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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.

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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?

REFERENCES

2001: A Space Odyssey (1968). Dir. Stanley Kubrick. Metro-Goldwyn-Mayer and Stanley Kubrick Productions.

Beech, Martin – Seckbach, Joseph – Gordon, Richard eds. (2022): *Terraforming Mars*. Hoboken–Beverly, Mass.: John Wiley & Sons – Scrivener Publishing.

Bensaid, Adam (2023): *The Race for Space Colonisation and Limitless Wealth Is Already Here.* Online: https://www.trtworld.com/magazine/the-race-for-space-colonisation-and-limitless-wealth-is-already-here-45430

Bini, Antonella (2008): The Moon Agreement: Its Effectiveness in the 21st Century. *ESPI Perspectives,* 14: 1–7.

Blount, P. J. (2021): Settling in Outer Space. In Schrogl, Kai-Uwe – Giannopapa, Christina – Antoni, Ntorina (eds.): *A Research Agenda for Space Policy.* Cheltenham: Edward Elgar, 187–203.

Blount, P. J. – Masson-Zwaan, Tanja – Moro-Aguilar, Rafael – Schrogl, Kai-Uwe eds. (2020): *Proceedings of the International Institute of Space Law 2020.* The Hague: Eleven International Publishing.

Bosi, Giulia (2021): Overcoming the "Soft vs Hard Law" Debate in the Development of New Global Health Instruments. *Opinio Juris,* 30 November 2021. Online: http://opiniojuris.org/2021/11/30/overcoming-the-soft-vs-hard-law-debate-in-the-development-of-new-global-health-instruments/

Böckstiegel, Karl-Heinz ed. (1991): *Handbuch des Weltraumrechts.* Cologne: Carl Heymanns Verlag.

Böckstiegel, Karl-Heinz – Benkő, Marietta – Hobe, Stephan eds. (2005): *Space Law. Basic Legal Documents.* The Hague: Eleven International Publishing.

Cambridge Dictionary (s. a.): *Visit.* Online: https://dictionary.cambridge.org/dictionary/learner-english/visit

Cheng, Bin (1997): *Studies in International Space Law.* Oxford: Claredon Press.

Chatzipanagiotis, Michael – Moro-Aguilar, Rafael (2014): *Criminal Jurisdiction in International Space Law: Future Challenges in View of the ISS IGA.* 57th IISL Colloquium on the Law of Outer Space, Toronto, 1–12.

Chung, Gordon (2019): Jurisdiction and Control Aspects of Space Debris Removal. In Froehlich, Annette (ed.): *Space Security and Legal Aspects of Active Debris Removal.* Cham: Springer, 31–47. Online: https://doi.org/10.1007/978-3-319-90338-5_3

Chladek, Jay (2017): *Outposts on the Frontier.* Lincoln: University of Nebraska Press.

Clarke, Arthur C. (1968): *2001. A Space Odyssey.* New York: New American Library.

Cockell, Charles (2019): *Interplanetary Liberty. Building Free Societies in the Cosmos.* Oxford: Oxford University Press. Online: https://doi.org/10.1093/oso/9780192866240.001.0001

COHEN, Marc M. (2004): Mobile Lunar Base Concepts. *AIP Conference Proceedings,* 699(1), 845–853. Online: https://doi.org/10.1063/1.1649649

CRAWFORD, James (2019): *Brownlie's Principles of Public International Law.* Oxford: Oxford University Press. Online: https://doi.org/10.1093/he/9780198737445.001.0001

ČEFERIN, Gaja (2018): *Mednarodnopravna ureditev rudarjenja na nebesnih telesih.* Master Dissertation. University of Ljubljana.

DE BERGERAC, Cyrano (1650): *Histoire comique des États et Empires de la Lune.* Folio Classique.

DE WAAL ALBERTS, Anton – MARTINEZ, Peter (2020): Possible Futures for Local and International Law Aplicable to the Governance of Moon Settlements as the Basis of a Settlement Strategy. In BLOUNT, P. J. – MASSON-ZWAAN, Tanja – MORO-AGUILAR, Rafael – SCHROGL, Kai-Uwe (eds.): *Proceedings of the International Institute of Space Law 2020.* The Hague: Eleven International Publishing, 183–196.

DE ZWART, Melissa (2021): To the Moon and Beyond. The Artemis Accords and the Evolution of Space Law. In DE ZWART, Melissa – HENDERSON, Stacey (eds.): *Commercial and Military Uses of Outer Space.* Singapore: Springer, 65–80. Online: https://doi.org/10.1007/978-981-15-8924-9_6

EINHORN, Bruce (2022): China, US Are Racing to Make Billions from Mining the Moon's Minerals. *Bloomberg News,* 17 May 2022. Online: https://www.mining.com/web/china-us-are-racing-to-make-billions-from-mining-the-moons-minerals/

ESA (2001): *Mir FAQs. Facts and History.* Online: https://www.esa.int/About_Us/Corporate_news/Mir_FAQs_-_Facts_and_history

ESA (2016): *Moon Village.* Online: https://www.esa.int/About_Us/Ministerial_Council_2016/Moon_Village

ESA (2023): *ESA Invites Space Firms to Create Lunar Services.* Online: https://www.esa.int/Applications/Connectivity_and_Secure_Communications/ESA_invites_space_firms_to_create_lunar_services

EUSTM (2023): European space traffic management for the 21st century. Online: https://eustm.eu

FARSARIS ELEFTHERIOS, Alexandros (2021): The International Space Station (ISS) Intergovernmental Agreement as a Precedent for Regulating the First Human Settlements on Mars. In FROEHLICH, Annette (ed.): *Assessing a Mars Agreement Including Human Settlements.* Cham: Springer, 63–74. Online: https://doi.org/10.1007/978-3-030-65013-1_6

Force, Melissa K. (2013): The Need to Define "Use" of Outer Space in Order to Distinguish "Appropriation". In Masson-Zwaan, Tanja – Moro-Aguilar, Rafael (eds.): *Proceedings of Outer Space Law.* The Hague: Eleven International Publishing, 404–421.

Freeland, Steven (2021): Space Debris: A Major Challenge for the Future of Humanity. *ILA Reporter,* 12 July 2021. Online: https://ilareporter.org.au/2021/07/space-debris-a-major-challenge-for-the-future-of-humanity-steven-freeland/

Freeland, Steven – Jakhu, Ram (2009): Article II. In Hobe, Stephan – Schmidt-Tedd, Bernhard – Schrogl, Kai-Uwe (eds.): *Cologne Commentary on Space Law.* Volume I. Cologne: Carl Heymanns Verlag, 44–64.

Froehlich, Annette ed. (2019): *Space Security and Legal Aspects of Active Debris Removal.* Cham: Springer. Online: https://doi.org/10.1007/978-3-319-90338-5

Froehlich, Annette ed. (2021): *Assessing a Mars Agreement Including Human Settlements.* Cham: Springer. Online: https://doi.org/10.1007/978-3-030-65013-1

Gerhard, Michael (2009): Article VI. In Hobe, Stephan – Schmidt-Tedd, Bernhard – Schrogl, Kai-Uwe (eds.): *Cologne Commentary on Space Law.* Volume I. Cologne: Carl Heymanns Verlag, 103–125.

Goh, Gerardine Meishan (2007): *Dispute Settlement in International Space Law: A Multi-Door Courthouse for Outer Space.* Doctoral Thesis. Leiden University. Online: https://hdl.handle.net/1887/11860

Gorove, Stephen (1969): Interpreting Article II of the Outer Space Treaty. *Fordham Law Review,* 37(3), 349–354.

Gough, Evan (2022): Space Junk Just Crashed Into the Far Side of the Moon at 5,800 MPH. *SciTech Daily,* 8 March 2022. Online: https://scitechdaily.com/space-junk-just-crashed-into-the-far-side-of-the-moon-at-5800-mph/

Green, Brian Patrick (2021): *Space Ethics.* Washington, D.C.: Rowman & Littlefield Publishers.

Grünfeld, Katja (2024): Die strategische Bedeutung von Weltraumsiedlungen. Eine Neue Welt? In Nötzold, Antje – Fels, Enrico – Rotter, Andrea – Brake, Moritz (eds.): *Strategischer Wettbewerb im Weltraum. Politik, Recht, Sicherheit und Wirtschaft im All.* Wiesbaden: Springer, 345–365. Online: https://doi.org/10.1007/978-3-658-42602-6_19

Grünfeld, Katja – Hobe, Stephan (2022): Hermann Potočnik Noordung – A Great Pioneer of Space Travel. *ZLW – Zeitschrift für Luft- und Weltraumrecht,* 71(3), 401–417.

GRUSH, Loren – KENDALL, Tyler – BLOOMBERG (2023): The Commercial Space Industry, Led by Elon Musk's SpaceX, Is Expected to Blast Off with 41% Growth over the Next 5 Years. *Fortune,* 24 July 2023. Online: https://fortune.com/2023/07/24/space-industry-revenue-growth-five-years/

HALLET, Lauryn (2021): Agreements Protecting Lives on Interplanetary Enterprises (ALIEN): Tailoring a Mars Criminal Justice System. In FROEHLICH, Annette (ed.): *Assessing a Mars Agreement Including Human Settlements.* Vienna: ESPI–Springer, 1–13. Online: https://doi.org/10.1007/978-3-030-65013-1_1

HARLAND, David M. – CATCHPOLE, John E. (2002): *Creating the International Space Station.* Heidelberg–Chichester: Springer – Praxis Publishing.

HEIKEN, Grant – JONES, Eric (2007): *On the Moon. The Apollo Journals.* New York: Springer. Online: https://doi.org/10.1007/978-0-387-48940-7

HOBE, Stephan (1997): The Legal Framework for a Lunar Base Lex Data and Lex Ferenda. In LAFFERRANDERIE, Gabriel – CROWTHER, Daphné (eds.): *Outlook on Space Law over the Next 30 Years.* The Hague: Kluwer Law International, 135–143.

HOBE, Stephan (2009): Article I. In HOBE, Stephan – SCHMIDT-TEDD, Bernhard – SCHROGL, Kai-Uwe (eds.): *Cologne Commentary on Space Law.* Volume I. Cologne: Carl Heymanns Verlag, 25–43.

HOBE, Stephan (2023): *Space Law.* Baden-Baden: Nomos.

HOBE, Stephan – SCHMIDT-TEDD, Bernhard – SCHROGL, Kai-Uwe eds. (2009): *Cologne Commentary on Space Law.* Volume I. Cologne: Carl Heymanns Verlag.

HOBE, Stephan – SCHMIDT-TEDD, Bernhard – SCHROGL, Kai-Uwe eds. (2013): *Cologne Commentary on Space Law.* Volume II. Cologne: Carl Heymanns Verlag.

HOBE, Stephan – SCHMIDT-TEDD, Bernhard – SCHROGL, Kai-Uwe eds. (2015): *Cologne Commentary on Space Law.* Volume III. Cologne: Carl Heymanns Verlag.

HOFMANN, Mahulena – BERGAMASCO, Federico (2020): Space Resources Activities from the Perspective of Sustainability: Legal Aspects. *Global Sustainability,* 3, 1–7. Online: https://doi.org/10.1017/sus.2019.27

HOLLINGHAM, Richard (2013): What Would Happen If All Satellites Stopped Working? *BBC News,* 10 June 2013. Online: https://www.bbc.com/future/article/20130609-the-day-without-satellites

ILWR (2023): Institute of Air Law, Space Law and Cyber Law at the University of Cologne, Cologne Manual on the International Law of Space Traffic Management. Online: https://ilwr.jura.uni-koeln.de/cologne-manual

International Court of Justice (1949): *Corfu Channel (United Kingdom of Great Britain and Northern Ireland v. Albania).* Online: https://www.icj-cij.org/index.php/case/1

International Court of Justice (1986): *Military and Paramilitary Activities in and against Nicaragua (Nicaragua v. United States of America),* Judgment (Merits), 27 June 1986, ICJ Rep. 1986.

International Institute of Space Law (2015): *Position Paper on Space Resource Mining (20 December 2015).*

Jakhu, Ram (2012): *Active Debris Removal – An Essential Mechanism for Ensuring the Safety and Sustainability of Outer Space.* 49th Session of the STSC of the UN COPUOUS.

Jamasmie, Cecilie (2021): Experts Warn of Brewing Space Mining War among US, China and Russia. *Mining.com,* 2 February 2021. Online: https://www.mining.com/experts-warn-of-brewing-space-mining-war-among-us-china-and-russia/

Kerrest, Armel (2009): Article VII. In Hobe, Stephan – Schmidt-Tedd, Bernhard – Schrogl, Kai-Uwe (eds.): *Cologne Commentary on Space Law.* Volume I. Cologne: Carl Heymanns Verlag.

Kulcinski, Gerald L. (1989): *Importance of Helium-3 for the Future.* Report of NASA Lunar Energy Enterprise Case Study Task Force, 150–171.

Kumar, Hari – Mashal, Mujib (2023): What's Next for India in Space Exploration. *The New York Times,* 23 August 2023. Online: https://www.nytimes.com/2023/08/23/science/india-space-whats-next.html

Kyriakopoulos, George D. (2020): Colonies on the Moon and/or Mars? New Challenges for International and National Law. In Blount, P. J. – Masson-Zwaan, Tanja – Moro-Aguilar, Rafael – Schrogl, Kai-Uwe (eds): *Proceedings of the International Institute of Space Law 2020.* The Hague: Eleven International Publishing, 169–181.

Lachs, Manfred (2010): *The Law of Outer Space. An Experience in Contemporary Law-Making.* Leiden–Boston: Martinus Nijhoff. Online: https://doi.org/10.1163/ej.9789004186675.i-180

Lafferranderie, Gabriel (2005): Jurisdiction and Control of Space Objects and the Case of an International Intergovernmental Organisation (ESA). *ZLW – Zeitschrift für Luft- und Weltraumrecht,* 54, 228–235.

LAN, Chen (2022): The Starlink-China Space Station Near-Collision: Questions, Solutions, and an Opportunity. *The Space Review,* 28 February 2022. Online: https://www.thespacereview.com/article/4338/1

LARSEN, Paul B. (2018): Solving the Space Debris Crisis. *Journal of Air Law and Commerce,* 83(3), 475–519.

LAY, S. Houston – TAUBENFELD, Howard Jack (1970): *The Law Relating to Activities of Men in Space.* Chicago: Chicago University Press.

LEE, Ricky (2012): *Law and Regulation of Commercial Mining of Minerals in Outer Space.* Dordrecht: Springer. Online: https://doi.org/10.1007/978-94-007-2039-8

LOFF, Sarah A. (2015): *Apollo 11 Mission Overview.* Online: https://www.nasa.gov/history/apollo-11-mission-overview/

Lunar Embassy to China (2005): *Haidian District Peoples Court.* Online: http://www.china.org.cn/english/China/203329.htm/

LYALL, Francis – LARSEN, Paul B. (2009): *Space Law. A Treatise.* Farnham: Ashgate.

MARCHISIO, Sergio (2009): Article IX. In HOBE, Stephan – SCHMIDT-TEDD, Bernhard – SCHROGL, Kai-Uwe (eds.): *Cologne Commentary on Space Law.* Volume I. Cologne: Carl Heymanns Verlag, 169–183.

Markets and Markets (2022). *Space Launch Services Companies – Space X (US) and Arianespace (France) are the Key Players.* Online: https://www.marketsandmarkets.com/ResearchInsight/space-launch-services-market.asp

MASSON-ZWAAN, Tanja – RICHARDS, Bob (2015): International Perspectives on Space Resource Rights. *Space News,* 8 December 2015. Online: https://spacenews.com/op-ed-international-perspectives-on-space-resource-rights/

MASUDA, Fumiko (2020): 'Jurisdiction and Control' over Space Products in the Age of Moon and Mars Settlement: An Analysis from a Private Law Perspective. In BLOUNT, P. J. – MASSON-ZWAAN, Tanja – MORO-AGUILAR, Rafael – SCHROGL, Kai-Uwe (eds): *Proceedings of the International Institute of Space Law 2020.* The Hague: Eleven International Publishing, 143–153.

MILLER, Zach (2020): Space Settlement and the Celestial Subjectivity Model: Shifting Our Legal Perspective of the Universe. In FROEHLICH, Annette (ed.): *A Fresh View on the Outer Space Treaty.* Cham: Springer, 59–66. Online: https://doi.org/10.1007/978-3-319-70434-0_6

Moon Village Association (s. a.). Online: https://moonvillageassociation.org/

NASA (1977): *Space Settlements: A Design Study.* Washington, D.C.: Scientific and Technical Information Office, National Aeronautics and Space Administration.

NASA (2023a): *Artemis.* Online: https://www.nasa.gov/humans-in-space/artemis/#missions

NASA (2023b): *Gateway.* Online: https://www.nasa.gov/mission/gateway/

NASA (2023c): *Station Record Holders.* Online: https://www.nasa.gov/international-space-station/space-station-astronaut-record-holders/

NASA (2023d): *Salyut 1.* Online: https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=1971-032A

NASA (2023e): *Station Facts.* Online: https://www.nasa.gov/international-space-station/space-station-facts-and-figures/

NASA (2023f): *International Space Station.* Online: https://www.nasa.gov/international-space-station/

Nemitz v. U.S., 2004 WL 316704, D. Nevada, 2004 (26 April 2004).

Němcová, Terezie (2021): Is Human Settlement on Mars Marking he Beginning of a New Era of Intellectual Property Rights Protection in Outer Space? In Froehlich, Annette (ed.): *Assessing a Mars Agreement Including Human Settlements.* Vienna: ESPI–Springer, 15–25. Online: https://doi.org/10.1007/978-3-030-65013-1_2

Noordung, Hermann (1995): *The Problem of Space Travel. The Rocket Motor.* Trans. by Richard Carl Schmidt & Co. Washington, D.C.: NASA.

Oberhaus, Daniel (2019): A Crashed Israeli Lunar Lander Spilled Tardigrades on the Moon. *Wired,* 5 August 2019. Online: https://www.wired.com/story/a-crashed-israeli-lunar-lander-spilled-tardigrades-on-the-moon/

Oberth, Hermann (1958): *Menschen im Weltraum. Neue Projekte für Raketen- und Raumfahrt.* Berlin: Deutsche Buch-Gemeinschaft.

OECD (2011): *The Economic Significance of Natural Resources: Key Points for Reformers in Eastern Europe, Caucasus and Central Asia.* Online: https://www.oecd.org/env/outreach/2011_AB_Economic%20significance%20of%20NR%20in%20EECCA_ENG.pdf

Petrova, Magdalena (2022): The First Crop of Space Mining Companies Didn't Work Out, but a New Generation Is Trying Again. *CNBC,* 9 October 2022. Online: https://www.cnbc.com/2022/10/09/space-mining-business-still-highly-speculative.html

Pistor, Katharina – De Shutter, Olivier (2016): *Governing Access to Essential Resources.* New York: Columbia University Press.

Pulp Mills on the River Uruguay (Argentina v. Uruguay), Judgment, I.C.J. Reports 2010.

Rome, Primož (2023): *Every Satellite Orbiting Earth and Who Owns Them.* Online: https://dewesoft.com/blog/every-satellite-orbiting-earth-and-who-owns-them

Royal Museums Greenwich (s. a.): *The Strange Things Humans Have Left on the Moon.* Online: https://www.rmg.co.uk/stories/topics/strange-things-humans-have-left-on-moon

Salmeri, Antonino (2020): Developing and Managing Moon and Mars Settlements in Accordance with International Space Law. In Blount, P. J. – Masson-Zwaan, Tanja – Moro-Aguilar, Rafael – Schrogl, Kai-Uwe (eds.): *Proceedings of the International Institute of Space Law 2020.* The Hague: Eleven International Publishing, 107–120.

Sancin, Vasilka – Grünfeld, Katja – Ramuš Cvetkovič, Iva (2021): Contemporary Challenges of International Law-Making for Outer Space. *Pravnik,* 36(1), 7–52.

Schmidt-Tedd, Bernhard – Mick, Stephan (2009): Article VIII. In Hobe, Stephan – Schmidt-Tedd, Bernhard – Schrogl, Kai-Uwe (eds.): *Cologne Commentary on Space Law.* Volume I. Cologne: Carl Heymanns Verlag, 146–168.

Schrogl, Kai-Uwe – Neumann, Julia (2009): Article IV. In Hobe, Stephan – Schmidt-Tedd, Bernhard – Schrogl, Kai-Uwe (eds.): *Cologne Commentary on Space Law.* Volume I. Cologne: Carl Heymanns Verlag, 70–93.

Schwartz, James S. J. (2021): A Right to Return to Earth? Emigration Policy for the Lunar State. In Boone Rappaport, Margaret – Szocik, Konrad (eds.): *The Human Factor in the Settlement of the Moon. An Interdisciplinary Approach.* Cham: Springer, 193–205. Online: https://doi.org/10.1007/978-3-030-81388-8_12

Singer, Peter W. – Corbett, Thomas (2023): China 'Colonizes' Space with Its First Rice Harvest. *Defense One,* 21 March 2023. Online: https://www.defenseone.com/ideas/2023/03/china-colonizes-space-its-first-rice-harvest/384285/

Shaffer, Gregory – Pollack, Mark A. (2009): Hard vs. Soft Law: Alternatives, Complements and Antagonists in International Governance. *Minnesota Law Review,* 94(3), 706–799.

Shaw, Malcolm N. (2017): *International Law.* Cambridge: Cambridge University Press. Online: https://doi.org/10.1017/9781316979815

Smith, Lesley Jane (2009): Article XII. In Hobe, Stephan – Schmidt-Tedd, Bernhard – Schrogl, Kai-Uwe (eds.): *Cologne Commentary on Space Law.* Volume I. Cologne: Carl Heymanns Verlag, 207–214.

SpaceX (s. a.): *SpaceX, Mars & Beyond.* Online: https://www.spacex.com/human-spaceflight/mars/

Stubbe, Peter (2018): *State Accountability for Space Debris.* The Hague: Brill.

Tarelli, Elis (2009): *The Strengths and Weaknesses of Soft Law as a Source of International Financial Regulation.* Online: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1467842

The Hague International Space Resources Governance Working Group (2019): *Building Blocks for the Development of an International Framework on Space Resource Activities.*

The Mars Society (s. a.). Online: https://www.marssociety.org/

The S.S. Lotus Case (French Republic v. the Turkish Republic), Judgement (1927), PCIJ Series A, No. 10.

Thompson, Clive (2023): How We'll Mess Up the Environment on the Moon. *Medium,* 19 June 2023. Online: https://clivethompson.medium.com/how-well-mess-up-the-environment-on-the-moon-fa554c96067c

Tobias, Paul (2005): Opening the Pandora's Box of Space Law. *Hastings International and Comparative Law Review,* 28(2), 299–318.

Tronchetti, Fabio (2009): *The Exploitation of Natural Resources of the Moon and Other Celestial Bodies.* Leiden: Brill.

Tronchetti, Fabio (2021): Importance and Relevance of the Use of Space Resources. In Schrogl, Kai-Uwe – Giannopapa, Christina – Antoni, Ntorina (eds.): *A Research Agenda for Space Policy.* Cheltenham: Edward Elgar, 171–177.

Tsiolkovsky, Konstantin (1928): *The Will of the Universe.* Kaluga: Published by the author. Trans. by Mykola Krasnostup.

UAE (s. a.): *Mars 2117 Project.* Online: https://u.ae/en/more/uae-future/2030-2117

UN Convention on the Law of the Sea 1994.

UN COPUOS (2013): *The Legal Framework for the International Space Station.* Online: https://www.unoosa.org/pdf/pres/lsc2013/tech-05E.pdf

UN COPUOS (2021): A/76/20, Annex III.

U.N. Doc. A/AC.105/C.1/2012/CRP,16 (2011).

United Nations (s. a.): *Peacekeeping.* Online: https://peacekeeping.un.org/en

UNOOSA (1967): *Travaux Préparatoires to the OST.* Online: https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/travaux-preparatoires/outerspacetreaty.html

UNOOSA (2010): *Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space.* Online: https://www.unoosa.org/pdf/publications/st_space_49E.pdf

UNOOSA (2021): *Guidelines for the Long-term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space.* Online: https://www.unoosa.org/documents/pdf/PromotingSpaceSustainability/Publication_Final_English_version.pdf

UNOOSA (2023): *National Space Law.* Online: https://www.unoosa.org/oosa/en/ourwork/spacelaw/nationalspacelaw/index.html

UNOOSA (s. a.): *Online Index of Objects Launched into Outer Space.* Online: https://www.unoosa.org/oosa/osoindex/search-ng.jspx?lf_id=

Uri, John (2021): 20 Years Ago: Space Station Mir Reenters Earth's Atmosphere. *Nasa.gov,* 23 March 2021. Online: https://www.nasa.gov/history/20-years-ago-space-station-mir-reenters-earths-atmosphere/

USA, National Aeronautics and Space Administration Transition Authorisation Act of 2017, Public Law 115-10-MAR. 21, 2017.

Vereshchetin, Vladlen S. (1981): International Space Law and Domestic Law: Problems of Interrelations. *Journal of Space Law,* 9(1–2), 31–40.

Verne, Jules (1865): *De la Terre à la Lune, trajet direct en 97 heures 20 minutes.* Paris: Pierre-Jules Hetzel.

Viikari, Lotta (2008): *The Environmental Element in Space Law. Assessing the Present and Charting the Future.* Leiden–Boston: Martinus Nijhoff.

Vincenzo, Cecilia (2023): Resolving Disputes in Outer Space: The Role of International Arbitration. *DLA Piper,* 6 April 2023. Online: https://www.dlapiper.com/en/insights/publications/2023/04/resolving-disputes-in-outer-space-the-role-of-international-arbitration

Vitt, Elmar (1989): *Marskolonie.* Doctoral Dissertation. University of Cologne.

Von Braun, Wernher (1952): Man Will Conquer Space Soon. Crossing the Last Frontier. *Collier's Weekly,* 22 March 1952, 24–29.

Von der Dunk, Frans (2020): 'For All Moonkind': Legal Issues of Human Settlements on the Moon: Jurisdiction, Freedom and Inclusiveness. In Blount, P. J. – Masson-Zwaan, Tanja – Moro-Aguilar, Rafael – Schrogl, Kai-Uwe (eds.): *Proceedings of the International Institute of Space Law 2020.* The Hague: Eleven International Publishing, 77–89.

Whitehouse, David (2019): *Apollo 11. The Inside Story.* London: Icon Books.

Zubrin, Robert (2011): *The Case for Mars. The Plan to Settle the Red Planet and Why We Must.* New York: Free Press.