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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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