space objects, a reasonable actor would probably strive to employ methods other than destruction and damaging. (This consideration may be formulated as a proportionality requirement.) Plausible alternatives, for example, include jamming, blinding, cyberattacks against or other non-kinetic disruption of the normal functioning of satellites. These are partly based on existing and proven technology. Nevertheless, if a manoeuvrable satellite becomes unable to make orbital corrections as a result of a non-kinetic attack, this may also contribute to the creation of space debris due to perturbation and/or in-orbit collisions. It should be noted that if the jamming of satellite communications is not carried out in preparation for an armed attack, or it is not accompanied by such an attack or by sufficient physical damage, it is normally not considered an armed attack.

The identification of the victim of an armed attack is not without challenges either. The difficulties related to identification are mainly due to the specificities of the launching, registration, ownership and use of space objects. It should be stressed that such difficulties are not bound to arise: the victim of an armed attack on an exquisite satellite carrying out a sensitive military mission should not be hard to identify. However, it is not difficult to imagine complex situations arising. For example, who is the victim of an armed attack in the event of the destruction, damaging or disruption of an unregistered satellite launched by a State from the territory of another State using a third State's launch vehicle, the services of which are used by a multitude of other States, one of which leases capacity for the purposes of military communications? This hypothetical question can be further complicated, but it perhaps suffices to

[71] KESSLER – COUR-PALAIS 1978: 2637–2646.

illustrate the potential difficulties of identifying a victim. The answer appears to be disturbingly complicated in theory, but would probably be simpler in practice. Since an armed attack always seeks to bring about a change on the planet, in the world of States, the course of events will rapidly reveal the actual victim of the armed attack.

This remark leads to the last scenario to be discussed. If an armed attack from the Earth and/or outer space is directed against targets simultaneously on the Earth and in outer space, determining whether the quantitative element prevails is arguably less challenging than in case of an attack against a target located in outer space. In this situation, the assessment of the gravity and intensity of the action should at least partly be performed in the "traditional" way, and the theory of "accumulation of events" may also play a significant role.[72]

The qualitative element of an armed attack is to be determined on the basis of the rules on the responsibility of States under international law. The attribution of an act is normally governed by the secondary rules of general international law. However, these general rules leave room for special rules in accordance with the *lex specialis* principle.[73] Even though it is not a self-contained regime,[74] space law contains several special rules. The most important of these from the perspective of self-defence is perhaps the rule that States bear international responsibility for "national activities" in outer space carried out by governmental agencies or by non-governmental entities, and for assuring that these national activities are carried out in conformity with the relevant treaty provisions. Space activities conducted by non-governmental entities require the authorisation and continuing supervision of the "appropriate State".[75] Hence, the responsibility of States in space law automatically extends to "national activities" conducted by non-governmental entities. This remarkably strict rule of attribution is a *lex specialis* compared to general international law, and somewhat mitigates the

[72] Tronchetti 2014: 117.
[73] Responsibility of States for Internationally Wrongful Acts, Article 55.
[74] Hobe 2019: 51–56.
[75] Outer Space Treaty, Article VI. See also, GA Res. 1962 (XVIII), 18 UN GAOR Suppl. No. 15 (A/5515), 15.

problems related to self-defence against non-state actors: an armed attack by a non-state actor constituting a "national activity" in outer space is automatically attributable to the "appropriate State". Different views have emerged as to what constitutes a "national activity": the term can be interpreted, for example, as an activity carried out by organs or nationals of a State, as an activity carried out as a launching State, or as an activity carried out under the territorial, personal or registration-based jurisdiction of a State.[76] The provisions under deliberation only apply to space activities, i.e. acts within the scope of space law. If an armed attack is carried out by means and methods not within the scope of space law, the rules of general international law will guide the determination of whether the qualitative element prevails. It should be added that the rules of international liability for damage caused by space objects, that is, the Outer Space Treaty, the Liability Convention, the customary rules of space law and the rules and principles of general international law also apply in the context of self-defence in outer space. Both damage caused by space objects belonging to the perpetrator and that of the victim of an armed attack need to be assessed, as appropriate, keeping in mind, *inter alia,* that no exoneration can be granted in cases of damage caused by activities not in conformity with international law, and that self-defence constitutes a circumstance precluding wrongfulness.[77]

Notwithstanding that circumstantial evidence may be sufficient, the identification of the perpetrator and the establishment of an armed attack involving outer space may also raise difficulties. The success of identification and proof will depend on the means, methods and duration of the attack, and on the space domain awareness capabilities of the attacked State. Kinetic or non-kinetic physical attacks are generally easier to detect than electronic attacks or cyberattacks.[78] Few players are capable of continuously detecting,

[76] Cheng 1998: 20–29; von der Dunk 2011: 9–18; Gerhard 2017: 383–405.

[77] Outer Space Treaty, Article VII; Convention on International Liability for Damage Caused by Space Objects, London, Moscow, Washington, 29 March 1972, 961 UNTS 187, Articles II–VI; Responsibility of States for Internationally Wrongful Acts, Article 21. See also, Jakhu–Freeland 2022: 16–17.

[78] Bingen et al. 2023: 6–7.

tracking, characterising and understanding events in outer space, which is essential to successfully identify and prove the occurrence of such an attack. If a State has such capabilities or has access to the information they provide, the perpetrator of a physical attack from the Earth is most likely to be identified. (Exceptions are, of course, conceivable.) This may not be the case for a physical attack from outer space. The perpetrator of an attack launched from Earth orbit is also likely to be identified, although unregistered space objects and/or military satellites hidden amongst space debris can make that task extremely difficult. However, the farther away the events take place from the Earth, the more the likelihood of successful identification and proof decreases. It is no coincidence that the States concerned are making serious efforts to develop their space domain awareness capabilities, particularly in the critical cislunar region, partly in an effort to prevent a "Space Pearl Harbor".[79]

The necessity, proportionality and termination of self-defence should be assessed in the "traditional" way. Having said that, the requirement of proportionality seems to be an exception: in the space environment, it arguably allows less leeway for measures taken in the exercise of the right of self-defence. For example, the proportionality of self-defence would appear to be seriously undermined by any measure that might generate a large amount of space debris. Nevertheless, the EU's Draft International Code of Conduct for Outer Space Activities would exceptionally but explicitly permit the direct or indirect destruction or damaging of space objects in self-defence.[80] Similarly, the use of nuclear weapons in outer space, which could irreparably and indiscriminately damage or disable any unshielded electronic system over a vast geographical area, would violate the proportionality of self-defence. Dual-use space objects further complicate the assessment of the legality of self- defence.[81] Since the proportionality of self-defence and respect for the law of armed conflicts are closely intertwined, the use of such means and methods of warfare may

79 Report of the Commission to Assess United States National Security Space Management and Organization, 11 January 2001, viii, xiii, 22.

80 Draft International Code of Conduct for Outer Space Activities, para. 4.2.

81 Tronchetti 2014: 119.

lead to the disproportionality not only of specific military actions, but also of self-defence as a whole. Remarkably, selected rules and principles of space law, such as the rules on the treatment of astronauts and of space objects, seem to further restrict the freedom of action of parties to an armed conflict involving outer space. It should not be forgotten that an armed conflict would not *ipso facto* terminate or suspend the core treaties of space law, and that some of their relevant provisions also have a customary character.[82] The law of armed conflicts and space law would have to be interpreted and applied together.

CONCLUSIONS

The right of individual or collective self-defence can be exercised in outer space. However, generally acceptable observations seem to end at this point. Not surprisingly, serious theoretical and practical challenges arise relating to all the specific issues lying at the intersection between the use of outer space and self-defence. Difficult and complex questions have to be answered concerning, *inter alia,* the place where self-defence is exercised, the quantitative element of armed attack, the qualitative element of armed attack, the proof of armed attack occurring and the proportionality of measures taken in self-defence. The prevailing unfavourable international environment, the intensification of the new space race and the need to ensure the security of space objects are likely to bring these scarcely examined issues related to the right of self-defence in outer space to the fore. Recently, and for the first time, measures have been taken in self-defence in outer space, as was mentioned in the introduction. The safe and sustainable use of outer space has not been affected by this particular interception, which is believed to have occurred below the lowest stable orbits. However, the consequences of a large-scale space war would be felt by the entire

[82] Draft Articles on the Effects of Armed Conflicts on Treaties, Articles 7, 10 and Annex. In Yearbook of the International Law Commission, 2011, Vol. II. Part 2, U.N. Doc. A/CN.4/SER.A/2011/Add.1 (Part 2), 106.

human civilisation, and this unsettling prospect lends particular weight to the unanswered questions relating to self-defence in outer space. Scholars of international law and space law should play a prominent and proactive role in the search for answers.

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Mathieu Bataille

The Impact and Consequences of the War in Ukraine on Military Space Policies and Operations

INTRODUCTION

On 24 February 2022, Russia started a full-scale war against its neighbour, Ukraine. Since then, the conflict has had considerable consequences on international relations and has impacted many sectors of the economy (e.g. energy, food production, etc.). Contrary to most of the conflicts since the start of the 21st century, which were opposing expeditionary forces to guerillas, the war in Ukraine is a "traditional" conflict witnessing the clash between two states and their armed forces. Interestingly, the space dimension has been a major component of this conflict and has gone beyond the classical use of GPS for navigation or precision-guided weapons. In this context, the employment of space solutions, and the conditions surrounding this use, in particular the major role of private actors, have created valuable lessons that will impact future conflicts.

THE SPACE DIMENSION, A KEY FACTOR OF THE WAR IN UKRAINE

Space solutions have enabled a lot of activities and operations related to the Ukrainian war. To better understand the importance of their role and influence, a few examples illustrating their use can be provided.

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First, in the months preceding the start of the conflict, the U.S. company Maxar published several pictures documenting the gathering of Russian troops at the border. These pictures were used by U.S. authorities to corroborate their other sources of information and convince their partners and public opinion that Russia was preparing a large-scale attack against the country.[1]

On the first day of the invasion, a cyberattack, since then attributed to Russian hackers, targeted the telecommunications satellite KA-SAT. The spacecraft belonged to the U.S. company Viasat and a part of its capacity was used by Ukrainian forces to conduct their operations. The attack also had ripple effects in other European countries, for instance in Germany, where thousands of wind turbines, which were managed through the satellite, stopped working.[2] Similarly, Ukrainian cyber activists claimed that they disrupted Russian communications satellites used by Russian military forces.[3] Cyberattacks, due to their relative simplicity and cost efficiency, are therefore tools that are appealing to both sides of the conflict.

A few weeks after the start of the war, the Ukrainian Government called to SpaceX[4] to provide access to its Starlink system to retrieve communications capabilities for the military and the population. Terminals were quickly shipped and Ukrainian troops used the satellites to communicate among themselves and better coordinate their offensives, but also to pilot and retrieve information from drones. However, at the end of 2022, SpaceX decided to curb some capabilities of the service due to disagreements over the way its satellites were used, especially in the case of "offensive purposes"[5] (e.g. to support lethal drone attacks). Similarly, it was later revealed that SpaceX turned down the Starlink network over Crimea to prevent a major Ukrainian attack against the Russian navy.[6]

1 McLeary 2021.
2 Poirier 2021.
3 Petkauskas 2022.
4 Fedorov 2022.
5 Roulette 2023.
6 Talmazan 2023.

During the conflict, commercial remote sensing companies have also provided a wealth of data to Ukraine, through allies or directly, including for free. Interestingly, the quick development of commercial imagery companies in recent years has allowed to diversify the type of data offered beyond “traditional” optical visible imagery. Therefore, Ukraine and its partners also received optical infrared and radar imagery, as well as radiofrequency mapping.[7] This allowed the country to receive the most accurate data possible, adapted to the weather and type of application considered. These technologies were also used by journalists and analysts to get an objective view on the evolution of the combats.

The involvement of the space industry has been massive during the first year of the war and has reached such a level that specific initiatives were established. For instance, the group “Space Industry for Ukraine”, which gathered 18 companies at its inception, was created. Each member of the group contributed $50,000 to support the implementation of critical humanitarian projects in the context of the conflict (related, for instance, to the supply of medical necessities and food, the restoration of communication, the facilitation of evacuation for civilians, etc.). While space companies that founded the group contributed financially, the projects on the ground were implemented by certified NGOs.[8]

The use cases of space in the context of the war in Ukraine are therefore multiple and varied, and the intensity of the use of these solutions has been matched by a high involvement of private space companies, and its publicisation, which is rather uncommon. Following this situation, from a space perspective, two main lessons have originally been drawn from the conflict in Ukraine. First, the cyberattack against the KA-SAT satellite and ensuing Ukrainian “counterattacks” have demonstrated the importance of the cyber dimension of space infrastructure. This has created a wake-up call to better link both domains. Indeed, the fact that space and cyber are heavily interlinked was assumed before the start of hostilities but few concrete actions were implemented. This wake-up call has already had some impact: for instance, cybersecurity has become an important component of the EU Space Strategy for Security and

7 Torrieri 2022.

8 Howell 2022.

Defence[9] released in March 2023 and, in the EU Policy on Cyber Defence of November 2022,[10] the attack against KA-SAT is explicitly mentioned as a prime example of the vulnerability of space systems to cyberattacks and on the consequences such attacks have on defence systems, the society and the economy. Second, the role of commercial space actors (in particular in the telecommunications and Earth observation fields) has been crucial for the conduct of military operations on the ground, but also to communicate about the conflict itself. Indeed, satellite imagery has been considerably used by Ukraine and its allies to document the scale of destructions caused by the war and point at alleged war crimes. Such a large ecosystem of space data providers was largely inexistent (or only in its nascent steps) a decade ago when Crimea was annexed. Due to this specificity, the current conflict in Ukraine has been nicknamed the "first commercial space war"[11] (as an obvious reference to the "first space war", i.e. the Gulf War of 1991).

A CONFLICT TAKING PLACE IN AN EVOLVING MILITARY SPACE ENVIRONMENT

The war in Ukraine thus displays a central space component, which has been noticed by many states. Therefore, it seems relevant to assess the impact of this conflict on space defence policies, in particular those of advanced spacefaring nations. However, it is first important to acknowledge that these policies were already undergoing an evolution before the start of the conflict. This evolution was revolving around three main dimensions.[12]

9 European Commission and High Representative of the Union for Foreign Affairs and Security Policy 2023.

10 European Commission and High Representative of the Union for Foreign Affairs and Security Policy 2022.

11 Erwin 2022.

12 Bataille–Messina 2020.

Firstly, major spacefaring nations triggered a change of their doctrines: they increasingly adopted the vision of space as a warfighting domain, together with the establishment of more assertive postures not shying away from planning operations directly in space. In parallel, some countries, especially the United States and other Western countries, called for international alliances with like-minded countries on military space issues, in order to defend common interests and values in the face of potential adversaries (namely China and Russia).

Secondly, organisational changes took place with the creation of entities dedicated to space in various militaries (i.e. space commands, space forces, etc.). The objective of these changes is usually twofold: on the one hand, better integrating space with other branches of the military and their associated operational domains (i.e. land, air, sea and cyber); on the other hand, better protecting space assets in orbit, to make sure that they can continue to provide their services without interruption.

Finally, most of the major space powers proceeded with further advancement of their military space capabilities. Of particular interest is the increasing development, testing and, in some cases, fielding of counterspace or anti-satellite systems, both destructive (with four tests having been conducted by China, the United States, India and Russia since 2007) and non-destructive (e.g. lasers to blind other satellites, technologies for rendezvous and proximity operations with cooperative and non-cooperative objects tested in orbit, etc.).

These developments are fairly recent and most of them took place in the months and years immediately preceding the war in Ukraine. Therefore, it is unlikely that the conflict will lead to major changes in the approach taken by space powers towards the military use of space. On the contrary, one could even expect an acceleration of the trends that have been ongoing. For instance, Philippe Adam, the French Space Commander, declared in a parliamentary hearing that the way in which space is used in Ukraine confirms the strategy of France in this domain and the decisions that have been taken in the past years, although he acknowledged that the implementation of these decisions could be rethought.[13] Moreover, the conflict appears as an opportunity to test some of the concepts that were developed in the past about the use of space in warfare but also reflections about the way to access these solutions. In this context, one of the trends that is likely to gain traction due to the conflict in Ukraine is the reliance on commercial actors for data provision, including for defence purposes. It becomes then necessary to assess the impact of this trend.

A RANGE OF IMPACTS DUE TO THE INCREASING USE OF COMMERCIAL SATELLITES

The war in Ukraine demonstrated the growing role, and the added value, of commercial space companies for the conduct of military operations. The "first commercial space war" will likely have consequences on the organisation of the space support to military operations, but states will also need to reflect on the questions that it raises about their own responsibilities.

Controlling the growing integration of commercial space actors in the military field

First of all, the conflict will likely feed the current trend towards a stronger integration of commercial space actors into warfighting plans. For instance, the U.S. Department of Defense clearly established that these actors can become a military tool by listing the provision of commercial satellite imagery services as part of its overall U.S. security assistance provided to Ukraine.[14] The role of commercial actors is therefore not perceived as a beneficial byproduct of U.S. actions, but as part of the whole U.S. effort to support Ukraine. More significantly, the United States is now actively reflecting on the ways in which commercial operators could be activated during a potential conflict in which U.S. forces would be involved. In this context, plans for the creation

13 Assemblée Nationale 2022.

14 Jewett 2022.

of a Commercial Augmentation Space Reserve (CASR) are being elaborated. Following the model of the Air Force Civil Reserve Air Fleet, the CASR would allow the government to call upon commercial companies in times of crisis and benefit from the pre-committed capacity of their spacecraft[15] (independently from the other arrangements that the Department of Defense may have with these companies). It remains to be seen whether other countries will follow the example of the United States. This initiative, as well as general prospects for greater involvement of the private sector, pushed the Pentagon to also consider adding indemnification provisions in future contracts to compensate commercial companies if their satellites were attacked while supporting the U.S. military in a conflict.[16]

However, the decision by SpaceX to reduce some of the capacities of its Starlink system to prevent some alleged "misuses" by Ukrainian forces also highlights the fact that this greater involvement of private actors should be carefully controlled. Indeed, states cannot afford to completely rely on private actors and they should take the appropriate measures to prevent these actors from becoming so powerful that they could directly influence the conduct of operations.[17] Moreover, the extension and relative novelty of this increased reliance on commercial companies raise new questions such as the responsibility of these companies in case the data they provide are erroneous and lead to strategic or tactical mistakes (in particular for remote sensing) and/or the loss of lives (military or civilian) as well as about the protection of commercial spacecraft themselves.

The difficult categorisation of commercial satellites

Space technologies have always been considered dual-use technologies. However, there has long been spacecraft dedicated to military missions and other with predominantly civilian objectives. Against this background, the current

[15] Erwin 2023b.
[16] Erwin–Werner 2022.
[17] Erwin 2023a; Copp 2023.

extensive use of commercial satellites in the conflict in Ukraine blurs even more the distinction between civil and military spacecraft. This situation has led some countries to amend their position *vis-à-vis* commercial satellites. Thus, Russian representatives expressed several times that "quasi-civilian infrastructure" could become a legitimate target for retaliatory actions because it serves military purposes. Such considerations have spread beyond the Ukrainian conflict, with Iranian speakers considering that Starlink and other constellation companies represent a threat to the national sovereignty and territorial integrity of their country.[18]

This situation and these statements raise questions. First, it can be debated whether attacking commercial spacecraft would really be legitimate. Indeed, even though they support military missions, these systems also provide services to civilians. In this context, would an attack against them respect the proportionality criterion of the International Humanitarian Law? Second, beyond the potential indemnification previously mentioned, it becomes necessary for states to reflect on the measures they could/should take to protect commercial spacecraft supporting their operations during a conflict. Recent attacks against commercial satellites have been limited to the cyber realm and have not triggered any official reaction, but one can wonder what would happen should these attacks reach another level or change their nature (e.g. if they become destructive). Although they will likely not be defended as much as governmental/military satellites, states and the operators themselves will have to design appropriate arrangements to preserve the integrity of commercial satellites.[19] For private actors, this is the price for meddling with international politics.

18 Hainaut 2023.
19 See, for instance, the comments of General Saltzmann, Chief of Space Operations in Clark 2023.

Towards new ASAT systems?

The current situation in Ukraine also has an impact on the reflection related to anti-satellite (ASAT) systems. So far, the only known measures against space systems have taken the shape of cyberattacks and electronic warfare (in particular, the jamming of signals). Indeed, while Russia has the capacity to conduct destructive anti-satellite operations and demonstrated it a few months before the start of the conflict, it nonetheless decided not to employ it when targeting the KA-SAT satellite. This seems to confirm that destructive ASAT attacks against foreign satellites will remain unlikely, due to the debris they create and the threats it would cause to the space systems of the attacker. The development of anti-satellite systems will therefore likely focus on non-kinetic or non-destructive systems, which will also impact the countermeasures to be taken (e.g. reinforcement of the spacecraft cyber defence or strengthening of the signals).

But the use of constellations to replace a lost capability has also caught the attention of some countries, which now aim at adapting their ASAT capabilities to the new "threats". For instance, reports suggest that there is an increasing interest of China in developing capabilities able to disrupt commercial communications constellations. Chinese researchers have indeed called for a way to disrupt Starlink (through hard and soft kills) given its military applications,[20] thus raising once more the stakes of finding appropriate methods to protect these systems.

The impact of easier access to space data on the narrative surrounding of conflicts

Finally, the involvement of commercial actors, in particular Earth observation companies and the multiple types of sensors that they own, also provide opportunities to get more data and intelligence on the situation in the field,

[20] Chen 2022.

at a more frequent pace. This easier access to remote sensing data happens in parallel with a trend towards the declassification of such data by some countries, in particular the United States. The goal of this declassification movement is in part to improve the ability to share data from satellites with allies and partners. The combination of these two approaches could lead to more (or, at least, easier) cooperation between militaries, especially related to the analysis and interpretation of these data, and facilitate the emergence of common views, including at strategic level. Indeed, the months preceding the war in Ukraine saw disagreement among Western countries on the interpretation of the situation, in particular because they did not all rely on the same sources of information.

Satellite images were instrumental for some Western countries (especially the United States) to convince that an invasion was imminent and, once the conflict started, to document potential war crimes. Therefore, this technology is used to feed communication and a specific narrative about the conflict. This is a practice whose strengths and weaknesses should be thoroughly analysed. Indeed, rivals (e.g. China) are also developing their commercial space sector; in the future, they could therefore use the same tools to propagate their own vision of a conflict in which Western forces would be involved. Satellite images from private actors could therefore become an integral part of the propaganda/disinformation warfare of the future.[21]

A GAME-CHANGING CONFLICT FOR THE SPACE SECTOR?

Finally, beyond the specific consequences stemming from an increased involvement of private actors in the conduct of military operations, the war in Ukraine has contributed to highlight the general added value of space for defence. This will have consequences on the investments of states in space defence but will also increase requirements to anticipate the future.

21 A risk that could even be reinforced by the modification of existing images or the creation of fake satellite images generated with the help of artificial intelligence.

Growing investment in space defence

Many states are currently witnessing the situation in Ukraine and drawing lessons for their future operations, including related to space. In the wake of the war, several states have been quick in announcing measures to increase their expenditures in the military space domain. It does not mean that all these spendings are a direct consequence of the war (some may have been planned before) but the conflict has undoubtedly accelerated the pace at which these investments are done, in particular in Europe.

For instance, in France, a new Law on Military Programming (LPM) was triggered as a result of the war. Indeed, the law that was applicable at the start of the conflict was supposed to end in 2025 but it was decided to immediately develop a new document in order to adapt to changes of the geopolitical environment. This new LPM, which covers the period 2024–2030, dedicates €6 billion to space, in particular to invest in new constellations[22] (which have proven their usefulness for ubiquitous communications and geospatial intelligence while being resilient during operations in Ukraine). The previous LPM dedicated only €4.3 billion to this domain, hence an increase of almost 40%.

Similarly, in Germany, the start of the conflict led to the announcement of a special fund for defence to be provided with €100 billion. This represents a major step for Germany and a significant growth of its military spending. Interestingly, this fund fully integrates the space dimension as a portion is expected to finance the development of early warning (Twister project) and satellite communications capabilities.[23]

In the same period, Poland purchased two Earth observation satellites from Airbus, based on the Pléiades Neo constellation on which the French military also partly relies. The satellites will provide very high-resolution to Polish armed forces and decision-makers and are expected to be delivered in 2027.[24] This investment demonstrates the interest of one of Ukraine's

22 France Info 2023.

23 Hofmann 2022.

24 Airbus 2023.

neighbouring countries in developing its military space capabilities, thus proving that these capabilities are perceived as a key factor to ensure the security and integrity of a country.

Finally, beyond Europe, Taiwan also demonstrated its will to support the development of indigenous satellite communications providers, in the perspective of a potential future invasion by China. The government has already allocated $18 million to high-tech companies to deploy their own communication satellites in high and medium orbits[25] and has organised massive experimentations, with non-geostationary satellite receivers being tested in 700 locations around the island.[26] Moreover, although it is not yet clear whether Starlink will be available in Taiwan, local companies are already negotiating with foreign operators to provide satellite communication services[27] and, therefore, ensure the continuous ability to communicate in case of crisis.

Improving recruitment and training

If states are willing to develop their hardware capabilities in the military space realm, they also need to make sure that these capabilities can actually be used and exploited by their armed forces. To this end, it is crucial for them to develop the skills associated with these missions. Indeed, a lack of competence within the military can have major consequences on the field. For instance, General Saltzmann, the Chief of Space Operations (i.e. the head of the U.S. Space Force), clearly asserted that this situation played a role in the conflict in Ukraine. According to him, while Russia had theoretically much better capacities than Ukraine, it appeared that either Russian forces did not use them properly, or that these capacities were not well integrated into the overall military effort. Therefore, Saltzmann concluded that there is a need for the United States to make sure that "not only do we have the systems to do the mission, but that our operators have the training and the experience, and we have validated tactics

25 Alaieva 2022.
26 Chen 2023
27 Alaieva 2022.

that actually enable those capabilities".[28] This remark is valid for all countries having integrated space into their military toolbox.

To respond to this challenge, two key aspects must be considered. First, it is crucial to attract people and convince them to stay and make a career in the space field (a challenge that the United States and Europe are currently facing, especially regarding engineers and technicians) and, more specifically, in the military space domain. This is why some countries, such as Luxembourg, have clearly integrated this need into their strategic objectives for space defence.[29] Second, once recruited, it is important to ensure an adequate training for military space operators. This can be done through exercises that aim at preparing the forces for an actual conflict in space or involving space. Several exercises and wargames already exist in the United States (e.g. Schriever wargame), in Europe (e.g. AsterX organised by the French Space Command and involving the participation of other countries' entities; the EU Space Threat Response Architecture) or at NATO level. However, one can expect a growth of the number and variety of these exercises in the future, which could involve an increasing number of nations with and without space capabilities and be based on actual scenarios (e.g. a scenario mimicking the situation in Ukraine, with a cyberattack taking down a key satellite at the immediate start of a conflict and, then, continuous cyberattacks against the systems deployed to replace it).

CONCLUSION

The war in Ukraine represents a game-changer for many states and will have long-lasting consequences on international politics. Since the beginning, this conflict has had an inherent space dimension, which has been highly visible in the past months. The most significant element is the major involvement of private actors in providing support to Ukraine through the delivery of remote

28 Hitchens 2023.

29 Indeed, the fourth Strategic Objective of the Luxembourg Defence Space Strategy, released in February 2022, is to "attract and secure a skilled and motivated workforce".

sensing data and communications, which raises new questions and concerns on the influence these actors can gain but also the measures to be taken by governments to protect commercial assets. Best practices can also be drawn from the way space is used in the Ukrainian context and there is no doubt that the current situation will feed reflection in many states on the evolution of doctrines and tactics for military space operations.

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Kaja Hopej

Satellite Communication as a New Dimension of Supranational Security

"Mankind is only partly aware of
the far-reaching consequences
of its entry into space..."[1]
Manfred Lachs

Introduction

The threats that have emerged over the past few years have increased the focus of the international community on security and defence matters, with the result that space assets are gradually being recognised as critical elements of defence strategies around the world. Although these domains remain mainly within national competences, it is clear that in the case of outer space, this is an area where international initiatives are vital, especially from the European perspective. The recent outbreaks of war and pandemic have highlighted the need to use satellite communications as a response to emerging hazards. However, supranational objectives are needed to make the use of space assets effective for safety as well as more accessible to those members that are less involved in space activities. With the European Space Programme implemented in 2021[2] and recently published Conclusions on the

1 As Manfred Lachs further stated: "[A]nd in any case the importance of the step, though all may sense it, can so far be fully appreciated only by the initiated few. Some of the results of the space venture are conspicuous: they have placed the dominating issue of the security and defence of States in a new light." See Masson-Zwaan – Hobe 2010: 5.

2 Regulation (EU) 2021/696.

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EU Space Strategy for Security and Defence,[3] work on defence and security using space infrastructure continues to move forward.

Considering the above, the author of this paper has identified several factors contributing to safety in and from space, namely: 1. governmental-focused space programmes such as the European Union Governmental Satellite Communication (Govsatcom) and the Infrastructure for Resilience, Interconnectivity and Security by Satellite (IRIS²) within the Union Secure Connectivity Programme;[4] 2. Space Situational Awareness (SSA); and 3. civil and commercial space endeavours. One of the pillars that includes a strong security dimension is the Govsatcom initiative which, together with the IRIS² programme, involves crisis management, surveillance and critical infrastructure such as water barriers, energy or transport. The first of these programmes aims to deploy the space services and capabilities used by EU and its Member States for safety critical missions, while the IRIS² satellite constellation, as the evolution of Govsatcom, is designed to provide value-added services such as flexibility and low latency.[5] The SSA is another important element as one of the capabilities that can enhance the resilience of both space systems and services. Therefore, the next part of the analysis will be an examination of the Space Domain Awareness concept that has been further developed with the first EU Space Strategy for Security and Defence. Finally, the author of this chapter examines the possible exchange of best practices on resilience measures among private entities. Their participation in ventures focused on space infrastructure will be analysed in the context of their involvement in international rivalry from the perspective of military and civilian space capabilities, the line between which currently tends to be blurred.

The objective of this paper is to investigate the activities taken at the regulatory and policy level to support all of the efforts aimed at improving safety in space identified above from both the national and international perspectives.

3 Council of the European Union 2023, preceded by the Joint Communication on an *EU Space Strategy for Security and Defence* presented by the Commission and High Representative to the European Parliament and the Council on 10 March 2023, 7315/23.

4 Regulation (EU) 2023/588.

5 European Commission s. a.

It will combine the analysis of recently adopted policies and regulations at national level and an examination of initiatives at the EU level, in response to space threats.

To achieve this, the paper will briefly characterise and compare the national space defence strategies of three selected States (Luxembourg, France and the U.K. as an example of a country outside the Union), in order to provide a sample of the type of activities being taken on the national level. Based on EU initiatives, such as the EU Space Programme with a focus on secured satellite communication i.e. Govsatcom and IRIS², the transnational defence and security objectives using space capacities will also be outlined. All of the above aspects demonstrate the transition from a national to a supranational approach in the field of space security and defence. In addition to factors contributing to the security of space infrastructure at the supranational level, the indicators that influenced this paradigm shift will then also be identified.

THE BACKGROUND OF CHANGES IN THE SPACE DISCOURSE

During the Space Race and at the height of the Cold War, space capabilities were mostly the preserve of two main spacefaring nations seeking to demonstrate their technological predominance and aspiring to begin the exploration of space. With the launch of the USSR's first artificial satellite, Sputnik 1, in 1957, which marked the beginning of the space age, the international community realised the significance of this event for the technological and military race on a global scale. One year after the USSR, in 1958, the U.S. placed its first satellite into orbit, Explorer 1 which clearly highlighted the huge capabilities in space technologies of both spacefaring nations, which indeed remained virtually the only space actors until the 2000s.

In the 21st century, the space discourse has changed and an increasing number of states across the globe are expanding their space capabilities and including space infrastructure among their key defence and security policy agendas. Not only satellite communications but the entire space infrastructure have become key elements in ensuring security both at the national and supranational level. Space-based assets are essential for a range of services such as communication, navigation, imagery and early warning mechanisms, thus playing a key role in the global security and defence fields as well as helping to tackle emergencies and humanitarian challenges.[6] The proper and uninterrupted functioning of the entire range of space-based and ground systems depends on many factors such as the condition of the outer space environment and this in turn relies on various activities in this regard i.e. governmental, civil and commercial space endeavours, SSA as well as respective regulations and properly targeted policies.[7] Satellite communications play an indispensable role in government communications (Satcom), which provide an alternative when terrestrial means of communication are inaccessible or unreliable. Satellite communication represents the basis of the use of satellites and the data they generate and, by seamlessly connecting and extending, they complement terrestrial communication networks.[8]

There are several factors that have influenced the paradigm shift toward a supranational approach to ensuring the resilience of space capabilities. These include: intentional actions to disrupt or destroy space infrastructure; the implications of intensified space activities worldwide due to the increasing number of space stakeholders; disruption of the international order as a consequence of Russian aggression against Ukraine and the outbreak of multiple conflicts around the world. In view of these developments the vulnerability of space infrastructure to various types of hazards has increased in recent years. Multidimensional security threats can arise not only from intentional actions but also as a consequence of the increased levels of activity in space, by both public and private entities, contributing, for example, to the increase of space debris, the amount of which can render some orbits unusable. These phenomena are an indirect consequence of human activity in space and affect

6 Lueschow–Pelaez 2020: 779.
7 Papadimitriou et al. 2019: 184.
8 Working document of the EEAS(2017)359 on the subject of High Level Civil Military User Needs for Governmental Satellite Communications.

the space environment, the functioning of which has been significantly disrupted by human interference. As a consequence of these activities, the threat of explosions, collisions, satellite breakups or the risk of Kessler Syndrome[9] are just some of the factors that may influence the effectiveness of satellite operations. On the other hand, possibilities for taking deliberate action have also been developed by actors seeking to disrupt or destroy space infrastructure, such as by means of cyberattacks, kinetic weapons such as ASAT missiles[10] or electronic warfare in the form of spoofing or jamming.[11] Furthermore, the outbreak of war and pandemic have highlighted, as never before, the need to possess adequate and resilient communication systems in times of crisis. It is also particularly important to emphasise that satellites have become strategic targets as a consequence of the growing dependence of states on space infrastructure and space capabilities.[12]

SPACE SECURITY AS A NATIONAL DOMAIN

Defence and security issues have always been primarily a matter of national interest. The vast majority of countries in Europe identify the space domain as a strategic area and it is becoming an operational domain in itself alongside

[9] According to the OECD: "An experimental model has been developed to assess the economic effects of a collision event through global value chains. It estimates worldwide monetary losses in the case of Kessler Syndrome to USD 191.3 billion. This is a large sum in proportion to the resources currently committed to debris mitigation and remediation globally." See Net Zero Space 2022.

[10] Since 1959 there have been around 80 ASAT tests carried out by countries such as the United States, Russia/USSR, China and India. The majority of the tests were conducted by the Soviet Union and the United States during the first two decades of the Cold War. Until 2020, in total, ASAT testing has created nearly 5,000 pieces of catalogued orbital debris, more than 3,200 of which are still on orbit. In November 2021, by conducting a destructive direct ascent test, Russia added around 1,400 new pieces of tracked debris, along with hundreds of thousands of smaller fragments. See Secure World Foundation 2020.

[11] ESPI 2020a: 1.

[12] ESPI 2020a: 1.

the land, sea, air and cyberspace.[13] Moreover, space has also been identified as of strategic importance at European level through the proposal of European Union Strategy for Security and Defence. Nevertheless, individual countries still remain the main players in the field of space defence due to the fact that the exploitation and development of space military assets are coordinated by national organisations, while military strategies are defined at national level.[14] In order to enhance their defence capabilities in the space domain several countries have recently adopted their first space defence strategies. Below, selected strategic documents dedicated to space defence are highlighted. These brief descriptions identify the most important strategic assumptions at the national level (including the allocated budget), which will be further reviewed in terms of supranational objectives.

France

France identified outer space as a major factor in its strategic independence as early as the 1960s, and since the 1990s the national armed forces have actively used their space capabilities as an instrument to support military operations.[15] The French Space Defence Strategy (SDS) was published in 2019 by the Armed Forces Ministry and is intended to cover the period up to 2030. This strategy focuses on developing a comprehensive SSA capability, protecting France's indigenous capacities, strengthening the resilience of its armed forces (which should also be able to operate without space support) as well as "on reviewing the doctrine for military space operations based on four functions: space service support, operations support, active space defence and situational awareness".[16] The strategy sets out a vision for the future of France's space defence, while considering the need to define the country's rules of engagement in space.

[13] Ministry of Defence 2022.
[14] ESPI 2020a: 4.
[15] The French Ministry of the Armed Forces 2019: 17.
[16] The French Ministry of the Armed Forces 2019: 4, 10, 11.

This policy document also refers to the private space sector, emphasising the stimulation of innovation, thus representing a renewed vision of the French space industry model.[17] In general, the strategy identified two main aspects: 1. the protection of national satellites by enhancing the country's capacity to monitor the space environment in order to identify unfriendly activities in orbits of interest; and 2. in accordance with international law, the development of the ability to defend national interests in space against aggressive, hostile or unlawful actions.[18] Following the objectives set out in the strategy, another milestone was reached in July 2023, when the Parliament approved the French Military Programme Act 2024–2030, allocating €6 billion to strengthen the country's activities in space during this period.[19]

Luxembourg

Luxembourg's Defence Space Strategy was implemented in 2022 and is built around four major strategic objectives, namely: the consolidation of Luxembourg's current space capabilities, improving their resilience and development of new systems; supporting freedom of action in and from space; fostering international as well as national cooperation and finally working to secure and attract human resources in the domestic space ecosystem. The coordination and implementation of Luxembourg's defence policy falls within the competences of the Defence Directorate and the Luxembourg Armed Forces, under the authority of the Minister responsible for Defence.[20] These objectives are complemented by an emphasis on the development of specific segments such as satellite communications for ensuring the resilience of communications systems targeting multi-orbit access, investing in strategic systems in GEO, MEO, LEO participating in the multinational Wideband

17 Pasco–Wohrer 2023: 2.
18 The French Ministry of the Armed Forces 2019: 25.
19 De Selding 2023.
20 Luxembourg's Defence Space Strategy: 7.

Global Satcom system (WGS) programme and the national GovSat-1 satellite, as well as investing in various programmes, giving preference to dual use of the commercial and military bands.[21] In 2018, Luxembourg launched the first dual-use Satcom (GovSat-1) based on a public–private joint venture between the Luxembourg Government and a Luxembourgish satellite telecommunications network provider (SES).[22]

The United Kingdom

The U.K.'s first Space Defence Strategy was published in 2022 and is based on three "strategic themes". These relate firstly to the development of space capabilities for protection and defence, identification of threats to space systems and appropriate responses to hostile action. A further element of the strategy is to strengthen military operations by integrating space with other defence activities, providing resilient space services that are of fundamental importance to military operations and strengthening the architecture and integration of the various domains. The last component is related to the improvement of skills through the development of coherent space plans and policies as well as by recruiting and retaining qualified space personnel, including the retention of human potential in the country.[23] An allocation of £1.4 billion is planned for the development of technology to protect the country's interests in space (of which £968 million will be allocated to the ISTARI[24] programme and £61 million will be invested in laser communication technologies).[25] Under the strategy, to secure domestic satellite communication capability, the U.K.

[21] Luxembourg's Defence Space Strategy: 12.
[22] ESPI 2020b: 80.
[23] Ministry of Defence 2022: 19, 22.
[24] Ministry of Defence – Defence Science and Technology Laboratory 2022.
[25] Ministry of Defence – Defence Science and Technology Laboratory 2022.

pledges to exploit and enhance the Skynet 6 programme[26] in order to support government operations and better fulfil its military objectives. The programme has been allocated £5 billion over the next 10 years and additional funding of almost £60 million will be invested in the development of Skynet 6 and other Satcom capabilities.[27]

Despite the clear focus of these documents on national aspects by emphasising the resilience of national space infrastructure as well as capacity building for domestic space activities, strengthening international cooperation is an integral part of all of the space defence strategies described above. According to Luxemburg's Space Defence Strategy:

> "Through the development of space capabilities at national level or in cooperation with NATO/EU partners, and by strengthening the resilience of these capabilities, Defence will not only meet its national needs but also contribute these capabilities to international organisations and allied countries."[28]

In line with the French strategy, a common vision of strategic space challenges should be oriented towards building a European space industry based on mutually agreed dependencies (i.e. tasks that need to be completed).[29] Deepening and broadening international as well as intergovernmental cooperation is also an important aspect of the U.K.'s strategy.[30] It is worth noting that despite the growing demand for space infrastructure for defence and security purposes, to date only a few European countries have decided to allocate a separate budget for space defence.

[26] Skynet 6 is the Ministry of Defence's satellite communications (Satcom) capability which is based on military communications satellites.

[27] Ministry of Defence 2022: 7.

[28] Luxembourg's Defence Space Strategy 2022: 9.

[29] The French Ministry of the Armed Forces 2019: 32.

[30] Ministry of Defence 2022: 16.

A NEW DIMENSION OF SUPRANATIONAL SPACE SECURITY

Space Security is defined in the Space Security Index[31] as "the secure and sustainable access to, and use of, space and freedom from space-based threats".[32] According to the Index:

> "This broad definition encompasses the sustainability of the unique outer space environment, the physical and operational integrity of manmade objects in space and their ground stations, as well as security on Earth from threats and natural hazards originating in space."[33]

Space security, according to this definition, is affected by the threats posed by space debris, a problem which is currently reaching a critical level.[34] Pollution of the space environment is a global concern, which affects, among other things, the proper functioning of satellite communications. Activities at the international level such as SSA are essential to ensure equal and unhindered access to space for both present and future generations.[35] At the same time, other hazards are rapidly emerging and will pose critical challenges for space safety, such as the ability to neutralise other countries' space systems which are designed for military purposes.[36]

31 The Space Security Index is a research partnership between the Project Ploughshares and the University of Adelaide which "aims to improve trust and transparency related to space activities, and to provide a common, comprehensive, objective knowledge base to enhance capacity for dialogue and policies that contribute to the governance of outer space as a shared global commons".

32 Polkowska 2018: 330.

33 Grego 2017: 5.

34 NASA 2021.

35 According to the Definition of Long Term Sustainability in Outer Space Activities: "The ability to maintain the conduct of space activities indefinitely into the future in a manner that realizes the objectives of equitable access to the benefits of the exploration and use of outer space for peaceful purposes, in order to meet the needs of the present generations while preserving the outer space environment for future generations." See LTS Guidelines 2018: 2.

36 Grego 2017: 6.

While space has become a significant national security issue, this domain is also undergoing significant and rapid change worldwide. The development of space technology is based both on international cooperation and on the achievement of technological goals, without which the effective use of space infrastructure would not be possible. In this domain, international relations require mutually agreed objectives. Due to the increasing demand for the protection of common space assets as well as the need to address collective security challenges and objectives, appropriate measures are taken at European level to ensure the resilience of the common space infrastructure and to enhance Europe's common defence capabilities. For the purposes of this study, the work on defence and security in this field will be illustrated using the example of the European Union. The rationale for this focus is the recent adoption of a key strategic document, namely the European Space Strategy for Security and Defence and the development of secure satellite communications programmes such as Govsatcom and IRIS², through the implementation of initiatives such as the European Space Programme, with a dedicated budget for this purpose.

EU Space Strategy

The need to set common goals for securing and improving space infrastructure at the European level has grown in importance recently as the outer space environment has been threatened by irresponsible and hostile behaviour. Addressing these challenges, the EU Council approved the *Council Conclusions on the EU Space Strategy for Security and Defence* on 13 November 2023. In response to threats of intimidation, destabilisation and economic disruption from hostile space activities, the common EU resilience framework was established. This represents that for the first time such a framework has been focused solely on space infrastructure, and space itself is considered strategic, as demonstrated by the statement that "space is key for the EU's freedom of action and autonomous decision-making in security and defence". The need for a common resilience framework (based on the sector's specifications and industrial base), in order to enhance the global competitiveness of the EU space sector also stems from the need to avoid the fragmentation of the single market for space services and products. The strategy also refers to the exploration of the potential development of services within the IRIS^2 Program (including for defence and security purposes) by the Commission in close coordination with the Member States.[37]

European Union Space Programme

The European Union Space Programme, as well as the European Union Agency for the Space Programme were established by Regulation (EU) 2021/696 of the European Parliament and of the Council of 28 April 2021. Under this regulation, an EU Space Programme has been developed based on a multi-annual funding framework for 2021–2027. The programme includes space activities in the fields of Satellite Navigation, Connectivity, Space Research and Innovation, as well as Earth Observation. Among the overall goals of the programme, in addition to strengthening European space services and assets and maximising their socio-economic benefits by fostering the development of innovations in both the downstream and upstream sectors, the objectives of the programme include enhancing the security of the Union and its Member States, by reinforcing the safety and "sustainability of all outer space activities pertaining to space objects and debris proliferation, as well as space environment".[38] The budget allocated for the implementation of the programme, and for covering the associated risks is €14.880 billion and it will run from 1 January 2021 to 31 December 2027. Out of the total budget €0.442 billion has been allocated to the Govsatcom and Space Situational Awareness Components.

[37] Council of the European Union 2023: 5, 6, 10, 22.

[38] Regulation (EU) 2021/696.

SUPRANATIONAL NATURE OF SPACE COMPONENTS

Govsatcom

Created in order to carry out security-critical missions and operations managed by the European Union and its Member States, the European Union Governmental Satellite Communication (Govsatcom) Programme is designed to guarantee cost-effective and secure communications capabilities.[39] The services provided by Govsatcom are intended to be used for security and safety operations and it includes crisis management[40] surveillance[41] as well as safeguarding critical infrastructure[42] such as water barriers, energy transport and space infrastructure. The capacity and services of Govsatcom shall be used by European Union and Member States Actors.[43] The programme seeks to create synergy between the civilian and military domains by overcoming the fragmentation of Govsatcom users. In addition, it aims to guarantee EU and national government users' access to satellite communications and to ensure European independence in terms of resources, technology and operations as well as services.[44]

Although Govsatcom is one of the flagship projects of the EU Space Programme, work on secure and resilient satellite communications for government purposes, involving the participation of Member States, began much earlier.

39 EUSPA 2023.

40 "Crisis management, which may include civilian and military Common Security and Defence missions and operations, natural and man-made disasters, humanitarian crises, and maritime emergencies." See Regulation (EU) 2021/696.

41 "Surveillance, which may include border surveillance, pre-frontier surveillance, sea-border surveillance, maritime surveillance and surveillance of illegal trafficking." See Regulation (EU) 2021/696.

42 "Key infrastructures, which may include diplomatic network, police communications, digital infrastructure, such as data centres and servers, critical infrastructures, such as energy, transport and water barriers, such as dams, and space infrastructures." See Regulation (EU) 2021/696.

43 Regulation (EU) 2021/696.

44 European Commission 2016.

Calling for close cooperation between the Commission, the ESA and the EU Member States, the EC conclusions of December 2013[45] began the preparations for the next generation of Govsatcom.[46] The European Defence Agency (EDA) in 2014 approved the initial satellite communications needs for European military entities dealing with the operation of Common Security and Defence Policy (CSDP) as well as national operations[47] and in June 2016 Govsatcom was identified as one of the elements of the Global Strategy for the European Union's Foreign and Security Policy.[48] A demonstration project called Govsatcom Demo began to be developed in March 2017 by the European Defence Agency.[49] A step towards demonstrating European capabilities to support the initiative was the creation of the Govsatcom Precursor programme which, in the form of public–private partnership projects (known as PACIS), enabled the participation of satellite operators and service providers in preparatory work related to this project.[50]

In addition to the supranational nature of the European Union's activities, some other space initiatives can also be characterised as intergovernmental. The Govsatcom Programme is an example of a project that takes the approach of pooling and sharing national assets.[51] According to Article 68 of the EU Space Programme:

45 "Remains committed to delivering key capabilities and addressing critical shortfalls through concrete projects by Member States, supported by the European Defence Agency, it welcomes [...] in the area of Satellite Communication: preparations for the next generation of Governmental Satellite Communication (Govsatcom) through close cooperation between the Member States, the Commission and the European Space Agency." See European Council 2013.

46 Regulation (EU) 2021/696.

47 Borek et al. 2020: 46.

48 Regulation (EU) 2021/696.

49 Borek et al. 2020: 46.

50 ESA s. a.

51 ESPI 2020b: 38.

> "Member States, the Council, the Commission and the EEAS shall be Govsatcom participants insofar as they authorise Govsatcom users, or provide satellite communication capacities, ground segment sites or part of the ground segment facilities. Where the Council, the Commission or the EEAS authorise Govsatcom users, or provide satellite communication capacities, ground segment sites or part of the ground segment facilities, on the territory of a Member State, such authorisation or provision shall not contravene neutrality or non-alignment provisions stipulated in the constitutional law of that Member State."

This programme, dedicated to ensuring secure satellite communications, is an example of the type of activities taken at the European level to achieve supranational, technological and operational independence with the close cooperation of Member States. It is implemented through the involvement of institutions such as ESA, EUSPA and the European External Action Service (EEAS).[52]

IRIS²

The IRIS² infrastructure contributes to implementing the Govsatcom programme, and is designed as a system of systems, incorporating the necessary ground and space components to provide the necessary government and commercial services for ensuring "resilience, interconnectivity and security by satellite".[53] It consists of Government Infrastructure including both self-standing Commercial Infrastructure and Shared Infrastructure. According to Article 3 of the IRIS² Regulation,[54] the general objectives of the programme are based on providing autonomous, secure, high-quality, cost-effective and reliable satellite communication services to users authorised by government. The second dimension of the programme seeks to "enable the provision of commercial services, or services offered to government-authorised users based on commercial infrastructure at market conditions, by the private sector".

[52] European Commission 2024.
[53] European Commission 2023.
[54] Regulation (EU) 2023/588.

According to the Regulation, the programme objectives include the integration and complementation of existing and future capabilities of the Govsatcom component. Another goal is to improve satellite connectivity over geographic areas of strategic importance such as the Baltic, the Black Sea, Mediterranean regions and the Atlantic, as well as the Arctic and Africa. In addition to the support provided to governments and the elimination of the so-called "dead zones" in Europe, Africa and the Arctic, this programme involves New Space ecosystem stakeholders by stimulating innovations.[55] A further objective of the Regulation is to

> "encourage innovation, efficiency, as well as the development and use of disruptive technologies and innovative business models throughout the European space ecosystem, including New Space actors, new entrants, start-ups and SMEs, in order to strengthen the competitiveness of the Union space sector".[56]

Space Domain Awareness

Space Situational Awareness (SSA) is based on detecting, identifying and tracking space objects as well as predicting their future locations.[57] The Space Foundation defines SSA as "the ability to view, understand and predict the physical location of natural and manmade objects in orbits around the Earth, with the objective of avoiding collisions".[58] According to the U.S. Space Policy Directive 3: "Space Situational Awareness shall mean the knowledge and characterization of space objects and their operational environment to support safe, stable, and sustainable space activities".[59] The European Space Agency completes the definition by identifying three elements of SSA knowledge,

[55] Copernicus 2023.
[56] Regulation (EU) 2023/588.
[57] Erwin 2019.
[58] Space Foundation s. a.
[59] Executive Office of the President 2018.

namely Space surveillance and tracking (SST), Space weather events (SWE) and Near Earth Orbit (NEO) observation. The European Space Situational Awareness system has dual-use military and civilian applications.[60] Outer space is becoming increasingly congested and the international order has been challenged in recent years.[61] In order to respond effectively to the development of counter-space activities by hostile states, the approach to SSA has changed towards ensuring safety by the urgent improvement of SSA capabilities.[62] According to the Strategy, Space Domain Awareness remains within the scope of national responsibility and "SDA is a sovereign prerogative and capacity of Member States stemming from a variety of sources and that sharing this information is a sovereign and voluntary decision by each Member State".[63]

As part of the SSA component, based on the Space Surveillance and Tracking (SST) Support Framework, the SST Consortium was established in 2015. The new EU SST Partnership Agreement which includes 15 EU Member States[64] entered into force in 2022, with the aim of connecting national assets to improve the EU's SST autonomy and performance in the SSA domain.[65]

COMMERCIAL SPACE ENDEAVOURS

Due to the intensified commercialisation of space activities and the growing demand for technology developed by private entities, cooperation between the private and public sectors is more visible and is becoming necessary and, indeed, crucial for security purposes. The line between the commercial space

60 Polkowska 2018: 342.
61 Council of the European Union 2023.
62 Polkowska 2018: 333.
63 Council of the European Union 2023: 14.
64 I.e. France, Germany, Italy, Poland, Portugal, Romania, Spain, Austria, the Czech Republic, Denmark, Finland, Greece, Latvia, the Netherlands, Sweden.
65 The EU Space Surveillance and Tracking (EU SST) Partnership Agreement has officially entered into force on 11 November 2022.

domain and that of military satellites tends to be blurred. Military forces rely on commercial space services and dual-use assets have become widespread throughout the world.[66] To promote best practices and responsible behaviour, space stakeholders in both the public and the private sector need to actively participate in interstate and non-governmental forums in order to contribute to the development of international standards and best practices,[67] especially in the context of ensuring common security. Mutually agreed goals, and the identification of related dependencies play a crucial role when it comes to international cooperation but they can also have a huge impact on public–private partnership, particularly in the upcoming projects dedicated to secure satellite communication. More and more countries are developing their own SSA capabilities, while commercial companies are also working to provide the necessary information to satellite operators. Currently, specialised services related to SSA are increasingly being offered by commercial entities, due to the development of space technologies related to this domain. However, a threat has emerged which is associated with the fragmentation of SSA data, which complicates the efforts being made to standardise and validate information derived from SSA.[68] The evolution of space sector is significantly influenced by governments, which play a range of roles in interacting with the private space sector from regulator to customer to supplier to competitor.[69] Within the IRIS² regulations, which enable commercial services, or services offered to government-authorised users based on commercial infrastructure, appropriate market conditions are essential. Furthermore, as indicated in the analysis of both the national and European strategies, the development of innovative and competitive national as well as European upstream and downstream sectors, including SMEs and startups are of particular importance.

66 ESPI 2020a: 1.
67 The French Ministry of the Armed Forces 2019: 27.
68 Satsearch 2023.
69 Polkowska 2018: 336.

IMPLICATIONS OF THE PARADIGM SHIFT TOWARD SUPRANATIONAL OBJECTIVES

The implications of the paradigm shift from a national to supranational scope for security and defence space activities are manifold. There are several reasons for favouring a cooperative approach. One is the development of international cooperation in information sharing, through the involvement of various agencies as well as public and private entities. This contributes to the improvement of common standards and norms of behaviour in space that benefit space stakeholders in terms of security objectives. Due to the increasing demand for the protection of common space assets, addressing common security challenges as well as setting common objectives are essential. In addition, public–private partnerships in the security and defence domain provide opportunities for exploiting commercial technological advances.[70] Components such as SSA involve space activities conducted by private entities due to the level of technological advancement they can provide. The economic aspects of such initiatives should not be overlooked either, as the dual nature of space technology and space activities foster the industrial ecosystem and lead to an expansion of Research and Development cooperation. In the context of initiatives taken at the European level, the autonomy and resilience of space systems is crucial, as is the avoidance of fragmentation in space infrastructures' operations and strategic decision-making capabilities.[71] However, it should also be borne in mind that this approach creates more dependencies, while becoming a challenge for intergovernmental coordination, management and operational capabilities.

70 Department of Defense 2020.
71 Mölling et al. 2021.

CONCLUSIONS

The fundaments of global space governance are based on the UN treaties on the use of space, which provide a crucial framework for the peaceful exploration and use of outer space "carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind".[72] It could be argued that these fundamental principles are being disrupted by developing military and defence capabilities in space. In response, it is worth pointing out that the freedom of space exploration and research as well as equal access to outer space is certainly being undermined by the development of counter-space activities.

A key measure for building trust and transparency is the sharing of doctrines as well as public security strategies and policies.[73] Such activities are undertaken both nationally and supranationally. European space capabilities on the technological level have been developed primarily through the establishment of the European Space Agency. The role of the EU in the European space ecosystem is increasing, however.[74] At the same time, it is important to recognise that this ecosystem consists of 22 ESA and 27 EU Member States, most of which have their own national space agencies and dedicated space programmes as well as strategies. A common goal for each indigenous sector is to preserve the space infrastructure in order to use it effectively, for security and defence purposes. To achieve this goal in such a fragmented institutional and regulatory environment, it is necessary to establish supranational mechanisms. European collaboration in space initiatives plays a vital role through strengthening legal

[72] Article I of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies Adopted by the General Assembly in its resolution 2222 (XXI), opened for signature on 27 January 1967, entered into force on 10 October 1967.

[73] Council of the European Union 2023.

[74] As Laurence Nardon noted in 2007: "European military space developments are limited. Acquisition of independent space surveillance means would change the situation. However, all European countries do not share the same motivation for space or indeed for military independence." See NARDON 2007.

frameworks, fostering collaboration in space initiatives and investing in the development of components dedicated to security and defence capabilities. Given the implications presented in this article, special attention should be paid to the evolution of the legal framework and the normative environment along with the development of unified standards for data management as well as ensuring interoperability at supranational level.[75] At the technological level, these instruments are fulfilling their role, but it is necessary to set up support mechanisms of both a strategic and unified nature in order for all the players involved to share a common vision of the strategic challenges of space.

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[75] Mölling et al. 2021.

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Don Koulaouzos

Security in Outer Space: Planning for Compromised Positioning, Navigation and Timing

INTRODUCTION

More than a hundred different Global Navigation Satellites orbit the Earth providing Positioning, Navigation and Timing (PNT) services, with the latter capability being the least appreciated or understood.

PNT does more than guide motorists, aviators, sailors and hikers. Many industries such as construction, mining, surveying, package delivery, logistical supply chain management, farming, fixed and wireless communications networks, banking systems, defence, security and emergency services, financial markets, water utilities and power grids depend on the accuracy and availability of PNT.

How robust is this 'invisible utility', what are the consequences of compromised PNT on critical national infrastructure and what contingencies exist to protect it?

Most of the terrestrial-based PNT systems have been or are being progressively decommissioned leaving satellite-based PNT as a vulnerable single point of failure for many users.

Several natural and human threats can temporarily or permanently deny access to accurate satellite PNT. Low probability but high-impact risks to satellites can come from space weather or meteor showers, as well as space debris or anti-satellite attacks. Terrestrial threats such as jamming and spoofing are far more prevalent and insidious. These can come from unfriendly state actors, domestic military tests and even civilians using low-cost equipment to evade surveillance.

DOI: https://doi.org/10.36250/01208_19

Mariners and aviators regularly report jamming and spoofing attacks that could have serious consequences. These attacks have also affected communications networks and financial services.

The financial impact on society from the loss of PNT has been estimated to be up to $1 billion per day for some countries, but there are initiatives underway to improve the resilience or availability of PNT. This includes alternative capabilities in space as well as from terrestrial networks, self-contained inertial navigation and timing systems or diverse radio signals of opportunity on Earth.

Governments, society and industry should have a greater awareness of the risks and impact of compromised PNT so that further investments to protect this essential invisible utility can be considered.

A COMPROMISED PNT WORLD

While far out at sea in the middle of the night, the crew of a merchant vessel wakes the captain to tell him they have lost all control of the ship's steering and throttle.

A few hours later, an airline pilot aborts a landing after receiving warnings that there is an error in the approach guidance system and is forced to make a night landing in dangerous conditions.

Later, a young girl is sent home early when school is unexpectedly closed owing to a national incident disrupting all electricity, water and heating. She cannot call home because the cellular mobile phone networks are down. She tries to withdraw money from the nearest Automated Teller (cash) Machine (ATM) to pay for a taxi home, but the banking system is not working. Meanwhile, police cannot manage traffic gridlock in the city as their emergency services radio network is also out of action.

This is not an extract from a sci-fi or disaster movie. Each of these scenarios involving compromised Positioning, Navigation and Timing (PNT) from Global Navigation Satellite Systems (GNSS), such as the Global Positioning

System (GPS), are derived from actual events. The schoolgirl scenario is an amalgam of several separate occurrences, but compromised GNSS PNT is not rare.

In 2016, a timing error in the GPS network disrupted TV, radio, banking and emergency services communications for over half a day in different locations worldwide.[1] A large container ship lost control in the Mediterranean in 2017 after its navigation system was hacked,[2] while an airliner lost all GPS position information, forcing the pilots to make a hazardous pre-dawn landing in 2020 at El Paso International Airport without vertical guidance.[3]

These events provide a chilling reminder of our dependency on GNSS PNT.

This analysis will explore some of the risks and impacts of compromised GNSS PNT, while reviewing the adequacy of several existing, planned and proposed resilience initiatives.

PNT EVOLUTION AND GNSS DEPENDENCY

We cannot imagine life without the four essential public utilities that we take for granted: water, energy, communications and waste disposal. Yet in less than half a century, almost every aspect of our life has become reliant on an 'invisible fifth utility' – GNSS PNT. Positioning provides a two or three-dimensional location of the user. Navigation lets the user determine the current and desired relative or absolute position and apply corrections to course, speed and heading. Timing provides and maintains accurate time locally or globally from a standard reference such as Coordinated Universal Time (UTC).[4] For many, the T (timing) in PNT is often overlooked and taken for granted as a hidden element embedded in this invisible utility. When GPS was initially established for the military, it was never envisaged that timing would become a critical service that many communities depend on globally.

1 Kovach et al. 2016.
2 Blake 2017.
3 Harris 2021.
4 Ordnance Survey 2023.

GNSS PNT is not only used by motorists, hikers, mariners and aviators. Many industries, such as construction, mining, surveying, package delivery, logistical supply chain management, farming, fixed and wireless communications networks, banking systems, security and emergency services, defence, financial markets, water utilities and power grids, all depend on the global availability and accuracy of GNSS-based PNT.

LIFE IN A WORLD BEFORE GNSS PNT

In 1904, the first time signals were sent to ships by radio to allow navigators to check their chronometers. This was followed by the first radio navigation beacon installed in 1921.[5] By the end of World War II, a global network of 72 high-power, Low Frequency (LF) radio transmitters provided Long Range Navigation (LORAN)[6] services, including the U.K.'s Decca Navigator system. Radio navaids for aviation and some maritime users progressively expanded after World War II. The number of Very High Frequency Omnidirectional Range (VOR) beacons peaked in 2000 when thousands of stations were operational in the United States[7] along with other radio navaids such as Distance Measuring Equipment (DME) and Non Directional Beacons (NDB).

All commercial airlines and aircraft flying in conditions without adequate outside visual references must fly under the Instrument Flight Rules (IFR). The Instrument Landing System (ILS), developed in the 1930s, provides precision radio navigation that allows suitably equipped IFR aircraft to approach and land at night and in bad weather by providing vertical (glide slope) and horizontal (localiser) guidance to and from the runway.

[5] Bowditch 2022.
[6] Bartlett et al. 2015.
[7] Harris 2021.

GNSS is progressively replacing radio navigation systems

The age of space-based navigation was launched in 1978 with the (then) $12 billion investment in the US GPS operating in Medium Earth Orbit (MEO) of approximately 20,200 km.[8]

The business case for replacing radio navigation systems with their significantly higher installation and operational costs compared to GPS was compelling. The U.S. closed their last LORAN-C and Enhanced LORAN (eLORAN) stations in 2010, followed by Europe and the U.K. in 2015. LORAN-C and eLORAN services remain operational in several countries, including equivalent LF systems in Russia and China.[9]

The U.S. is also progressively decommissioning VOR stations, which will be reduced to 580 sites by 2030.[10] The Australian Civil Aviation Safety Authority removed half of Australia's radio navigation network after mandating GNSS as the primary means of navigation for IFR aircraft from 2016.[11] In a similar cost-saving measure in 2018, the U.S. Federal Aviation Administration (FAA) approved IFR aircraft equipped with suitable avionics to make precision approach and landings using GNSS as an alternative to ILS at those airports that have installed Ground Based Augmentation Systems (GBAS).[12]

GNSS has also enabled the replacement of traditional navigation methods in the air. American Airlines achieved $1.2 million annual fuel cost savings in 2013 by removing 16 kg of flight manuals and navigation charts from the flight deck, becoming the first airline to operate through all phases of flight with iPads.[13]

8 ESA 2021a.
9 Bartlett et al. 2015.
10 Alwin 2023.
11 Casa 2016.
12 FAA 2023.
13 Huguely 2013.

GNSS is an essential service for all mariners

In 2000, the International Maritime Organization amended regulations to allow Electronic Chart Display and Information Systems to replace paper nautical charts for seagoing vessels, eventually becoming mandatory for new and existing ships from January 2011.[14] Plans to withdraw paper charts by 2026 and replace them with digital equivalents were announced by the U.K. Hydrographic Office in 2022. However, this deadline was subsequently extended to 2030.[15] It is now common for pleasure yachts to be equipped with GNSS-enabled chart plotters that sailors often use as their primary means of passage planning, pilotage and en route navigation. The Automatic Identification System (AIS) uses Very High Frequency (VHF) radio to broadcast their GNSS-determined ship location, direction and identity automatically. AIS is compulsory for all vessels over 300 Gross Registered Tonnes and is also becoming more popular with pleasure yachts.[16]

Motorists and pedestrians rarely use paper maps for navigation today. To find their way to an unfamiliar address, almost all motorists and some pedestrians once carried a street directory, atlas or paper map. After Garmin launched the first portable Street Pilot GPS navigation system in 1998, drivers eventually became more dependent on this convenient technology.[17]

The growth of Satnav has reduced the demand for printed maps. For example, in 2017, the Map Shop stopped printing the once popular Fuller's Street Directory.[18] The end of this once indispensable travel aid is representative of similar trends worldwide. More than one billion people use and rely on Google Maps every month.[19]

14 IMO 2011.
15 UKHO 2022.
16 NATO 2021.
17 Leite 2018.
18 Whetham 2021.
19 Mukherjee–Zalani 2024.

PNT will play an important role in autonomous vehicle operations

The International Standards Organization and the Society of Automotive Engineers International have jointly established performance and system requirements for autonomous vehicles. There are six defined levels of driving automation, ranging from no driving automation (Level 0) to full driving automation (Level 5).[20] These vehicles must achieve 95% confidence of horizontal position accuracy of around 20 cm with availability greater than 99.9%.[21] They accomplish this by integrating multiple sensors and technologies, including GNSS, to accurately ascertain the vehicle's environment and maintain optimal real-time control.[22]

Financial services globally depend on reliable precision timing. Almost all aspects of financial services utilise GNSS timing for compliance, operational analytics, market transparency, automated share trading algorithms and ATM operations. Regulators require mandatory timestamping of at least 100 microseconds accuracy for the Consolidated Audit Trail in the USA and Markets in Financial Instruments Directive II in Europe. These systems rely on atomic clocks synchronised between Earth and GNSS satellites, which provide accurate UTC down to the nanosecond.[23]

GNSS is a key enabler for precision agriculture. Nearly 40% of large farms in the U.S. employ some form of Precision Agriculture (PA). Adoption of PA by large farms has reached 30% in Germany, 20% in Australia and almost 10% in Hungary.[24] PA relies on GNSS in 4 key areas: 1. guidance and steering systems; 2. land preparation; 3. yield monitoring and mapping; and 4. Variable Rate Application (VRA). Sensors, maps and GNSS are used in VRA to automate the application of irrigation, fertilisers, chemicals and seeds. Other PA

[20] ISO 2021.
[21] Petovello 2019.
[22] Giannaros et al. 2023.
[23] Hoptroff 2023.
[24] Trimble 2022.

applications reliant on GNSS include field planning, soil sampling, pest and crop monitoring, as well as farm vehicle and drone guidance.

Global and regional PNT systems

The military relies on assured GNSS PNT for everything from navigation and positioning of ground vehicles and dismounted ground forces to weapon guidance. It is used to synchronise elements of Command, Control, Communications, Computers (C4) Intelligence, Surveillance and Reconnaissance (ISR) (C4ISR).[25] Consequently, adversaries now recognise the strategic value of GNSS PNT, making it a high-value target for Electronic Warfare.

GPS is often incorrectly used as a generic term for GNSS, which can also refer to augmentation systems used to improve the accuracy and stability of PNT. There are currently four operational GNSS and two Regional Navigation Satellite Systems (RNSS), which are listed in Table 1.

Galileo is the only civilian controlled GNSS, and it also currently offers the highest accuracy down to 20 cm horizontally and 40 cm vertically with its High Accuracy Service.[26]

Each GNSS and RNSS transmits data on more than one dedicated frequency, some of which is encrypted, to enhance availability accuracy and mitigate Radio Frequency Interference.

GNSS plays a vital role in society, delivering (mostly) reliable, accurate and ubiquitous positioning, navigation and timing services worldwide for Critical National Infrastructure (CNI) and services that include:

- cellular, emergency services and defence telecommunications
- autonomous vehicles and drones
- air, sea, road and rail transportation
- power and water utilities
- financial services
- digital broadcast and land mobile radios

[25] Ascencio 2021.

[26] ESA 2023a.

Table 1

Global and regional navigation satellite systems

Name	FOC*	Constellation**	Control	Type
GPS (Global Positioning System)	1995	24 MEO	U.S. Government	GNSS
GLONASS (Globalnaya Navigazionnaya Sputnikovaya Sistema, or Global Navigation Satellite System)	2011	24 MEO	Russian Government	GNSS
BDS (BeiDo Navigation Satellite System)	2020	30 MEO, 5 GEO***	Chinese Government	GNSS
Galileo	2021	24 MEO	European Union	GNSS
NavIC (Navigation Indian Constellation)	2017	3 GEO, 4 IGSO****	Indian Government	RNSS (1,500 km around the Indian mainland)
QZSS (Quasi-Zenith Satellite System)	2018	1 GEO, 3 IGSO	Japanese Government	RNSS (East Asia and Oceania)

Notes: *Full Operating Capability; **Baseline constellation; ***Geostationary Earth Orbit; ****Inclined Geosynchronous Orbit
Source: ESA 2023

The dismantling of ground-based systems such as VOR, LORAN and other radio navigation systems further increases dependency on GNSS PNT, which, in some cases, has created a single point of failure for CNI.

There is no doubt that we now live in a world where all aspects of life are directly or indirectly dependent on GNSS PNT.

PNT RISKS AND IMPACT

Many human threats and some natural hazards could compromise GNSS PNT, affecting its accuracy, integrity, continuity and availability. Most of society and some industry segments are unaware of the fragility of this ubiquitous, free and 'invisible utility', expecting it always to be globally available.

Jamming, spoofing and cyberattack are threats to GNSS PNT. To illustrate one aspect of this vulnerability, consider that the strength of a GNSS signal is less than one billionth of a watt by the time it travels over 20,000 km to Earth. This is like trying to see a 20-watt light bulb in Lisbon from Moscow at midday. Therefore, it does not require a very strong or sophisticated source of interference to jam or spoof GNSS.

A direct Line of Sight (LOS) signal must be received from at least 4 GNSS satellites to obtain an accurate 3D fix (latitude, longitude and altitude). The user's environment can impact LOS, where high terrain or buildings (known as Urban Canyons) can either block direct signals or generate reflected signals off these objects. These multipath reflections can degrade the accuracy of GNSS positions. Loss of primary LOS creates a vulnerability that can make it easier to inject false signals or jam them.

GNSS jammers are not only used by adversarial state actors. Construction of GNSS jammers with off-the-shelf components only requires a basic knowledge of radio and electronics. Jammers are illegal to use in most jurisdictions, but the production and sale of these devices are not universally regulated. Portable vehicle and fixed installation 'chirp jammers' are small devices that can be plugged into a car cigarette power socket. These units, known as Personal Privacy Devices (PPD), can be purchased online from around US $10.00 an example of which is shown in Figure 1.[27]

27 DHgate 2024.

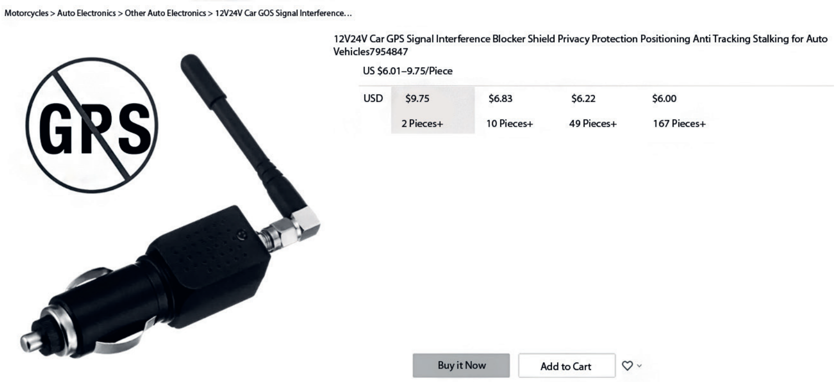

Figure 1
Low-cost in-vehicle GPS jammer
Source: DHgate 2024

A common use of PPD jammers is taxi and Heavy Goods Vehicle drivers evading rules on maximum driving hours, toll payments or trying to stop employers from tracking them. PPDs block GNSS and can cause inadvertent interference to other users when operating near sites such as airports or even fixed GNSS PNT users. The London Stock Exchange was affected by repeated GNSS outages caused by passing PPDs that impacted the timestamping of financial transactions.[28]

Jamming and spoofing represent the greatest immediate threat of all the risks that could compromise GNSS PNT. Unfriendly and friendly actors can affect GNSS PNT. The U.S. defence forces have been responsible for several compromised GPS events while developing countermeasures against jamming. In 2007, a U.S. Naval exercise testing GPS interference in San Diego harbour prevented residents from making ATM cash withdrawals, and doctors' emergency pagers stopped working – it took three days to identify their warships as the cause.[29]

28 Champion 2020.
29 Champion 2020.

Aviation Safety Reporting System (ASRS) data released by the FAA, revealed that hundreds of aircraft lost GPS reception near military tests in 2017 and 2018. One day in March 2018, Los Angeles Air Traffic Control (ATC) received as many as 21 reports from aircraft experiencing GPS navigation problems, with some pilots requesting help to re-establish their correct course. Figure 2 shows a six month extract of aircraft types affected in 2017.[30]

GNSS anomalies may impact some aircraft more than others because of the way complex automated flight control and navigation systems are integrated. In 2016, the FAA issued a Notice to Airman (NOTAM) warning pilots and operators of one of the best selling light jets, the Embraer EMB-505 Phenom 300, that in the event of GPS failure, the aircraft could enter a dangerous 'Dutch Roll' condition (unexpected rolling and yawing oscillations) at high airspeeds.[31]

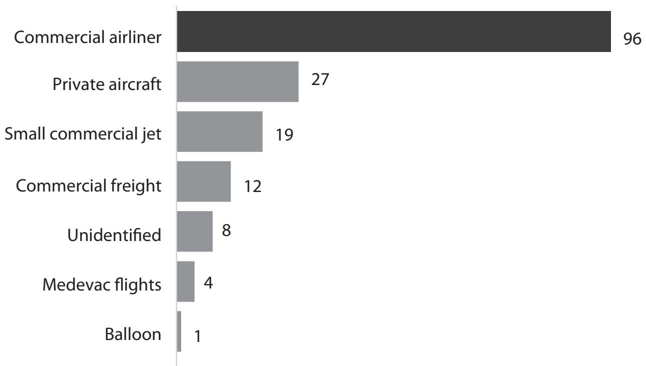

Figure 2
NASA ASRS GPS problems by Type of Aircraft Affected released by the FAA (February to July 2017)
Source: Harris 2021; FAA 2016

[30] Harris 2021.
[31] FAA 2016.

Since GNSS is so widespread, reliable and easy to use, an important human factor should also be considered. Aviators, mariners, motorists and hikers, to name just a few, may be more vulnerable to compromised GNSS if they lack basic traditional navigation proficiency. In 2019, a passenger airliner lost GPS near Salt Lake City. The pilot stated in his ASRS report: "To say that my raw data navigation skills were lacking is an understatement! I've never done it on the Airbus and can't remember having done it in 25 years or more."[32]

Automatic Dependent Surveillance Broadcast (ADS-B) is an unencrypted surveillance and tracking technology required by all aircraft operating in IFR. It provides position, velocity, heading and identification data to ATC and other ADS-B users to maintain safe separation. Position is mainly determined automatically by GNSS.

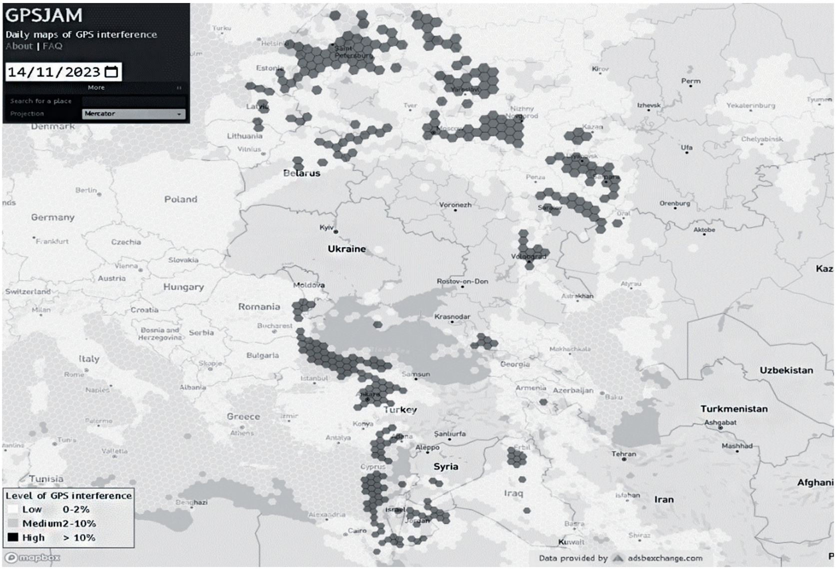

Figure 3
Screenshot with dark spots representing GPS interference >10%
Source: gpsjam.org

32 Harris 2021.

The screenshot from gpsjam.org in Figure 3 uses data provided by ADS-B Exchange to generate maps of likely GPS interference based on aircraft reports of reduced navigation system accuracy without specifying the type of navigation system. It could be caused by GPS, another GNSS like GLONASS, or an Inertial Navigation System (INS) issue. Most navigation accuracy degradation occurs in the Middle East, especially in the eastern Mediterranean. Jamming activity is often observed in Iraq, Lebanon, Cyprus, Turkey and Armenia. In North Africa, Libya is also affected. Suspected jamming activity in Europe has occasionally been detected in Poland, Romania, Lithuania, Latvia and Finland.[33]

Researchers analysed air traffic impacted by GPS interference over Eastern Europe between February and August 2022. On some days, this affected more than 1,000 flights or 60% of the daily traffic in the analysed area.[34] In February 2023, the European Union Aviation Safety Agency issued a Safety Information Bulletin warning pilots of degraded navigation or surveillance because of GNSS outages from jamming and possible spoofing.[35]

GNSS jamming is harmful, but spoofing is a far more insidious threat. According to David Last, former president of the U.K.'s Royal Institute of Navigation: "Jamming just causes the receiver to die, spoofing causes the receiver to lie."[36]

Malicious actors spoof or replicate satellite navigation signals by blocking the original transmission with a stronger, false, identical signal that the GNSS receivers then use. Meaconing is the most common form of spoofing attack, where GNSS signals are intercepted and rebroadcast on the same frequency, resulting in misleading location, velocity and heading.[37]

GNSS are essential enablers for today's shipping which heavily relies on integrated IT networks and Industrial Control Systems (ICS). Many merchant

33 Wiseman 2022.
34 Figuet et al. 2022.
35 EASA 2023.
36 Dawson 2018.
37 Lo 2019.

vessels' ICS will not even allow engines to start or leave port without receiving a valid GNSS signal.[38]

Malicious state and non-state actors could use GNSS spoofing to create ship-to-ship or ship-to-shore collisions, diversion into hostile territories for military gains or terrorism purposes or be used by pirates to intercept and divert ships into vulnerable areas.

A maritime transport industry source reported that the captain of a Post-Panamax[39] class container ship en route from Cyprus to Djibouti in February 2017 could not manoeuvre when "the IT system of the vessel was completely hacked". For 10 hours, pirates successfully remotely hacked the vessel's satellite navigation system to effectively control the throttle and steering to divert the vessel to an area where they planned to board and take over.[40]

Students demonstrated how easy it was to 'hijack' and reroute an $80 million superyacht 30 miles off the coast of Italy using a $1,000 device they built to spoof GPS signals, without triggering an alarm or alert. In March 2016, GPS jamming signals along the North Korean border affected over 1,000 aircraft and 700 ships for over a week.[41]

Since February 2016, nearly 10,000 suspected instances of GNSS spoofing have been identified, affecting more than 1,300 commercial vessels. The disruptions appear to have originated from ten or more locations in Russia and Russian-controlled areas in Crimea and Syria.[42] One of many examples of adversarial jamming occurred during the Ukraine war in October 2023. The Russians deployed their Pole-21 GNSS jammer (which also blocks GLONASS) to interfere with incoming drones and other precision-guided munitions. However, on this occasion, the Russian jammer became the target and was destroyed.[43] In October 2023, the U.S. Department of Transportation (DoT)

38 Akpan et al. 2022.

39 A merchant vessel with 8,250 Twenty-Foot Equivalent Unit (TEU) container capacity, ~366 m long and 49 m wide.

40 Blake 2017.

41 Akpan et al. 2022.

42 Center for Advanced Defense Studies 2019.

43 Axe 2023.

Maritime Administration issued a warning that "significant GPS interference has been reported worldwide" and that the unencrypted AIS can be spoofed.[44]

On 25 September 2023, twenty civil aircraft in northern Iraq experienced a GNSS spoofing attack, creating false track positions of around 60 nautical miles. A Boeing 777 airliner was so far off course that the crew asked Baghdad Air Traffic Control: "What time is it, and where are we?" Two days later, the FAA issued a NOTAM warning of potential spoofing activities in Iraq and Azerbaijan that could pose a safety of flight risk, leading to potential accidents or loss of life.[45]

According to reports from some of the affected pilots, the built-in safety systems, such as Receiver Autonomous Integrity Monitoring (RAIM), could not identify or discriminate between a legitimate and spoofed GNSS signal. Modern Flight Management Systems (FMS) use navigation inputs from Radionav and GNSS, with some also equipped with Inertial Measurement Units (IMU) or Inertial Navigation Systems (INS), which integrate an IMU with GNSS. Unless the flight crew is aware of a GNSS spoofing event and can disengage the GNSS inputs, the FMS will accept the invalid spoofed PNT data, affecting the entire system.

Space weather is a natural hazard that can affect GNSS. In 1859, a solar Coronal Mass Ejection (CME) caused the most intense geomagnetic storm facing Earth in recorded history. Known as the Carrington Event, it created havoc on telegraph communications networks worldwide in an era well before satellites and GNSS. The U.K. Government listed adverse space weather as one of the most serious natural hazards in its National Risk Register.[46] Apart from a Carrington scale CME, space weather is unlikely to cause satellite failure because of their robust, hardened design. However, GNSS errors can be caused by more frequent severe space weather events, which create scintillation in the ionosphere that adversely affects space-to-earth

44 MARAD 2023.
45 Zee 2023.
46 May et al. 2022.

signals. In December 2006, a major solar flare disrupted GPS and satellite communications for around 10 minutes.[47]

The impact of Geomagnetic superstorms can be severe, but these are rare events. On average, there is a ~4% chance of at least one great storm and a ~28% chance of at least one severe storm per year, while there is only a 0.7% chance of a Carrington class superstorm per year.[48]

Fifteen of the eighteen CNI sectors were found to be at risk of GNSS failure by the U.S. Department of Homeland Security. These included communications, emergency services, information technology, banking and finance, healthcare and public health, energy (electric, oil and gas), nuclear, dams, chemical, critical manufacturing, defence industrial base, postal and shipping, transportation, government facilities and commercial facilities.[49]

Inadvertent and hostile human activities can compromise GNSS PNT

The Kessler syndrome describes an uncontrolled growth of space debris (space junk) that could cause a catastrophic chain reaction of collisions with satellites and other space debris.

Space debris represents a relatively low direct threat risk to GNSS in MEO. However, the proliferation of space debris in other orbits may have indirect consequences for GNSS. In 2022, more satellites were launched than in any previous year, owing to the growth of megaconstellations[50] such as Starlink. In 2023, it was estimated that around 30,000 pieces of space debris greater than 10 cm remain in earth orbit from defunct satellites, launch vehicles, satellite collisions and other objects. Orbital debris has grown in number and total mass since the beginning of the space age, as shown in Figure 4.[51] Almost 70%

47 Malik 2022.
48 Chapman et al. 2020.
49 Hoptroff–Suarez 2023.
50 Constellations with hundreds or thousands of satellites.
51 Colvin et al. 2023.

of space debris is concentrated in Low Earth Orbit (LEO), with debris below 650 km naturally deorbiting within 25 years owing to atmospheric drag.[52]

Anti-satellite (ASAT) weapons, which can be launched from Earth or placed in orbit to destroy an adversary's spacecraft, may present a latent threat to GNSS. The USA, Russia, China and India have all developed and deployed these. In 2007, when China tested its ASAT capability in LEO, total space debris increased by 25%. In May 2013, China conducted another test that was suspected to be a kinetic kill vehicle that could potentially reach MEO and GEO orbits.[53]

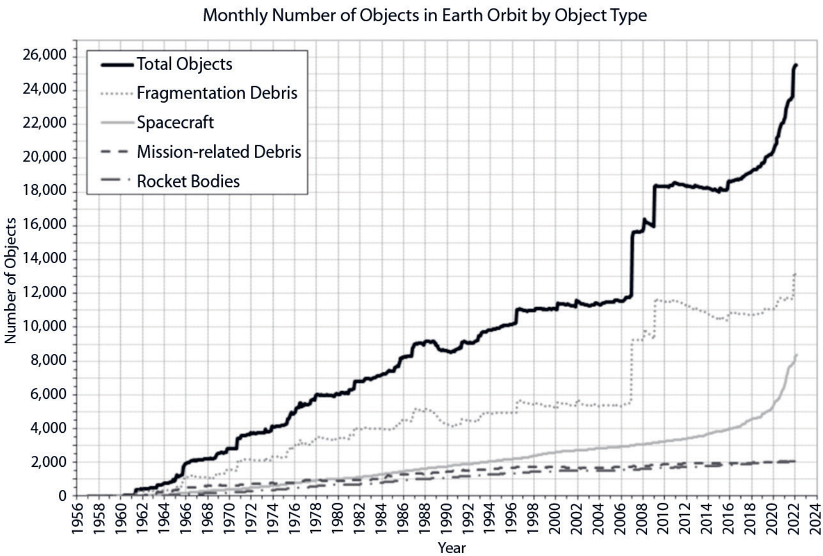

Figure 4
Chart showing the number of objects >10 cm in LEO
Source: NASA ODPO

[52] Colvin et al. 2023.
[53] Weeden 2014.

Because of the serious repercussions, a direct ASAT attack from a peer adversary is improbable. However, the deployment of space weapons such as these and other provocative actions in space (and on Earth, which are harder to attribute) highlights the impotence or absence of effective international space law. These 'Grey Zone' hostile activities which exploit legal ambiguities in treaties are known as 'Lawfare'.[54]

The direct threat to GNSS from space debris is relatively low because MEO orbits, where most GNSS operate, are relatively clear. However, concern over this risk may rise as more PNT initiatives and capabilities are planned to be delivered from LEO. Launch and replenish missions for GNSS in MEO may be at greater risk while transiting space debris in LEO. An April 2023 study by the University of Malaga concluded that the human use of space "will disappear for both commercial and scientific activities if the current rate of space debris generation continues".[55]

Space is becoming increasingly congested and contested

Existing and proposed megaconstellations, such as 'Starlink' with plans for 12,000 and 'Kuiper' with 4,236 satellites, will be dwarfed by China's 'G60 Starlink' with up to 12,000 and 'Guo Wang' with 12,992 satellites. The largest megaconstellation proposal comes from Rwanda, which filed its 337,320 satellite 'Cinnamon-937' programme with the International Telecommunications Union (ITU).[56] Up to 75,000 LEO satellites from 7 countries could operate between 328 and 2,000 km in the next ten years.[57] The scale of new LEO constellation growth can only increase the risk of collision with space debris, even if the estimated satellite population does not fully materialise. This should not present an immediate threat to MEO-based GNSS but may have implications for emerging LEO GNSS.

54 Erwin 2023.
55 Innovation News Network 2023.
56 Kuthunur 2023.
57 Hainaut 2020.

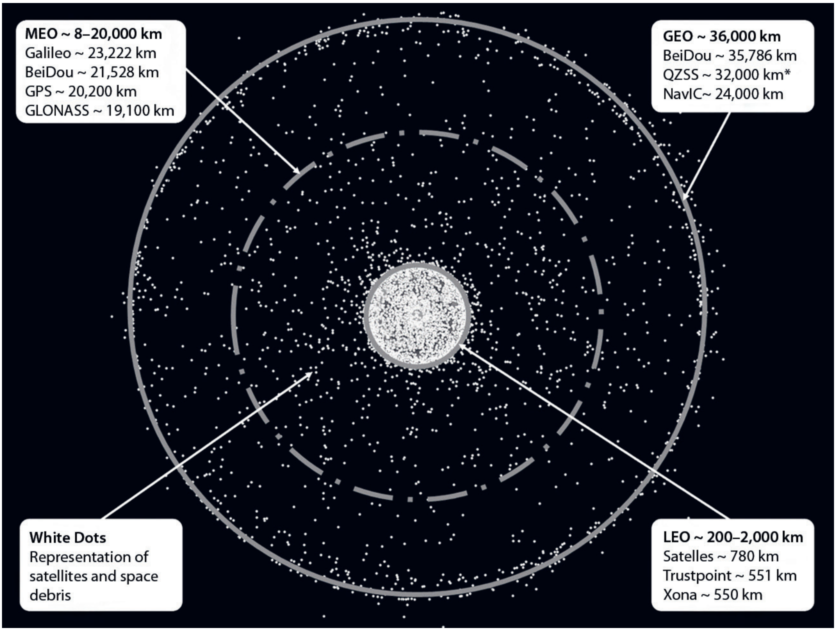

Figure 5
LEO, MEO and GEO orbits with Satellite and Space Debris field overlay (QZSS perigee)*
Source: Compiled by the author based on Debris-GEO1280 p.jpg and Comparison satellite navigation orbits.svg

The nominal altitudes of the LEO, MEO and GEO GNSS/RNSS orbits together with an overlay of current satellites and space debris fields are presented in Figure 5. The density of space debris is greatest in the LEO orbits where it exhibits the greatest risk to space operations, especially with the growth of emerging megaconstellations.

Radio Frequency Interference to GNSS can compromise PNT. GNSS operates in L-Band (1 to 2 GHz) because the propagation characteristics of these radio frequencies are ideal for all weather operations day and night as they can penetrate clouds, precipitation, fog and vegetation. The ITU has allocated separate L-Band frequencies between 1.1 GHz and 1.6 GHz for each of the 4 GNSS and 2 RNSS operators.[58] However, national administrations are responsible for the local licensing and permitted use of frequencies within the ITU global and regional allocations.

In 2020, the U.S. Federal Communications Commission (FCC) approved using a portion of L-Band to Ligado, a 5G cellular phone operator, provided they separated their transmissions from GPS systems.[59] However, the U.S. Department of Defense (DoD) commissioned a study which confirmed that Ligado's planned 5G deployment would interfere with DoD GPS receivers. The DoD report rejected the FCC's suggested mitigation and replacement plans as unfeasible, prohibitively expensive and possibly ineffectual.[60] The concerns raised by the DoD were also raised by the U.S. aviation industry, which determined that Adjacent Channel Interference from this 5G network could pose a safety risk to civil aviation.

Interference with radio navigation satellite services has become so widespread that the ITU published a warning in August 2022 stating: "Between 1 February 2021 and 31 January 2022, ITU received 329 reports of harmful interference or infringements of the Radio Regulations"[61] and tabled this item at the 2023 World Radiocommunication Conference.

Food security may be at risk from compromised PNT

A GEO Inmarsat communications satellite provides GNSS augmentation in the Asia-Pacific region, enabling two-centimetre guidance accuracy for self-driving agricultural machinery. In April 2023, a suspected fault in one of the satellite's solar arrays interrupted all services, including Precision Agriculture, dependent on this capability. Farmers across Australia and New Zealand reported that their farm machinery was down for three days during the peak

58 ITU 2020.
59 Pelkey 2020.
60 U.S. DoD 2022.
61 ITU 2022.

of the sowing season. One farmer said “the outage had taken his operation back about 25 years”. Another farmer with 1,700 hectares complained that a lot of boom sprays were out of operation, stating: “I haven’t been in a tractor without auto-steer for 15 years.” He was forced to use a backup free-to-air GPS that was much less accurate.[62]

Failures of this nature are quite rare, but events such as this, affecting a broad user community including aviators, mariners and farmers, illustrates how space assets and orbital altitudes outside of GNSS MEO can have an impact on PNT when compromised.

Systemic and human factors can compromise PNT

All GNSS have experienced failures. At 23:26 UTC on 25 January 2016, a 13.7 microsecond error occurred during a data upload while retiring a single GPS satellite. This resulted in incorrect timing data being transmitted throughout the global constellation. The data error impacted telecommunications networks in the U.K., triggering hundreds of alarms while Digital Audio Broadcast radio services were disrupted. At the same time, public safety communications in the USA and digital TV services in Spain were also affected. The timing error, which also affected other GPS-dependent systems and services such as ATMs, continued for over half a day until the anomaly was corrected at 13:11 UTC on 26 January.[63]

Although this specific fault only affected timing and did not disrupt positioning and navigation, a small but very important community of users worldwide were severely impacted by the timing fault. The severity of the impact was related to the specific design and implementation of the user’s PNT equipment and data processing systems.

[62] Claughton–Conn 2023.
[63] Kovach et al. 2016.

The Russian GLONASS and the Chinese BeiDou systems have also experienced various technical issues. However, none of these events can be compared to the weeklong outage of Galileo from 10 to 17 July 2019. The outage was caused by a ground infrastructure issue during an essential upgrade of the Galileo control centre, not by the Galileo satellites. The impact of this outage could have been far more severe if the 100 million plus Galileo receivers could not automatically switch to GPS as backup.[64] Because of this failover capability, most casual users would have been unaware of this extended Galileo system failure.

Outages from most of these causes are quite rare, and several interventions have been applied. However, this will not eliminate other systemic risks that could also compromise PNT.

The cost and impact of compromised GNSS PNT

The financial benefits to the U.K. from using GNSS have been monetised at £13.6 billion per annum. The economic loss due to a seven-day GNSS outage has been estimated at £7.6 billion.[65] A loss of GPS in the U.S. was estimated to have a $1 billion per day impact, which could be 50% higher if this were to occur during the April and May planting season, owing to the widespread adoption of GPS-dependent Precision Agriculture.[66] Between 1999 and 2027, GNSS was estimated to contribute around €2 trillion in economic benefits and 100,000 highly skilled jobs in the EU.[67]

Not all analysts agree that the risks and impact of compromised PNT justify large investments in backup GNSS. The U.S. think tank, the RAND

64 Todd 2019.
65 Flytkjær et al. 2023.
66 O'Connor et al. 2019.
67 Bonenberg et al. 2023.

Corporation, issued a report in May 2021 entitled "Analyzing a More Resilient National Positioning, Navigation, and Timing Capability", which asserted that "the risks of potential attacks or other failures of such systems may be exaggerated, and even impossible in some instances".[68]

Most of the risks and some of the alternative PNT solutions to GPS cited in the RAND report are valid and aligned with many of those identified in this analysis. However, it is difficult to give unqualified acceptance to their conclusions given the extent of natural and growing human threats that could compromise GNSS PNT, some of which cannot be easily mitigated. Some of the conclusions in the RAND report have also been challenged by several industry specialists, including Dana Goward, President of the Resilient Navigation and Timing Foundation and Dr Patrick Diamond, member of the (U.S.) President's National Space-based PNT Advisory Board.[69] The basic premise of the RAND report was a cost–benefit assessment of a duplicate backup GPS system. Perhaps the report should have placed greater emphasis on wider alternative solutions to ensure PNT is not compromised.

It is difficult to compile an accurate comparative threat probability vs. impact assessment of the seven main threats to GNSS PNT as there is little data available with a common baseline. Furthermore, the scale of impact can be measured in many ways such as geographically, temporarily, safety of life, economic or social. However, a coarse qualitative assessment of the relative probability and impact of seven major natural and human threats to GNSS PNT is proposed in Figure 6.

Even if a precise assessment of specific threats to PNT could be convincingly accomplished, it is unlikely that such findings would alter the conclusion. The significant impact of denied access to accurate PNT is so great that adequate technical and financial investments in mitigation would be justifiable.

68 Mason et al. 2021.
69 Goward 2021.

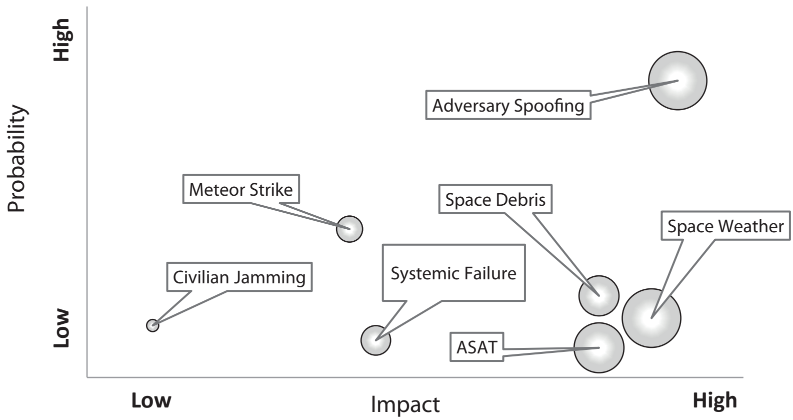

Figure 6
Threat probability vs. impact and scale (coarse qualitative assessment)
Source: Compiled by the author.

RESILIENT PNT INITIATIVES

The U.S. DoD recognises the importance of resilient PNT capability with the rollout of up to 32 upgraded next generation GPS III/IIIF satellites. These new satellites are three times more accurate, with an eight-fold improvement in anti-jamming capabilities, as well as greater compatibility and connectivity with other GNSS, such as Galileo.[70] The U.S. is not alone in undertaking initiatives to address space and Earth threats to minimise the risk of compromised PNT.

Redundancy and diversity in the space segment already exists. Over 100 GNSS satellites are in orbit within the four constellations operated by the U.S., Europe, Russia and China.[71] Access to such a large population of GNSS satellites also improves accuracy and coverage. Together with the two RNSS constellations from India and Japan, the impact of a system outage, like the

[70] Lockheed Martin 2023.
[71] GNSS from Russia and China may not be appropriate for all users.

January 2016 GPS or July 2019 Galileo events, is less likely to be as great, provided that user terminals can safely operate across all these systems.

Although MEO is used by the four existing GNSS, LEO is about to play a bigger role in contributing to PNT. Startups, such as Xona, Trustpoint, Satelles and Future Navigation Technology, are proposing PNT augmentation solutions that can offer up to 10 times the accuracy of GPS using LEO satellites with increased signal strength, enhanced security and worldwide coverage.[72]

Successful PNT trials with Starlink as a Signal of Opportunity (SoP) have led to the company filing with the U.S. Patent and Trademark Office in December 2022 for "electronic global positioning and geo-locations systems".[73]

Researchers have developed an algorithm that can use a SoP from almost any satellite to locate any point on Earth with an accuracy of up to 5.8 metres for a stationary receiver.[74] Other LEO PNT solutions use the global Iridium constellation, which operates within the same L-Band as GNSS but on different frequencies. While it delivers a stronger signal than MEO GNSS, it does so with lower position and timing accuracy. Using SoP from non GNSS constellations such as Iridium has been examined to include other megaconstellations such as Starlink, OneWeb and Kuiper. Further research is needed, but these opportunities would require significant investment in user terminals and may not be universally accepted.

A LEO GNSS constellation from Xona Space Systems will consist of around 300 CubeSats,[75] which will provide sub-10 cm accuracy anywhere on Earth, independently[76] or to enhance legacy GNSS.[77] Geespace, a privately owned Chinese subsidiary of Geely, is rolling out a constellation of 240 LEO PNT satellites, with the first phase of 72 to be in orbit by 2025 to support their future

72 Bonenberg et al. 2023.
73 Dennehy 2022.
74 Woodall 2023.
75 Miniaturised satellites less than 2 kg with a standardised form factor in multiples of 1 or more 10 cm^3 units.
76 With degraded performance in the absence of GNSS or ground sourced clock disciplining.
77 Luccio 2023.

self-driving cars.[78] Another Chinese LEO constellation from Future Navigation (CentiSpace/Xiangrikui) has launched 6 out of a planned constellation of 120 PNT microsatellites to provide GNSS augmentation using laser Inter Satellite Links.[79] A conceptual design has been developed by the Iranian Ministry of Science Research and Technology to provide regional PNT using Commercial Off the Shelf LEO CubeSats.[80]

In urban environments where GNSS is challenged or denied, it may be possible to obtain PNT using non-satellite SoP from diverse terrestrial radio frequency sources such as digital radio, TV, broadcast AM/FM and cellular radio signals, but only using special receivers.[81] An example of such a novel solution is the StarNav Multi-Frequency Positioning and Timing Receiver. This is an aided inertial navigation system powered by one or more SoP such as cellular, television, Globalstar, Iridium, GPS or Xona Pulsar.

The benefits of diversity in space using multiple constellations, including SoP or LEO, can only be realised if the GNSS receivers are capable of using them. This may require substantial investment and re-fit across all sectors globally, considering that the number of installed GNSS devices are projected to grow from 5.6 billion in 2023 to almost 9.0 billion in 2033.[82] However, solutions that can employ legacy hardware with firmware upgrades or minimal integration could streamline adoption.

Augmentation systems improve the accuracy, availability and integrity of GNSS PNT. Satellite Based Augmentation Systems (SBAS) provide PNT augmentation using GEO satellites to monitor signals received from GNSS at accurately surveyed sites to compare any error between the actual position and GNSS fix. These errors are uplinked to GEO satellites, which then broadcast any identified errors that are corrected by special user terminals. SBAS does not provide independent PNT; it only augments existing GNSS over a specified

78 Geely 2022.
79 Kulu 2023.
80 Naseh et al. 2021.
81 Kassas 2021.
82 EUSPA 2024.

wide area. Four major SBAS systems are in place, including the European Geostationary Navigation Overlay Service, U.S. Wide Area Augmentation System, Japanese Multi-functional Satellite Augmentation System and the Indian GPS Aided Geo Augmented Navigation system.[83] The joint Australian and New Zealand Southern Positioning Augmentation Network uses Inmarsat GEO communications satellites to deliver SBAS accuracy down to 10 centimetres.[84]

GBAS delivers high accuracy and integrity navigation for aircraft, making precision approaches to airports using GPS as an alternative to ILS. GBAS broadcast integrity values via VHF data link to the aircraft ILS style avionics to achieve protection levels of an actual vertical (4 m) or lateral (16 m) error being less than 1 in 10 million.[85]

Another integrity architecture employed in aviation is the Aircraft Based Augmentation System (ABAS), which focuses on integrity rather than accuracy. ABAS is achieved with two techniques: Receiver Autonomous Integrity Monitoring (RAIM), which only uses GPS for inputs and Airborne Autonomous Integrity Monitoring (AAIM), which uses GPS and other on-board sensors.[86] Whereas RAIM only provides horizontal integrity. Advanced RAIM uses GPS and Galileo to increase the diversity and integrity of signals, especially ionospheric errors, to deliver 3D positions with improved integrity.[87]

All these systems greatly enhance integrity but are not invincible to malicious or inadvertent jamming.

Technical, voluntary and regulatory initiatives to mitigate the risk of space debris

Re-usable launch vehicles such as SpaceX, Blue Origin, United Launch Alliance and Rocket Lab may partially help alleviate the amount of space debris

83 Grunwald 2023.
84 Geoscience Australia 2023.
85 FAA 2023.
86 ESA 2014.
87 Cozzens 2022.

compared to conventional launchers. Voluntary guidelines have been proposed by the Space Safety Coalition, which recommends the responsible design, management and disposal of space assets.[88] Regulators and space agencies are also taking action. The European Space Agency (ESA) introduced the Zero Debris Charter on 16 October 2023, intending to reduce debris in Earth and Lunar orbits by 2030.[89] The U.S. FCC has gone one step further in October 2023 by imposing a fine of $150,000 to DISH, the operator of EchoStar-7, for failing to properly deorbit this satellite, which ran out of fuel and remains in orbit 178 km above the Earth.[90]

Several space debris removal methods are being proposed and developed that range from ground and space based lasers to 'nudge' small debris (1–10 cm) into re-entry, through to physical sweeping, collection or recycling of larger objects (>= 10 cm).[91]

Alternative capabilities that can deliver PNT

The European Commission Joint Research Centre initiated a project to analyse technologies that could deliver Alternative PNT independently from GNSS. The U.S. DOT commissioned an assessment of seven different Alternative PNT systems in May 2020. These include PNT systems based on networks of sparse radio beacons, a LEO satellite constellation providing a timing service on the ground, eLORAN, fibre optic networks with time and frequency transfer and navigation using map matching.[92] The U.K. Government announced its '10 Point Policy Framework for Greater PNT Resilience' in October 2023. This includes setting up bodies and assessing alternative space and terrestrial based

88 SSC 2023.
89 ESA 2023c.
90 Wiquist 2023.
91 Iyer 2023.
92 Bonenberg et al. 2023.

PNT capabilities, including U.K. SBAS, eLORAN, U.K. Quantum Navigator and a possible U.K. sovereign regional satellite system.[93]

eLORAN offers many advantages over GNSS as its LF signal is three to five million times stronger with 99.999% reliability and availability. It can be used within buildings, in tunnels, underground and underwater. By applying encryption and authentication, it could provide spoof-resistant PNT throughout the U.S. using only six towers for timing and 19 for position and navigation.[94]

Improvements in GNSS receivers, antennas and cybersecurity measures can contribute to a non-compromised PNT capability. Historically, shipboard systems were not designed to deal with cybersecurity threats. AIS does not employ authentication or integrity checks. Electronic Chart Display and Information Systems use input from multiple unsecured sensors. ICS relies on complex legacy systems, with some IT networks configured for third party remote access that are not effectively isolated from steering and navigation systems. Recognising these and other vulnerabilities, the International Maritime Organization mandated cybersecurity countermeasures to be employed from January 2021.

Galileo was the first satellite system to employ Open Service Navigation Message Authentication as an anti-spoofing method by authenticating the consistency of data signals from multiple satellites.[95]

Aircraft operations are particularly susceptible to jamming and spoofing of GNSS PNT, even where GBAS is employed, because of the omnidirectional characteristics of most GNSS antennas. As a countermeasure, special anti-jamming antennas using sophisticated algorithms to identify any anomalies, block false signals that come from near the horizon while only accepting valid signals coming directly from above.[96]

93 Freeman 2023.
94 Shepard 2020.
95 ESA 2021b.
96 Handrigan 2022.

Use of non-GNSS PNT sources independently or integrated with GNSS

Before GNSS, Inertial Navigation Systems (INS) provided aviators and mariners with an accurate Attitude and Heading Reference System source. Historically, these systems were large, expensive and power-hungry. Modern INS uses IMUs that typically contain a three-axis gyroscope, accelerometer and sometimes a magnetometer to measure angular rate and acceleration but do not retain the same level of accuracy over time as GNSS. Compact 'postage stamp size' INS are now available in low-Cost Size, Weight and Power (C-SWaP) form factors, with some units integrating GNSS modules as little as 11 cm^3, 16 grams with less than 500 mW power consumption.[97] Future INS could employ Atomic Interferometer Gyroscopes that use tiny gyroscopes and atom interferometry techniques with lasers to derive accurate positioning. These devices could operate independently of GNSS and compete with current ring laser gyroscopes, fibre optic gyroscopes and hemispherical resonator gyroscopes.[98]

For time-sensitive systems or applications that cannot withstand long 'holdovers' (loss of synchronisation with other devices or systems), there is a need to provide accurate timing backup in the event of GNSS failure or when operating in natural or urban canyons. Low C-SWaP atomic clocks such as Microchip's CSAC-SA65 or Orolia's MRO-50 employ a miniaturised rubidium oscillator offering superior timing oscillator holdover of anywhere between 11 and 29 hours compared to crystal oscillators that only provide holdovers of 9 minutes to just over an hour.[99] However, these devices can only provide short-term continuity of service by extending holdover until GNSS PNT is restored. In the next five to ten years, miniaturised quantum clocks may offer a more resilient and superior timing capability accurate to the picosecond compared to around 30 nanoseconds for GPS.[100]

97 Vectornav 2021.
98 Shepard 2020.
99 Garigen et al. 2021.
100 Freedberg 2023.

Non-terrestrial platforms that could support PNT

Very Low Earth Orbit (VLEO) between 100–450 km (nominally 250–350 km) has the advantage of low launch costs at an orbital altitude relatively safe from space debris. However, this would be at the cost of reduced orbital lifetime and the need for larger constellations to provide adequate coverage. ITU regulations place constraints on power levels if operating in the same GNSS L-Band. High Altitude Long Endurance or High Altitude Platforms may potentially be employed for local PNT augmentation or emergency restoration, which could be done relatively quickly at a significantly lower cost than space-based vehicles. However, these systems would need access to a Stratum-0 reference[101] to maintain timing accuracy, typically from existing GNSS, so they would potentially only offer augmentation, not substitution.

Space weather, debris or meteor impact mitigation

The main mitigation for space weather risks includes shielding, component tolerances and design redundancy within the space vehicle. Some constellations include 'hot standby satellites'[102] in orbit or on the ground. Less common are evasive manoeuvres for kinetic impact threats by temporarily aligning the satellite to expose the smallest area to known meteor showers or debris.[103] Should a Kessler syndrome event ever occur, this would almost certainly end all space operations at the affected orbital altitude.

Satellites in MEO orbit are exposed to ten times the radiation of LEO,[104] so they are designed and shielded to survive in that environment. The U.S. GPS satellites are further hardened against High Altitude Nuclear Explosion

[101] A high-precision timing reference such as atomic clocks.
[102] A redundant satellite, not in service, that can be quickly enabled to replace a failed or retired satellite.
[103] This would require unplanned delta-v thrust consuming station-keeping fuel reducing the satellite lifespan.
[104] Tsuiki et al. 2014.

radiation. Although the probability of a severe Carrington-like event is extremely low, with a once in 500-year likelihood,[105] shielding and system redundancy are unlikely to provide sufficient protection.

Space debris and space weather represent the lowest relative risks to GNSS PNT compared to jamming and spoofing. However, all space-based assets are exposed to multiple sources of risk, some of which cannot be entirely eliminated.

Human factors that should be considered in a compromised PNT event

Navigation and timing requirements were satisfied without GNSS prior to the launch of GPS in 1978. Aviators, sailors and other travellers should retain sufficient skills and recency of experience with basic navigation principles to maintain their situational and spatial awareness in the event of GNSS loss.

According to a psychologist at Temple University specialising in spatial cognition: "GPS devices cause our navigational skills to atrophy, and there's increasing evidence for it."[106] Student pilots and sailors use traditional paper charts and methods for ab initio training before transitioning onto sophisticated electronic navigation. Regulatory bodies and training organisations should retain these fundamental skills in the curriculum. Not only to provide a solid foundation but as a final fallback in the event of total GNSS loss, provided they maintain proficiency and recency!

Other initiatives to mitigate against compromised PNT

ESA has acquired several patents that could enhance or avert compromised PNT. These patents cover hardware, software, machine learning, data analysis solutions and real-time analysis to detect jamming and spoofing.[107] System design should consider the natural and human threats to GNSS PNT to

[105] May–Dobrijevic 2022.
[106] Stromberg 2015.
[107] ESA s. a.

ensure greater resilience. For example, infrastructure reliant on GNSS to function, such as radio communications networks, Digital Audio Broadcast radio and some digital TV services, should consider alternative architecture or ground-based stable timing sources to increase holdover times in the event of GNSS interruption.

Blended technologies incorporating GNSS with INS and potentially radio-based PNT could provide enhanced assurance for transport and mobile users. Network-based timing and low C-SWaP atomic clocks, as well as radio timing signals could provide primary, holdover or augmented timing references for some use cases.

Each of these initiatives will require various levels of technical development and financial investment. Most of these are either mature and well-established, such as multi-constellation receivers which are common in most smartphones, or are progressively being implemented such as LEO Augmentation. As there is a very broad range of platforms, use cases, environments and user terminals, it is not possible to accurately assess the cost vs. complexity of PNT capability improvements or assurance initiatives on a global scale. Notwithstanding this challenge, Figure 7 offers a coarse attempt to qualitatively estimate the relative cost vs. complexity and scale of a sample of seven of the many initiatives that could be employed to enhance the resilience and performance of PNT. Some of these initiatives can or have been combined.

Eliminating a single point of failure is one of the best ways to achieve capability resilience and assurance. Industry and governments are now recognising the extent and potential impact of threats to GNSS. An October 2023 report from the Royal Institute of Navigation recognises society's over-reliance on the GNSS PNT 'fifth utility', especially for CNI, recommending multiple alternative technologies to maintain the capability.[108]

[108] Pottle et al. 2023.

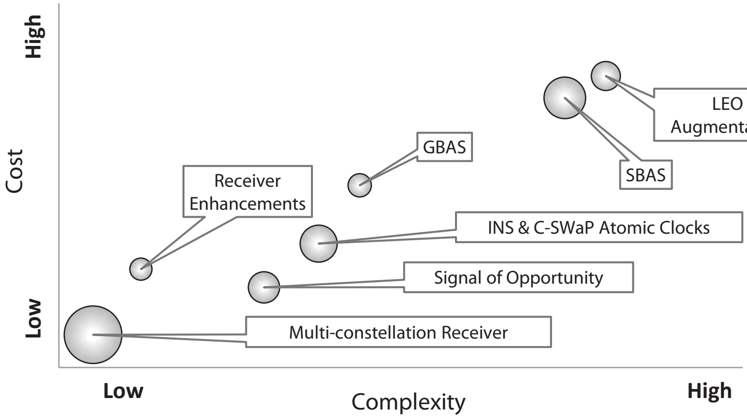

Figure 7
Initiative cost vs. complexity and scale (coarse qualitative assessment)
Source: Compiled by the author.

PNT IMPORTANCE AND CONCLUSIONS

There is little doubt that the world heavily depends on the accuracy, stability, integrity, continuity and availability of PNT. GNSS, pioneered by the U.S. GPS, has expanded the range of applications well beyond its original military function. Transportation in all three domains represents only a fraction of the use cases for PNT. This hidden utility supports communications, financial systems, agriculture, public utilities and emergency services in ways that most citizens are unaware of – that is, until PNT is compromised.

The global availability and relatively low cost of delivery and maintenance of GNSS PNT have replaced traditional radio-based systems used by aviators and mariners. GNSS PNT is a key enabler for drones, supports autonomous vehicles and revolutionises the Precision Agriculture industry. The European Union and several nations have invested in their own GNSS to deliver or augment PNT.

However, this invisible utility is fragile and vulnerable to natural and human threats, some of which cannot be mitigated. The most severe natural threats are space weather and impacts from meteors, which are reassuringly rare. The human threats in space from ASATs and space debris remain a concern.

However, the more significant human threat comes from hostile actors on Earth, with attacks growing in scope and scale that are having a measurable impact on transportation networks and other PNT users. Threats from less belligerent sources are difficult to manage owing to their localised nature and the ease with which they can be deployed at very low cost.

The significant adverse impact of compromised PNT has been evaluated in financial terms for some major economies. Although a cost–benefit assessment does not support GPS replication, the impact of unexpected PNT interruptions may be greater for some users, especially when alternative PNT fallback options cannot be easily, quickly, or economically implemented.

Nations and industries have developed countermeasures to mitigate against many of these threats. Further research and development is underway to expand the capability with ESA encouraging innovation through access to their Intellectual Property Rights.

There may be a role for terrestrial solutions such as eLORAN to provide a resilient fallback or adjunct to GNSS PNT, as would low C-SWaP INS and atomic clocks. Potentially, other platforms, such as High Altitude Long Endurance and High Altitude Platforms, may be able to deliver augmentation or restoration of GNSS, along with LEO and VLEO satellites.

The greatest challenge to mitigating compromised GNSS PNT will not be technological; it will be attitudinal. Society, government, industry and individuals often tend to accept the higher consequential costs of remediation rather than make prudent investments in prevention or mitigation.

As with all complex, high-value interventions required to address known risks, one must assess the probability of the risk occurring versus the societal and economic impact. Political imperatives make it difficult for governments to make hard choices on long-term, capital-intensive projects that reinforce or remediate an essential but invisible part of critical national infrastructure.

Some industry sectors or corporations may be reluctant to make large investments to "fix what ain't broke", that is, until it does break.

The G in GNSS highlights the importance of global cooperation, as very few nations will escape the adverse impacts of a compromised GNSS PNT, even with independent sovereign solutions. International maritime and air transport, as well as financial services, need access to globally available, reliable and accurate PNT.

GNSS PNT is probably used and relied upon by more people, directly or indirectly, than any other satellite service in the world.

Many of us have been lulled into a false sense of security or allowed our basic navigation skills to become less proficient, further exposing our vulnerability to compromised PNT. Greater awareness of the risks and impacts may help governments, society and industry recognise that further investment, development and implementation of alternative and backup PNT solutions should remain on the agenda. GNSS PNT is not only an invisible 'fifth utility'; it is an indispensable utility that must be protected.

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András Edl

Supply Chains and Space Capabilities in the New Space Age

Introduction

The globalisation of value chains has had a significant impact on the U.S. and EU economies and, as a consequence, on their defence and space capabilities. From the point of view of supply chains and production capacities, the military and civil space sectors are tightly interconnected and will become even more so in the future. Recent years have witnessed increasing instances of supply chain disturbances which have directly or indirectly affected the space sector, highlighting its vulnerability. This chapter will examine the interconnectedness between geopolitics, supply chains, raw materials and space activity. Limiting the analysis to the space supply chain would only provide a limited understanding of the challenges the sector faces today or might face in the future which could hold it back from reaching its full potential.

The Growth of the Space Sector

One of the most well-known and often repeated facts about New Space is that the sector is growing rapidly and opening many new opportunities to participants. A key measurement of this growth is the increasing revenue generated by the market and its future prospects seem to be very promising, which is a strong incentive to invest in the sector. However, the amount of actual revenue generated by the industry is not easy to identify, and the sources of it vary greatly. The numbers for 2023 are not available yet, but there are considerable

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deviations even in the 2022 figures. The Space Foundation reported a revenue of USD 546 billion,[1] while Euroconsult gave a figure of USD 464 billion[2] and the Satellite Industry Association (SIA) estimated it at USD 384 billion.[3]

The differences can be often attributed to different calculating methods, simply due to the fact that it is not always easy to decide what constitutes revenue generated by space. How much of a delivery company's profit can be attributed to the GPS they use? What about a company providing data about agriculture which uses Earth observation satellites among many other sources of information? There is no consensus about what should be included and to what degree when calculating the value of the industry. The OECD is aware that there is a wide disparity between the numbers and suggests a range rather than attempting to name a single figure, stating that space revenue excluding government spending is between USD 200–350 billion.[4] At the same time,

Table 1
Change in the value of the space economy in billion USD from 2019 to 2022 based on SIA data

	2019	2022	Difference	Growth in %
Global Space Economy	366.0	384.0	18.0	4.91%
Government Spending	95.0	103.0	8.0	8.42%
Satellite Industry	271.0	281.0	10.0	3.69%
Satellite Service	123.0	113.0	**−10.0**	**−8.13%**
Ground Equipment	130.3	145.0	14.7	11.28%
Satellite Manufacturing	12.5	15.8	3.3	26.40%
Share of the U.S.	*7.8*	*10.2*	*2.4*	*30.76%*
Launch Industry	4.9	7.0	2.1	42.85%
Share of the U.S.	*1.7*	*3.9*	*2.2*	*129.41%*

Source: Compiled by the author.

1 Space Foundation 2023.
2 Euroconsult 2023a.
3 Satellite Industry Association 2023.
4 OECD 2023.

the OECD also encourages discussion about the proper methodology for estimating these amounts and has published material about the topic.[5]

Even if we take the most conservative estimates, the growth figures are impressive.

Based on the SIA's dataset the sector's total revenue in 2019 was around USD 366 billion. Of this, USD 271 billion was from the satellite market. In that subsector, USD 123 billion is derived from services provided by satellites, telecommunications, satellite detection, etc. USD 130.3 billion is the value of the terrestrial infrastructure and the launch industry reported a profit of USD 5 billion.[6] In comparison, by 2022, so after only three years, there had been substantial growth in nearly all aspects.[7] The value of ground equipment, satellite manufacturing and the launch industry as a percentage grew by double digits. The performance of the U.S. exceeded the world average, especially in the launch industry sector, while non-U.S. commercial launches even decreased by USD 0.1 billion. This growth is largely due to SpaceX. In 2019 the company only performed 13 launches, while the world total was 102. 78 of these were commercially procured launches. In 2022 the company carried out 61 launches from a total of 186 global launches, of which 161 were commercially procured. The company shows no signs of slowing down, and in 2023 they completed 96 launches.[8]

Government spending is estimated by the three sources in a range between USD 103 and 119 billion. While the SIA does not provide data on it, the U.S. governmental space budget is between USD 69.5 and 73.2 billion according to the Space Foundation and Euroconsult. There are even fewer sources for Russian and Chinese spending due to a lack of data and the rather opaque relations between civil and military entities. Euroconsult estimated the Chinese budget at USD 14.15 billion while the Russian budget was at USD 3.4 billion. Euroconsult

5 OECD 2022.
6 Satellite Industry Association 2019.
7 Satellite Industry Association 2023.
8 SpaceX 2024.

also highlighted a significant change compared to previous years, as for the first time space defence spending surpassed the budget for civil programmes, at USD 59 billion.[9]

Not surprisingly, the predictions about how much the industry will grow also vary. Jules Varma of the ESA compared a few predictions. For entities which did not give such estimates, he extrapolated their figures and used their calculating methods to illustrate how they would evaluate the space sector's performance in 2040. The Union Bank of Switzerland estimates this 2040 value at USD 926 billion, Morgan Stanley puts it at USD 1.1 trillion, the U.S. Chamber of Commerce gave a figure of USD 1.5 billion, Goldman Sachs goes for the multi-trillion range, while the SIA's projected value calculated by Varma would be USD 580 billion.[10] The origin of most of these predictions can be traced back to a 2017 study by Morgan Stanley. Nevertheless, estimates all agree that there will be considerable growth and suggest that the value of the sector could double by 2040. Calculating the often mentioned high economic multiplier effect also poses various challenges. This number is supposed to show how much the total economic output increased after every dollar invested in the space sector. There is agreement among experts that even for less advanced economies, space investment can be beneficial and have a positive multiplier effect. However, the actual figure depends on the calculation methods employed (e.g. based on income, expenditure and production method), which will have different effects in various sectors, and it is dependent on the development level of a given economy. The analysis of calculating methods and their results is not the subject of this paper but the most frequent numbers are from 5 to 9 for countries with highly developed space sectors. For countries in the early stages of space development, the multiplier could be from 1.5 to 5 in this field.[11]

Another indicator that is widely used to demonstrate the rapid expansion of the space economy is the number of satellites in space. Back in 2020, more conservative assessments assumed that the number of satellites would reach

9 Euroconsult 2023b.

10 Varma 2023.

11 Barjak et al. 2015.

10,000 by 2029, with the most optimistic estimate being close to 100,000.[12] The Union of Concerned Scientists (UCS) maintains a database about the number of satellites and usually updates its figures three times a year. On 1 April 2020, there were 2,666 satellites in space. On 31 July 2020, the UCS reported 2,787 satellites orbiting the Earth, of which 1,425 are owned by the United States or U.S. companies.[13] The majority of these satellites, around 2,032, were in Low Earth Orbit (LEO). The same database gave a figure of 7,560 satellites by 1 May 2023, among which 5,184 were U.S. satellites.[14] By 11 February 2024, this number had reached 9,359. This rise in numbers is undoubtedly impressive. However, the context is important. The building of megaconstellations has had a significant impact on these statistics. 5,236 of the satellites were active Starlink satellites. OneWeb had an additional 632 active assets in LEO.[15] Based on this, unless there are significant developments, we can assume that the number of active satellites will exceed 10,000 in 2024. The amount of space debris is just as significant. According to the ESA's calculations, in December 2023 there were 36,500 pieces of space debris larger than 10 cm, 1,000,000 debris objects between 1 cm and 10 cm and approximately 130 million pieces from 1 mm to 1 cm.[16]

MINERALS FOR THE SPACE SECTOR

In order to realise the full potential of the industry and to accomplish the goals of crucial scientific and defence projects, the space sector needs an industrial base. The supply chains of the space industry have many sector-specific attributes. The uses of rare earth elements show how much the space industry can be affected. As Bleddyn E. Bowen puts it, the value chains for the space

[12] Satellite Industry Association 2020.
[13] Datta 2020.
[14] Union of Concerned Scientists 2023.
[15] Orbiting Now 2024.
[16] European Space Agency 2023.

industry extend across nations, continents and oceans. Maintaining a space industry supply chain (or rather a network) consisting only of companies in one specific country would be very costly or often impossible. The solution is to rely on foreign countries and companies, but if external actors are used, there is a risk that they will not provide capacities according to the needs of the country concerned.[17]

Moreover, the sector requires numerous high-technology and high-quality components which are able to withstand the harsh environment of space or another celestial body. For example, Intelsat's Galaxy 30 (G-30) communication satellite is made up of several hundreds of units which are themselves made of several hundreds of components in total having more than a hundred thousand components.[18] The satellite weighs 3,298 kg and uses a GEOStar-2 Bus as the basis for its specific configuration. This design was originally built by Orbital ATK and the fact sheet provided states that the 800–1,500 kg dry mass bus, with a payload capacity of 500 kg usually takes 2 years to manufacture.[19] The company was acquired by Northrop Grumman in 2018 and renamed Northrop Grumman Innovation Systems. This firm also delivers the more advanced GEOStar-3 design with a 1,000 kg payload mass capacity, which is also supposed to be delivered 24 months after the order was placed.[20]

To manufacture all the necessary components at the first level of the supply chain, raw materials are needed, and without these no production is possible. To model the concept of the supply chain and the role of each step depending on the approach some classifications have divided the chain into upstream, midstream and downstream levels. Other models only distinguish between upstream and downstream. The mining of raw materials is usually at the beginning of each supply chain or it is among the first levels of the upstream category. The following diagram presents a more detailed model of the mineral value chain.

17 Bowen 2020: 139–148.
18 Intelsat 2021.
19 Orbital ATK 2017.
20 Northrop Grumman 2024.

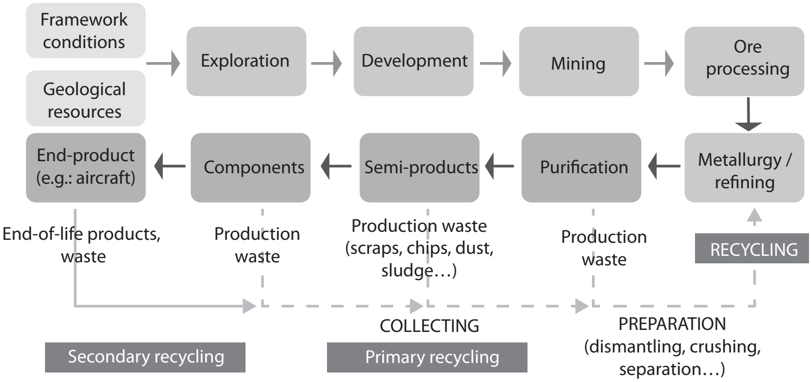

Figure 1
Schematic representation of a minerals or metal-dependent value chain
Source: Ayuk et al. 2020

Depending on the supply chain model, ore processing, metallurgy/refining or purification could be the highest level of the upstream category, although these are sometimes put in the mid-stream category.

A 2023 report by the EU Joint Research Centre on supply chains and material demand forecast dedicates a whole section to space. The report combines launchers and satellites into a category called space systems. According to the report, the European space sector itself is somewhat concentrated in terms of both geography and the corporations involved. Four industrial groups (Airbus, Thales, Safran, Leonardo) dominate the sector, along with smaller players such as OHB, RUAG or GMV and these corporations are mostly located in France, Germany, Italy, Spain, Belgium and the U.K., which is still a member of ESA. The report also provides a list of elements that are crucial for the space industry. Critical raw materials as per the EU's definition are important for the European economy and have a high risk of supply disruption. Strategic raw materials are a subgroup of critical raw materials, and they are the most important for strategic technologies used in green, digital, defence and space applications. Table 2 lists the critical raw materials for the space sector and a few of their usages:

Table 2
Critical raw minerals for the space sector

CRM	Usage
Aluminium (Al)	component for metal alloys
Antimony (Sb)	glasses and ceramics in optical devices
Arsenide (As)	semiconductors
Beryllium (Be)	component for metal alloys
Chromium (Cr)	coating for alloys
Hafnium (Hf)	component for metal alloys
Helium (He)	for pressurisation tanks, inert purge and cooling agent
Niobium (Nb)	mostly in nozzle and thrusters as metal alloy components
Phosphorus (P)	semiconductors for photovoltaic panels, treatment of lenses and optical filters
Vanadium (V)	in metal alloys for structural and propellent tank parts

Source: Compiled by the author.

Strategic raw materials are a subgroup of critical raw materials, and they are the most important for the strategic technologies used in green, digital, defence and space applications.

The list also contained xenon and krypton as propellants for Hall effect power systems, but they were not considered to be critical or of strategic importance by the EU, similar to other elements of which the EU has an abundant supply.[21] China, Australia, Japan and Canada also maintain lists of raw materials whose supply is of crucial importance to their economies. In 2022 Japan was the only one of these countries which had lead (Pb) on its list, while China was the sole country to include oil and iron on its list.[22]

[21] Carrara et al. 2023: 128.

[22] Su–Hu 2022.

Table 3
Strategic raw minerals for the space sector

SRM	Usage
Bismuth (Bi)	propellant for electric propulsion (Hall thruster)
Boron (B)	special glass ingredient for optical instruments
Carbon (C)	space-grade composite materials, like graphite, space-grade ceramics and silicon carbide, coating combined with other elements
Cerium (Ce)	increasing radiation resistance
Cobalt (Co)	alloys especially for injectors and thrusters, cathode materials, semi-permanent magnets
Copper (Cu)	electronics and wiring
Gallium (Ga)	semiconductors and chips used for satellite communications, lasers, solar panels, spacecraft power management
Germanium (Ge)	solar cells and semiconductors, infra-red filters
Lithium (Li)	alloys, batteries, glasses and ceramics for optics
Magnesium (Mg)	light alloys
Nickel (Ni)	alloys especially for injectors and thrusters, 3D printing powder
Phosphorus (P)	semiconductors for photovoltaic panels, treatment of lenses and optical filters
Platinum group minerals[23]	nozzles and combustion chambers (specific usage for different elements, e.g. iridium (Ir) container for plutonium fuel, coating on X-ray mirrors)
Rare earth elements[24]	Semi-permanent magnets, crystal laser sources, glass for optical devices (specific usage for different elements, e.g. samarium [Sm] in magnets for three-axis attitude control system, or in magnets exposed to huge temperature variations)
Titanium (Ti)	metal alloys, electro-optical systems and robotic devices
Tungsten (W)	alloys for nozzle and thrusters

Source: Compiled by the author.

[23] Platinum group metals (platinoids): ruthenium (Ru), rhodium (Rh), palladium (Pd), osmium (Os), iridium (Ir), platinum (Pt).

[24] Rare earth elements: a group of 17 elements, the lanthanides group: lanthanum (La), cerium (Ce), praseodymium (Pr), neodymium (Nd), promethium (Pm), samarium (Sm), europium (Eu), gadolinium (Gd), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), ytterbium (Yb), lutetium (Lu). In addition, yttrium (Y) and scandium (Sc) are also included in the group.

Different countries have different critical or strategic mineral lists, depending on their production, circle of allies and industrial needs. Examining only the materials relevant to the space industry listed above, significant differences between them are evident:

Table 4
Critical and strategic metal lists comparison in relation to the space industry

Material	U.S.	EU	PRC
Aluminium (Al)	x	x	x
Antimony (Sb)	x	x	x
Arsenic (As)	x	x	
Beryllium (Be)	x	x	
Bismuth (Bi)	x	x	
Boron (B)		x	
Carbon (graphite) (C)	x	x	x
Cerium (Ce)	x	x	
Chromium (Cr)	x		x
Cobalt (Co)	x	x	x
Copper (Cu)	x	x	x
Gallium (Ga)	x	x	
Germanium (Ge)	x	x	
Gold (Au)			x
Hafnium (Hf)	x	x	
Helium (He)		x	
Lithium (Li)	x	x	x
Magnesium (Mg)	x	x	
Nickel (Ni)	x	x	x
Niobium (Nb)	x	x	
Phosphorus (P)	x	x	x
Platinum Group Minerals	x	x	
Rare Earth Elements	x	x	x
Titanium (Ti)	x	x	
Tungsten (W)	x	x	x
Vanadium (Va)	x	x	

Source: EU critical mineral list; U.S. critical mineral list; Su–Hu 2022; Carrara et al. 2023

The obvious conclusion is that China is much less in need of minerals compared to the U.S. and Europe. The simple reason for this is that China is a mining powerhouse which cannot only cover its own needs but is also able to export various minerals. Indeed, many countries are heavily reliant on Chinese capacities, not only in raw material mining but also in refining and smelting. Anomalies like the presence of gold on China's list can be attributed to Beijing's decision to buy a large quantity of gold for financial reasons.

To give just a few examples of sensitive minerals for the space industry, in January 2023 the U.S. was heavily dependent on China for arsenic (100% dependency), gallium (100%), graphite (100%), tantalum (100%), yttrium (100%), bismuth (96%), antimony (83%), germanium (50%) and tungsten (50%). Many other elements were imported from other countries but the supply risk is more limited in the case of Mexico, Brazil or Canada.[25]

RARE EARTH ELEMENTS

The security risk posed by the disruption or loss of supply of raw materials and products imported from abroad has been a major concern for the United States and Europe since the early 2010s. This is especially true when China is involved. The space industry was also affected when China imposed restrictions on the volume of rare earth elements (REE) exports in 2009. China had gained an REE market share of 90% by the 2000s, which has affected the vulnerability of several countries and companies. This position in the world market was not a spontaneous development but the result of a deliberate long-term strategy by China intended to make the country dominant in the sector. Beijing was aware of the possible future influence it could wield due to REEs. As early as 1992, Deng Xiaoping compared REEs to oil in the Middle East.[26]

The reason for this is that the 17 metals in this group are essential raw materials for high-tech applications. They cannot be substituted or are very

25 U.S. Geological Survey 2023.

26 Pitron 2023: 92–94.

difficult to substitute, mostly with a loss of performance or only at the cost of increased weight, which is a crucial factor for all space equipment.

The 2012 U.S. National Strategy for Global Supply Chain Security highlighted this dependency problem. It stressed the need to make the supply system more secure while ensuring that any shortages can be quickly compensated for in the event of an incident.[27] The U.S. also established a research team in 2013 to find solutions to replace rare earth elements. However, the results of this effort were modest for several years.[28] New developments have emerged recently but industrial scale production and incorporation into designs remain elusive. One example of such progress is a 2022 announcement from Cambridge, where researchers managed to synthesise tetrataenite, an iron-nickel alloy only found in meteorites until their breakthrough. The lab-produced version has magnetic properties that are similar to REE magnets.[29]

Similarly to the EU, the U.S. has made efforts to increase domestic production. Decree 13817, issued on 20 December 2017, aims to help secure supplies of critical raw materials, mainly by developing the domestic private sector.[30] U.S. domestic production of certain REEs in 2019 was 26,000 tonnes (a 44% increase compared to 2018), but even for these elements imports still amounted to 14,000 tonnes. 80% of the country's REE imports between 2015 and 2018 came from China.[31] Washington therefore pushed for the previously loss-making mining at the Mountain Pass deposit in California to be re-started.[32] The operating company, MT Materials, has rapidly increased production, although the ore still had to be shipped to China for processing. However, the company planned to have the ore processed on site by 2022 and to produce magnets, which are also essential for the space industry. In November 2020, the Pentagon provided $9.6 million to achieve this goal.[33] The objective of on-site processing was met

27 The White House 2012.
28 Kalantzakos 2018: 77.
29 Zaleski 2023.
30 The White House 2017.
31 U.S. Geological Survey 2020.
32 Kalantzakos 2018: 16–28.
33 Magnuson 2020.

but the goal of magnet production was not achieved and in 2022 they had only started to build their factory in Fort Worth, Texas. The first phase production capacity will be around 1,000 tonnes of magnets which will be 1% of the current world production. Three other known sites in the U.S. and the EU are set to start production, hopefully in the near future. At the same time, China is still responsible for 90% of world production.[34] The Biden Administration continued to tackle the problem and has also implemented different policies. Executive Order 14017 and Executive Order 14051 are examples of these. The emphasis is on building up U.S. capabilities and developing supply chains while also managing stockpiles to serve as a buffer against potential problems.[35] Not surprisingly, the 2023 National Defense Industrial Strategy highlights the need for stockpiling as only a short-term tool. The document treats minerals as being equally important to chemicals, medical supplies, parts or technologies.[36]

Another option could be to source the metals from friendly foreign states. Australia, Myanmar, India, Vietnam and Japan seem to be suitable candidates. The latter discovered rich deposits on the seabed near Minami-Torishima Island in 2013. In 2021 a feasibility study was carried out which concluded that with new methods and considering the current needs, extraction is financially feasible.[37] Japan intends to test the technology in 2024 and this might be a crucial step towards achieving the goals set in the 2020 international research strategy. A key organisation in this regard will be the Japan Oil Gas and Metals National Corporation (JOGMEC).[38] A 2023 analysis evaluated 146 individual rare earth projects. Among these, many have not reached maturity yet but as soon as they are completed, they can form additional supply chains outside of China. Because of their military applications, heavy rare earth projects might have a greater impact on strategic positions, especially the ones promoted by the U.S. and Canada (Round Top, Zeus, Strange Lake, Bokan Mountain,

34 Okun–Cefai 2024.
35 The White House 2022.
36 U.S. Department of Defense 2023.
37 Yamazaki et al. 2021.
38 Pereira 2023.

Foxtrot sites). Projects in Europe, Greenland and Africa might have the greatest economic value but a significant number of projects have been delayed due to environmental issues and the protests of the local population.[39]

GALLIUM AND GERMANIUM

Of course, apart from the supply of REEs, there are other threats to space supply chain security. In July 2023, China announced limitations on its exports of gallium (Ga) and germanium (Ge), then in August the country did not export any of these elements at all. As noted above, both of these elements are important for the space sector. Gallium (Ga) is used for semiconductors and chips for satellite communications, lasers, solar panels and spacecraft power management. Germanium (Ge) is applied in solar cells, semiconductors and infrared filters. China gained a dominant position in the supply chain of these materials, especially in the case of gallium. By July 2023 China had gained a 98% share of the global market of the element. It is worth considering that the Western powers knew about the risk of such a monopoly situation arising. The U.S. Geological Survey has had gallium on its critical minerals list since 2018. According to a CSIS analysis, there was a bias towards a few minerals needed for green technologies and it simply did not pay attention to lesser-known minerals like gallium.[40] The U.S. and Europe reacted immediately, by launching recycling initiatives. One example is a joint project launched in 2022 between the U.S. Department of Defense and the Defense Logistics Agency. Instead of dumping old military optical equipment scrap into a landfill or selling it as scrap metal to China, they intend to recycle it and produce 2,200 to 3,000 kg of germanium. This could cover about 10% of the U.S. yearly consumption of germanium. The purity grade obtained is also reasonably good 99.999%.[41]

39 Liu et al. 2023.
40 Funaiole et al. 2023.
41 Reece 2022.

However, for high-end applications, this might need additional purification. Besides projects like this, governments have also approached private companies to start or re-start germanium and gallium production, but these projects still require time and cannot replenish the missing Chinese supplies, at least not within the near future.

A segment of the market compared the restriction of the two elements to the 2010 Chinese export control on rare earth elements. Like today, the materials were available in abundance, but only in China. Using the metals inside China and then taking the end product outside China was also legal. Worstall argues that the gallium and germanium supply problem can be solved just like the rare earth problem and that the West will find alternative sources although it might take a few years. Raw gallium can be obtained by refitting already existing bauxite processing plants and extracting the small quantities of gallium present in the ore. Raw germanium can also be secured when extracting zinc from sphalerite or fly ash from coal power plants. The output of this could be thousands of tonnes, while the world only uses 200 tonnes per year.[42] This is rational, as normally bauxite ore contains 30–80 ppm[43] gallium, and above 100 ppm is considered good quality. Black coal can contain up to 500 ppm and the ash remaining after burning the coal could even reach levels above 10,000 ppm, and thus above 1%.[44] Again, the Chinese dominance in the market was the result of a long-term strategy, because Beijing required its aluminium producers to have the capacity to extract gallium, effectively forcing companies in Germany, Kazakhstan, the U.K. and Hungary out of business. In time this production could be started again.

However, there is a shortage of processing plants that can refine the raw mineral up to the required purity for semiconductor production, although the technology is known and old plants can be reopened. The purity required

42 Worstall 2023.

43 ppm = parts per million. The amount of unit, usually a chemical, in relation to the substance that contains it.

44 Földessy 2020.

for semiconductor production is ultra high quality (usually 8N),[45] which is suitable for use in vacuum chambers part of an MBE[46] system. One facility that is able to produce gallium of such purity is the Vital Pure Metal Solutions plant in Langelsheim, Germany. The company is a fully owned subsidiary of Vital Materials Group. The plant restarted production in 2021 and its main customers include producers of compound semiconductors and optics or infrared advanced sensor manufacturers.[47] Another company active in the field is CMK, s.r.o. in Slovakia, which recycles and refines low quality (3N or 4N) gallium or even gallium arsenide scraps.[48]

Research projects are also working on ways to improve the existing technology. One example of such efforts is the Selective Vanadium recovery by the Alumina Refinery (VALORE) supported by the EU. The project should be ready by the end of 2024 and bring an already validated technology in a relevant environment (TRL5)[49] to a system prototype demonstration at an operational environment (TRL7) level. The technology will provide the tools to extract gallium and the often neglected vanadium during aluminium production. This technique will increase the purity of gallium and also provide an additional vanadium source which was often previously regarded as a waste product.[50] EU support can be crucial to such projects because, at this stage of technology development (between TRL 4 and 7), research institutes and private sector players do not prioritise investment.

This all may seem simple enough but the consequences should not be underestimated. Gallium-based semiconductors, or more precisely gallium

45 8N = N refers to the number of 9s in the purity grade. 99% of purity and 1% contaminating material is 2N, 99.99% purity is 4N, the highest commercially available grade is 9N (99.9999999%) purity.

46 MBE = Molecular-beam epitaxy. A special type of crystal growth or material deposition method used in semiconductor manufacturing and nanotechnology development.

47 Vital Pure Metal Solutions 2024.

48 CMK s.r.o. 2024.

49 TRL = Technology Readiness Level, the 9-grade classification system was originally developed by NASA in the 1970s for space exploration technologies. Level 1 is a basic principle observed and level 9 is an actual system proven in an operational environment.

50 VALORE 2024.

arsenide (GaAs) and gallium nitride (GaN), are vital for the defence industries. GaAs semiconductors can be found in GPS satellites, while GaN is used in many types of cutting-edge radar equipment including missile defence systems. While it is true that the needed resources could be diverted to meet defence industry needs, the same companies which supply space and defence products also rely on sales to the civilian sector.[51] This means that supply problems will affect their profits and thus the potential for them to pursue R&D projects.

When considering the space sector, it is worth noting that space-based capabilities help to manage supply chains while Earth observation satellites can prospect for new potential mineral extraction locations much more quickly and effectively. Optimists also suggest that space itself might be the actual answer to our resource needs because space resource extraction on other planets or asteroids is a viable alternative to extraction on Earth. Others are much more pessimistic, raising the issue of costs and lack of technology. Nevertheless, governments, institutes and corporations are contemplating the possibility of resource extraction in space and are trying to find ways to make it a reality.

MOVING UP THE SUPPLY CHAIN

Even though the above-mentioned minerals are only used in relatively small quantities, their availability is crucial. To better understand this need it is worth examining a few actual products they are used for. Vulnerabilities in the supply of these minerals are not a new phenomenon. A 2018 U.S. Department of Defense report in a dedicated section about the space sector mentions a few applications that are heavily reliant on critical minerals. The first of these is precision gyroscopes. These devices are key components for altitude determination and stabilisation in space vehicles or rockets. The components they use include integrated optical chips and laser diodes, and the production of these components was moving away from the U.S. which can cause loss

[51] Funaiole et al. 2023.

of expertise, delays, or decreased orbital lifetime because of the usage of less reliant substitutes. The situation was even worse for infrared sensors that can be used in space. Only one foreign manufacturer was able to supply the necessary components of sufficient quality. A disruption of the supply of these lasting more than a few months would effectively halt production. The production of special highly radiation tolerant integrated circuits was also in a bad state. These circuits are not used in the civil sector, which leads to low production volumes. Only 1% of the suppliers' revenues came from these products. However, these components are essential for missile warning systems, missile defence, reconnaissance and space situational awareness (SSA).[52]

Research and development efforts are also hindered in many ways. R&D requires large capital investment and unique expertise. The civil sector and private investors are reluctant to build such R&D and manufacturing capacity, so to a certain degree, it is up to the state to develop next generation technologies and create the conditions for their production. The GaN and GaAs semiconductors were also originally developed by DARPA.

A 2014 report that partly concerned solar cells emphasised the extent of dependence on foreign suppliers in this field. The paper mentions rare earth elements and examines the issue of solar cells in particular detail. According to the paper, the production of space-grade solar cells used by satellites would not be enough on its own to maintain a business and pay for the extensive supply chain needed to manufacture them. Therefore, most manufacturers are supported by related commercial, land-based solar panel manufacturers, and their capacity is mostly dependent on China. They also had an incentive to move higher tier production closer to the source of extraction and smelting. In 2014, China accounted for 64% of commercially available solar panel production, compared with just 3% in the U.S.[53] This situation did not improve based on a 2022 International Energy Agency report. The document shows that China produced 79.4% of polysilicon, 96.8% of wafers, 85.1% of cells and 74.7% of

52 U.S. Department of Defense 2018.

53 Autry et al. 2014.

modules. Its average share of global solar panel manufacturing capacity is 84.0% while the country constitutes 36.4% of the global demand.[54]

Some examples in the industry are worth examining. Azur Space Solar Power GmbH is a 250 employee strong company in Heilbronn, Germany. It produces high-end wafers and solar cells[55] and assembles them with glasses and interconnectors for space applications. The company's products can be found in 600 space projects including satellites from Intelsat, Globalsat, Hotbird, ATV, Galileo, Meteosat, GLONASS and GMES. Customers include the ESA, DLR, Airbus Defence & Space, Leonardo, OHB SE, Thales Alenia Space and Mitsubishi Electric. Through them, Azur Space solar cells are also on missions like Hubble Space Telescope, Rosetta, Venus Express, Mars Express, Herschel-Planck and others. To achieve such good results the company uses germanium and gallium as a key component in their panels.[56] The company was acquired in 2021 by 5N Plus Inc. a Montreal based Canadian company providing purified metals and semiconducting compounds. 5N Plus Inc.'s products are also used in infrared and earth imaging applications. This chain of events shows that the company had already been producing valuable, high-tech products and another company providing the refined materials for such manufacturing thought that it would be a viable strategy to tightly integrate the production of the two entities, thus strengthening the position of the joint entities in both relevant tiers of the supply chain.

Due to the strategic importance of its products before acquiring Azur Space, a thorough screening process was carried out, to ensure supply safety. Publicly available shareholder information showed that board members and North American companies owned 41.7% of the shares while 58.3% were owned by the general public.[57] The screening process had to make sure the owners and the

[54] International Energy Agency 2022.

[55] Efficiency rate is between 28% to 32% while commercially available panels are usually between 17% and 20%. The panels are also designed to withstand the harsh space environment, like heat variations, radiation, etc.

[56] Azur Space 2024.

[57] MarketScreener 2024; Simply Wall St. 2024.

companies involved pose no security risk, for example by demonstrating that there are no potentially harmful foreign owners behind the North American companies. However, the screening process must be done on a regular basis to avoid undetected changes in the ownership structure.

COUNTERING RISK

The mention of screening processes offers a good opportunity to briefly look at a different kind of threat to space supply chains. The ownership of the actors in the supply chain is constantly changing, so the risk they carry is also subject to fluctuations. In 2020, the United Launch Alliance (ULA), a major player in the U.S. space sector reported that one of their industrial software suppliers had been found to be partially Chinese-owned. According to the ULA director, the security risk was discovered quickly and no valuable information was leaked. One possible solution to the problem, in addition to regular reviews, is to break down components purchased from other sources into such small parts that no one knows what they are working on.[58]

According to the data analytics firm Govini, in 2020 the presence of Chinese firms in supply chains, especially at the lower end, was significant. Between 2010 and 2019, the number of Chinese-owned suppliers among firms in this section increased by 420%. In 7 of the 18 key industries surveyed, the share of foreign suppliers was as high as 75%, mainly in chemicals and electronic components.[59] Because the presence of Chinese firms is common in all strategic industries, this growth does not seem to have a direct connection with conflicts regarding space activity, like the so-called Wolf Amendment from 2011. It has more to do with general U.S.–China tensions and economic prospects for investors. In 2023 Govini published a more detailed report focusing on the situation in 2022. The space supply chain had 565 Chinese companies out of 27,043 Tier

58 Erwin 2020.
59 Govini 2020.

2 suppliers, and 502 of 7,784 Tier 1 suppliers were Chinese companies.[60] This is not large as a percentage, but it is still a greater share in both Tiers than any other allied country and the report does not give an evaluation of the Chinese positions in the supply network. They could be key players in certain segments and as we can see from ULA's example, their covert influence can be significant, with Chinese entities hiding behind multiple layers of seemingly harmless local companies. The report also warns that the number of patents issued in China in 12 key areas is larger than in the U.S., including in space-related fields, where in 2022 there were more than 60,000 Chinese patents, while fewer than 30,000 were from the U.S.[61]

To counter such vulnerabilities, a number of supply chain reviews are being conducted. Apart from the U.S. space industrial base reports and the EU JRC report, another good example is the U.K. Space Supply Chain document which provides detailed explanations for decision-makers, maps out the location of companies and facilities, and explains the related challenges, etc.[62] There are also efforts to put barriers up against potentially harmful foreign entities. The U.S. Government has placed several companies with close links to the Chinese military on a ban list. Washington has drawn up at least nine lists of people and entities which are in connection with the Chinese military or which may otherwise endanger U.S. interests.[63] These lists are expanded or sometimes shortened when the administration wants to send a message to Beijing.

The West has also embarked on a long process to reduce dependencies by decoupling (U.S. term) or de-risking (EU term). This costly and lengthy process will not result in a full separation, but rather a balanced approach. Experts even talk about the possibility of a patchwork globalisation with different blocks and regions interacting rather than countries and companies. It is worth adding that different kinds of decouplings exist, such as technology decoupling, information

60 Govini 2023.
61 Govini 2023.
62 Red Kite Management Consulting 2022.
63 Dorsey and Whitney 2021.

decoupling and economic decoupling.[64] Space decoupling is at an interesting stage at present, due to the U.S. decision to not cooperate with the Chinese, although the supply chains are still interconnected. A gradual shift can be observed, as in 2023 the U.S. imported more goods from Mexico than from China.[65] Europe has also started a much more limited and gradual space decoupling, as well as increasingly approaching the U.S. in terms of space cooperation where defence needs play a crucial role due to the Russia–Ukraine war.

New initiatives in this regard include the U.S. Space Force's International Reverse Industry Days, such as those held on 25 and 26 October 2023 which involved a discussion between representatives of industry and government agencies from the U.K., Canada, Australia, New Zealand, France, Germany and Japan focusing on shared supply chain problems. Such events are partly classified and partly unclassified.[66]

At the same time, companies are trying to adapt to the new environment, by applying methods and designs that are less reliant on the materials mentioned in this paper. These efforts are also facilitated by recent technological developments. 3D-printed structures were first launched into space in 2015 on the Arabsat-6B satellite. Thanks to the same technology, the aluminium antenna dishes on the intelligence-critical Sentinel satellites are 25% lighter and stronger, while their production time has been halved. SpaceX used 3D-printed parts in its engines as early as 2014. These processes and the constellations of small satellites being built in low Earth orbits are also transforming supply chains. Manufacturers are moving towards the verticalisation of production and the use of readily available off-the-shelf components already used in other devices. Moreover, 3D printing is opening up new horizons for In-Space Manufacturing (ISM), assembly and maintenance. Thanks to the rise of mass production and automation, the need to outsource production is decreasing. For example, 70% of the Falcon rocket components are produced in SpaceX's California

64 Houtari et al. 2021.
65 U.S. Census Bureau 2024.
66 Hitchens 2023.

plant. Thanks to this, production has been accelerated and R&D time has been reduced. Other companies such as Blue Origin are also following this vertical pattern. In addition to manufacturing, they have a facility in Florida for assembly and testing.

Increasingly, companies are experimenting with off-the-shelf technologies and components because of the increasing efficiency of small satellites, as well as their relatively short planned lifetime and therefore their rapid replacement. These are usually sourced from other faster-growing industries (e.g. electronics). Good examples of such readymade components are lithium batteries or on-board computers installed in CubeSats. The battery manufacturers include some firms known specifically in the defence industry, but also civilian companies such as Canon, Molicel, LG or Samsung.[67]

Strategies like nearshoring,[68] friendshoring,[69] reshoring[70] and China Plus One[71] have gained popularity due to companies putting a greater emphasis on managing risk instead of reducing costs. Even if reshoring is expensive for space companies, it is feasible especially with regard to electronics, because lead times are now months instead of weeks, and time is very important. Some companies would rather deliver their product by air instead of using normal shipping. Delays are especially critical for programmes where there is a launch window. Although there has been an increase in the use of off-the-shelf components, special parts are still needed. Because of this, even though space is a small market compared to car manufacturing, aviation and green energy there are significant increases in prices and lengthened lead times.[72] Of course, most companies

67 OECD 2014.

68 A practice where supply chains are focused and relocated into countries geographically closer (usually neighbours) to the given country.

69 A practice where supply chains are focused and relocated into countries which are considered to be political and economic allies.

70 A practice where supply chains are moved back to the country of production/HQ.

71 A practice where supply chains are partly kept in China but also diversified to other countries to mitigate risk. ASEAN countries are very popular destinations for this strategy.

72 Foust 2022.

try to balance security with profits. As a general rule of complacency dictates, a steady and fair-priced supply from China would be highly detrimental to any initiative to find alternatives to China.

REORGANISING AND LEVERAGING THE WEST

In addition to the problem of foreign actors in the supply chains, the space sector also has to deal with its own bureaucratic structures. It is clear that the procurement system for space equipment is too slow and complicated for various reasons, both in Europe and in the U.S. According to an analysis published by the Secure World Foundation in December 2020, one of the Biden Administration's main tasks was to address these challenges. In 2017, more than 60 organisations still had some influence on space procurement in the U.S.[73] It is partly to address this problem that Space Command and, more recently, Space Force have been re-established, with Space Systems Command as one of its departments, and the Procurement Division under it. One of its main tasks was to enhance the security of supply.[74] According to Dr Aaron Bateman, a space policy specialist at George Washington University:

> "The Space Development Agency, now under USSF, has indeed been able to cut through much of the acquisition red tape that has plagued DoD procurement. It is too soon to say if this is indeed a successful model, but thus far SDA's 'move fast' strategy seems to be working."[75]

Western powers have also opted to apply some of the leverage that is available to them to secure supply chains. The whole issue of microchips and semiconductor production revolves around limiting China's and Russia's industrial, defence and space capabilities and their development. Around 2015, the U.S.

[73] Secure World Foundation 2020.
[74] U.S. Department of Defense 2020.
[75] Bateman 2024.

Government began to realise that the West is losing its comparative advantage over China. Taiwan and South Korea are already more advanced than the West in various high-tech fields and China is quickly catching up, while also employing restrictions and subsidies in an attempt to become the leading power. Intel is no longer comparable to TSMC or Samsung and the defence industry needs to buy components from abroad, which poses additional risks of foreign actors tampering with the chips. For this reason, the DARPA applies a zero trust policy and carefully tests every component. China has also started to invest in foreign chipmakers while acquiring their technology or simply stealing it through espionage.[76] In 2020, the U.S. began to impose a "chip choke" on China. These measures have been fairly effective but Miller emphasises that they are only a temporary solution, as countries can find ways around restrictions in a highly connected global market. The U.S. wants to increase its market share, but so does Europe, and leading companies are not ready to give up their positions either. Luckily, leading production sites are based in allied or friendly countries.[77] In 2022, Washington ratified the CHIPS and Science Act and the EU followed with the European Chips Act which entered into force in September 2023.

An interesting shift can be seen in the documents produced by the U.S. It seems that the main attention of its reports has to some extent shifted from supply chain security to technological competition, including space technology. This is also reflected in the reports of the U.S.–China Economic and Security Review Commission. In 2022, section 4 of the report highlighted supply chain vulnerabilities and the concentration of key segments in China. These critical points included active pharmaceutical ingredients, rare earth elements, castings and forgings, etc. while at the same time, the report claims that China is deliberately trying to maintain or increase its influence over U.S. supply chains. The potential risk caused by Chinese counterfeit or corrupted components is also significant. On top of that, due to Beijing's efforts to achieve technological self-reliance, the need to protect intellectual property is also important in this

76 Miller 2022: 283–295.

77 Miller 2022: 327–335.

regard, not just the loss of financial revenue. The Commission recommended a coordinated supply chain mapping effort and a more consistent and simpler procurement system.[78] This would serve to improve the resiliency of Western supply chains, so they can adapt and rebound more quickly in case of any unexpected events. The space sector is not directly affected by the mineral trade and sanctions and does not have a stockpile capacity of metals, but it is dependent on the availability of spare parts and on component manufacturers, and therefore stockpiling these items, establishing lean networks with partners and finding off-the-shelf substitutes can mitigate the risks for the sector.

The 2023 report by the same commission report also focuses on supply chain issues, but not to the same degree. In the 785 page long 2022 report, the word supply is mentioned 693 times, while in the 2023 report, it is "only" used 177 times and a special Section is not dedicated to the problem. On the other hand, in the 2023 report, there is a Section about weapons, technology and export control which includes a large segment dedicated to Chinese space capabilities and the importance of striving towards technological self-reliance and a leadership position. The document quotes a testimony given to the Commission by Dr Pollpeter, warning that China's space and missile program can provide a case study of how the country circumvented the attempts of the U.S. to isolate it by simply cooperating with other countries.[79]

CHINESE RESPONSES

As the U.S. and the EU try to reduce their supply chain vulnerabilities so their defence, commercial and space objectives can be achieved while at the same time trying to limit China and Russia in various areas there has been a reaction from these powers. As noted earlier, China's aspiration to become a leading technology powerhouse is backed by a long-standing plan. Since at least 1986,

78 U.S.–China Economic and Security Review Commission 2022.
79 U.S.–China Economic and Security Review Commission 2023.

or more precisely since the announcement of the 863 Program,[80] the Chinese Government has been seeking to move up the value chain and take the lead in several areas. Beijing used to offer various concessions to attract foreign companies to set up operations in the country, but at the beginning of the 2010s, it became more assertive, not only in the area of raw materials. Beijing has been applying political pressure to extract concessions from big companies. For example, in 2014 it launched investigations into Microsoft and Apple. This was only suspended when Apple promised to set up an R&D facility in China. Some software companies have been obliged to hand over source code, and the office responsible for reviewing the security of IT companies is under the Ministry of State Security[81] which is in charge of intelligence. According to the cyber intelligence firm Recorded Future, the same office is linked to APT3, a cyber espionage group.[82]

The new export limitation on gallium and germanium is regarded as a countermeasure to previous U.S. steps limiting the trade of high-end chips or the tools to produce them. Wei Jianguo,[83] a former vice-minister of commerce warned in July 2023 that this limitation is only the beginning and that China has many other tools at its disposal and that things could escalate further.[84] The process of bringing more resources under Beijing's control is well underway. While the West is trying to diversify its supply chains, China intends to further strengthen its influence in mineral mining. In 2023 there was a 131% growth in the country's metals and mining area investment, which is focused heavily on Africa and Latin America.[85] At the same time, according to Pitron, Beijing does not shy away from using coercion, diplomatic actions and economic takeovers to stop rivals from opening new mines.[86] One more crucial parameter for the

80 863 jìhuà, 863计划. Its official name: State High-Tech Development Plan, Guójiā gāo jìshù yánjiū fāzhǎn jìhuà国家高技术研究发展计划.

81 Guójiā Ānquán Bù 国家安全部.

82 U.S.–China Economic and Security Review Commission 2018.

83 Wèi Jiànguó 魏建国.

84 Ma 2023.

85 Wang 2023.

86 Pitron 2023: 170–172.

future of mining is the growing energy needs for extraction. The quality of the ore deposits is decreasing, which entails more work to obtain the same amount of ore, while at the same time, the demand for raw materials is increasing. As a result, China has started to prioritise its own resource needs and can use minerals as a diplomatic tool.[87]

There are also intermediaries at play which can circumvent EU and U.S. restrictions. An example of a country employing this strategy is Morocco. The country has free trade agreements with the U.S. and the EU and has a well-developed infrastructure and a stable political and economic system. This creates a perfect environment for Western and Chinese cooperation. Canadian and South Korean firms have also chosen Morocco as a good location for joint projects with their Chinese counterparts.[88] Of course, such behaviour is not only limited to supply chains. Other countries are also using various strategies to try to cooperate with both the West and China while following their own national interests. Cooperation on different levels can help to mitigate tensions while also producing benefits. One example of a country cooperating with multiple partners is the United Arab Emirates, a signatory of the Artemis Accords, yet at the same time the University of Sharjah signed a memorandum of understanding to take part in the Chinese led International Lunar Research Station (ILRS) project.[89]

Furthermore, China is also making attempts to build up its chip manufacturing capabilities to ensure a higher grade of independence and possibly to capture a share of a market which is still mostly controlled by the Taiwan Semiconductor Manufacturing Company at the high-end part of the market. ASML, a firm based in the Netherlands, is the only company to manufacture the machines that are able to produce these chips. In addition, U.S. companies like Lam Research, KLA and Applied Materials are industry leaders in other

87 Pitron 2023: 159–168.
88 Byamungu 2024.
89 Xin 2023.

tools needed for the chip manufacturing process and they also try to limit cooperation with China.[90]

On a final note, it is worth noting that research and development initiatives and a push to build up a more resilient space commercial sector can also be found in the toolbox of Beijing. The reform of the innovation chain is continuing and the Chinese Government is focusing on strategic areas with numerous grand-scale projects in the background, with the Chinese Communist Party exerting tight control over the goals of the research.[91] Recent analysis has shown that the space industry in China is still strongly interwoven with the state while being supervised closely by the government. The commercial sector is still in its infancy compared to the West but Chinese companies are slowly catching up and the growth potential is very promising.[92]

CONCLUSION

Raw Materials, geopolitics, supply chain security and space capabilities are strongly interconnected. The space industry is unable to function and achieve its full potential without a secure and well-functioning supply chain. In many regards, the space sector is more dependent on supply chains than other industries due to its often unique requirements, smaller and irregular purchases and a constant struggle with skilled workforce shortages. Disturbances in the raw material markets can indirectly affect space companies and government institutions and may result in increased delays, cost overruns, missed launch windows, smaller revenues and in consequence, a smaller amount being available to dedicate to R&D projects. Western governments are attempting to secure critical and strategic mineral supply chains and become more independent from China, while China is working towards opposite objectives, trying to

90 Cheng 2022.
91 Groenewegen-Lau – Laha 2023.
92 Han et al. 2023.

keep and increase its market share and at the same time acquire cutting edge technologies like high-end chip manufacturing expertise. These tensions and trends also affect the space supply chains.

Western stakeholders need to cooperate even more closely and ensure that a more resilient, responsive system is in place to meet the industry's needs. Decision-makers might be advised to acquire a basic knowledge of minerals to avoid making mistakes in the future as they did when they disregarded warnings of a gallium supply risk. Stockpiles, even of materials which seem to have an undisturbed supply, should be built up, especially when sources are close to China. Alternative replacement technologies should be emphasised and supported. The space sector will not do these things on its own but is responsible for communicating its needs to decision-makers and encouraging cooperation with other industry sectors. If current geopolitical trends continue there might be increased impetus for decoupling which will sever a few ties between China, Russia and the West while other dependencies will become covert and less obvious. In terms of space supply chains, the already evident two blocks centring around the U.S. and China might become more solidified and distant from each other, pointing toward technology, R&D and space decoupling.

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Gregorio Salatino

Security and Defence Implications of Earth Observation[*]

INTRODUCTION

In 1958 Lyndon B. Johnson, a future President of the United States, proclaimed that "control of space means control of the world".[1]

This contention represented a futuristic projection based on the experience gained by armies throughout the history of military strategy. Indeed, since ancient times, every army has sought to view the ground from above. What has changed over time are the developments in technology that enable this aerial surveillance.

While the ancient Greek and Roman armies could only rely on hilltops and watchtowers for this purpose, a significant step forward was made in 1794 when, during the battle of Fleurus, the French army used hot air balloons for the first time to scout enemy movements.[2] Subsequently, in the First and Second World Wars, airplanes equipped with cameras were employed.[3] The

[*] In this article, the Author expands upon a speech delivered on 9 May 2023, at the international conference on "Security, Defence and Outer Space" organised in Budapest by the Institute of Space Law and Policy (University of Public Service) and the Hungarian Association of Military Science. The Author would like to thank Professor Balázs Bartóki-Gönczy and Professor Gábor Sulyok for the invitation to join the conference as a speaker and the opportunity to contribute to this publication.

[1] Wasser 2005; Hersch–Steer 2021: 5.

[2] *Military Use of Balloons During the Napoleonic Era* s. a.

[3] The Normandy landings in 1944 were planned relying on observation techniques from above. See in this respect *History of Earth Observation*: "As part of preparations for the Normandy Invasion (D-day), aerial photographs were used to map coastal conditions to identify the most suitable sites on which to land. By measuring waves close to the coast it

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most recent advancement occurred in the 1960s during the "race to space" when mankind invented satellites. In our modern world, satellites are employed for various activities, both civilian and military.

In this article I intend to delve into security and military issues. In particular, following a preliminary examination of Article IV of the Outer Space Treaty, the first part of the article will focus on the use of satellites to acquire intelligence information. This activity, indeed, raises certain issues of compliance with the "space legal framework", specifically when carried out during peacetime. Continuing my analysis, I will examine the applicability of Article 51 of the United Nations Charter in the context of satellite espionage, that is, whether the State whose territory is being "spied on" by another State may lawfully act in self-defence.

In the second part, the focus will shift to the use of satellites to guide armed attacks against objectives on Earth. I will delve into the principles of International Humanitarian Law, outlining the conduct that must be strictly adhered to in a warfare scenario. The utilisation of precise, advanced technology, such as satellites, in carrying out attacks should enhance the application of the principles of distinction, proportionality and precaution in such military operations. To conclude this part, considering the support that satellites can give in military operations, I will examine how the aforementioned principles of International Humanitarian Law would apply when satellites are targeted.

HOW DOES ARTICLE IV OF THE OUTER SPACE TREATY APPLY TO SATELLITES?

Preliminarily, it is crucial to establish the scope of what is permitted under Article IV of the "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies" (the so-called "Outer Space Treaty", adopted in 1967). Article

was possible to determine wavelength and thereby calculate water depth. Furthermore, infrared film was used to identify green vegetation and distinguish it from camouflage nets."

IV definitively sets the boundaries beyond which the military use of space is prohibited. It has been argued that Article IV aims to prevent the so-called "weaponisation"[4] of Outer Space.

The guiding principle is stated in paragraph 2 of the article, where it stipulates that "the Moon and other celestial bodies shall be used by all States Parties to the Treaty exclusively for peaceful purposes". Article IV includes, as ancillary to that principle – but also by way of implementing it – a series of obligations, i.e.

> 1. "States Parties to the Treaty undertake not to place in orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner";
> 2. "The establishment of military bases, installations and fortifications, the testing of any type of weapons and the conduct of military manoeuvres on celestial bodies shall be forbidden".

Article IV then concludes by clarifying that neither "the use of military personnel for scientific research or for any other peaceful purposes" nor "the use of any equipment or facility necessary for peaceful exploration of the Moon and other celestial bodies" is forbidden.

The key to understanding Article IV lies in the interpretation of the wording "peaceful purposes". The article defines in detail the aims that States can legitimately pursue in carrying out space activities. According to one

[4] A distinction has been drawn between the so-called "militarisation" and "weaponisation" of outer space. Regarding this matter, see Ferreira-Snyman 2022: 75–76. The Author explains that non-militarisation (or demilitarisation) means "the prohibition of using space-based facilities for any military purpose". The majority of States consider such utilisation of Outer Space "non-aggressive" and, therefore, not in violation of Article 2, paragraph 4 of the United Nations Charter. In summary, "militarisation" is considered legal. On the other hand, "weaponisation" means "the deployment of weapons of an offensive nature in outer space or on the ground with their intended target located in space". The majority of States view this kind of space utilisation as illegal. As a result, Article IV of the Outer Space Treaty aims at preventing the "weaponisation" of outer space, while "militarisation" has been accepted as legal.

interpretation, supported by the United States, "peaceful" is not the opposite of military, but means non-aggressive only. A second interpretation, supported by the Soviet Union, held that "peaceful" means non-military, i.e. any military activity, aggressive or not, is prohibited.

The first interpretation has prevailed and consequently, "peaceful" must be interpreted as "non-aggressive". This means that States may use and place weapons and other military equipment in space, on condition that they do not use them for aggressive purposes. So, by way of rephrasing the principles set forth in Article IV, it can be concluded that the Moon and other celestial bodies shall be used exclusively for what could be called "non-aggressive" purposes; the use of military personnel and the use of any equipment (including military one) is allowed, provided that the use is non-aggressive.

The language adopted in Article IV raises another implication. Paragraph 2 of the article, when setting forth the principle of "peaceful purposes", only refers to the "Moon" and "other celestial bodies", but it does not mention "Outer Space" at all. This may imply that "peaceful purposes" should only apply to "the Moon and other celestial bodies", but not to Outer Space.[5]

Apart from posing the above interpretative puzzles, Article IV sets forth a specific obligation, i.e. the obligation "not to place in orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner". Certain States have, over time, developed the capability to fire intercontinental ballistic missiles (even carrying nuclear warheads) or other weapons of mass destruction. Would firing such kinds of weapon perhaps trigger a violation of Article IV?

Scholars have rejected the possibility that firing intercontinental ballistic missiles (including those carrying out nuclear warheads) or other weapons of mass destruction through space may violate Article IV, since such weapons, actually, only temporarily cross the orbit, but they are neither placed in orbit

5 See SALATINO 2022: 423.

around the Earth, nor installed on celestial bodies, nor they station in outer space in any other manner.[6]

Having examined the principles and obligations set forth in Article IV of the Outer Space Treaty, it can now be assessed how they relate to satellites.

Satellites are, indeed, "space objects"[7] that are typically stationed in orbit around the Earth or in space. However, they do not carry nuclear weapon or other weapons of mass destruction.

Under certain circumstances (which will be examined later), a satellite may also be considered to have "military" objectives.[8] However, only "the Moon and other celestial bodies" shall be used for "peaceful purposes", while satellites, as already pointed out, are usually stationed in orbit around the Earth or float in space. In any case, since "peaceful" must be interpreted as non-aggressive, the use of satellites does not preclude peaceful purposes, as these satellites are not inherently aggressive.

In addition, the last sentence of Article IV confirms that it is permitted to use any equipment or facility necessary for "peaceful" exploration (which should be interpreted as non-aggressive exploration) of the Moon and other celestial bodies.

Article IV also prohibits "the testing of any type of weapon and the conduct of military manoeuvres on celestial bodies". A satellite can, of course, contribute to performing those actions, but the prohibition clearly focuses on the "weapon" and the "military manoeuvres", while it does not relate to satellites as such. The other obligations contained in Article IV are even less applicable

6 Schmitt 2006: 104; Dinstein–Dahl 2020: 4. See the commentary to Rule 2: "In order to be considered to be 'placed in orbit' an Outer Space object must complete at least one orbit. WMD or nuclear weapons that simply transit through Outer Space without completing an orbit, such as an Intercontinental Ballistic Missile (ICBM), do not fall within the scope of the prohibition."

7 See the definition included in Article I of the Convention on International Liability for Damage Caused by Space Objects.

8 According to the definition of Article 52 Additional Protocol I to the Geneva Convention, military objectives are "those objects which by their nature, location, purpose or use make an effective contribution to military action".

to satellites: a satellite is obviously neither a military base, nor an installation, nor a fortification. In light of the above, it can be concluded that the use of satellites does not trigger any violation of Article IV of the Outer Space Treaty.

THE USE OF SATELLITES FOR ACQUIRING INTELLIGENCE INFORMATION

Although the use of satellites does not *per se* trigger any violation of Article IV of the Outer Space Treaty, certain activities conducted by means of satellites may raise concerns regarding other principles outlined in the Outer Space Treaty. One such questionable activity is the acquisition of intelligence information through satellites, specifically when performed during peacetime. Such an activity, even during peacetime, is rather common for States, as all States with the technological capabilities "spy" via satellites for security reasons. Consequently, few would raise doubts regarding its lawfulness.

However, it must be noted that the Outer Space Treaty was inspired by the principles of collaboration and benefit-sharing between States. In contrast, the acquisition of intelligence information through satellites, like any act of espionage, is carried out not only without the collaboration of the surveilled State, but even against its will.

Some authors have suggested that "peacetime espionage" benefits from a permissive customary international law exception.[9] This view, however, has been strongly contested by others.[10]

In the 1960s there were two opposing theories.[11] According to the first theory, supported by the Soviet Union, the acquisition of intelligence information through satellites had to be considered illegal under international law. Such activity is military in nature and, consequently, non-peaceful. Furthermore, it violates the sovereignty of the sensed State, regardless of where the observer is

9 Scott 1999: 226.

10 Navarrete–Buchan 2019: 897.

11 Soraghan 1967: 463.

located. According to the second theory, supported by the United States, the acquisition of intelligence information through satellites should be considered legal under international law. The activity is non-aggressive and, consequently, "peaceful". Additionally, there is no violation of the sovereignty of the sensed State, since the observer is located high above the admitted boundaries of sovereignty. Third, such activity is necessary for security and proper self-defence. In particular, the United States intended to use satellites to close the information gap with the Soviet Union, as the latter was a closed society that made the acquisition of information more difficult compared to the open society of the United States.[12]

I believe that the second theory has now prevailed. It has been admitted that "peaceful" must be interpreted as "non-aggressive". The acquisition of intelligence information through satellites is not inherently aggressive. Moreover, the Outer Space Treaty has established the principle of free exploration and use of Outer Space, which means that space activities can be conducted freely and States are not required to seek permission from other States or to inform them in advance about the activity being carried out.[13] Consequently, the use of satellites for the acquisition of intelligence information cannot in itself constitute a violation of the sovereignty of the sensed State. The issue, however,

12 The Soviet Union contested in formal documents the use of satellites for the acquisition of intelligence information twice. The first time was in 1962, when the Soviet Union argued that: "8. The use of artificial satellites for the collection of intelligence information in the territory of foreign States is incompatible with the objectives of mankind in its conquest of outer space" [see the "Draft declaration of the basic principles governing the activities of States pertaining to the exploration and use of outer space" (A/AC.105/L.02)]. The second such protest occurred in 1963, when the Soviet Union argued that: "Space vehicles aboard which devices have been discovered for the collection of intelligence information in the territory of another State shall not be returned" [see the "USSR: Draft International Agreement on the Rescue of Astronauts and Spaceships Making Emergency Landings" (A/AC.105/12/Annex I (B)]. It should be noted, however, that while the Soviet Union championed the idea of the illegality of the acquisition of intelligence information through satellites, it actually extensively used its own satellites for spying purposes. For this reason, Navarrete–Buchan 2019: 933, characterised the Soviet Union's opposition as "only lip service".

13 Li 2020: 344.

is not the lawfulness of the activity in itself. In my opinion, the real question is: does the legal framework include an obligation to share data and information acquired by satellites?

There are indeed certain legal instruments from which such an obligation may be construed.

According to the Outer Space Treaty, the exploration and use of Outer Space shall be carried out "for the benefit and in the interests of all countries" (Article I); additionally, "States Parties […] shall be guided by the principle of cooperation and mutual assistance" (Article IX); and, in a more detailed way, "States Parties […] agree to inform the Secretary-General of the United Nations as well as the public and the international scientific community, to the greatest extent feasible and practicable, of the nature, conduct, locations and results of such activities" (Article XI).

Moreover, according to the "Principles Relating to Remote Sensing of the Earth from Outer Space", adopted by the United Nations Organization in 1986, "the sensed State" shall have access to "primary data and processed" data as well as "to the available analysed information concerning the territory under its jurisdiction", "on a non-discriminatory basis and on reasonable cost terms" (Principle XII).

Obviously, States intend to keep the intelligence information they acquire from satellites confidential. However, if there is an obligation to share this information, the strategic advantage of States that engage in intelligence activity would be compromised, and, consequently, the activity itself would lose effectiveness and utility.[14]

[14] According to Lee–Steele 2014: 102, on the assumption that Principle XII of the Principles Relating to Remote Sensing of the Earth from Outer Space has attained the status of customary law, they argue that the obligation for the sensing State to share intelligence information also applies in a warfare scenario. They contend that this obligation must be complied with "unless there is a resolution of the Security Council authorizing the denial of the remote sensing data to the sensed target state". However, I find this conclusion to be far-reaching. Firstly, as I will further elaborate in this article, the Principles Relating to Remote Sensing of the Earth from Outer Space have the limited scope defined in Principle I (i.e. "improving natural resources management, land use and the protection

If it were to be confirmed that the "space legal framework" includes an obligation to share information acquired through satellites, States carrying out the activity without complying with such an obligation would commit a violation of international law.

In such an event, States may exempt themselves from the obligation to share the acquired information by invoking "necessity" under Article 25 of the International Law Commission's Articles on State Responsibility. More precisely, "necessity" can be invoked "as a ground for precluding the wrongfulness of an act not in conformity with an international obligation", provided that: 1. the wrongful act "is the only way for the State to safeguard an essential interest against a grave and imminent peril"; 2. it "does not seriously impair an essential interest of the State or States towards which the obligation exists, or of the international community as a whole".[15]

In light of these conditions, a State may engage in the activity of acquiring intelligence information from another State only if there is a "grave and imminent peril" that the "observed State" is planning an attack against the "observing State".

If such interpretation prevails, however, the room for manoeuvre of States in carrying out intelligence gathering activities by means of satellites would be significantly reduced.

Several arguments can be developed to challenge the reconstruction of the obligation to share intelligence information acquired through satellites.

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of the environment"). Secondly, in a warfare scenario, even the Outer Space Treaty is likely to be suspended and, consequently, if one were to entertain the assumption (which is not endorsed) that there is an obligation to share intelligence information during times of peace, such an obligation would not endure in times of war.

15 For the sake of completeness, it must also be added that according to paragraph 2 of Article 25 of the International Law Commission's Articles on State Responsibility: "In any case, necessity may not be invoked by a State as a ground for precluding wrongfulness if: (a) the international obligation in question excludes the possibility of invoking necessity; or (b) the State has contributed to the situation of necessity."

As for Article I and Article IX of the Outer Space Treaty, the principles of cooperation, mutual assistance, benefit and interest of all countries are more guiding principles than obligations from a technical standpoint.[16]

To "defuse" Article XI of the Outer Space Treaty (i.e. the sensing State would be obliged to share "the nature, conduct, locations and results of such activities") reference can be made to the specific wording used in the clause. The clause states that "State parties [...] agree to inform" rather than using the term "shall". Therefore, it could be argued that not even Article XI can be interpreted as imposing an obligation.

In relation to the "Principles Relating to Remote Sensing of the Earth from Outer Space", it is important to mention that their binding nature is debated, given that they are considered to be a soft law instrument. Moreover, their scope is limited in the wording of Principle I: they govern remote sensing activities only "for the purposes of improving natural resources management, land use and the protection of the environment". Consequently, any remote sensing activity with different objectives would not fall within the purview of said principles.

To conclude, after examining the opposing theories, I can affirm that the acquisition of intelligence information during peacetime is not as straightforward as the common practice of States would suggest; on the contrary, it gives raise to certain doubts.

I am aware that States typically gather a substantial amount of information through satellites, ranging from non-sensitive to sensitive information. It is likely that those States which aim to adhere to the greatest extent possible to the legal framework described above will share non-sensitive information, while keeping sensitive information confidential.

In relation to the acquisition of intelligence information, one final issue is worth examining. Can a State invoke Article 51 of the United Nations Charter in relation to the acquisition of intelligence information on its territory by another State? According to Article 51 of the United Nations Charter:

[16] Marchisio 2022: 278.

> "Nothing in the present Charter shall impair the inherent right of individual or collective self-defence if an armed attack occurs against a Member of the United Nations, until the Security Council has taken measures necessary to maintain international peace and security."

The interpretation of Article 51 of the United Nations Charter is currently a matter of contention.[17] Strictly adhering to the text of the clause, the right of self-defence is triggered only by an armed attack that is currently happening. Therefore, since the mere acquisition of intelligence information cannot be equated with an ongoing armed attack, any claim of a right to self-defence under Article 51 of the United Nations Charter can be ruled out. In other words, the State that is being observed by satellites would not have the right to attack either the satellites or any other assets (or the territory) of the observing State.

On the other hand, according to a broader interpretation of Article 51 of the United Nations Charter, a State may invoke the right of self-defence even before being attacked and "strike first" to prevent an attack. As a precondition, however, it is necessary that the attack by the other State be at least imminent. Under this interpretation, the acquisition of intelligence information may be considered a preparatory activity for an armed attack, which could be used as a pretext by the observed State to launch an attack against the observing State.

My view on these two interpretations of Article 51 of the United Nations Charter is rather straightforward: in general terms, I believe that the first interpretation should be followed, and no right of self-defence can be triggered unless an armed attack is actually occurring.

However, even if one were to apply the second interpretation and accept the concept of "preventive strikes", I firmly believe that the mere acquisition of intelligence information by means of satellites would not be sufficient to justify acting in self-defence under Article 51 of the United Nations Charter. This type of activity does not imply that an attack is imminent. Furthermore, it is inherently non-aggressive and, consequently, it must be considered to be

[17] Ferreira-Snyman 2022: 78; Picone 2016: 11.

permitted under the Outer Space Treaty and international law. Since there is no violation of international law, the observed State cannot take any form of countermeasure.

On the contrary, if someone were to argue that even non-aggressive military activities are prohibited in space (which is, however, a rather outdated theory), the principle of proportionality inherent in Article 51 of the United Nations Charter would imply that only non-aggressive countermeasures can be taken. Consequently, even under the interpretation that allows for preventive attacks, the mere activity of acquiring intelligence information would not be sufficient to justify a claim of self-defence. The observed State would need to provide additional evidence to substantiate that the State acquiring intelligence information is actually planning an attack.

GUIDANCE FOR WEAPON ATTACKS AGAINST TARGETS ON EARTH

Satellites also play a significant role in warfare scenarios. As in peacetime, satellites are used to gather intelligence information on other States that are regarded as enemies in this context. In my opinion, in a warfare scenario, there is no doubt that there are no prohibitions on employing satellites for this purpose, nor is there an obligation to share the acquired information with the enemy. In a wartime context, however, an additional use of satellites may play a fundamental role. This is the application of satellites as "gun sights" to guide missile attacks against objectives located on Earth. In the following paragraphs, I will delve into the legal implications associated with this usage of satellites.

I believe that the use of satellites to guide weapon attacks should actually be welcomed, as the greater the accuracy of the technology, the more tailored the attacks can be, thereby aligning with the legal framework known as "International Humanitarian Law".

International Humanitarian Law tries to strike a delicate balance between the principle of military necessity and the principle of humanity.[18] Through this legal framework, the interpretation of the principle of military necessity has evolved over time.[19] Prior to the First World War, it was commonly believed that the principle of military necessity granted a State that is engaged in warfare with another State the authority to employ any means it deemed necessary to subjugate the enemy, even if it involved committing atrocities and disregarding humanitarian laws.

However, this perspective is now considered outdated. The International Court of Justice has recognised that "certain general and well-recognized principles, namely: elementary consideration of humanity"[20] must always be taken into account, as a "minimum yardstick".[21] Therefore, the use of force is now subject to limitations: it should be employed only to the extent that is strictly necessary to subdue the enemy, with the aim of minimising unnecessary suffering. In other words, when States engage in armed conflict, they are now obligated to comply with the rules of humanitarian law.

In this new perspective, the use of precise technologies such as satellites to target objectives on Earth represents a double-edged sword. On the one hand, as mentioned earlier, satellites can assist states in complying with the International Humanitarian Law. On the other hand, belligerent States have no justifications for non-compliance, and they must be held accountable for any violations.

18 Schmitt 2010: 798.

19 Ronzitti 2020: 215.

20 *The Corfu Channel Case* 1949: 22. *Case Concerning Military and Paramilitary Activities in and against Nicaragua (Nicaragua v. United States of America)* 1986: para. 215. Legality of the Threat or Use of Nuclear Weapons, Advisory Opinion 1996: para. 79.

21 *Case Concerning Military and Paramilitary Activities in and against Nicaragua (Nicaragua v. United States of America)* 1986: para. 218.

The fundamental principles of International Humanitarian Law

With this in mind, it is worth reviewing the fundamental principles of International Humanitarian Law, which implement the balance between the principle of military necessity and the principle of humanity, namely the principle of distinction, the principle of proportionality and the principle of precaution in attacks.[22] This examination will refer to the codification of these principles contained in the Additional Protocol I to the Geneva Convention. It is important to note, however, that these principles have been recognised as principles of international customary law.[23] As a result, these principles bind all States, including those that are not party to Additional Protocol I to the Geneva Convention.

The principle of distinction

At the core of the system lies the principle of distinction. According to Article 48 of the Additional Protocol I to the Geneva Convention, the parties involved in the conflict "shall at all times distinguish between the civilian population and combatants and between civilian objects and military objectives" and "accordingly shall direct their operations only against military objectives". Consequently, only combatants and military objectives are lawful targets.

In this respect, Article 52 defines "military objectives" as "those objects which by their nature, location, purpose or use make an effective contribution to military action and whose total or partial destruction, capture or neutralization, in the circumstances ruling at the time, offers a definite military advantage".

An explanation of the definition of "military objective" is contained in the *Commentary on the HPCR Manual on International Law Applicable to Air and Missile Warfare* 2010: 106–108. According to the commentary, in order for an object to qualify as a military

22 Stephens–Steer 2015: 13.

23 Legality of the Threat or Use of Nuclear Weapons, Advisory Opinion 1996: para. 78; *Prosecutor v. Stanislav Galić* 2006: para. 87.

objective, it must fulfill not only the requirement of "making an effective contribution to military action" through its nature, location, purpose, or use but also the condition that its "total or partial destruction, capture, or neutralization, in the circumstances ruling at the time, offers a definite military advantage". The commentary further elaborates that qualifying an object as a military objective by "nature" requires the object to possess inherent characteristics or attributes that contribute to military action. Examples include military equipment and facilities, tanks, military aircraft, military airfields, or military barracks, among others. Consequently, even when not in use, these objects are legitimate targets during armed conflict. The criterion of "location" refers to specific areas that hold strategic significance in military operations, such as a particular mountain pass that could serve as an escape route for enemy forces during a planned attack. Considering the location of the pass, it is permissible to target it through aerial attacks regardless of its current use. The distinction between "purpose" and "use" is more intricate. "Use" refers to the present function of an object, whereas "purpose" focuses on its intended future use. By applying the "purpose" criterion, if an attacker has reasonable grounds to believe that the enemy intends to use an object for military purposes in the future, the attacker can lawfully target it even before the commencement of its military use. The commentary provides an example: the attacker, based on reliable intelligence and other information, discovers that an apartment building is being renovated to serve as a military barracks. In this case, the apartment building becomes a military objective by dint of its purpose, regardless of its actual use. The "use" criterion, on the other hand, requires the object to be actively used for military purposes, even if it initially appears civilian in nature. In other words, the object is not inherently a military objective but becomes a legitimate target as a result of its conversion for military use. It is important to clarify that once the object ceases to serve a military purpose, it no longer qualifies as a lawful target and may not be attacked.

Furthermore, if there is any doubt regarding whether an object that is typically dedicated to civilian purposes is being used to contribute effectively to military action, it shall be presumed that it is not being so used.[24]

[24] According to Article 52, para. 3 of the Additional Protocol I to the Geneva Convention: "In case of doubt whether an object which is normally dedicated to civilian purposes, such

As a consequence of the principle of distinction, "indiscriminate attacks" are always prohibited.[25] In particular, given their indiscriminate nature, "carpet bombing", which treats clearly separated and distinct military objectives located in a populated area as a single military target, are prohibited.[26]

The principle of proportionality

It is possible, however, that despite an attack being directed at and hitting a military objective, it may also result in what is known as "collateral damage", i.e. damage to civilians or civil objects.[27] In order to avoid or at least minimise

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as a place of worship, a house or other dwelling or a school, is being used to make an effective contribution to military action, it shall be presumed not to be so used."

[25] According to Article 51, para. 4 of the Additional Protocol I to the Geneva Convention: "Indiscriminate attacks are: a) those which are not directed at a specific military objective; b) those which employ a method or means of combat which cannot be directed at a specific military objective; or c) those which employ a method or means of combat the effects of which cannot be limited as required by this Protocol; and consequently, in each such case, are of a nature to strike military objectives and civilians or civilian objects without distinction."

[26] Ronzitti 2020: 320. According to Article 51, para. 5 of the Additional Protocol I to the Geneva Convention: "Among others, the following types of attacks are to be considered as indiscriminate: a) an attack by bombardment by any methods or means which treats as a single military objective a number of clearly separated and distinct military objectives located in a city, town, village or other area containing a similar concentration of civilians or civilian objects; and b) an attack which may be expected to cause incidental loss of civilian life, injury to civilians, damage to civilian objects, or a combination thereof, which would be excessive in relation to the concrete and direct military advantage anticipated." According to the *Commentary on the HPCR Manual on International Law Applicable to Air and Missile Warfare* 2010: 89, Rule 13 (b), various factors can contribute to an attack being regarded as indiscriminate. These factors include the nature of the target, the choice of weapons, the malfunctioning of weapon systems, human error and other circumstances. Even when target identification and weapons guidance systems are employed, there may still be instances where attacks become indiscriminate due to factors such as adverse weather conditions or other unforeseen circumstances.

[27] According to the definition contained in Bruderlein 2009: 3, "collateral damage" means "incidental loss of civilian life, injury to civilians and damage to civilian objects or other protected objects or a combination thereof, caused by an attack on a lawful target".

collateral damage, the principle of proportionality comes into play. According to this principle, attacks that "may be expected to cause incidental loss of civilian life, injury to civilians, damage to civilian objects, or a combination thereof, which would be excessive in relation to the concrete and direct military advantage anticipated" are prohibited.[28]

The principle of proportionality must be taken into consideration at all stages of an attack, from planning to implementation. If it becomes apparent during the planning phase that the attack may result in the incidental loss of civilian life, injury to civilians, or damage to civilian objects, commanders must refrain from launching it. Similarly, if it becomes apparent after the attack has been launched that it may cause the aforementioned collateral damage, those responsible for its implementation must suspend it.

In order to fully understand the scope of the principle of proportionality, it is worthwhile examining the language used in the rules contained in Additional Protocol I to the Geneva Convention. Firstly, it should be emphasised that collateral damage is relevant only if it is "excessive". Furthermore, the concept of excessiveness is not absolute, but must be weighed against "the concrete and direct military advantage anticipated". Consequently, even if the collateral damage caused is extensive, it does not necessarily imply that it is "excessive".[29]

The terms "expected" and "anticipated" indicate that the assessment of the attack and military advantage must be made in advance *(ex ante),* and not after the fact *(ex post).* The evaluation is based on all available up-to-date and reliable information accessible to the attacking party at that time, considering the reasonable precautions that could have been taken in the given circumstances. The consequences of any actions taken must be assessed in terms of probability, i.e. whether an outcome is more likely than not.[30]

28 See Articles 51, para. 5, point b), 57 para. 2, point a), iii) and 57 para. 2, point b) of the Additional Protocol I to the Geneva Convention.

29 *Commentary on the HPCR Manual on International Law Applicable to Air and Missile Warfare* 2010: 92.

30 *Commentary on the HPCR Manual on International Law Applicable to Air and Missile Warfare* 2010: 92.

The term "concrete and direct", in reference to military advantage, implies that only measurable, "substantial and relatively close"[31] advantages are relevant. Speculative advantages,[32] long-term effects, or psychological consequences[33] are to be disregarded.[34]

Another aspect to be considered pertains to the specific segment of the military operation on which the proportionality assessment must be conducted. Specifically, there is a debate regarding whether proportionality should apply to each individual attack on a specific target, a series of attacks within the same military operation, or the entire armed conflict. According to the majority view,[35] the proportionality assessment should be applied to the military operation as a whole, rather than to each individual attack on a specific target or the entirety of the armed conflict.

31 Sandoz et al 1987: para. 2209.

32 *Commentary on the HPCR Manual on International Law Applicable to Air and Missile Warfare* 2010: 92.

33 Ronzitti 2020: 279. According to the *Commentary on the HPCR Manual on International Law Applicable to Air and Missile Warfare* 2010: 91, the definition of "collateral damage" does not include inconvenience, irritation, stress, fear or other intangible conditions caused to the civilian population. It is limited to death/injury to civilians, or to damage/destruction of objects.

34 According to the *Commentary on the HPCR Manual on International Law Applicable to Air and Missile Warfare* 2010: 110, there is a contentious debate regarding the qualification of "war-sustaining" economic objects as military objectives. "A war-sustaining economic object is one which indirectly but effectively supports the enemy's overall war effort." Those who argue in favour of considering war-sustaining economic objects as military objectives assert that it is permissible to target export production generating revenue for financing the war. For example, Stephens–Steer 2015: 21 report that during the American Civil War, Confederate cotton fields were destroyed because the sale of cotton funded the importation of weapons and ammunition. The U.S. Courts that afterwards adjudicated on the matter deemed such targets as lawful. However, as the commentary reports: "The majority of the Group of Experts took the position that the connection between revenues from such exports and military action is too remote. Consequently, it rejected the war-sustaining argument."

35 Ronzitti 2020: 279. *Commentary on the HPCR Manual on International Law Applicable to Air and Missile Warfare* 2010: 93.

As a final comment on the principle of proportionality, it is worth considering a passage from the judgement rendered by the International Criminal Tribunal for the former Yugoslavia in the *Kupreskic* case.[36] The Court highlighted that the language used in Additional Protocol I to the Geneva Convention suggests a broad margin of discretion for the attacking party when assessing proportionality.

> "In the case of attacks on military objectives causing damage to civilians, international law contains a general principle prescribing that reasonable care must be taken in attacking military objectives so that civilians are not needlessly injured through carelessness. This principle, already referred to by the United Kingdom in 1938 with regard to the Spanish Civil War, has always been applied in conjunction with the principle of proportionality, whereby any incidental (and unintentional) damage to civilians must not be out of proportion to the direct military advantage gained by the military attack. In addition, attacks, even when they are directed against legitimate military targets, are unlawful if conducted using indiscriminate means or methods of warfare, or in such a way as to cause indiscriminate damage to civilians. These principles have to some extent been spelled out in Articles 57 and 58 of the First Additional Protocol of 1977. Such provisions, it would seem, are now part of customary international law, not only because they specify and flesh out general pre-existing norms, but also because they do not appear to be contested by any State, including those which have not ratified the Protocol. Admittedly, even these two provisions leave a wide margin of discretion to belligerents by using language that might be regarded as leaving the last word to the attacking party." (*Prosecutor v. Kupreskic and others* 2000: para. 524)

However, the Court also underscored that this is an area "where the 'elementary considerations of humanity' [...] should be fully used".

36 *Prosecutor v. Kupreskic and others* 2000.

> "Nevertheless this is an area where the 'elementary considerations of humanity' rightly emphasised by the International Court of Justice in the Corfu Channel, Nicaragua and Legality of the Threat or Use of Nuclear Weapons cases should be fully used when interpreting and applying loose International rules, on the basis that they are illustrative of a general principle of international law" (*Prosecutor v. Kupreskic and others* 2000: para. 524)

Consequently, the prescriptions of the Additional Protocol I (and the corresponding rules of customary law) "must be interpreted so as to construe as narrowly as possible the discretionary power to attack belligerents and, by the same token, so as to expand the protection accorded to civilians".

> "More specifically, recourse might be had to the celebrated Martens Clause which, in the authoritative view of the International Court of Justice, has by now become part of customary international law. True, this Clause may not be taken to mean that the 'principles of humanity' and the 'dictates of public conscience' have been elevated to the rank of independent sources of international law, for this conclusion is belied by international practice. However, this Clause enjoins, as a minimum, reference to those principles and dictates any time a rule of international humanitarian law is not sufficiently rigorous or precise: in those instances, the scope and purport of the rule must be defined with reference to those principles and dictates. In the case under discussion, this would entail that the prescriptions of Articles 57 and 58 (and of the corresponding customary rules) must be interpreted so as to construe as narrowly as possible the discretionary power to attack belligerents and, by the same token, so as to expand the protection accorded to civilians." (*Prosecutor v. Kupreskic and others* 2000: para. 525)

In essence, notwithstanding the loose language used in framing the rules, the ultimate aim remains the protection of civilians.

The principle of precaution in attacks

The third principle to be examined is the principle of precaution in attacks. As a preliminary and basic form of precaution, Article 57, paragraph 1, of the Additional Protocol I to the Geneva Convention recalls the principle of distinction: "In the conduct of military operations, constant care must be taken to spare the civilian population, civilians and civilian objects." To further strengthen this form of precaution, the last paragraph of Article 57 states: "No provision of this Article may be construed as authorizing any attacks against the civilian population, civilians or civilian objects." Such clarification is not redundant, considering that according to Article 57, paragraph 2, point c) when the attack may affect the civilian population, the attacking party is requested to give "effective advance warning", unless "circumstances do not permit". The wording of the clause may open the door to interpretations that legitimise attacks against the civilian population. Therefore, in order to eliminate the risk of such an interpretation, it is crucial to emphasise that any interpretation authorising attacks against civilians or civilian objects must be rejected.

Article 57 also mentions, as a form of precaution, the principle of proportionality. As previously pointed out, the assessment of proportionality shall be carried during the planning phase of the attack and may require adjustments during the implementation stage.

Other precautions are related to the selection of "military objectives" and "means and methods of attack". Regarding military objectives, "when a choice is possible between several military objectives for obtaining a similar military advantage" the objective that is "expected to cause the least danger to civilian lives and to civilian objects" shall be selected.[37] For instance, if the military advantage is similar and less danger is expected to civilians and civilian objects, attacking facilities providing power to the military objective instead of directly targeting the objective itself may be preferable.[38]

Regarding "means and methods of attack",[39] all feasible precautions must be taken "with a view to avoiding, and in any event to minimising incidental

37 Article 57, para. 3, of the Additional Protocol I to the Geneva Convention.

38 This example was given in the *Commentary on the HPCR Manual on International Law Applicable to Air and Missile Warfare* 2010: 128.

39 According to Bruderlein 2009: 4–5: "'Means of warfare' mean weapons, weapon systems or platforms employed for the purposes of attack" [Article 1, point (t)]; "'Methods of

loss of civilian life, injury to civilians and damage to civilian objects".[40] Consequently, the aim of avoiding, or at least minimising "collateral damage" must be the driver in the selection of all "weapons, weapon systems and munitions, as well as tactics (such as timing, angle and altitude of attack)".[41]

With specific reference to precision guided missiles, the Harvard Manual states that there is no specific obligation for belligerent parties to use such weapons. However, the Manual recognises that there may be situations where the use of precision guided missiles is the only way to avoid indiscriminate attacks or to reduce the risk of collateral damages.[42]

The Commentary on the Harvard Manual provides further insight into this issue, clarifying that when "appropriate target identification or weapon guidance technologies" are available and their use is "militarily feasible", conducting air missile attacks against military objectives without employing such technology is prohibited. Similarly, the attack must be cancelled if "such assets are not available, and the attacker for this reason is not able to comply with the prohibition against indiscriminate attacks".[43]

Lastly, precautions should not only be taken by the attacking party but also by the defending party. The defending party, "to the maximum extent feasible"

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warfare' mean attacks and other activities designed to adversely affect the enemy's military operations or military capacity, as distinct from the means of warfare used during military operations, such as weapons. In military terms, methods of warfare consist of the various general categories of operations, such as bombing, as well as the specific tactics used for attack, such as high-altitude bombing" [Article 1, point (v)].

40 Article 57, para. 2, ii), Additional Protocol I to the Geneva Convention.

41 Bruderlein 2009: 126. According to the *Commentary on the HPCR Manual on International Law Applicable to Air and Missile Warfare* 2010: 127: "For instance, an attacker ought to choose a weapon with greater precision or lesser explosive force if doing so would minimize the likelihood of collateral damage, assuming the selection is militarily feasible. [...] Similarly, angle of attack is one of the factors that determine where a bomb may land if it falls short of, or beyond, the target. Thus, to spare a building located, e.g., to the west of a target, it may be advisable to attack from the north or the south."

42 Bruderlein 2009: 9, Rule 8.

43 *Commentary on the HPCR Manual on International Law Applicable to Air and Missile Warfare* 2010: 127. The commentary also specifies: "This general rule is particularly relevant if the military objectives are located in a densely populated area."

must ensure that military objectives are not located in close proximity to the civilian population.[44]

In conclusion, the application of the aforementioned principles of International Humanitarian Law implies a certain degree of discretion, and, consequently, it requires a careful consideration and weighting of various circumstances to strike an appropriate balance. The use of satellites can undeniably offer invaluable support in this respect.

IN WHICH CIRCUMSTANCES CAN A SATELLITE BECOME A MILITARY TARGET?

Satellites serve as a means to acquire intelligence information, and satellites can guide attacks against targets on Earth. It is evident that satellites play a crucial role in modern warfare, which makes them potential primary targets for belligerent parties. Therefore, it is essential to provide a brief overview of the circumstances and extent under which satellites can be lawfully targeted during armed conflicts.

The question of whether the rules of International Humanitarian Law also apply to Outer Space is a subject of debate. The legal framework governing warfare has traditionally been compartmentalised into different theatres such as land, sea and air, but there is currently no dedicated stand-alone regulation specifically addressing warfare in space.[45]

Such lack of specific regulation, in my opinion, does not mean that the principles of International Humanitarian Law do not apply to the domain

44 According to Article 58 of the Additional Protocol I to the Geneva Convention: "The Parties to the conflict shall, to the maximum extent feasible: a) without prejudice to Article 49 of the Fourth Convention, endeavour to remove the civilian population, individual civilians and civilian objects under their control from the vicinity of military objectives; b) avoid locating military objectives within or near densely populated areas; c) take the other necessary precautions to protect the civilian population, individual civilians and civilian objects under their control against the dangers resulting from military operations."

45 Stephens–Steer 2015: 8.

of space. As highlighted by the International Court of Justice in the Nuclear Weapons Advisory Opinion, the "intrinsically humanitarian character" of the legal principles in question permeates the entire law of armed conflicts and "applies to all forms of warfare and to all kinds of weapons, those of the past, those of the present and those of the future".[46]

Consequently, the reference to "all forms of warfare" and "all kind of weapons" (including those of the present and of the future) makes the "humanitarian legal framework" applicable also to wars which include Outer Space as a theatre, and to space weapons. Moreover, the applicability of the law of armed conflict in space has been recognised by the Oslo Manual[47] and prominent experts of space law.[48]

Given the applicability of the principles of International Humanitarian Law to warfare in space, it is important to examine how the principles of distinction, proportionality and precautions when making an attack are applied in relation to space assets such as satellites.

According to the principle of distinction, only military satellites can be targeted, while civilian satellites cannot be subjected to attacks.[49] As previously

[46] Legality of the Threat or Use of Nuclear Weapons, Advisory Opinion 1996: para. 86, 259.

[47] Dinstein–Dahl 2020: 3, Rule 2: "Outer Space operations are governed by international law, including the Charter of the United Nations and the applicable principles and rules of the Law of Armed Conflict (LOAC)."

[48] Stephens–Steer 2015: 11. In particular, the authors justify the applicability of the law of armed conflicts to space, referring to: 1. articles 35, para. 3 and 55 of Additional Protocol I to the Geneva Convention, posing obligations in relation to the environment; 2. the 1976 Convention on the Prohibition of Military or Any Other Hostile Use of the Environmental Modification Techniques; 3. the *Nuclear Weapons Advisory Opinion* of the International Court of Justice; 4. the Nicaragua and Corfù Channel cases; 5. Article 3 of the Outer Space Treaty; and 6. Article 38, para. 1 (c), of the Statute of the International Court of Justice, in relation to the applicability of the general principles of law, in absence of treaty and/or customary international law.

[49] According to Schmitt 2006: 121, a possible means of distinguishing between military and civilian satellites is by referring to the registration of the space object under the Registration Convention. However, it is crucial to emphasise that the registration must not be deceptive. Article 37 of the Additional Protocol I to the Geneva Convention prohibits acts of "perfidy", namely "Acts inviting the confidence of an adversary [...] with intent to betray

mentioned, the definition of "military objective" outlined in Article 52 of the Additional Protocol I to the Geneva Convention, is based on an asset's ability to make an effective contribution to military action through its nature, location, purpose, or use, while considering the advantage derived from its destruction.[50]

By applying this definition, satellites belonging to armed forces are considered military objectives by nature.[51] Consequently, they are "in principle"[52] considered lawful targets "at all times and in all circumstances during an armed conflict".[53] Satellites used for military operations are considered military objectives by use[54] and can be targeted as long as they are actively employed for military purposes.[55] Satellites located in strategically significant areas[56]

that confidence". Specifically, under point c), the clause explicitly mentions "the feigning of civilian, non-combatant status". Therefore, if a military satellite is falsely registered as a civilian satellite, such registration could be considered an act of perfidy, constituting a violation of International Humanitarian Law.

50 Dinstein–Dahl 2020: 9, Rule 10: "Civilian Outer Space systems and assets must not be the object of attack unless they qualify as military objectives – if not by nature – by location, purpose or use."

51 Dinstein–Dahl 2020: 9, Rule 9: "In principle, Outer Space systems and assets belonging to the armed forces constitute military objectives because, by nature, they make an effective contribution to the enemy's military action."

52 Dinstein–Dahl 2020: 9 emphasised: "The words 'in principle' were included to clarify that this was a general rule subject to exceptions. For example, medical aid stations in Outer Space belonging to the military would be excluded."

53 Dinstein–Dahl 2020: 9.

54 According to the *Commentary on the HPCR Manual on International Law Applicable to Air and Missile Warfare* 2010: 109: "Any military use of a civilian object renders it a military objective."

55 *Commentary on the HPCR Manual on International Law Applicable to Air and Missile Warfare* 2010: 108.

56 According to the *Commentary on the HPCR Manual on International Law Applicable to Air and Missile Warfare* 2010: 107: "Similarly, an attacker may wish to blind the enemy by depriving it of high ground from which it could observe the attacker's operation. […] The governing criterion is the need to attack a location so as to enhance or safeguard the attacker's operations or to diminish the enemy's options." For instance, the cislunar space is considered to hold strategic significance (see in this respect Berger 2022) and therefore an attacker may target a satellite located in that area.

may qualify as military objectives by location,[57] and they may be targeted even regardless of their use.[58] Additionally, certain satellites that are not currently used for military reasons but may be used for such reasons in the future can be qualified as military objectives by purpose, meaning their "intended future use".[59] These satellites can be targeted if there are reasonable grounds to believe that the enemy intends to use them for military purposes in the future.

The distinction between civilian objects and military objectives can become more difficult to draw when considering the existence of dual-use satellites, which provide both civilian and military services.[60]

Despite their role in providing civilian services, dual-use satellites can be qualified as military objective by use, if, and as long as, they are also used for military purposes. Furthermore, they may also be qualified as military objectives by purpose, if there are reasonable grounds to believe that they will be employed for military reasons in the future.

As in any other case where a military objective is targeted, collateral damage can occur when attacking a satellite that is deemed a "military objective". Therefore, the principle of proportionality must also be applied when targeting satellites, balancing the incidental damage to civilians and civilian objects (which is relevant only if it is "excessive") against "the concrete and direct military advantage anticipated".

In particular, the proportionality assessment must be conducted with utmost care when targeting dual-use satellites. Dual-use satellites, by definition, provide both civilian and military services. As a result, the likelihood of collateral

[57] *Commentary on the HPCR Manual on International Law Applicable to Air and Missile Warfare* 2010: 107.

[58] According to Stephens–Steer 2015: 17: "A satellite which is not used by military, but which may be in close proximity to a military satellite, and whose total or partial destruction, capture or neutralisation may affect a military need due to its proximity to any other military object, may become legitimate target."

[59] *Commentary on the HPCR Manual on International Law Applicable to Air and Missile Warfare* 2010: 107.

[60] Certainly, also for satellites, Article 52, para. 3, Additional Protocol I to the Geneva Convention applies whereby, in case of doubt, it is presumed that an object is not used for military purposes.

damage significantly increases when such satellites are targeted. A strike on a dual-use satellite will inevitably disrupt services provided to civilians.

In cases like these, Article 54, paragraph 2, of the Additional Protocol I to the Geneva Convention plays a crucial role in establishing the boundaries beyond which collateral damage is deemed unacceptable. This provision explicitly makes it prohibited "to attack, destroy, remove, or render useless objects indispensable to the survival of the civilian population".[61]

Consequently, attacks on satellites that are essential for delivering critical civilian services on Earth should be prohibited. There is ongoing debate regarding satellites that provide positioning systems, such as GPS. These types of satellites provide both military and civilian services, which, among other things, have a significant economic impact, considering that 6–7% of European GDP relies on satellite navigation.[62] In our opinion, when a global positioning system is integrated into applications that provide services that are crucial for human safety, targeting such satellites should be ruled out.[63]

As for the principle of precaution in attacks, it is essential to exercise careful judgment in selecting the means and methods of attack. Specifically, belligerent parties should avoid conducting kinetic attacks against satellites.[64] Kinetic attacks refer to actions that have the potential to completely destroy satellites, resulting in the generation of a significant amount of debris that poses a risk of collision with other space objects. Therefore, when targeting satellites, it is preferable to use weapons that can disable the functionality of the device without causing its complete destruction.

61 Article 54, para. 2, of the Additional Protocol I to the Geneva Convention also provides a list of "objects indispensable to the survival of the civilian population", such as "foodstuffs, agricultural areas for the production of foodstuffs, crops, livestock, drinking water installations and supplies and irrigation works".

62 Such data are provided by the European Space Agency in ESA s. a.

63 Reference can be made, for instance, to "disaster management applications, or remote monitoring of dams and drinking water installations". See in this respect Stephens–Steer 2015: 20.

64 See in this respect Dinstein–Dahl 2020: 10, Rule 11: "In Outer Space operations constituting attacks, assessments of collateral damage should take into consideration the effects of space debris expected to result from the attack."

CONCLUSIONS

The "space legal framework" often faces criticism, with many arguing that it is outdated, excessively vague and inadequate for regulating modern space activities. As explained earlier, even certain "ordinary activities", such as acquiring intelligence information during peacetime, can come under scrutiny due to specific clauses outlined in legal instruments.

During times of war, the "inherently humanitarian character" that permeates the entire law of armed conflicts enables the establishment of rules of conduct that should always be adhered to (although, unfortunately, violations of International Humanitarian Law continue to be witnessed in contemporary conflicts).

All the principles discussed in this article – the principle of cooperation, benefit-sharing and the principles of International Humanitarian Law – are undoubtedly of great value. These principles are common among all States and are fully recognised by the international community.

It is to be hoped that these principles will not remain mere declarations but will inspire individuals to conduct themselves accordingly, both in space and on Earth, especially in these uncertain times.

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Nikolaos Charalampopoulos

The Menace of Space Terrorism

INTRODUCTION

As we delve further into the cosmos, propelled by technological advancements and an insatiable curiosity, we face an intriguing yet sobering prospect: the possibility of terrorism in space. While our exploration of the final frontier has thus been characterised by wonder, scientific discovery and international cooperation, we must acknowledge that the vastness of outer space also presents unique security challenges.

The use of violence and intimidation in the pursuit of political, religious, or ideological aims knows no bounds when it comes to its potential theatre of operations. Just as we have seen terrestrial acts of terrorism target critical infrastructure, civilian populations and political entities, so too must we consider the implications of such actions extending beyond our atmosphere. The allure of space, with its strategic importance, valuable assets and potential for disruption, makes it a possible target for those with malicious intent. From satellites vital for communications, navigation and weather forecasting to space stations serving as hubs for scientific research and international cooperation, the potential targets are numerous and significant.

Moreover, the democratisation of space exploration has lowered barriers to entry, allowing both state and non-state actors to access space with relative ease. The decreasing launch cost and the increasing capability of relatively cheap, small satellites make it easier for governments, corporations and academics to access space. The risk of interference, sabotage, or outright attacks grows commensurately as space becomes increasingly crowded with satellites, spacecraft and future habitats. While the prospect of terrorism in space may seem like science fiction to some, we must confront it with the same seriousness

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and foresight that we apply to terrestrial security challenges. This necessitates robust technological safeguards, international collaboration, and a deeper understanding of the socio-political dynamics driving such threats. As scholars and practitioners in science, technology and international relations, we must explore these issues with nuance, foresight, and a commitment to safeguarding the peaceful exploration and utilisation of space for the betterment of humanity.

The paper contains five sections: Introduction; Methodology; Literature review about terrorism and space terrorism; Review of historical space terrorism cases; and Conclusions. This structure provides information about historical trends and cases that can constitute the frame for systematic research on space terrorism.

The third section presents proposed definitions of terrorism to expand the notion of what can be considered space terrorism. The following section describes various cases and incidents reported as space terrorism. The goal is to present how non-state groups and organisations attacked the space sector for political reasons. The exact section presents how some states use the space industry to counterterrorism. Consequently, since the state uses the space industry for counterterrorism, it becomes a target for non-state actors to protect themselves.

THE CONCEPT OF TERRORISM

For this article, it is essential to understand terrorism as the use of violence aimed at political goals and executed by either a state or a non-state actor.

It has been widely discussed by the academic community dealing with the subject of terrorism that there is no commonly accepted definition of terrorism. Also, a few of those who have been labelled as terrorists describe themselves as such. Despite this fact, however, it is typical for adversaries in a violent conflict to describe each other as terrorists or to characterise their actions as an exercise in terrorism. This is partly because the term is politically and emotionally charged, "a word with an inherently negative connotation, in modern times, which one generally applies to one's enemies and opponents".[1]

Scholars of terrorism, mainly in the 1970s, 1980s and 1990s, preferred their definition, but no one was widely accepted. Here are indicative views of some academics on the subject: Paul Wilkinson notes that in the literature, the terror practiced by the state is referred to as "terror", while the terror practiced by para-state actors is referred to as "terrorism". He uses this distinction in his analyses, pointing out that state terror has been far more massive and deadly than terrorism. According to him, terrorism is not a philosophy or a movement but a method.[2] Martha Crenshaw considers that terrorism becomes transnational when it relates to people of different ethnicities and when its goals do not affect the government of just one state.[3] The American historian David Rapoport developed the wave theory and, in doing so, summarised the evolution of modern democracy. According to Rapoport, starting from the end of the 19th century, four waves were described as "anarchist", "anti-colonial", "new left" and "religious". Rapoport does not treat terrorism independently of political ideas but as a result of them.[4] Noel O'Sullivan argues that political terrorism exists when a group, whether it owns or does not hold a government position, decides to pursue a series of ideological goals by methods that not only subvert or ignore the demands of domestic and international law but also rely primarily on the threat or use of force for their success.[5] Walter Laqueur points out that in the 1970s, it was common for "terrorism" to be attributed almost exclusively to left-wing and revolutionary groups, as at that time, these types of organisations had priority. This targeting led to errors and misunderstandings, as it ignored the history of terrorism at the global level.[6] Louise Richardson, seeking to define the difference between insurgents and

1 Hoffman 1998: 32.
2 Wilkinson 2001: 21.
3 Crenshaw 1975: 20.
4 Rapoport 2002.
5 O'Sullivan 1986: 5.
6 Laqueur 2004: 1.

terrorists, states: "Insurgents are a rogue army fighting the regular forces of the state. They follow military methods and usually have many followers, allowing them to engage in quasi-military operations. The purpose to them is the military defeat of the enemy. In contrast, terrorists rarely have any illusions about their ability to coerce to military defeat the enemy."[7] Alex P. Schmid proposed the following definition in 1992 in the United Nations Crime Branch: "Act of Terrorism = Peacetime Equivalent of War Crime."[8]

According to Professor Wilkinson, to understand modern terrorism, "it is useful to employ a basic typology of contemporary perpetrators of terrorism based on their underlying cause of political motivation".[9]

Wilkinson's typology is as follows:

- *Nationalist terrorists are groups seeking political self-determination.* Their struggle focuses mainly on the area they want to liberate, but they may be active both in their homeland and abroad.
- *Ideological terrorists.* These groups seek to change their entire political, social and economic system either to an extreme left or extreme suitable model.
- *Religiopolitical terrorists.* Examples of this type of terrorism are groups such as Hamas or Hezbollah. Violent groups from other religions can also be found among Sikhs, Hindus, Hebrews and Christians.
- *Single issue terrorists.* These groups focus their activities exclusively on changing a specific policy or practice, such as environmental issues, animal rights and anti-abortion.
- *State-sponsored and state-supported terrorists.* States use this type of terrorism both as a tool of domestic and foreign policy.[10] Consequently, and following Wilkinson's typology, we cannot limit terrorism, and hence space terrorism, to being carried out only by non-state actors. So-called "state terrorism" cannot be excluded from this study.

7 Richardson 2007: 37.
8 Schmid–Jongman 1988: 5–6.
9 Wilkinson 2001: 20.
10 Wilkinson 2001: 21.

In addition to the lack of a commonly accepted definition of terrorism, the meanings attributed to the term change according to the historical and social frame. After the French Revolution, in which terrorism was considered a virtue, anarchist organisations and later members of the Russian organisation Narodnaya Volya did not hesitate to call themselves terrorists and present their actions as terrorists.[11]

Recently, several terms, such as extremism, terrorism, insurgents, anti-government struggle, liberators and militants, have been used to describe the same or a similar situation. Further, "extremist" or "extremism" may refer to political ideologies opposing a society's fundamental values and principles. In the context of liberal democracies, this could apply to any ideology that advocates racial or religious supremacy and disagrees with the basic principles of democracy and universal human rights. The term can also describe the methods by which political actors try to realise their goals, that is, by using means that "show indifference to life, liberty and human rights of others".[12]

Today, the diversity of the situations and activities described as "terrorism" shows that this word is used as a technical term by the official authority of each state either to define a domestic threat (for example, a minority group, a different political expression, immigrants) or identify a threat from abroad, depending on interests. This practice is inconsistent, as it is applied differently in similar cases. For example, al-Qaeda in Afghanistan was treated quite differently by the Western allies than al-Qaeda in Libya or Syria. Also, far-right violence was not, until recently, labelled as terrorism, as is usually the case with far-left violence and Islamist violence.[13]

For all the above reasons, the writer argues in his book[14] that instead of trying to interpret the definitions of "extremism", "guerrilla", "terrorism" and other terms, it should first be seen that in all cases, the violence used by these groups or organisations has a political purpose and, secondly, to give an interpretation

11 Most 1987: 100–109.
12 Neumann 2010: 21.
13 Charalampopoulos 2019: 157.
14 Charalampopoulos 2019: 158.

of the reason why a specific characterisation will be given to these groups by the respective subject (governments, international organisations, official authorities). This practice will allow those interested in it to examine political violence against official institutions of power as a timeless phenomenon that existed from ancient Greece, with the assassination of tyrants, to the French Revolution, the anti-colonial struggles and the terror activities of our days.

THE SHIFTING DOMAINS OF TERRORISM

For this article and to understand the main argument, it is essential to present the development of violence from the land to the sea and further to the air. This will help us realise that forms of political violence follow wherever human activity develops. This applies not only to the territory of states where a state's essential human, social and political functions are carried out but also to the areas of the Earth, such as sea and air, where man mainly develops business, research and war activities.

Historically, terrorism has predominately been associated with acts of violence perpetrated on land, targeting government institutions, government personnel, properties, infrastructure, and, recently, civilian populations. However, the changing dynamics of global security have led to a paradigm shift, prompting terrorist organisations to explore new theatres of operations.

One such theatre is the sea, which has also become a fertile ground for terrorist activities. Maritime terrorism encompasses a range of illicit activities, including piracy, smuggling and attacks on maritime infrastructure. The vastness and complexity of maritime domains, coupled with limited surveillance and enforcement capabilities, create ample opportunities for terrorist organisations to operate with relative impunity.

Notable examples of maritime terrorism include the 2008 Mumbai attacks, where terrorists arrived by sea to launch coordinated assaults on multiple targets along the Indian coastline, showcasing the adaptability and resourcefulness of terrorist groups in exploiting maritime vulnerabilities.

Possible problems with shipping, especially oil tankers, pose significant problems for Western economies and could prove a potential parameter of extremist movements. During the last decade, the activities of piracy have increased the likelihood of terrorists being involved in such operations. The possibility of a terrorist attack at sea, as it is an area without clear boundaries and rules, has preoccupied researchers of violence.[15]

The Houthis exemplify this phenomenon. As a rebel group active in Yemen, they have recently engaged in assaults against maritime vessels within the region. Specifically, their targets often include ships navigating strategic maritime passages like the Bab el-Mandeb Strait and the Red Sea. The tactics employed by the Houthis encompass missile strikes, deployment of sea mines and utilisation of explosive-laden watercraft. These aggressive actions pose a substantial menace to maritime security, jeopardising both trade routes and the safety of individuals aboard targeted vessels.[16] The global community vigilantly monitors such occurrences and endeavours to mitigate the underlying conflicts and tensions exacerbating maritime instability in the area.[17]

Some scholars identify pirates with terrorists as "enemies of humanity" as they operate outside the bounds of legal behaviour.[18] However, in the conclusion of their research, they do not suggest an absolute identification of the pirate with the terrorist, as the two acts – piracy and terrorism – are not identified mainly due to the perpetrators' intentions behind each act. That is, while piracy was originally a form of private use of force, it could be part of general terrorism as a means for financing activities. Moreover, the sea has not historically been a central area of terrorist activities.[19] Moreover, there have also been reports of suicide attacks on Western-interest shipping in the Mediterranean using small supertanker boats in the Strait of Gibraltar and yachts carrying tourists from Israel to Turkey.[20]

15 Murphy 2007: 11–44.
16 Charalampopoulos 2024.
17 Krane 2024.
18 Thorup 2009: 401–411.
19 Jenkins et al. 1989: 3.
20 Percival 2005: 9.

Further, the kidnappings of EU citizens and the deaths of some of them have identified piracy with terrorism, leading to the British Government's view that "ransom is not paid to terrorists".[21] Sharing the same view, French President Nikolas Sarkozy authorised the French Special Forces to attack pirates inside Somali territory after the abduction of the ship "Le Ponant" in April 2008.

Moreover, on 6 October 2002, the suicide bombers' attack against the French oil tanker "M/V Limbur" in the Gulf of Aden caused a short-term collapse of navigation in the Gulf, an oil price rise of 40 cents per barrel and a cost of 3.8 million to the economy of Yemen.[22] This is an example that causes worries as to the capabilities of extremist groups to cause extensive damage to specific countries' economies. Also, on 12 October 2002, an al-Qaeda attack against the U.S.S. Cole in the port of Aden killed 17 U.S. Marines. Finally, the sea attacks coming from Tamil Tigers against the authorities in Sri Lanka, as well as the sea attacks of the Free Aceh Movement in Indonesia, contribute, in some cases, to the further identification of piracy with terrorism.[23]

In addition to maritime environments, the airspace has emerged as a fertile ground for terrorist activities. The emergence of aviation has heralded a paradigm shift in modes of transportation and commerce, offering a potent means for inflicting mass casualties and instilling widespread fear. Regrettably, instances such as the 11 September attacks exemplify the devastating consequences when commercial airliners are weaponised, thereby underscoring the vulnerability of the aviation sector to exploitation by terrorist entities. Furthermore, the proliferation of uncrewed aerial vehicles (UAVs), colloquially known as drones, has introduced novel complexities in airspace security. While drones offer multifaceted advantages across diverse sectors such as agriculture, filmmaking and surveillance, their deployment also poses a potential threat, as they could be utilised by malevolent actors to perpetrate aerial assaults or to conduct reconnaissance in preparation for future terrorist activities.

21 BBC News 2008.

22 Sheppard 2003.

23 Charalampopoulos 2020: 24.

Air piracy, also referred to as aircraft hijacking, has been a persistent challenge throughout the history of commercial aviation. While its roots trace back to the early days of flight, recorded instances began gaining prominence notably in 1931, exemplified by Peruvian revolutionaries' hijacking of a commercial airliner.[24] During the post-World War II period, the initial wave of hijackings essentially involved refugees seeking asylum from communist regimes.[25] However, hijacking emerged as a widespread phenomenon during the tumultuous decades of the 1960s and 1970s.

Motivated primarily by political objectives, hijackers during this era often aimed to draw attention to various causes or secure the release of political prisoners. Prominent examples include the 1968 hijacking of El Al Flight 426 by members of the Popular Front for the Liberation of Palestine and multiple instances of aircraft hijacked to Cuba by individuals seeking asylum or refuge from political persecution.[26] Palestinians employed airplane hijackings as a political tactic to internationalise their cause and pressure Israel and its allies into releasing Palestinian prisoners. The same year, U.S. criminals began hijacking flights to Havana to evade law enforcement.[27]

In response to the escalating threat of air piracy, governments worldwide implemented various security measures. These measures included the deployment of metal detectors and armed air marshals on flights. Additionally, international agreements such as the Hague Hijacking Convention of 1970[28] were established to define protocols for addressing hijackings and prosecuting perpetrators. Despite these initiatives, further shifts occurred with the introduction of sabotage bombings, exemplified by the Air India bombing in 1985 and the PanAm bombing over Lockerbie in 1988. Following the 9/11 attacks, hijackings decreased, yet the threat has not vanished entirely.

24 Veilleux-Lepage 2020: 58.
25 Scott 2019: 213–245.
26 Porat 2024.
27 Porat 2024.
28 November 1972: 642–656.

Despite significant advancements in aviation security and international cooperation, hijackings have persisted, albeit less frequently, in recent decades. Incidents are often motivated by criminal or terrorist agendas, underscoring the enduring relevance of aviation security as a paramount concern for governments and aviation authorities globally.[29] Paul Wilkinson underscores the utility of hijacking for terrorist groups as a means to symbolise enmity towards designated "enemy" nations and to acquire hostages, often including prominent individuals from various countries, thus accentuating the potential significance of airspace hijackings in this context.[30]

The expansion of terrorism into airspace and the sea underscores the need for a comprehensive and multi-dimensional approach to security. This includes bolstering aviation security measures, enhancing maritime domain awareness, and fostering international cooperation to address space security threats effectively.

EXAMPLES OF SPACE TERRORISM

In continuation with all the above, we observe that just as with the term "terrorism", the same applies to "space terrorism": specific definitions that emerge from the literature are debatable, and none have become widely accepted. However, these efforts highlight the growing significance of space terrorism as a subject of study. Below are two of these definitions:

> According to Cain, space terrorism is "an act of violence perpetrated by one or more individuals or groups to obstruct the establishment or objectives of a space settlement(s), spacecraft, or space station during humanity's space exploration".[31]

29 Wilkinson 2001: 162.
30 Wilkinson 2001: 162.
31 Cain 2016: 98.

> According to Bernat and Posłuszna, space terrorism can be defined as a "deliberate act of destruction targeting human and/or material assets within the space industry, perpetrated by individuals or groups driven by ideological motives. The term 'space industry' encompasses the sector of human endeavour focused on manufacturing components destined for Earth's orbit or beyond, transportation to these regions, and providing associated services".[32]

In any case, the author argues that as for space terrorism, one should follow the dialogue of classical terrorism. From the moment an act is characterised as terrorist, it is of secondary importance whether it occurred on land, at sea, in the air, or in space.

As we explore the intersection of terrorism and outer space, it is crucial to examine real-world examples that illustrate the potential threats faced by the space industry and personnel. While incidents involving space-related terrorism remain relatively rare, several noteworthy events underscore the vulnerability of this domain to malicious actors. In this section, we will examine instances of space terrorism, which we categorise into three distinct classifications based on the source of the threat.

In their article entitled "Space Terrorism: A Historical Study", Cyprian Aleksander Kożera and Paweł Bernat[33] endeavour to investigate the feasibility of hostile actions perpetrated by non-state entities, potentially involving individuals as young as adolescents, within the context of space exploration and exploitation. Subsequently, the ensuing discourse aims to provide an anticipatory exposition of their thesis.

Echoing their arguments within the broader context of terrorism, Kożera and Bernat may expound upon how technological advancements have facilitated greater accessibility to space-related capabilities for non-state actors, including individuals with limited resources or expertise. The dissemination of knowledge and the availability of off-the-shelf components necessary for space-related activities diminish the entry barriers for potential space terrorists. Among other examples, they mentioned:

[32] Bernat–Posłuszna 2019: 32.

[33] Kozera–Bernat 2023.

- The first ever recorded act of "satellite terrorism", or politically motivated space sabotage, occurred back in April 1986. Surprisingly, a disenchanted Home Box Office (HBO) subscriber, John R. MacDougall, perpetrated it. MacDougall was frustrated with the rate of his monthly subscription (USD 12.95) for the satellite TV and wanted to protest that. Being a satellite dish dealer and knowledgeable electronics engineer, he decided to override the HBO satellite signal with a protest message. He ran a successful test on the night of 20 April, and then a week later, at 12:32 AM on 27 April, MacDougall superimposed a specific message for four and half minutes over the HBO signal.[34]
- The case of the 15-year-old Jonathan J. James from Miami broke into 13 NASA computers at the Marshall Space Flight Center in Huntsville, Alabama. The U.S. Department of Justice claims that he "downloaded proprietary software from NASA valued at approximately $1.7 million", including the software that "supported the International Space Station's (I.S.S.) physical environment, including control of the temperature and humidity within the living space". Furthermore, "[a]s a result of the intrusions and data theft, the NASA computer systems were shut down for 21 days in July 1999".[35]

The above-mentioned cases underscore that such malicious attacks can be performed by a non-state actor, even a mere teenage individual. This shows the vulnerability of the space sector and paves the way for possible terrorist attacks against satellites and space systems in the future. Space systems have become more affordable, available, disseminated and easier to manage, but they are also more vulnerable to being targeted.

Moving forward from individual cases to terrorist activities, the existing examples show that the space industry and sector are already targets for this kind of violence.

[34] Kozera–Bernat 2023.

[35] Kozera–Bernat 2023; Department of Justice 2000.

The reasons why the space sector would be an attractive target for terrorist groups are as follows:

- extensive media coverage
- symbolic meaning – by attacking the industry, terrorists attack the state where the agency or the company is registered
- relative easiness of carrying out such an attack
- severe economic consequences

Possible targets:

- Measures against satellites. The most direct way to eliminate a satellite is to destroy it. However, suppose the objective is to stop an operator from benefiting from its satellite access. In that case, there are several options: disruption, denial, degradation and deception of the space system. The simplest possibility of interference with a satellite is electronic interference (jamming).
- Attacks on launch facilities and ground stations. The biggest space targets for terrorists who want to disrupt satellite operations are here on Earth in the form of ground stations, industrial sites and critical individuals. Instead of destroying the communication link between the satellite and the ground station, one could simply damage or destroy the ground station.
- Attacks on the user/service equipment.

In 1984, six people were injured after a bomb exploded outside the headquarters of the European Space Agency (ESA) in Paris. The left-wing terrorist group "Action Directe" took responsibility for the attack. A member of the group called ESA a "practical base to apply the imperialist strategy of domination of NATO and its enfeoff fed flunkey, the French state".[36]

Moreover, in 2005, Tamil Tigers in Sri Lanka took over a U.S. commercial satellite and, through it, broadcasted Tamol's messages over the Indian

[36] Miller 2019: 41.

periphery. This satellite piracy lasted for two years until the American-based company Intelsat shut down the transporter in 2007.[37] In addition, in 2012 and 2014, Hamas hijacked the Israeli channel and broadcasted its message.[38] In 2022, a hacker group linked with the Anonymous movement claimed to have shut down the Control Center of the Russian Agency "Roscosmos" causing interference with Russia's vehicle monitoring system.[39]

In 2003, NASA increased security for the Columbia shuttle launch out of concern that al-Qaeda would attack the launch pad because of the Israeli astronaut on the flight.[40]

Finally, in 2002, activists affiliated with the Falun Gong spiritual movement executed a notable cyber intrusion into a state television station in China. This incident underscored the movement's innovative strategies for disseminating its message and challenging state authority. By infiltrating the broadcasting infrastructure, Falun Gong activists aimed to convey their grievances and promote their cause to a broader audience, defying the stringent media censorship prevalent in China. This event exemplifies the evolving tactics employed by non-state actors to circumvent traditional channels of communication and exert influence in contentious socio-political environments.[41]

Moving forward to states' reaction to the issue of space terrorism, we see, lately, states like Nigeria, Pakistan, Syria and Egypt using the space industry as a weapon for counterterrorism and competition, while in Israel, officials claim that the first-ever combat in space has already occurred between Israeli forces and the Houthi terrorist groups.[42]

On 31 October 2023, Houthi forces, operating from Yemen, launched ballistic missiles toward Israel. These missiles were intercepted and destroyed by Israel's Arrow missile defence system. The significance of this event lies in

37 Kwok 2021.
38 Leyden 2014.
39 Pitrelli 2022.
40 Stein 2010.
41 Caldwell 2002.
42 Blinken 2024.

the claim made by Israeli officials that it marked the first-ever combat to occur in space.[43] Israeli officials claimed that the interception of the Houthi missiles by the Arrow system occurred at an altitude that technically qualifies as space. While the exact altitude at which this interception occurred is not specified, it likely exceeded the Kármán line, commonly considered the boundary between Earth's atmosphere and outer space, at approximately 100 kilometres (62 miles) above sea level. If the Israeli claim is accurate, this event would mark the first recorded instance of combat occurring in space. This outcome, combined with the accusations that Iran supports the Houthis, presents the first recorded example of state-supported terrorist activity in outer space.[44] While space has historically been viewed as a domain primarily associated with peaceful exploration and scientific endeavours, the increasing militarisation of space and the development of anti-ballistic missile systems capable of intercepting targets in space have raised concerns about the potential for conflict beyond Earth's atmosphere. Overall, the events of 31 October, involving the interception of Houthi missiles by Israel's Arrow missile defence system, represent a significant milestone in the intersection of military technology and space security, with potential implications for future conflicts and the broader geopolitics of space exploration and utilisation.

Moreover, and since states continue to use their space capability to target terrorist groups, then we should expect space assets to become one of the main targets of these groups.

For example, in the 2010s, Nigeria demonstrated a heightened commitment to addressing security challenges, particularly in response to the insurgency led by Boko Haram in the northeastern region.[45] This strategic recalibration involved a deliberate emphasis on harnessing satellite technology for counter-terrorism endeavours. In 2011, Nigeria launched the NigComSat-1R satellite, succeeding the defunct NigComSat-1 and significantly augmenting the nation's satellite communication and remote sensing capabilities. This development

43 The Economist 2023.

44 Robinson 2024; Tabaar 2024; Nakhoul–Hafezi 2024.

45 Tella 2002.

facilitated the establishment of robust communication infrastructure, particularly beneficial for security forces operating in remote and conflict-prone areas, enhancing their coordination and response capabilities. Throughout the 2010s, Nigeria increasingly integrated satellite-derived intelligence into its counterterrorism operations.[46] Satellite imagery signals intelligence and geospatial data emerged as pivotal surveillance, reconnaissance and target identification tools. These resources enabled security agencies to monitor terrorist movements, identify clandestine training facilities and effectively preempt potential attacks. Furthermore, advancements in satellite technology, characterised by higher-resolution imagery and real-time monitoring capabilities, significantly bolstered Nigeria's situational awareness and operational efficacy in combating terrorism.[47]

Additionally, Pakistan, confronted with enduring security challenges emanating from terrorist organisations, has increasingly turned to remote sensing applications to bolster its counterterrorism endeavours. In response to these persistent challenges, Pakistan has strategically employed remote sensing technology to fortify its counterterrorism capabilities.[48] Remote sensing, encompassing satellite imagery, aerial surveillance and various geospatial techniques, offers inherent advantages in the monitoring, tracking and analysing terrorist activities across diverse terrains and operational contexts. Leveraging satellite-based reconnaissance, Pakistani security agencies can effectively surveil terrorist training camps, border regions and areas of heightened risk, thereby facilitating early threat detection and preemptive measures.[49] Moreover, using geospatial analysis techniques in conjunction with remote sensing data, Pakistani security forces are empowered to execute precise targeting and strategic planning against terrorist elements. Through the adept utilisation of satellite imagery, aerial surveillance and geospatial analysis, Pakistan has markedly

46 Tella 2002.
47 Tella 2002.
48 Asmat 2010.
49 Asmat 2010.

enhanced its intelligence-gathering capabilities, situational awareness and operational effectiveness in confronting terrorist threats.[50]

Finally, Egypt, with support from Syria, has submitted a proposition advocating for an extensive dialogue concerning the utilisation of satellite technology in counterterrorism efforts within the United Nations' Committee on the Peaceful Uses of Outer Space (COPUOS). This initiative embodies a proactive stance by Egypt and Syria towards addressing the escalating menace of terrorism through innovative technological means. By orchestrating discussions within COPUOS, these nations endeavour to harness the collective expertise and resources of the international community to explore the prospective applications of satellite technology in bolstering global counterterrorism endeavours. Such deliberations promise to foster collaboration, facilitate knowledge dissemination and facilitate the formulation of best practices to optimise the utilisation of satellite assets for intelligence gathering, surveillance and coordination of response efforts in the global anti-terrorism campaign.[51]

CONCLUSION

The examples mentioned in this paper serve as reminders of the multifaceted challenges posed by terrorism in the context of space exploration. While the likelihood of a catastrophic space-related terrorist attack remains relatively low, the potential consequences demand continued vigilance, cooperation and innovation in safeguarding the peaceful exploration and utilisation of space for the benefit of all humanity.

Examining space terrorism underscores the evolving landscape of security threats in the modern world. By highlighting the potential for weaker actors, such as terrorist groups and individuals, to leverage space-based technologies for disruptive purposes, it prompts a critical reevaluation of traditional notions of power and security in the context of outer space. While the immediate threat

50 Asmat 2010.

51 Spacewatch Global s. a.

of space terrorism may seem distant, the documented attempts to disrupt the space industry indicate a concerning trajectory. This suggests we are at the nascent stages of a potentially significant security challenge that will likely escalate over time.

The conclusion drawn from this analysis is clear: Policymakers must proactively address the emerging threat of space terrorism by developing robust counterterrorism policies tailored specifically for the space domain. Such policies should encompass preventative measures to safeguard space infrastructure and assets and mechanisms for intelligence gathering, threat assessment and international cooperation. Furthermore, given the inherently global nature of space activities, effective policy responses must be collaborative and multilateral, involving cooperation between governments, international organisations and private sector stakeholders.

In essence, the imperative to address space terrorism underscores the need for forward-thinking and proactive governance in space security. Failure to do so risks leaving critical space assets vulnerable to exploitation and disruption, with potentially far-reaching consequences for national security, economic stability and technological advancement. By acknowledging the emerging threat of space terrorism and taking decisive action to address it, policymakers can help to ensure the continued peaceful and secure use of outer space for the benefit of all humanity.

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France's Role in the Global Space Efforts

INTRODUCTION

Space, along with cyberspace and international waters is a strategic common space that – at least theoretically – can be used by all states. However, it is not difficult to realise that utilising space requires specific means that only a very small proportion of states possess. Less than half of the states have orbital platforms, and only around 3% of states have autonomy of action in space, meaning the ability to design, manufacture, launch and operate orbital platforms on a regular basis. In strategic terms, just over 1% of states can be considered to be real military space powers with a coherent space component to their defence policy.[1] In this particular sense, these few states enjoy strategic dominance over the others, and are in a special position that has rarely been witnessed in history. One such state, alongside the United States, the Russian Federation, China, the United Kingdom and Japan, is France.[2]

Fifty years ago, France experienced first-hand what the lack of freedom of access to space meant when the United States denied it the right to commercialise one of its satellites, which was to have been launched on a U.S. rocket. It drew its own conclusions from this incident and offered Europe a launch vehicle of its own design. Thus, the Ariane programme was born, which has given Europe independent access to space for decades. Another key element of space autonomy for a state is to own a launch base on its own territory. Aware of these strategic issues, France took the necessary steps at a very early stage, as a result of which the French space programme is now clearly the largest in Europe, with both civil and military components. The aim of this chapter is

[1] Steininger 2019: 21–28.
[2] Kopp 2022.

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to explore the theoretical basis of France's space activities and to describe the practical implementation of this theory, covering both the civil and military components, while not neglecting the organisational background.

THE FOUNDATIONS OF FRENCH SPACE ACTIVITIES IN THE 20TH CENTURY

Autonomy in space has two main components: the first is a self-developed launch vehicle while the second is a launch base on a state's own territory. By the mid-1960s, France had already laid the foundations for its space activities by creating both.

Turning first to the beginnings of the development of the indigenous launcher, the French aeronautical and missile industry was born at the dawn of the 20th century, but the real breakthrough in this regard came after the Second World War. In 1946, the Ballistics and Aerodynamics Research Laboratory[3] was set up at Vernon with the explicit aim of developing the next generation of missiles. It did not take long for the Véronique N1 rocket to be successfully launched from Algeria on 22 May 1952, building on the versions already tested and improved by military personnel during the war.[4] Subsequently, following Charles de Gaulle's return to power, scientific research was given a new impetus, which led to structural changes and new developments. In 1959, the Commission for Space Research[5] was established, the predecessor of the National Centre for Space Research (CNES),[6] created in 1961. The centre, which began operations on 1 March 1962, employing a mere eight members of staff,[7] was set up to coordinate French space activities with the unconcealed aim of

[3] Laboratoire de recherches balistiques et aerodynamiques (LRBA).
[4] *Véronique et Vesta* s. a.
[5] Comité d'études spatiales.
[6] Centre National d'Études Spatiales (CNES).
[7] By the end of the year, the number of employees reached 80.

centralising the hitherto dispersed space research and development activities.[8] The development of the first launch vehicle by a Western European country, the Diamant, began in 1962. It was followed three years later, on 26 November 1965, by the successful launch of Astérix, the first French satellite, from the Algerian desert, on a Diamant rocket, which transmitted uninterrupted for two days. In 1965, France became the third space power in the world.[9]

The next step was for France to establish a launch base on its own territory, for which the biggest problem was finding the right geographical location for the launch sites. Initially, it was planned to set up the necessary infrastructure on the coast of Aquitaine, between Biscarosse and Mimizan but as the geographical location would have necessitated launches in the opposite direction to the Earth's rotation other sites had to be found. This was when French Guiana came into the limelight, where the initial focus on logistical problems was eventually overcome by the persuasive arguments of mathematics. The launch site decided upon, at Kourou, is located 5.3° north of the equator, and this position allows the rockets to gain propulsion from the Earth's rotation (which means an extra speed of 460 m/s, or 170 km/h) when they are launched eastwards, thus saving propellant. No other government launch site has physical parameters remotely comparable to those of the Guyana Space Centre (CSG), while the French space programme can launch satellites from this spaceport.

The criteria for choosing the site were very diverse,[10] but eventually the spaceport near Kourou was selected in 1964,[11] and later the European Space

8 *Le Centre National d'Études Spatiales* s. a.

9 Although less well known, as part of this development France also started testing a ballistic missile in synergy with the Diamant missile, intended to form part of the French nuclear deterrent. This shows that the need for dual use was already present in early space activities.

10 Thus, in addition to favourable launch conditions at the equator or the poles and a suitable distance from the inhabited areas, a seaport was also needed to solve logistical issues, along with a suitable area and a runway of at least 3,000 m in a politically stable region, preferably not too far from Europe, and with tolerable climatic conditions with a minimum risk of earthquakes and hurricanes.

11 Prior to this, France had carried out space launches from Algeria, in Colomb-Béchar and Hammaguir.

Agency, ESA[12] also chose it as a launch site. Kourou can now claim to be the spaceport with the highest number of successful launches, both in terms of consecutive and total launches.

THE LEGAL AND STRATEGIC FRAMEWORK FOR FRENCH SPACE ACTIVITIES

The lack of legal regulation of important segments of space activities is a crucial problem.[13] Therefore, in the absence of international regulation, the role of national legislation and national strategy documents as a theoretical approach, as well as the objectives, security environment assessments and strategic visions set out in them, is considerably more significant.

For a long time, the legal framework was based on administrative practices and it was only in 2008 that the first space law was adopted. On 3 June 2008, the French Space Operations Act No. 2008-518 (FSOA) was adopted, codifying the activities and obligations of satellite operators. The legislation, which entered into force in December 2010, also stipulates that the government oversees French space activities by exercising de facto control over private activities, while remaining in line with France's international commitments.[14] The FSOA sets

12 The European Space Agency was created in 1973 at the incentive of France. The French space budget is still the largest of the ESA member states.

13 It is only the 1967 Outer Space Treaty that seeks to regulate the behaviour of all states in space by prohibiting the launch of weapons of mass destruction and the use of celestial bodies for military and other purposes.

14 The country has signed and ratified all the five space conventions under the auspices of the UN, except one (the Moon Convention). These conventions are the following: the Treaty on Principles Governing the Activities of States in Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies 1967; the Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space 1968; the Convention on International Liability for Damage Caused by Space Objects 1972; the Convention on Registration of Objects Launched into Outer Space 1975 (the Registration Convention); and the Agreement Governing the Activities of States on the Moon and Other Celestial Bodies 1979 (the Moon Agreement).

the general principles on the authorisation and monitoring of space operations under French jurisdiction or for which the French Government is responsible under international commitments. The law also provides for implementing regulations that allow the government to adapt the requirements easily and quickly if necessary.[15] On 23 February 2022, the French law on space operations was substantially amended[16] in view of the need to adapt the legal environment to the unprecedented military developments in the country (and in particular to the operations carried out by new means), thus ensuring the protection of national defence interests. Under the amendment, the generally applicable rules can be disregarded when the defence of the country is at stake, since the control of space services and commercial satellites can be taken over by the state in an emergency without the owner's authorisation. The State is then liable for any damage resulting from the operation of the satellite. If the owner refuses to cooperate, he or she could face up to five years in prison. This new provision will allow the Space Command (Commandement de l'Espace – CDE) to conduct integrated space operations (i.e. planned and intensive cooperation with other forces), on the basis of which it can provide additional support to ground operations by means of observation or communication satellites, or by directly taking control of satellites and placing them in defensive or offensive positions during operations in space.[17]

The Defence and National Security Strategic Review,[18] the main strategic document of the country, provides the basis for the strategic framework of French space activities. The document, issued by President Macron within months of his election, provides a comprehensive assessment of the country's security situation. What is new is that, while previous White Papers defined space as a domain within the other operational domains, the Review now defines space as a separate domain.

15 Bird & Bird LLP 2023.
16 Ordonnance 2022.
17 Satellite Observation 2022.
18 *Revue Stratégique de Défense et de Sécurité Nationale* 2017.

As a sectoral strategy, France published its first Space Defence Strategy in 2019, presented on 25 July 2019 by Florence Parly, Minister of the Armed Forces.[19] This makes France the first country to openly declare its space ambitions and military space strategy. The Minister's speech provoked a great deal of debate within foreign ministries around the world, mainly because of its reference to an "active defence" doctrine, which will be discussed in more detail later, to protect French assets. The phrase 'strategic autonomy', so often used by President Macron and which is at the heart of the Strategic Review, was taken up and given substance in the Space Strategy: France is seeking to ensure its freedom of choice and action in space, which may be facilitated by arming satellites for self-defence.

The strategy identifies three key aspects, each with a chapter devoted it. The first chapter presents space as an important area for the armed forces, where competition has been intensifying. In space, challenges such as cyber threats, electromagnetic interference, the increasing prevalence of commercial space services, conventional attacks against ground facilities and newly developed kinetic anti-satellite missile capabilities have to be addressed. The second chapter describes the basic elements of the ambitious French space defence policy, while the third chapter outlines a roadmap for achieving the country's political and military objectives. The central elements of this roadmap are the strengthening of the French space defence doctrine, the development of military space administration, the alignment of space capabilities with the country's ambitions and the creation of a space defence expert corps.

In its second chapter, the space strategy sets out a dual ambition. The first is to ensure the capacity required to protect its satellites by improving the French armed forces' ability to monitor the space environment. The aim is to detect unfriendly or hostile acts, for which France will rely on space situational awareness capabilities. These capabilities may be developed and operated sovereignly or in conjunction with other states (European partners,

[19] The French Ministry of the Armed Forces 2019.

in particular Germany). The second ambition is to improve France's ability to defend its interests in space against unfriendly, unlawful or aggressive actions, in accordance with and respecting international law. The French field of interest is not limited to French military satellites, but may also include French commercial satellites, some allied satellites and satellites of the European Union. The aim is therefore to improve the protection of national and key European space assets, involving the possible fitting of satellites with on-board lasers for defence purposes. Both are closely linked to the French vision of maintaining and further supporting national and European space industrial capabilities. In addition, the key supporting elements of France's nuclear deterrent will be space-based intelligence, reconnaissance and surveillance. National laws are also being amended to ensure that the armed forces will be the operators and maintainers of these assets, not just their beneficiaries.[20]

Many parallels can be drawn between Paris's space strategy and its cyber strategy. France has adopted a declarative strategy in both areas, based on active defence and deterrence. As with cyberspace, it recognises space as an operational area and stresses the need to ensure compliance with international law in both cases.[21] Nevertheless, the major difference is that the space strategy is purely defensive, regardless of the country's suggestion of placing laser weapons on satellites, as opposed to its behaviour in cyberspace. Even though, in her speech on 25 July 2019[22] Minister Florence Parly stated that there was no arms race in space, the development of a space strategy is clearly the result of the fact that space has been becoming an increasingly conflictual environment and that space as an operational field plays an important role in deterrence and, should it fail, even in hostilities.

20 Until now, operations have mainly been carried out through the CNES civil space agency.
21 Taillat 2019.
22 Satellite Observation 2019.

THE ORGANISATIONAL FRAMEWORK OF FRENCH SPACE ACTIVITIES

Organisational issues are discussed in terms of civil and military structures, although this distinction is becoming less tenable. At present, it is the civilian sector that is at the forefront of developments and which fully supports and provides the military sector with the necessary intellectual and technical resources through technology and knowledge transfer. In 2022, two years after the creation of the Space Command, CNES was still providing the technical expertise, but was about to transfer some of it to the CDE, in particular concerning satellite operations.[23] The MoD clearly hopes to capitalise on the dynamism of the civil space industry to develop its modern capabilities more rapidly. To this end, contracts with commercial providers such as WeTrack and Geotracker are critical as they will ensure efficiency and flexibility to complement government capabilities. Another example of civil–military cooperation is the LISA space innovation lab[24] set up by the CDE and CNES to identify and support projects that might be of interest to the ministry, whether they originate from traditional space manufacturers or new space companies. Other initiatives include the MIL-IoT Military Linked Objects project, the ExoOps software for simulating adversary manoeuvres, and Nemesis for high-performance computing in C2 space. On the other hand, the Defence Industrial and Technological Base (BITD),[25] which produces, maintains and develops French military capabilities, should also be considered a defence capability in its own right. As part of this, the French aerospace BITD is particularly rich and not limited to large companies, but is also made up of small and medium-sized enterprises and is a constant source of innovation. France can certainly build on these technical foundations successfully in the future.[26]

[23] Satellite Observation 2022.
[24] Laboratoire d'innovation spatiale des armées.
[25] Base industrielle et technologique de défense.
[26] Barre 2019: 13–19.

The civil structure and the CNES

The implementation of national policy in the civil sphere is the responsibility of the Prime Minister. The Prime Minister relies on the General Secretariat for Defence and National Security (SGDSN),[27] which coordinates the preparation of measures in support of the national security strategy and ensures their implementation. Based on its analysis of threats to national interests, the SGDSN is responsible for planning the state's response. Its activities take the form of long-term security measures to prevent malicious acts and respond to attacks in the shortest possible time.[28]

At the heart of the civil space field in France stands the National Centre for Space Studies (CNES), Europe's largest and most important national organisation of its kind. The French Government's space agency, based in Paris and set up in 1961 under the de Gaulle presidency, is under the supervision of the French Ministry of Defence, and of the Ministry of Higher Education and Research. It operates from the Toulouse Space Centre and the Space Centre of Guyana,[29] while also launching spacecraft from space centres operated by other countries. The Toulouse Space Centre (CST)[30] is the research and development centre of CNES, founded in September 1968 and located in the Rangueil-Lespinet district of Toulouse, in the Haute-Garonne department of the Occitanie region. With more than 1,700 staff, it carries out most of the operations for which the CNES is responsible, with the exception of launchers and their launching.

The CNES focuses on five broad areas: access to space, civil applications of space, sustainable development of space-related activities,[31] scientific and technological research, and security and safety. In addition to its scientific

27 Secrétariat général de la défense et de la sécurité nationale.

28 Michel 2019: 74–78.

29 For more details see the chapter authored by Philippe Ch.-A. Guillot in this book.

30 Centre spatial de Toulouse.

31 For example, CRES has achieved a 48% reduction in greenhouse gas emissions between 2014 and 2019. Furthermore, 38% of employees are women, whose salaries differ negatively from men by only 0–3%, compared to the national average of 18%. See CNESMAG 2021.

and technical functions, the centre also performs military tasks, and the dual supervision of the centre by the Ministry of Higher Education and the Armed Forces also reflects the civil–military dichotomy.[32] CNES is currently collaborating with other space agencies on a number of projects, including space telescopes such as the INTErnational Gamma-Ray Astrophysics Laboratory,[33] XMM-Newton[34] and COROT,[35] and space probes such as Mars Express, Venus Express, Cassini-Huygens and Rosetta. CNES has also collaborated with NASA on missions such as the PARASOL Earth observation satellite[36] and the CALIPSO environmental and weather satellite.[37] One of the most successful elements of French–Indian cooperation, which will be discussed below, is the Megha-Tropiques Mission, launched in October 2011. This mission was designed to study the water cycle and the effects of climate change, and although it ended in April 2022 (due to technical problems), there are already plans to continue it: the Thrisna mission[38] will be dedicated to studying the temperature of the Earth's surface.[39]

In addition to the CNES as an umbrella organisation, the main components of the civil structure consist of 1,704 space industry companies.[40] Although there are aerospace companies in almost every major city in the country, two cities stand out: Paris is home to 108 companies and Toulouse to 107.[41] The country's leading aerospace company is Airbus, based in Balgnac (Occitanie), which employs 127,000 people and has annual revenues of more than $56 billion. It is followed by two Paris-based companies, Safran (83,000 employees, $18.6 billion of revenue) and Thales (80,100 employees, with revenues of $18.3

32 Azarian 2021.
33 ESA 2022.
34 ESA s. a.
35 ESA 2006.
36 EoPortal 2012.
37 CALIPSO s. a.
38 Thermal infraRed Imaging Satellite for High-resolution Natural Resource Assessment.
39 Kumar 2022.
40 Morénillas et al. 2022.
41 CNES 2020.

billion).[42] The sector is therefore quite large compared to the investment funds available. France has only two operating space-tech investment funds: Expansion Ventures and Cosmicapital, and both performed well below expectations in 2022.[43] The development of the area is a top priority in the country's plans up to 2030, not least because it is a pillar of the much-vaunted strategic sovereignty. It is also encouraging that two French companies active in the space sector have recently closed financing rounds with private investors comparable to their U.S. competitors: Exotrail has raised €54 million to develop a transport satellite for small satellites,[44] while the Exploration Company has raised €40 million for developing a space capsule[45] intended for transporting freight and subsequently humans to orbital stations and to future lunar bases.[46]

The military structure and the Space Command (CDE)

Today, space capacities are essential for policy making, target setting, operational planning and implementation. Space support for military operations therefore extends beyond applications for meteorology and geographical assistance to intelligence, target acquisition, communications, positioning and navigation.[47] France must also develop its new military structures within this complex system.

The head of the military space system is the Space Command (CDE).[48] On 13 July 2019, President Emmanuel Macron announced the creation of the

[42] Zoominfo 2023.

[43] Leaders League 2023.

[44] Its products include an on-board electric propulsion system, designed for small 100–150 kg satellites, trajectory and satellite placement optimisation software to reduce costs, and a "spacevan". Designed as a type of space truck and capable of transporting 400 kg in low orbit, the spacevan will be responsible for inspecting, maintaining and repairing satellite constellations in orbit. The launch is planned for the end of the year.

[45] NYX spaceship is a transport capsule to be developed by Exotrail, comprising a Franco–German team of specialists, which will be the first European spaceship capable of resupplying stations in orbit and future lunar stations.

[46] La French FAB 2023.

[47] Friedling 2019: 67–73.

[48] Commandement de l'Espace (CdE).

new command, arguing that space had become a "real national security issue" due to the increased spending by and interest from the United States, India, China and Russia.[49] The Space Command was set up within the French Air Force on 3 September 2019 with the aim of becoming the headquarters of the "Air and Space Force". It is based in Toulouse, the current centre of the French aeronautics industry. The CDE, which reports directly to the Chief of Staff, is a special command because it manages both training and operations. The reason for this is that it is very small in size, so it would not make sense to split it in two. A specificity of it, therefore, is that it receives its functional instructions from the Chief of Staff of the Armed Forces on operations and military space policy, i.e. in particular on strategy, cooperation and capabilities, while the Chief of Staff of the Air and Space Forces is in command of organisational matters.[50] The CDE is expected to employ a total of 500 staff, with a further 100 non-permanent staff. At the same time, the multi-building complex of some 11,500 m² will also host a NATO Centre of Excellence, which will initially employ 70 permanent and 100 non-permanent staff from 14 nations as a separate organisation. The investment, worth around €60 million, should be completed by September 2025.[51] The operations centre will host a range of activities: senior activities (administrative, operational support, research and development, management), operational activities (involving space manoeuvres while also guaranteeing the security of the site) and training activities related to space operations provided by the CDE and NATO partner forces.[52]

The Space Command aims at ensuring France's access to space and freedom of action in space. Its objectives are based on three main pillars.[53]

1. Strengthening operational support of space. This refers to the capabilities that space assets provide for ground operations. This process is already ongoing and a new generation of satellite programmes will become operational in

49 Deutsche Welle 2019.
50 Friedling 2021.
51 Chapleau 2022.
52 Chapleau 2022.
53 Satellite Observation 2020.

the next few years, which could also lead to a shift. While until now space capabilities have been used mainly by political authorities and the highest levels of the armed forces only for strategic purposes, in the future they will be used by the armed forces (and other military services) on a much wider scale for operational purposes, down to the tactical level.

First, CSO[54] optical Earth observation satellites will replace the ageing Helios II satellites. Dedicated to military observation, CSO is a constellation of three satellites in polar orbit at different altitudes. Its reconnaissance mission is carried out by two satellites at an altitude of 800 km (already in orbit).[55] A third satellite, paid for and partly operated by Germany, will monitor at an altitude of 480 km and will benefit from the highest levels of resolution, image quality and analytical accuracy. Delays are expected, however, as it was planned to be launched from French Guiana on a Soyuz rocket, which is no longer possible due to the ongoing Russian–Ukrainian war. This system, expected to be fully deployed soon, will continue to maintain sovereign access to optical imagery in clear day or night time, with unrivalled sensor performance and data collection capacity.[56]

On the other hand, ELISA will be replaced by the CÉRES[57] signal detection system, consisting of three identical microsatellites, which will represent a revolution in French electronic intelligence capabilities.[58] In addition to the non-spatial capabilities already deployed in this area, CÉRES will also provide the armed forces with an operational area surveillance capability by searching for and detecting a wide range of radar or telecommunications transmitters almost anywhere in the world. The analysis of the data collected by this system will provide information on areas where the armed forces are almost blind today while also providing data at the strategic, operational and tactical levels.

54 Composant spatial optique.
55 The first was launched in December 2018 and the second on 29 December 2020 from the Guyana Space Centre in Kourou.
56 Friedling 2019: 67–73.
57 Capacité d'écoute et de renseignement électromagnétique spatiale.
58 The programme is estimated to be worth between €400 million and €450 million and the industrial implementation of the project has been provided by Airbus Defence & Space, Thales Systems Aéroportés and Thales Alenia Space. See Bussiere 2021.

The scarcity of such capabilities and the expected performance of the CÉRES system,[59] with its increased autonomy of assessment, will represent a real advantage for the French armed forces and France in general.[60] In November 2021, the CÉRES satellites were launched, adding France to the exclusive club of countries able to collect electromagnetic data from space.[61]

The current Syracuse III communications satellites will be replaced by two satellites, Syracuse 4A and 4B (Syracuse 4C will be released later). 4A is equipped with devices to monitor the nearby environment and has the ability to move to avoid attack as well as being protected against electromagnetic pulses from a nuclear explosion. The Syracuse programme represents a total investment of around €4 billion. France plans to have 400 stations, which will be able to communicate from the ground, airplanes, ships and submarines.[62] The first Type 4A satellite was launched on 23 October 2021, a few weeks after Australia cancelled its contract for French submarines (in favour of U.S. submarines), weakening French power in the Indian Pacific. The new capability could improve the country's prestige.[63]

2. Space observation, monitoring of deployed devices (SSA).[64] Space observation and space situational awareness are prerequisites for any exploitation of the space environment and, in particular, for the conduct of military operations, whether in space or not, as well as for the implementation of military space policy. Therefore, the most effort, among the three pillars, should be concentrated in this area in the next ten years. Today, knowledge of the situation in space has become a prerequisite for the exercise of sovereignty, and SSA has become a priority for the major space powers, both to minimise the risk of collisions and to assess possible hostile satellite manoeuvres.[65] Ultimately,

59 Although these are the latest capabilities, preparatory work has already started on the IRIS and CELESTE programmes to replace CSO and CERES.
60 Friedling 2019: 67–73.
61 La Dépêche 2021.
62 Souilla 2021.
63 Le Parisien 2021.
64 Space Situational Awareness.
65 Pasco 2019: 147–154.

France aims to be able to observe all orbits, and to detect and identify objects in a distinguishable way. Due to the large and growing number of objects in space, the collection and analysis of information needs to be automated. France wishes to remain independent in this field, but is open to cooperation in order to develop its own capabilities.

3. Active defence in space. This is the third and most controversial pillar. It involves carrying out operations to prevent aggression against space assets and, if necessary, to defend them. The aim is to take action while respecting the principle of the "non-aggressive" use of space. Thus, as part of its active defence capability, France is planning to launch and deploy small bodyguard satellites in space around its geostationary assets to detect and prevent enemy approaches against them.[66]

The above three pillars are divided into four types of space-related military operations: space services support (e.g. launch, satellite deployment, etc.), space support for ground operations, which supports the first pillar, space situational awareness, which supports the second pillar, and active space defence, which supports the third pillar. In order to be able to carry out these operations, it is necessary to provide and train personnel in addition to setting up a headquarters.[67] Moreover, all this cannot be implemented without adequate financial backing. The Military Planning Act for 2019–2025 provides €3.6 billion for space security issues, mainly for the development of a new generation of satellite programmes. Furthermore, Minister Parly has announced an additional €700 million to fund preparatory work on space situational awareness and active defence.[68] Plans include upgrading the network of TAROT telescopes and modernising the GRAVES surveillance radar. However, this will require amendments to the Military Planning Act. This has sparked heated debates in the ministry over which commands will have to be deprived of money and personnel to further increase space capabilities. However, what is certain is

66 Satellite Observation 2019.

67 Currently the headquarters has around 220 staff. It is planned that 90% of the staff, which will increase to 500 by 2025, will be based in Toulouse and 10% in Paris.

68 Le Figaro 2019.

that a comprehensive programme, named Aerospace Action and Resilience (ARES),[69] which combines space awareness, active and passive space defence and Command and Control (C2) tools, is already underway. According to the schedule, the first phase will be completed by 2023 as Yoda[70] comes into service, reaching full operational capability by 2030.[71]

MILITARY AND CIVIL SPACE ACTIVITIES IN FRANCE

The process of the militarisation of space is becoming increasingly spectacular today, as space is emerging as a new arena for strategic competition between the major powers. Although asymmetric conflicts with smaller states are not present in space due to the ownership of space and their lack of space capabilities, military events in space can have a direct impact on all states. Therefore, this chapter focuses mainly on the military aspects, whilst not neglecting the civilian aspects.

The year 2019 brought major changes to French space policy. In addition to the publication of the aforementioned Space Defence Strategy, on 13 July 2019, President Emmanuel Macron announced the creation of an autonomous Space Command[72] to replace the former Joint Space Command (which was effectively implemented on 3 September 2019), under the responsibility of the Air Force. This organisational transformation was a clear sign of the re-evaluation of space and its processes, which was triggered by a process of reform, development and transformation. In this context, the following three main trends are now emerging.[73]

69 Action et résilience spatiale.
70 Eyes in Orbit for an agile demonstrator (Yeux en orbite pour un démonstrateur agile – Yoda).
71 Friedling 2021.
72 Commandement de l'Espace (CdE).
73 Delaporte 2021b.

1. *Transforming the military space command chain.* France – unlike the United States, which has set up an autonomous space command – went in the opposite direction by officially creating the French Air and Space Force on 11 September 2020.[74] This integrated the Space Command,[75] set up a year earlier, and the Air Force into a single organisation. The new force currently consists of around 200 personnel in four centres (compared to 9,000 in the United States):

- in Balard, the management offices
- Space Operations Command and Control in Toulouse (C2)
- in Lyon, home of the Space Situational Awareness Centre, COSMOS,[76] which acts as a centre for the military observation of space objects, and the Military Satellite Observation Centre, CMOS[77]
- a unit of the CMOS in Creil

Both the centres and the staff are being integrated into the European Space Centre in Toulouse, which is gradually being expanded, currently including a space academy, a space laboratory and a complete international research and industrial ecosystem. By 2025, the French Space Command will be increased to 500 people and will move from its current headquarters at the National Space Research Centre to a separate building.

2. *Modernising space capabilities through coordination between the military and the civilian sector and between the public and private sectors.* There is an increasing amount of innovation in the private sector, from which the Ministry of the Armed Forces aims to benefit, but of course the civilian sector also benefits from military developments. If we look at the annual programme of the CNES, it is essentially full, while the number of military activities is still much lower – although they already account for 12% of expenditure,

[74] Armée de l'Air et de l'Espace (AAE).

[75] Commandement de l'Espace (CdE).

[76] Centre opérationnel de surveillance militaire des objets spatiaux.

[77] Centre militaire d'observation par satellites.

worth €280 million.[78] CNES is also involved in research to develop new French active defence capabilities, one of the milestones of which is the Yoda programme. This will involve the development of "patrol" nanosatellites that will identify threats to French satellites in orbit and, if necessary, disarm them using an on-board laser. The aim of the programme is for France to acquire knowledge of orbital manoeuvres in geostationary orbit that neither the CDE nor CNES yet possess. As part of the programme, the ministry will test the flight of a small demonstration satellite as early as 2023 as part of the Yoda experiment.[79] The French Parliament's National Defence and Armed Forces Committee report of October 2020 estimates that it could be in a larger orbit with initial operational capability by 2030.[80]

3. Pursuing enhanced allied cooperation. International cooperation is indeed vital for France (and Europe). In addition to Germany and Italy, the U.K., the U.S., Canada, Australia, India and Japan are France's key partners according to the 2019 Space Strategy. The United States is regarded by France as a critical partner in space operations (also), boosted by the fact that France formally joined the Combined Space Operations Centre (CSpO) in 2020,[81] which initially included only the five member states of the Five Eyes cooperation (the U.S., the U.K., Canada, Australia and New Zealand). After France and Germany were granted observer status, they became full members in 2020 and 2019 respectively. The aims of the CSpO are to develop interoperability between countries so that they can share their capabilities, and to create a space doctrine that details how operations in space will be conducted, along with data sharing and the development of norms of behaviour.[82]

78 Azarian 2021
79 Delaporte 2021a.
80 Ferrara 2020: 58, 94.
81 Combined Space Operations.
82 Satellite Observation 2020.

MILITARY AND CIVILIAN ASPECTS OF INTERNATIONAL COOPERATION

The preceding sections will have made it clear that civil–military cooperation is also essential at the international level, and that these two areas can only work effectively if they support each other.

As regards the military domain, in addition to the creation of the Space Command, the French army has initiated several programmes to ensure that it can act in a sovereign way with the latest technologies. This is understandable, since France sees cooperation in space as a means of strengthening Europe's defence and thus its strategic autonomy. What is new, however, is that in recent years it has called for a more ambitious approach to space defence, shifting the focus from capability-oriented cooperation to real operational cooperation.

This was the background to the central event of 2021, AsterX, the first European space exercise organised in Toulouse, which imagined a geopolitical crisis on a fictional continent in the middle of the Atlantic Ocean. The exercise's codename is a tribute to the very first satellite, Asterix, launched by the Diamond rocket in 1965, as well, of course, as to the famous cartoon character who generations of French people have grown up with since 1959.[83]

The exercise was based on a scenario of a crisis involving a state with space capabilities and a state with a military assistance agreement with France, and involved 18 simulated events in an operations room.[84] The exercise condensed the four-week conflict into four days from 8 to 12 March 2021, during which the sixty or so participants had to face anti-satellite weapons fire, space encounters and even solar meteorological phenomena.

The significance of the exercise is that, while previously France had been an observer in exercises of this type led by the United States, this time the exercise was led by France, in cooperation with Germany and Italy, as well as the United States Space Forces. The former commander of the French Space

83 Astérix is the very stubborn chief of a Gallic village, where the worst and constant fear of the inhabitants is that the sky will fall on their heads – even though it is an irrational fear.

84 La Dépêche 2021.

Command, Air Chief Marshal Michel Friedling, described the exercise as a "stress test" for France's burgeoning space command processes and systems.[85] According to the then commander, the aim of the exercise was not to simulate a space attack, but rather to train the French space units and command units and to implement all internal operational procedures within the space command and with all external partners.[86]

Building on the success of the 2021 exercise, the second AsterX space exercise was held from 24 February to 4 March 2022, with the objective of training military operators and testing and experimenting with the command-and-control organisations and processes. For the exercise, which simulated 24 days over 6 full days, a space population of 10,000 objects was simulated and 16 elements covering the full spectrum of threats were incorporated.[87] The mission network linking all the assets and actors included the Cyber Command, Military Intelligence (DRM,[88] which provided the surveillance satellites), the Military Communications Directorate (DIRISI,[89] which provided the communication satellites), CNES, selected so-called trusted service providers (other agencies, organisations) and foreign actors (four other nations and the European External Action Service, which handled a simulated incident involving Galileo).[90] The innovative feature of the exercise, which was much broader than the one conducted in 2021, was the setting up of the Trade Integration Cell, in which information provided by trusted commercial service providers was collected and organised, thus integrating the civil component. The exercise, which was attended by 27 foreign delegations (from 25 countries as well as from the EU and NATO), was declared successful.

Finally, it is perhaps not an exaggeration to say that the AsterX exercise had come of age by 2023. The 18-day exercise that year, which took place from 21

85 Delaporte 2021b.
86 France Info 2021.
87 Satellite Observation 2022.
88 Direction du Renseignement Militaire.
89 Direction Interarmées des Réseaux d'Infrastructure et des Systèmes d'Information.
90 *Le mot du Général GDA Michel Friedling, Commandant de l'Espace – AsterX* 2022.

February to 10 March 2023, was a military space exercise with very ambitious objectives, based on a realistic and complex environment, and focused on integration, interoperability and cooperation. In contrast to the accelerated time approach taken in previous years, in 2023 the exercise took place in real time, in close cooperation with the combined forces exercise Orion, which was designed to prepare for a large-scale military operation. The C2 interoperability of space operations with other command and control structures was tested and methods of achieving combined ground effects were validated. The exercise was based on a specially designed technical platform, enriched with new features and involved a scenario that included twenty-nine space events, including one in cyberspace, which foreshadows the direction of future exercises.[91] Five other countries and around 30 international partners participated in the 200-strong exercise, further enhancing its international importance.[92]

The framework for civilian cooperation revolves around the close relationship between CNES and the European Space Agency (ESA) (as the focus of cooperation remains primarily European), as demonstrated by the Copernicus programme, the largest satellite Earth observation programme, among many others. France also promotes cooperation on a bilateral basis, which has a very promising future. Its primary target countries are the States identified in the Space Strategy, although this scope is already expanding (for example with China). The most significant bilateral space cooperation activities are as follows:

– The United States is a leading partner in oceanography (Jason satellites), research into Mars (Curiosity, Insight, Mars 2020) and lunar research (the Artemis agreement was signed in 2022), and France is also involved in these research activities.[93] In 2020, NASA launched the Solar Orbiter, which includes instruments designed by CNES and other French industrial players.[94]

[91] Air Defense 2023.

[92] French Air and Space Force Public Affairs Office 2023.

[93] Douarin 2022.

[94] ESA 2020.

- Space-related cooperation with India is very diverse. In 2016, CNES and the Indian Space Research Organization (ISRO) spearheaded the New Delhi Declaration, in which more than 60 countries committed to using space assets to curb global warming by establishing an independent greenhouse gas emissions estimation system.[95] During the Indian lunar mission (Chandrayaan-1) launched in January 2018, CNES provided some basic instruments (cameras), and in 2018 the CNES-led consortium also installed Argos instruments on the Indian Oceansat-3. A third and rather spectacular programme is called Team Indus, the first private mission to the Moon, presented at the 2016 Bengaluru Space Expo, for which CNES will supply a number of the latest generation of CASPEX micro-cameras,[96] while in January 2018 the PicSat nano-satellite was launched to explore the star Beta-Pictoris in search of exoplanets.[97]
- On 20 October 2018, CNES and the Japanese Space Agency (JAXA)[98] launched the BepiColombo mission to study Mercury's magnetic field and map its surface.[99] A joint mission to study the moons of Mars is currently planned for 2024, using a dedicated rover.[100]
- On 29 October 2018, the Sino–French ocean research satellite CFOSAT[101] was launched into orbit to study ocean surface winds and waves. Following President Macron's official state visit to China in January 2018, Franco–Chinese cooperation in space has increased significantly and includes deeper collaboration, in particular in sharing CFOSAT data to study the oceans and their interaction with the atmosphere.[102]

95 France Science 2016.
96 CNES 2016.
97 Minassian 2018.
98 Japan Aerospace Exploration Agency.
99 CNES 2018.
100 Martian Moons Exploration (MMX) mission.
101 CFOSAT s. a.
102 CFOSAT s. a.

- The CNES signed its first cooperation agreement with Australia on 1 September 2018, which not only sets out the framework for a strategic dialogue but also outlines specific areas of cooperation such as Earth observation, with a special focus on climate and navigation employing satellite technologies and regulatory approaches. In addition, the signing of a Memorandum of Understanding between the Australian National Space Industry Hub and a French hub (Aerospace Valley[103]) was a major step that is expected to boost space industry relations.[104]
- The French Taranis satellite was launched in November 2020 as a result of international cooperation, but due to a launch vehicle failure, it was never used. It would have been the first satellite designed to monitor lightning at an altitude of 20–100 km.[105]

CONCLUSION

Closely linked as they are to the idea of strategic autonomy, the issues of controlling access to space and preserving freedom of action in space are priorities for France. There are two main reasons for this: the close link between space and nuclear deterrence, and the dependence of modern military operations on space capabilities. France will therefore certainly continue to be an active player in shaping the space environment, albeit with a somewhat specific focus. To be precise, the French Ministry of Defence is only interested in near space, up to geostationary orbit, whereas the more distant orbits have no military relevance. The possible future exploitation of celestial bodies therefore remains the responsibility of the civil space agency, as it is not part of the military space strategy. In contrast, in other countries, where a single national space strategy has been adopted, the full exploitation of the potential of space is a major issue.

103 This industry community involves over 830 member companies.

104 McAneny 2022.

105 Taranis 2020.

Examples include China and Japan, which are already in the preliminary stages of the third phase, with plans to power their fusion reactors with Helium 3 from the Moon.[106]

Turning to the French Government's position, space remains a top priority in the current cycle. In 2022, the Minister of the Armed Forces announced that €9 billion would be earmarked for space activities for the three-year period up to 2025, to successfully achieve high-priority objectives such as climate observation, participation in scientific research and the provision of services from orbit and satellite constellations, while putting a strong emphasis on the military component of French space power.[107] France envisages this primarily in the framework of European cooperation, which it proposes to deepen further, for example by creating a European Space Strategy and a European Space Command.[108]

However, France's vision of federation and its ambition to play a leading role in space issues in Europe is not always appreciated in Europe. Germany, for example, has mostly applied the logic of industrial catching-up rather than strategic thinking, and sees space primarily in economic and industrial terms. However, considering developments in recent years, such as the establishment of the German Space Command in 2021 or the Italian Space Command in 2020, it is reasonable to think that this could easily change.

What is certain, on the one hand, is that France has become a very significant military space power in just a few years – although with an annual military and civilian space investment of $2 billion, it is still far behind the United States ($50 billion), China ($10 billion) and Russia ($4 billion).[109] On the other hand, the New Space period will undoubtedly be dominated by emerging companies, for which France has already been consciously preparing: there are currently

[106] McAneny 2022.
[107] Pons 2022.
[108] Schnitzler 2022.
[109] La Dépêche 2021.

56 New Space startups in the country,[110] and this number is expected to grow rapidly. If France continues to exploit its potential, it could become a dominant player in the New Space era.

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110 Tracxn 2023.

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András Edl – Gyula Speck

Germany's Space Activity: Balancing Security Needs and the Opportunities of New Space

INTRODUCTION

German space activity is among the most notable in the world. Germany is active not only in its own as a national space project, but also as a member state of the ESA and a participant in EU space projects. With the increased activity in the space sector, often referred to as New Space, and the changing geopolitical environment, Germany needs to readjust its posture, in order to both make full use the opportunities arising from these developments and to strengthen its own security.

The latter is not an easy task for Germany. Russia's attack on Ukraine came as a shock to many inside the German leadership, and three days after the Russian attack chancellor Olaf Scholz stated that the day of the attack signalled a change of times and the end of an era *(Zeitenwende)*. Due to these new circumstances, the defence capabilities provided by space-based systems have received even more attention and changes have been initiated or accelerated in the German defence sector. Germany is increasingly attempting to support national space endeavours, participate in European joint projects and increase its space defence capabilities.

The German contribution to early rocket technology is well known. German scientists worked on rockets as early as the 1920s and the Third Reich also recognised the promise of the technology and invested heavily in its development. The first ever man-made object to reach space was a V-2 rocket produced

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by this project, although it was an achievement costing many lives. After 1945, however, the facilities and expertise of rocket building basically disappeared from Germany. The rocket factories were destroyed and most of the scientists involved were taken to the U.S. or the Soviet Union. Rocket development was officially allowed only after the 1955 peace treaty of Paris, enabling the country to participate in space activity. In 1962 West Germany joined the freshly formed organisations aiming to develop a European space launcher and seven years later, on 8 November 1969 West Germany launched its first satellite, named Azur. The same year saw the establishment of the organisation now known as the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt, DLR), which is responsible for civilian space activity. The country joined the European Space Agency in 1975. However, the first German in space was from the eastern bloc, Sigmund Jähn from the GDR. After the Cold War, the reunified country took part in the building of the International Space Station, which began in 1998.[1] In the following years, Germany cemented its position as a capable and reliable partner in various forms of space cooperation, while being a steady proponent of the European integration, including closer cooperation between the ESA and the EU, while acknowledging that not all member states of ESA are EU members. The formulation of several space-related documents and policies was unimaginable without German participation. Cooperation with Japan, the United States and other countries was established in the first decade of the new millennia, while at the same time Berlin became more aware of the need to deploy space-based capabilities to bolster the country's defensive capabilities and security situation. The current paper explores how Germany has reevaluated its security posture and what may be the current and possible future role of space capabilities in this shift.

1 Fischer et al. 2019.

THE DEVELOPING ROLE OF SPACE IN GERMANY'S SECURITY POLICY

The role of space in Germany's security policy has been fundamentally determined by the country's foreign policy identity and its role in the world economy since 1945. Although the Federal Republic was allowed to conduct space exploration in a national and international context from 1955 onwards, its pre-1945 history meant that its activity in this field was exclusively concentrated in the civilian domain. Technological progress has enabled the economic exploitation of space: the first German telecommunications satellite went into operation in 1974, and since the 1990s there have been more commercial than public operators in space. As the economic importance of space increased in the 2000s, more attention began to be paid to security aspects.[2]

By the 2000s, a broad understanding of security had become a feature of German strategic thinking, which was first emphasised in the 2006 White Paper on Security Policy and the Future of the Bundeswehr. The White Paper introduced the concept of 'networked security' *(Vernetzte Sicherheit),* according to which security policy in the future will be determined not primarily by the military but by economic, social, environmental and cultural factors, and therefore security cannot be understood in a purely national context and cannot be provided solely by the armed forces: "Rather, there is a need to create a comprehensive approach that thinks in terms of networked security policy structures and a concept of security as a nation-state and a global security."[3]

The emergence of this wide-ranging perception of security has also had an impact on space policy, although in the early 2000s space was not yet an integral part of security policy. In 2001, the Social Democrat-Green government acknowledged that security aspects were increasingly playing a role in space activities and that in the changed security environment, the strategic reconnaissance capabilities of the German armed forces needed to be developed

[2] VOGT 2012: 35–47.

[3] Bundesministerium der Verteidigung 2006: 25.

to be capable of early warning in a crisis, while space activities also contributed to the state's ability to act. For German security policy, participation in peace operations beyond NATO territory and especially the Kosovo conflict has highlighted the security implications of space activities, in particular the importance of strategic reconnaissance capabilities.[4]

The whole-of-government approach was first reflected in the German Space Strategy of 2010, which addressed space activities in the context of disaster relief, climate protection, energy planning, border protection, arms control, strategic reconnaissance and military command and control capabilities. This strategy required all ministries that are relevant to space to align their policies with the overall national security policy. The document states that Germany's internal and external stability is highly dependent on its space infrastructure and is therefore vulnerable to both intentional and unintentional interference and that the protection of space infrastructure is necessary for the future. The strategy specifically addresses the military aspects of space activities: given the fact that in Germany, unlike the United States, the civilian science sector is the driver of technology and innovation, rather than the military, it is necessary to assess the extent to which civilian space activities are compatible with security policy needs. In other words, synergies between the civilian and military segments should be sought in a national and European context, which can exploit the potential of dual-use technologies.[5] One example is the cooperation between the Fraunhofer Society and the Bundeswehr Space Situations Centre *(Weltraumlagezentrum der Bundeswehr)* to prevent damage caused by space debris.[6]

The "Munich Consensus", a security policy guideline that was developed between 2014 and 2016, with the intention of renewing strategic thinking, called for Germany to take a more active role in foreign and security policy and stressed that Germany must assume greater responsibility for defending the rules-based international order. An important milestone in the development

4 Bundesministerium für Bildung und Forschung 2001.
5 Bundesministerium für Wirtschaft und Technologie 2012.
6 Vogt 2012.

of this new approach was the foreign policy review process of the Ministry of Foreign Affairs *(Review 2014 – Außenpolitik Weiterdenken),* whose final report considered how Germany can contribute more actively to the protection of global assets, including outer space.[7] The *White Paper 2016 on Security Policy and the Future of the Bundeswehr,* which was formerly the highest level security policy document, addressed the security challenges posed by threats to information, communication, supply, transport and supply lines, as well as to the security of raw materials and energy supplies. Since Germany, as an economic superpower, has an open economy, its prosperity is increasingly dependent on the security of these global assets in sea, air, cyber and information domains and outer space. The White Paper explicitly identifies space security *(Weltraumsicherheit)* as a strategic priority. It states that space infrastructures, especially satellite systems, are an essential part of German critical infrastructures, as international communication and navigation are dependent on them. Regarding arms control, disarmament and non-proliferation, Germany aims to establish confidence-building measures in space. However, the most important new feature of the 2016 White Paper compared to the 2006 edition is that the Bundeswehr's tasks were extended to include the surveillance of critical space infrastructure. Networking of operations was also included in the document among the capability development goals of the armed forces, enabled by communications systems and satellite connectivity.[8]

With the change in German security perception, for the first time a strong emphasis was laid on outer space in defence planning. In 2017, the Federal Ministry of Defence defined the Bundeswehr's goals and areas of action for the outer space segment in a document entitled "Strategic Guidelines for Space" *(Strategische Leitlinie Weltraum),* the details of which are classified. Reiterating the findings of the White Paper, the document states that Germany's digital economy and society, as well as its military, make it increasingly dependent on space infrastructures, the protection of which must be a task for the entire

7 Auswärtiges Amt 2014.
8 Die Bundesregierung 2016.

state. The document establishes the goal of developing reconnaissance and communication satellites as an essential element of the Bundeswehr's command and control capabilities.[9]

The Bundeswehr Concept *(Die Konzeption der Bundeswehr)* published in 2018, which follows the findings of the White Paper and defines the tasks and general guidelines of the armed forces, declared homeland and collective defence to be the primary task of the Bundeswehr. Although homeland and collective defence is traditionally understood as a defence against a conventional, symmetrical attack, the document emphasises that an unconventional attack in cyberspace or outer space may also require collective defence action. The Bundeswehr concept includes the securing of critical space infrastructures among the defence tasks not covered by collective defence, similarly to the White Paper. To perform these tasks effectively, capabilities must be developed in the space segment in addition to land, air, sea and cyberspace. According to the Concept, the Bundeswehr should possess the capabilities required to carry out two types of space operations: on the one hand, "operational support and exercises from space" and on the other hand, "deployment, operation and protection of space systems". Such operations include, for example, the provision of information by the force on the entry of space objects or the protection of civilian critical space infrastructure within the constitutional framework.[10] Germany's first National Security Strategy, published in 2023, puts even more emphasis on space security than the previous documents. It states that Germany will work with its partners to build a global sensor network to strengthen space security. The government will also develop a new space security strategy, which will provide future guidelines, especially for strengthening resilience and military capabilities.[11]

[9] Bundesministerium der Verteidigung 2017.
[10] Bundesministerium der Verteidigung 2018.
[11] Die Bundesregierung 2023.

The strategy documents clearly show that, over the last 30 years, space has become an increasingly important part of German security policy, which has gone hand in hand with a broadening conceptual understanding of security and Germany's growing international role. Like other developed industrial countries, Germany has recognised that its globalised economy is increasingly dependent on space infrastructures, the security of which must be of paramount significance. The strategic documents of the 2010s made it clear that space security is of strategic importance since it ultimately enables Germany's sovereign ability to act.[12] This development is illustrated by the fact that the coalition agreement of 2021 was the first to address space activities not only in terms of technology and innovation but also in terms of security. The document addresses space debris removal and disarmament, while pledging that the government will promote the peaceful use of space and cyberspace and will implement arms control measures in the field of space weapons, in addition to restricting biological, cyber and AI-based weapons.[13]

However, despite these developments, the development of German space security policy is not without its shortcomings, especially in the field of intelligence. The Federal Intelligence Service (*Bundesnachrichtendienst,* BND), which is responsible for foreign intelligence, relies on the satellites of the Bundeswehr for satellite reconnaissance, as well as those of allied intelligence services such as the US NSA, as it does not have its own satellites. The outbreak of the WikiLeaks scandal, the use of chemical weapons in Syria, the 2014 conflict in Ukraine and the growing terrorist threat posed by the Islamic State prompted the BND to develop and procure its own electro-optical surveillance satellites. To facilitate this, the federal government allocated 400 million euros in 2016 for the development of spy satellites, which was due to be completed by 2022.[14] Unfortunately, the procurement of the satellite system has been delayed by two years, according to the BND, due to slow production. The coronavirus

12 Vogt 2012.
13 Die Bundesregierung 2021.
14 Mascolo–Pinkert 2016.

pandemic and most recently the Russian–Ukrainian war have highlighted the need for the BND to acquire the satellites as soon as possible, because without them the federal government is unable to respond to crises in a timely manner and continues to rely on its allies. This ultimately limits Germany's ability to act in international crisis management.[15]

DEVELOPMENT OF THE INSTITUTIONAL FRAMEWORK OF SPACE SECURITY

In the early 2000s, with the increasing recognition of the importance of space security, the institutional architecture for space security policy began to take shape. First, the Bundeswehr's Air Force *(Luftwaffe)* started to explore the extension of the German armed forces' capabilities to space, and in 2006 a working group on space was set up within the Federal Ministry of Defence. In 2009, the Bundeswehr Space Situations Centre *(Weltraumlagezentrum der Bundeswehr)* was established in Uedem, under the Federal Ministry of Defence, which has traditionally been responsible for space security and which has been operating the Centre jointly with the Federal Ministry of Economics since 2011. The Centre was initially staffed by Air Force officers but they have since been supplemented by civilian employees of the German Aerospace Centre (*Deutsches Zentrum für Luft- und Raumfahrt*, DLR), in exchange for a liaison officer from the Centre. The Centre is also in close contact with the Deutsche Flugsicherung GmbH, which is responsible for air traffic, as well as with the Federal Office for Civil Protection and Disaster Management and the Federal Police. The Space Situations Centre monitors the movement of space debris, warns military and civilian satellites of possible satellite collisions, contributes to the weapons verification process, and provides early warning and reporting on space weather. The Centre's services are used not only by the armed

15 Bewarder–Jungholt 2022.

forces but also by various ministries (foreign affairs, economy, environment), intelligence services and international partners.[16] The Centre works closely with the European Space Agency (ESA)'s Near-Earth Object Coordination Centre, which provides information on asteroids and meteors approaching Earth. It exchanges technical and operational information twice a year with the ESA Space Debris Office in Darmstadt and has access to ESA's DISCOS database.[17] The Centre has been part of the Bundeswehr's Space Command since July 2021.[18]

The DLR is also an important player in national space security, essentially acting as Germany's space agency and conducting, among other things, space security research. For example, in 2019 the DLR, together with the Fraunhofer Institute for High-Frequency Physics and Radar Technology, funded by the Ministry of Defence and the Ministry of Economics, developed a German Experimental Space Surveillance and Tracking Radar (GESTRA), which plays an important role in tracking space debris.[19] The DLR also has an agreement with the Air Force concerning expert and scientific cooperation to develop military applications. The DLR carries out defence industrial research with support from the Ministry of Defence in areas such as satellite technologies, sensors and fast-response satellite communications.[20]

In Germany, in line with the strategy documents, space security has become an interministerial and nationwide task. At the highest level, the Federal Ministry of Defence is currently responsible for space security. However, the Federal Chancellery is also involved in space security, as it oversees the Federal Intelligence Service, while the Federal Ministry of the Interior is responsible for critical infrastructure protection and crisis management in Germany, and

16 Vogt 2012; Deutscher Bundestag 2021.

17 The DISCOS (Database and Information System Characterising Objects in Space) is the database of ESA, which collects and stores information on space launches, registered and unidentified space objects as well as space vehicles.

18 Bundeswehr 2022a.

19 DLR 2019.

20 Deutscher Bundestag 2021.

the Federal Ministry of Economic Affairs and Climate Protection deals with civilian space activities. The Ministry of Foreign Affairs also plays an important role in the area as it is actively involved in international legal negotiations on space security.[21]

GERMANY'S CURRENT STRATEGIC INTERESTS AND PRIORITIES IN SPACE SECURITY

In line with the strategic documents discussed above, the current security aspects of space are best summarised in the Federal Government's parliamentary briefing published in September 2021 and the April 2021 report prepared for the UN Secretary-General. In these documents, the Federal Government has stated that Germany has an interest in free access to space and in the provision of space-based services such as banking systems, energy systems, water supply and maritime and air transport systems, all of which are made possible by satellite technologies. Satellites enable the early warning of crises, which is of major security policy importance. The operation of the armed forces depends on key space-based technologies such as satellite communications and geo-information systems. According to the briefing, space security challenges largely arise from the growth in the number of space actors, satellites and space debris, and the growing capabilities of other international actors. Germany should be aware that in the early stages of conflicts, civilian and military space infrastructures, as well as space-related data, services and products, may be at risk in hybrid operations.[22] The report to the UN points out that, since civilian and military space infrastructures could easily become targets in a future conflict, it is necessary to prevent the emergence of a space arms race and to ensure the peaceful use of space. In this respect, Germany considers counter-space capabilities a major security threat, because they are increasingly present in the toolbox of states as a result of the growing mistrust between states. Such counter-space

21 Antoni et al. 2020.
22 Deutscher Bundestag 2021.

capabilities include direct ascent anti-satellite (DA–ASAT) capabilities, which can kinetically destroy satellites launched from the ground, sea or air, energy weapons (e.g. utilising high-energy microwaves or electromagnetic pulses), anti-satellite weapons deployed on satellites, electronic jamming devices capable of blocking satellite signals and cyberattacks. Of particular interest are dual-use capabilities, such as the robotic arm satellites currently under development, which are designed primarily for maintenance, or Rendezvous and Proximity Operations (RPO),[23] which can also be used to jam or damage other satellites. Although these capabilities and assets are not a threat in themselves, they may become so when combined with hostile behaviour and actions.[24]

To promote its space security interests, Germany acts in an international framework, supports multilateral international treaties, monitors space-related security and defence policy issues in the EU and NATO framework, and participates in international cooperation initiatives and multinational planning.[25]

Germany pays particular attention to supporting UN arms control initiatives, especially confidence-building mechanisms. Although the 1967 Outer Space Treaty banned the deployment of weapons of mass destruction in space and provided consultation mechanisms, it did not include security and confidence-building rules. On arms control, the German position stresses that traditional measures, such as banning certain devices, are not sufficient in outer space, as dual-use devices can be used as weapons. In the space segment, the definition of 'weapon' is problematic.[26] According to the federal government, this means that norms, rules and guidelines must be agreed internationally that require actors to refrain from actions and acts that can be interpreted as threats. These pragmatic principles should be independent of international law while reflecting the common interests of the international community.

23 RPO operations are usually used for the maintenance, repair, refuelling or docking of space vehicles or space capsules. However, by exploiting the physical properties of space, these manoeuvres can also be used to deliberately damage satellites.

24 United Nations 2021.

25 Deutscher Bundestag 2021.

26 Auswärtiges Amt 2021.

Germany has proposed to the UN the international adoption of the following eight principles:

1. States must inform each other about the launch of missiles and spacecraft.
2. States must be vigilant about the generation of space debris in their space activities and must not knowingly cause its generation.
3. States should provide information on their space rendezvous operations, including the time, trajectory and purpose of the manoeuvre.
4. States shall not conduct or intentionally support space rendezvous operations that impair the safe manoeuvrability of a space asset. States shall seek the highest possible degree of transparency in space rendezvous operations.
5. States shall not conduct or intentionally support cyber and electromagnetic operations that damage space systems.
6. States must provide a national 24-hour contact line to provide information to other states at any time, thus reducing errors.
7. States should strive to make public their national space security policies, strategies and doctrines.
8. States should establish a system of oversight rules at the national level to ensure that the above principles are respected by national private sector space actors.[27]

In addition to the above proposals, in 2020 Germany joined the British-led international initiative "Reducing Space Threats through Rules, Principles and Norms for Responsible Behaviours", which aims to promote responsible space activities. Berlin and London have also proposed that the UN General Assembly set up a working group to identify current and future threats and risks and to develop norms, principles and standards for behaviour. The proposal was adopted by a large majority in the UN General Assembly in December 2021.[28] Germany, together with the United States, Canada, New Zealand, Japan, the

[27] United Nations 2021.
[28] Auswärtiges Amt 2021.

United Kingdom and South Korea, declared in 2022 that it will stop testing anti-satellite missiles.[29]

THE BUNDESWEHR'S SPACE ACTIVITY

Initially, Germany's military did not have strategic reconnaissance satellites or satellite communications and was therefore dependent on American assets. However, as the Bundeswehr increasingly became involved in peace operations outside NATO territory, there was an increasing demand for these capabilities. First, Defence Minister Rudolf Scharping ordered the development of the country's own reconnaissance satellite systems, which resulted in the SAR-Lupe military reconnaissance satellite system which entered service in 2008. Launched from the Plesetsk Space Centre in Russia and using Russian Cosmos 3M rockets, SAR-Lupe initially consisted of five satellites and a ground component.[30] Its technical sophistication was demonstrated by its ability to take images around the clock, regardless of weather conditions, making Germany the third country after the United States and Russia to have such advanced technology.[31] In addition to reconnaissance satellites, since 2010 the Bundeswehr has had its own command and control communications satellite system (SATCOMBw 2), which enables voice and data transmission.[32] Satellite communication has played a key role in Bundeswehr missions and operations abroad, such as the now-finished UN mission in Mali (MINUSMA) or the NATO Baltic air policing mission.[33]

The next important milestone in the revaluation of the military importance of outer space came in the late 2010s, when NATO declared outer space an operational area at its London Summit in December 2019, and then declared

[29] Auswärtiges Amt 2022; Giri 2022.
[30] Wiesner 2011.
[31] Lühmann 2011.
[32] Vogt 2012.
[33] Deutscher Bundestag 2021.

at the Brussels Summit in 2021 that attacks in and from outer space could trigger the activation of Article 5 of the North Atlantic Treaty.[34] NATO also published its overarching Space Policy in January 2022.[35] In December 2019, the United States created the U.S. Space Force as its sixth military branch along with the associated U.S. Space Command, responsible for all military activities in the space segment. In addition, in 2020, the Trump Administration issued the Defense Space Strategy, which declared space an operational domain. France, another important ally of Germany, issued its Space Defence Strategy *(Stratégie Spatiale de Défense)* in 2019, renamed its Air Force as the Air and Space Defence Force *(Armée de l'air et de l'espace)* and established its own Space Command *(Commandement de l'espace)* in Toulouse. France also aims to develop an anti-satellite laser weapon. The United Kingdom set up its own space command (U.K. Space Command) in 2021.[36]

At the same time, it has become clear that more and more states outside of the transatlantic alliance are developing military space capabilities. China already tested an anti-satellite missile in 2007, and India destroyed a satellite from Earth for the first time in 2019. Russia also possesses anti-satellite weapons, and during a test in November 2021 it destroyed a satellite, the debris from which threatened the International Space Station. In addition, at the start of its attack on Ukraine in February 2022, Russia launched a targeted cyberattack against Viasat's KA-SAT network, damaging not only Ukrainian but also European systems, including the remote control of 5,800 wind turbines controlled by the German company Enercon.[37] These steps represent a threat to Germany, which is committed to the peaceful use of space.[38]

Overall, the actions of NATO allies, as well as the growing threats to space security, have pushed Germany to develop its military space capabilities. In September 2020, the Federal Ministry of Defence, together with the Air Force

34 NATO 2019; NATO 2021.
35 NATO 2022.
36 Rotter 2022; Hegmann 2019.
37 Stupp 2022.
38 Deutscher Bundestag 2022.

Observatory, established the Air and Space Operations Centre (ASOC). The ASOC, as a centralised command element, brings together the previously parallel Air Force Operations Center, the Situation and Operations Center for National Airspace Security and the Air Intelligence Center, which performs various situational awareness and operational command functions. The establishment of the ASOC was an important step in the development of national command and control capabilities.[39] The next important milestone was the establishment of the Bundeswehr Space Command *(Weltraumkommando der Bundeswehr)* in May 2021. The initial civilian and military staff of the Space Command which currently numbers almost 80, will increase to 250 in the future.[40] The Space Command is responsible for coordinating military space activities, planning and leading the Bundeswehr's operations in space, and preventing attacks on the force's space assets. The Space Command conducts ground observation, tracks the movement of space debris and provides up-to-date information on the space situation to other Bundeswehr command units such as the Bundeswehr Operations Command and the Homeland Defence Command.

The next generation SARah (Synthetic Aperture Radar) satellite system, developed by Airbus and the German company OHB System AG, which will replace the SAR-Lupe system and be launched by SpaceX's Falcon 9 rockets in the United States, was acquired in the summer of 2022 to improve strategic reconnaissance capabilities. The SARah-1 satellite, developed by Airbus, is equipped with a multiphase antenna system, while the SARah-2, developed by OHB, has three passive reflector antennas. SARah-1 is based on the TerraSAR, TANDEM-X and PAZ Earth observation satellite technologies previously developed by Airbus, which allow very fast antenna movements.[41]

Of the 100 billion Euro special defence fund announced by Chancellor Olaf Scholz in his *Zeitenwende* speech in February 2022, a substantial amount, more than 20 billion Euros, will be spent on digitisation and

39 Vogel 2020.
40 Weltraumkommando der Bundeswehr s. a.; Austin et al. 2022.
41 Bundeswehr 2022b; Davenport 2022; Airbus 2022.

communications systems for the Bundeswehr, including the development of satellite communications.[42] Moreover, the significant sum of 2 billion euros was allocated to SATCOMBw in 2023.[43]

The Bundeswehr continues to be heavily dependent on its allies for some of its space capabilities and is exposed to the threat of space debris and possible space attacks, but it is taking these challenges into account in its space operations planning. This demonstrates that the German armed forces are increasingly aware of space as an operational area.[44]

As can be seen from the above, the military dimension has also developed significantly in the last 20 years as part of the space security policy in Germany. Although Germany has traditionally rejected the militarisation of space, as a dominant member of NATO it cannot ignore the changes in the space security domain and it is committed to adapting to them. Thanks to the development of its military space capabilities, Germany is now recognised by the international community as a major military space actor. It is important to emphasise, however, that Germany, unlike the United States, France and the United Kingdom, is developing its military space capabilities for defensive purposes only, and that its military space operations are designed to support the Bundeswehr in its missions and to maintain the military space infrastructure. The government justifies this defensive strategy on the basis of international law, specifically the prohibition of force and the sovereignty of states.[45]

THE NEW DEFENCE GUIDELINES AND THE NEW FEDERAL SPACE STRATEGY

As should be evident, there has been gradual development in the German approach to space and security. Since 2023, however, several documents on

[42] Krempl 2022.
[43] Tenenbaum – Péria-Peigné 2023.
[44] Deutscher Bundestag 2021.
[45] Rotter 2021; Deutscher Bundestag 2021.

space security have been published which were greatly influenced by the Russian attack against Ukraine and the accelerating changes in technology and the geopolitical landscape. However, the direction of these documents was not completely new and they reflected previous intentions.

Due to the recent changes in Germany's security environment, the development in space technology and the various changes implemented by major or emerging space actors made it clear that the previous German space strategy which was applied from 2010 November has become outdated. The necessity for a new strategy was known to multiple stakeholders and also recognised by the new government, and it was raised in the 2021 Coalition Agreement *(Koalitionsvertrag)* between the SPD, the Green Party and FDP. The document promises that the new administration will strengthen the German national space program, support cooperation with ESA and develop the badly needed space strategy.[46] The document also addresses space in other places, as a key capability to solve global problems and improve the economy while it emphasises the peaceful uses of space and the need for arms control and regulation.[47]

As well as outlining the new strategy, it was also necessary to align it with other strategic documents. The first ever National Security Strategy, published in June 2023, served as a good foundation for this and the *Zeitenwende* idea of Olaf Scholz is clearly visible in the document. This document deals with space in a designated sub chapter to highlight its importance.

The German Federal Government's Space Strategy *(Raumfahrtstrategie der Bundesregierung)* was published in September 2023. The strategy aims to support increasing commercial involvement and digitalisation. In order to achieve that goal, the strategy outlines nine key areas where the government can take action. These areas are the following:

1. *European and international cooperation.* The independence of the ESA and Europe's technological and strategic sovereignty are among the main goals in this area. The wording of the document suggests that the two are interconnected and should not be separated. Related objectives include the

[46] Die Bundesregierung 2021: 27.
[47] Die Bundesregierung 2021: 146.

clear distribution of roles and working more closely with EUMETSAT and other EU and international partners.

2. *Space as a growth market: high-tech and New Space.* This area refers to the need to strengthen private investment in space, through competition and demand-oriented tenders. The ESA and other sources of funding are also taken into consideration.
3. *Climate change, resource protection and environmental protection.* In line with the German commitment to a green energy transformation and to combat climate change, this area focuses on providing accurate space-based data including the measurement of emissions.
4. *Digitalisation, data and downstream activities.* The government intends to make the data available to all potential users, especially data related to climate change and at the same time further develop satellite communications including 5G and future 6G technologies.
5. *Security, strategic opinions and global stability.* The need to strengthen European space resiliency and protect critical infrastructure is underlined in this area, while pledging to participate in the EU's space surveillance and tracking projects. The strategy also stressed that sensitive technologies must be under export control.
6. *Sustainable, safe use of space.* EU space traffic management, international sustainability standards and regulations, best practices, collision avoidance capabilities, reducing space debris and the creation of a space law are the main points in this area.
7. *Space research.* The area focuses on the continuation of German space research, in particular on small-satellite projects, keeping the ISS functional at least until 2030 and finding new opportunities within the ESA for additional German participation.
8. *International space exploration.* The main focus of this area is Germany's participation in the Artemis program, for example in the building of the Lunar Gateway, the European Service Module for the Artemis missions and supporting robotics projects. Another element is to urge the UN to create a regulatory framework for mining on other celestial bodies.

9. *Space activities in the context of recruiting and attracting talent.* This area contains two main elements, firstly the raising of public awareness of space and promoting the field, especially in schools. The other is increasing the number of women in the space sector and training or attracting new talent. The latter also includes supporting the immigration of skilled people.[48]

The nine areas and their objectives highlight several important points. Certain key areas reflect German politics, for example the major emphasis on climate change, or the goal of creating opportunities for German industry and research. Other elements are understandable but could create friction with other EU member states. In reference to attracting talent, even through immigration, it is not stated that this can only be someone with a migration background from outside the EU. Therefore, other European countries also struggling with the lack of skilled labour force may also be affected. For them, the other side of the coin is the problem known as "brain drain".

In addition, thirteen specific key projects are mentioned in the document which may provide additional insight into Germany's intentions in space. Each project is designated to a given area which cannot thrive without the success of the designated project.

Table 1
Activity areas and designated key projects of the German Space Strategy

Activity area	Key project
European and international cooperation	Kp1: European Launcher Competition – this is necessary to secure Europe's unhindered access to space, a capability gap already well known and emphasised in recent years.
	Kp2: Participation in international missions – this will allow Germany to participate in projects which are otherwise beyond its reach. The two partners highlighted in the description are NASA and Japan.

48 Bundesministerium für Wirtschaft und Klimaschutz 2023.

Activity area	Key project
Space as a growth market; high-tech and New Space	Kp3: Small Satellite Initiative – small satellites are considered important for SMEs, while the government intends to build up a relevant value chain in Germany.
	Kp4: Space Innovation Hub – to foster innovation and synergies between providers of space services and public sector consumers the government will create a platform to serve as a point of contact.
Climate change, resource protection and environmental protection	Kp5: Precise space-based measurement of emissions – focusing heavily on methane and carbon dioxide emission measurements, to allow the creation of a detailed database about local emissions. This is intended to make a major contribution to the European Green Deal.
Digitalisation, data and downstream activities	Kp6: Cloud platforms for climate and environmental data – sharing the gathered data free of charge and without limitations to stakeholders will increase the effectiveness of climate actions and initiatives.
Security, strategic opinions and global stability	Kp7: The establishment and expansion of national capabilities for space situational awareness – Germany aims to play a leading role in the EU SST partnership and therefore seeks to further develop its SSA capabilities. These will also be crucial for the protection of space-based systems.
The sustainable, safe use of space	Kp8: Space Traffic Management (STM) – closely connected to Kp7 there is a need for space traffic management on a global level. For the establishment of this framework, Germany will cooperate with the EU and the UN.
	Kp9: Space Act – the government aims to implement a space law *(Weltraumgesetz)* to ensure the sustainability of the space sector. The law will streamline the process of acquiring permits and will establish a system for monitoring and evaluation.
Space research	Kp10: Promoting high quality research in low Earth orbits, following the termination of the ISS – the project intends to explore German options to have access to experiment time in low Earth orbits after the ISS program ends. This will be done in preparation for the decisions which the ESA has to take.
International space exploration	Kp11: A return to the moon, via international partnership – the project refers to the European Service Module and German robotic research, and the possibility of technology transfer into other areas of industry.

Activity area	Key project
Space activities in the context of recruiting and attracting talent	Kp12: Explaining the space sector – this project has three distinct strands focusing on the media, on educational institutions and special programs including the small satellite program for universities.
	Kp13: Experiencing the space sector – the government intends to bring space closer to the wider population, allowing visits to locations and organising a German Space Day in 2025.

Source: Compiled by the authors based on Bundesministerium für Wirtschaft und Klimaschutz 2023.

There are several interesting elements in the key programs which can offer additional insights into German intentions. Kp1, the European Launcher Competition, seeks to go beyond the proposed launcher alliance which is supposed to secure enough revenue for European launch provider Ariane to make Ariane 6 rocket a viable alternative to competing systems and to provide the support needed for further development. The background of this key project is the joint statement released in November 2022 during the ESA Council Meeting at a Ministerial Level held in Paris. Germany, France and Italy released a joint statement on their support for the Ariane 6 and Vega C launcher systems. The dedicated funding serves to compensate for the financial risks of the service providers, as well as to decrease the costs of launches. The statement sets June 2024 as the final deadline for the new architecture to be in place, including the legal framework.[49] Germany states in the first key project description that it wants to support the *near-term* commissioning of the Ariane 6 system, but at the same time it proposes changing the narrative and introducing competition and thus further innovation.

It is worth mentioning that the strategic documents released after the space strategy also follow the new direction outlined in it. The new defence policy guidelines *(Verteidigungspolitische Richtlinien 2023)* were released on 10 November 2023, shortly after the new space strategy, and it is evident that the

[49] Cowing 2022.

two documents were created in parallel. The new defence guideline was also long overdue since the last version had been published in 2011. The guidelines emphasise that the biggest threat will remain Russia and that crisis management is only secondary. Germany's partnership with NATO is of great importance but a greater emphasis on the Indo-Pacific region and China can be seen. Some partners in Asia, such as Japan, are also important in Germany's space activity. In terms of defence, a significant change in attitude, stressing the importance of improving warfighting capability *(Kriegstüchtigkeit)* as the main task for the German armed forces, which is direct in its assertive language compared to previous years. The document also claims that at least 2% of the GDP would be necessary to create and maintain the required capabilities. The document does not state that this funding is assured and therefore this can be interpreted as a message for the decision-makers, who might not be fully dedicated to securing this amount of consistent funding in addition to the 100 billion euros in special funding. This uncertainty creates tensions and might delay or severely limit the development of space capabilities, because the main focus will be on building up conventional forces. The guidelines mention space seven times and acknowledges space as a geostrategic domain and dimension together with land, air, sea, cyber and information.[50]

The Federal Government also has a future strategy for research and innovation *(Zukunftsstrategie Forschung und Innovation).* The strategy highlights the innovation potential in politics, the economy, science and society. Six key areas can help to support innovation and to foster research. Climate protection, resilience, resource efficiency, digital and technological sovereignty are listed, but one of the key areas is the exploration, preservation and sustainable usage of space and the seas. The first report about the strategy was published in December 2023. The six key areas will be supported by mission teams comprised of people from different stakeholder ministries. One area emphasised by the report is the need for technology leadership and the ability to understand, develop and

[50] Bundesministerium der Verteidigung 2023.

manufacture key technologies.[51] Space technology belongs to this category and a push for such technological sovereignty is an important security goal not only for Germany but also for the EU.

OBSTACLES FOR TURNING THE STRATEGY INTO REALITY

While there is no doubt that there was a dire need for a new space strategy, some critical voices argue that the end result is far from enough. The strategy is rather vague and does not set out a detailed roadmap about how the government intends to reach specific goals. In addition, real vision and thus inspirational power seems to be missing from the document. There is much talk about the European idea, but it does not set a clear goal for the area which Germany wants to be the best at.[52] Markus Schiller, a space expert and the head of ST Analytics, has a similar opinion. It seems the new strategy only repeats well-known phrases, but lacks real content. However, there are more pressing problems as well. One of them is the lack of interest, vision and ambition at the highest political levels with regard to space. As a consequence, larger scale projects are only supported inside the ESA framework. The other problem revolves around decision-making and responsibility *(Zuständigkeit)*. Everything space related has to go through the DLR at some point and to a certain degree it has to be fine-tuned to fit in with ESA activities and coordinated with other member states. He added that: "Hundreds of important people have to say 'yes' to any space initiative, and just a few 'no's are enough to starve that initiative of 'political' support".[53] Decision-making on space seems to be a complicated area. Cornelius Vogt has highlighted a structural problem which is not immediately visible in the new strategy but which concerns political decision-making in Germany in general and thus also applies to space strategy-making and policy implementation. This problem is connected to the organisational structure of the Federal Republic,

[51] Bundesministerium für Bildung und Forschung 2023.
[52] Weissflog 2023.
[53] Schiller 2024.

which is set up in a way that reflects the idea of "Never again!" ("Nie wieder!"). The slogan refers to the founding fathers of the Federal Republic – the Parliamentary Council, the Parlamentarischer Rat, which convened from 1948 to 1949 – wanting to prevent Germany becoming a dictatorship ever again.

The German political system, from its constitutional set-up to the day-to-day business of party politics is characterised by a very high degree of separation, the sharing and entanglement of powers, checks and balances at various levels, and cooperative political decision-making mechanisms. As much as this system prevents any single power centre from overpowering all the others, it also makes powerful and swift decision-making highly unlikely. As many stakeholders need to be consulted in the preparation of decisions and many stakeholders hold de facto veto powers, strategising and long-term planning are effectively hindered. The development of space capability and space missions typically requires ambitious goal-setting and long-term planning (budgets, schedules, technology development). The German political system therefore poses serious obstacles to space strategy implementation.[54]

The honesty of the government's dedication to space is also questionable. While Berlin seems to be determined to support the national space industry, at the same time an organisation for German space SMEs wrote an open letter to chancellor Olaf Scholz in July 2023 due to the proposed 15% budget cuts for the 2024 national space budget, while the ESA contribution increased. The open letter warned the chancellor not to commit a strategic mistake. The budget cuts could lead to decreasing investment, loss of position and revenue, and several other disadvantages.[55] The ongoing debates surrounding the 2024 budget *(Bundeshaushalt 2024)* flared up again in November 2023 when the constitutional court *(Bundesverfassungsgericht)* declared that a part of the government's plans for using the 60 billion euros remaining from pandemic emergency funds for climate and transformation funds is unconstitutional. A revised plan was drafted in December 2023 but debates continued way into January. In addition, there are worries that the gap in the budget will

[54] Vogt 2024.

[55] Arbeitskreis Raumfahrt KMU 2023.

be even bigger in 2025. Of the amounts in the proposed new budget plan, it seems that the funds allocated to defence increased slightly compared to 2023 from 50.1 billion euros to 51.8 billion euros. The budget for the Ministry for Economic Affairs and Climate Action fell to 11 billion from 14.5 billion.[56] This is important because in 2022 90% of the DLR's budget came from this ministry, a proportion which further increased in 2023 and 2024.

The above data means that even amid severe cuts in other areas the defence budget slightly increased. At the same time, however, the spending only amounts to 2% of the GDP because of the 100 billion euro special fund allocated to defence purposes. If the government wants to meet this goal in the future, the special fund will have to cover an even bigger proportion of this, but this will only be possible until the fund runs out, which could happen very soon. It is very likely that the modernisation of the Bundeswehr will be slower and that defence-related space spending will also be limited. The DLR's budget might also be decreased and an additional strain will be put on decision-makers to make cuts in the DLR, by allocating less resources to space programs. On 1 February 2024, there were still no data available about the exact amount of funding dedicated to the German space program.[57] At the end of the debate, these problems might be solved and crucial projects might still be on the way, but problems like these might make it difficult to plan ahead, attract investment or keep to original timelines for various programmes.

However, there are also other perspectives. According to Cornelius Vogt, the challenge for German space activity is not necessarily the question of the proportion of the space budget that is spent on national space missions versus the budget being contributed to ESA missions. Compared to some other countries, Germany contributes a rather large proportion of its space budget to optional ESA space programmes. However, the ESA's industrial policy of geographic return ensures that national contributions are returned to a member state in the form of industrial contracts. Thus, German contributions to ESA can be channelled back to German companies and institutions. This

56 Tagesschau 2024.

57 Bundeshaushalt 2024.

mechanism effectively supports the objectives of improving competitiveness, building industrial capacities and advancing expertise. Therefore, the main challenge is to ensure the growth of the combined, total German space budget (both the purely national budget plus its contributions to the ESA). Fully implementing the new strategy and making projects a reality will require a growing overall space budget.[58]

GERMAN SPACE INDUSTRY

Naturally, a key element in German space capabilities or in any future project is the country's industrial background. According to the German Aerospace Industries Association (BDLI) report published in 2021 Germany had a space-related workforce of 9,200 and produced 2.4 billion euro in commercial revenue.[59] The figures for 2023 show a slight decrease in the workforce down to 9,000 but the revenue increased to 2.6 billion euros.[60]

The country's space sector involves multiple companies including various major partners and sometimes competitors or their subsidiaries. Many of these companies are involved in aerospace, defence and other kinds of technology production and development. One of them is Airbus, which is considered to be the 2nd largest space company in the world. Their Bremen centre is the focus point for space flight, space robotics and the assembly site of the European Service Module. Together with a startup company, Voyager and the ESA they also intend to build the Starlab a commercial space station aimed to succeed the ISS. In their facility at Friedrichshafen they focus on weather satellites, the next generation of Copernicus and Galileo satellites, and radar satellite technology. At its Ottoburn–Taufkirchen site the company produces mainly solar arrays and in addition it has a clean room for the installation of optical

58 Vogt 2024.
59 BDLI 2022.
60 BDLI 2023.

equipment.[61] Another company that is active in the space field is ArianeGroup which has four sites in Germany, in Bremen, Lampoldshausen, Ottobrun and Trauen. These sites produce hydrazine, various rocket and engine components.[62] Telespazio and Thales are also active in the country.

Of course, there are also space companies founded in Germany. Possibly the most prominent of those is OHB System AG, founded in 1981 in Bremen. According to the latest company report, OHB had more than 3,000 employees from more than 35 nations.[63] The company delivered equipment and component parts for the ISS and is active in Earth observation, human space flight and space exploration, in particular the Moon. Similarly to many other companies, OHB also experienced a setback in revenues due to the pandemic but in 2021 and 2022 a growth trajectory can be seen.

The list of startup companies in the field is also considerable and the government intends to further encourage the establishment and growth of SMEs. A few examples for these companies are Rocket Factory Augsburg AG, Isar Aerospace Technologies GmbH, HyImpulse Technologies GmbH, UP42, Reflex Aerospace GmbH, Mynaric AG.

GERMANY'S INTERNATIONAL COOPERATIONS

Traditionally, the security policy of Germany is based on multilateralism. Its space security policy is no exception, since some key capabilities are only available to its allies. Its most important ally in the area is the United States, which plays an essential role in the development and deployment of its space capabilities because Germany does not have its own space port or launch vehicle technology. The Space Operations Centre relies heavily on the United States for data collection. The Bundeswehr has had a liaison officer at the U.S. Space Operations Center in Vandenberg since 2017 and at the U.S. Space Command

[61] Airbus 2024.
[62] ArianeGroup 2024.
[63] OHB 2023a.

since 2021. The German Foreign Office and the Federal Ministry of Defence are in regular consultation with their U.S. counterparts. Cooperation between Germany and the United States is based on mutual interest. In the face of China's and Russia's space capabilities, the United States needs its European allies, including Germany.[64] Recently the two partners have started to build an even stronger connection. On the 14th of September 2023 Germany became the 29th country to sign the Artemis Accords.[65] Berlin also looks to the U.S. for some space-related defence technology. Lockheed Martin also received a contract to deliver traffic management software. In addition, the Bundeswehr is the first foreign military to receive the most advanced M-code GPS receivers. The deal was announced in 2020 and BAE systems reported in July 2022 that an undisclosed quantity of equipment has been delivered.[66]

France has long been among Germany's most reliable partners in Europe. Since the Franco–German summit held in Mainz, in 2000, France has had access to SAR-Lupe satellite data, while Germany has access to French Helios 2 satellite data.[67] In 2012, the French and German Defence Ministers agreed to cooperate on Earth observation and both sides pledged to acquire next generation satellite systems, resulting in France acquiring the CSO *(Composante Spatiale Optique)* system to replace the Helios 2 satellite system and Germany commissioning the SARah system mentioned above.[68] In 2017, the Franco–German Security and Defence Council decided to continue data sharing on the new generation of satellites and to share their satellite images with the European Union Satellite Centre.[69] In the field of strategic reconnaissance, the German armed forces are working closely with their French partner, which is providing the electro-optical component of the Bundeswehr's remote sensing capabilities.

64 Deutscher Bundestag 2021.
65 DLR 2023.
66 Erwin 2022.
67 Vogt 2012.
68 Deutscher Bundestag Wissenschaftliche Dienste 2018.
69 Antoni et al. 2020.

The Bundeswehr is also present in France with a liaison officer, working with its partner to build a new space situational awareness sensor system, while the NATO Space Operations Centre was established in 2021 in Toulouse.[70] From the French perspective, it is also important to stress that it needs Germany to develop its space security and defence capabilities, as the French space strategy underlined. The document considers the exchange of data between French optical systems and German radars to be essential, which could form the basis for the development of a future Space Situational Awareness (SSA) system. The benefits of such cooperation are obvious, given the complementary capabilities of the French GRAVES and German GESTRA radars.[71] Cooperation with France also remains a key issue because of the Future Combat Air System (FCAS) that they are jointly developing. The FCAS, which is expected to be in service by 2050 and will be composed of a fighter aircraft, a combat air surveillance system and unmanned aerial vehicles, will require, among other things, a very high-speed satellite link to enable remote control and communication independent of geographical obstacles. Satellite connectivity will also significantly increase the survivability of fighter aircraft by allowing early warning of enemy missiles.[72]

Given that the Bundeswehr does not have the appropriate sensors, it relies on all allied space actors beyond France and the United States, as well as on the civilian capabilities of the DLR, to collect data to protect space infrastructures.[73]

German forces are actively involved in international military space exercises, such as the French Space Command's AsterX exercise,[74] and participates in the annual Schriever Space War Games organised by the U.S. Space Command.[75]

70 Deutscher Bundestag 2021.
71 The French Ministry of the Armed Forces 2019.
72 Le Gleut – Conway-Mouret 2020.
73 Deutscher Bundestag 2021.
74 The AsterX exercise has been carried out by the French Space Command since 2021, with the aim of training the French armed forces to defend France's space infrastructure against attacks from other states, by practising different scenarios.
75 The Schriever Wargame has been conducted by the United States every year since 2001 in order to work with allied space forces to identify critical space security challenges, and

By setting up its own space command, the Bundeswehr intends to conduct its own space exercises in the future.[76]

Since 2019, Germany has been a member of the Combined Space Operations (CSpO) initiative, an international multilateral forum that aims to promote cooperation on space security and the interoperability of space capabilities. The organisation currently brings together seven nations: in addition to Germany, it includes the United States as the leading nation, France, Canada, Australia, the United Kingdom and New Zealand. In February 2022, the CSpO issued a joint declaration, Vision 2031, which sets out common interests and principles for the peaceful use of outer space and aims to develop the interoperability of military space capabilities, information sharing and joint specialist training.[77]

An interesting development in recent years is that Italy is building closer ties with Germany and France. For example, the three countries are cooperating on SpaceFounders, a New Space accelerator launched in 2021 by CNES and the University of the Bundeswehr, which Italy joined in 2023.[78]

In November 2023 Giorgia Meloni and Olaf Scholz signed an Action Plan in Berlin. The bilateral relations between the two states should be steered according to the guidelines and proposals set out in the document. There are multiple issues the two partners wish to tackle, including climate change, migration, economic issues and energy trade, which includes an ambitious plan for a pipeline across the Alps. The plan evens mentions the approach to China. The document envisages space as an important area of cooperation, already building on the existing programs.[79] Earlier, in 2007, the Italian Space Agency (ASI) and DLR had signed a joint declaration on cooperation in the Galileo and the EGNOS programmes. One other example of a joint program

potential military uses of new space systems and to improve the space support capabilities of the armed forces.

[76] Deutscher Bundestag 2021.

[77] Federal Ministry of Defence 2022; Combined Space Operations s. a.

[78] ASI 2023.

[79] Agenzia Nova 2023.

is the European Large Logistic Lander (EL3), also known as the Argonaut, which is mainly being built by Germany and Italy.

German cooperation with Russia in the space field basically stopped after the invasion of Ukraine, which even affected ongoing projects such as the eROSITA telescope, designed to find black holes. The device was launched in 2019 from Baikonur and two days after the invasion Germany decided to shut it down, limiting the joint project's effectiveness. Roscosmos chief Rogozin claimed in an interview that the organisation will basically hijack the German satellite and resume operations.[80] According to official communications this did not happen, however.

Likewise, Japan is also a valuable partner for Germany. The two countries have worked together for nearly three decades on space-related projects. The first framework agreement for a strategic partnership was signed in 2016. This was followed up with an extended framework agreement signed in April 2022, making R&D cooperation even more tight between JAXA and DLR. The partnership already has plenty of success stories under their belt. They are working on joint projects on the ISS in the areas of medicine, material science and fundamental research. The Hayabusa 2 mission, the DESTINY+ mission and the upcoming Martian Moons eXploration (MMX) mission can also be added to the list of their achievements.[81]

GERMANY AND EUROPEAN PROJECTS

The goals of the German space program will not only influence the national space sector but, due to Germany's position inside Europe, they will also have an important impact on European space activity as a whole. Berlin is serious about space and cooperation with European partners. This is also visible in the ESA's budget. In 2023 Germany became the biggest contributor, paying 1,046.8 million euros, which was 21.4% of the 4.9 billion euros paid by the member states

80 Deutsche Welle 2022.

81 DWIH Tokyo 2022.

of ESA. France was the second biggest contributor, at 1,000.9 million euros (20.4%), while Italy made the third largest contribution of 580.1 million euros, or 11.8% of the total budget. The overall budget in 2023 was 7.08 billion euros.[82] In 2024 the budget of the ESA increased by nearly 10% to 7.9 billion euros. Of the member states' contributions, Germany covered 22.4% with 1,171.6 million euros, France will contribute 20.1% with 1,048.4 million euros and Italy has pledged to cover 16.9% with an 881.2 million euro contribution.[83] This contribution is mostly provided from the internal budget of two ministries, the Federal Ministry of Economic Affairs and Climate Action (BMWK) and the Federal Ministry of Transport and Digital Infrastructure (BMVI) although the Federal Ministry of Defence (BMVg) is also involved in the process.

The size of the German contribution will also entail a considerable German influence on the decision-making of the ESA. While the independence of the ESA is emphasised by the German space strategy, at the same time Germany, like all the other member states will also consider their own national interests. Kp10 explicitly states that the to-be-proposed German options for the era following the end of the ISS are intended as a preparation for ESA decision-making. This is without a doubt a foresight and represents the long-term thinking needed in the European space endeavour, yet the possibility remains that Berlin will receive criticism and some pushback if the proposed options are perceived as being too much in favour of German interests.

Germany is also involved in other joint European space projects outside ESA. At the moment there are four PESCO projects in progress that focus on space: Defence of Space Assets (DoSA); Common Hub for Governmental Imagery (CoHGI), European Military and Space Surveillance Awareness Network (EU-SSA-N) and the EU Radio Navigation Solution (EURAS). Germany is member of all these projects and the coordinator of one of the projects, the Common Hub for Governmental Imagery. Italy is the coordinator of EU-SSA-N, while the remaining two are coordinated by France.[84]

82 ESA 2023.

83 ESA 2024.

84 PESCO s. a.

German companies and institutions also participate in joint projects initiated under the European Defence Fund (EDF). One example of these is the Odin's Eye II project which is one of the three projects approved in 2022. This will provide a European space-based missile early warning system. The program coordinator is OHB System AG, along with 37 other participants, including 9 German corporations or institutions. The project is related to the Timely Warning and Interception with Space-based Theater Surveillance (TWISTER) project initiated under PESCO.[85] Another initiative approved in 2022 was the Responsive European Architecture for Space (REACTS) project. Its goal is to provide an interoperable, resilient and scalable network of responsive space systems, capable of launching satellites and starting data delivery within 72 hours. The coordinator of this project is the DLR. Airbus Defence and Space Gmbh, OHB System AG, Rocket Factory Ausburg AG are among the participants.[86] The third space-related project approved in 2022 is the Space Based Persistent ISR for Defence and Europe Reinforcement (SPIDER) project. The coordinator of this initiative is the French branch of Airbus, although German participation is considerably lower than in the two other projects.[87]

A PROJECT FOR THE WHOLE SPACE SECTOR? – THE GERMAN OFFSHORE SPACEPORT ALLIANCE

Steps have also been taken to assure not just a more diverse national launch industry, but at the same time to move closer to European launcher independence. The spaceport in Kourou, French Guayana is a modern facility, but it does not offer the required capacity. The German Offshore Spaceport Alliance (GOSA), established in 2020 intends to build a mobile sea-based platform for micro launchers. These would be rockets with a payload of maximum 1 ton and

85 EDF 2022a.
86 EDF 2022b.
87 EDF 2022c.

mostly loaded with small satellites. The platform should operate 350 kilometres away from the coast, at the farthest point of the exclusive economic zone. That location would guarantee that in case of an accident the rocket might impact the sea instead of a densely populated area. The platform not only gives access to the fast-growing launcher market, thus helping to reduce the so-called launcher bottleneck, but at the same time it has possible defence applications. In the event that an attack destroyed or damaged satellites they could be replaced more rapidly, without the necessity for foreign service providers to launch German assets.[88] It is worth mentioning that the base of operations for the GOSA consortium and the port they plan to operate from is Bremen, where Airbus, ArianeGroup and OHB also have sites.

The proposed location of the site, similarly to other launch sites being developed in Scandinavian countries and the U.K. is seemingly not a suitable location for launches, compared to other sites closer to the equator, because it could not take advantage of the Earth's rotational speed to the same degree. However, for micro launchers delivering payloads to lower altitudes this is not such an important issue and they could still launch payloads for example to sun-synchronous orbits effectively. A feasibility study has already identified the best type of ship for these operations, which would be the Combi Dock provided by Harrer & Partner. The rocket would load into the ship horizontally, be transported to the location by the ship, raised into a vertical position and launched. [89]

The site is also far from busy air and sea routes. An additional advantage is that it is inside the EU, unlike sites in the U.K. or Norway, which could be a great advantage when companies wish to launch EU security-related missions such as satellites, like those for the IRIS² constellation. However, the site has been declared a maritime protection area and this would only allow 250 days of operation per year. The initial phase could have 12 launches per year and with a considerable logistical improvement the fully operational platform would allow up to 25 launches per year. Support for the platform is not universal, however. Doubts have been raised as to whether the platform

[88] OHB 2023b.
[89] Moontomars 2023.

could be operated in a financially feasible way. Because of this Isar Aerospace, a significant Munich-based launcher startup is not among the supporters either and is looking for land-based launch sites instead.[90]

Despite such criticism in the background, the idea itself seems to be a tempting one. A Danish company, EuroSpaceport, intends to do something very similar. They will utilise the expertise acquired with offshore platforms by the companies operating in Esbjerg, a harbour town on the west coast of Denmark. According to the company's timeline they intend to test a rocket in September 2024 and by October 2025 a small satellite launch is a possibility.[91]

The possibility of offering a national launch site could help to keep companies and a skilled workforce in Germany. After it becomes operational, Berlin could offer services to NATO and the EU, not to mention the potential benefits for the German armed forces itself. In 2020 there were even hopes that government backing for the program would help to bring the NATO space centre of excellence to Germany.[92] This hope ended on 28 January 2021 when NATO chose the French proposal and set up the centre in Toulouse.

The first launch of the GOSA project is scheduled for 2024 but delays are always possible and not uncommon in the space sector. Until the platform is fully operational, using or not-using it is more of a theoretical question. Understandably, then, German companies are looking for other solutions, including providers outside the EU.

One such firm is Rocket Factory Augsburg. Their rocket, the RFA One launch vehicle is built to deliver a payload of 1,300 kilograms to an altitude of 300 kilometres. The launch site chosen by the company was originally Norway's Andøya Spaceport, but the delays in the Norwegian site's opening have made them consider other alternatives. SaxaVord Spaceport on Unst, an island of the Shetland Islands, might be the best option. The U.K. Space Agency provided additional support for their first flight and one of the launch pads is

90 Parsonson 2023.
91 EuroSpaceport 2022.
92 Sprenger 2020.

to be exclusively used by the RFA. The site might also host companies such as Lockheed Martin, or startups like the California based ABL Space Systems, Skyrora or Orbex.[93]

A similar company, Isar Aerospace, secured its first contract with Airbus Defense and Space in April 2021. The company also intends to use the Andøya facility, where the company has full access to the first launch pad, built to Isar's specifications that are aimed to optimise the structure for their Spectrum launch vehicle able to deliver a 700 kg payload to a sun-synchronous orbit or 1,000 kilograms to low Earth orbit. Both Isar Aerospace and Rocket Factory Augsburg are carrying out additional tests in Esrange Spaceport, located in Sweden.[94]

Towards a "Space Security Awareness"

Germany's space security policy has evolved considerably in recent decades. The integration of space into security policy started in the 2000s and was completed in 2016. As a result, today a kind of "space security awareness" is present in German strategic thinking. The integration of the military dimension, on the other hand, is still at an early stage: ambitions range from the protection of space infrastructures to the maintenance and development of command-and-control capabilities, although the defence policy documents, the international presence and the establishment of the Space Command clearly indicate that this area will become a major focus in the future.[95] There is no doubt that, as in other areas of security policy, Germany's actions in space security currently lag behind those of its American, French and British partners. It is important to emphasise that, because of its pre-1945 history, the Federal Republic has followed a civilian power role in its security policy, refraining from great power politics, pursuing its interests multilaterally, diplomatically and economically, and

93 Rainbow 2023.
94 Jones 2023.
95 Mölling 2022.

using military force as a last resort, thus understandably adopting a different attitude from France, for example. Nevertheless, the challenges to the rules-based international order have forced Germany to adapt to these changed circumstances. This shift is also reflected in Germany's changing space security policy, involving the development of independent capabilities and increased international engagement.

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As the “final frontier”, space has been a domain of rapidly evolving human activities in the early 21st century. The orbital space around the Earth has become an essential component of the global economy by enabling navigation, communication, defence and security activities, along with several other types of services both on our home planet and in outer space. The Moon could soon play a similarly crucial role. Complex geopolitical factors, state ambitions and private investment are the main driving forces leading us to a New Space Age.

However, the international legal framework governing space activities has not kept pace with these developments, resulting in unanswered questions, diverging interpretations and even the risk of conflict. It is thus more important than ever to discuss the legal and policy aspects of this new era of space activities. The international team of authors of the present volume undertook to scrutinise and assess some of the most pressing and topical issues of the New Space Age in twenty-three chapters to contribute to the ongoing professional discourse on space and to promote the peaceful use of outer space for the benefit of all mankind.