THE FRENCH MINISTRY FOR THE ARMED FORCES

SPACE DEFENCE STRATEGY

Report of the "Space" working group

2019

SPACE DEFENCE STRATEGY

"A new frontier" is the memorable phrase used by John Fitzgerald Kennedy to describe space in his speech accepting the Democratic presidential nomination in 1960. A new horizon for the development of human knowledge had been identified and the space race had begun.

If space was once a new frontier to be crossed, it is now a "new front" that we have to defend. In a world at the mercy of live, unpredictable, technological threats, and at a time when powers are looking to assert themselves, space is a cornerstone of our defence. Space capabilities are a critical factor of all our operations, whether anticipating and planning manoeuvres, locating the enemy, guiding our forces in the field or communicating.

The sudden emergence of disruptive innovation methods in the space sector – known generically as "New Space" – calls for a change in the way we approach the development of our space capabilities. Alongside central governments, private-sector actors play a key role in the economic development of a space industry which is now more flexible, more innovative, more connected to other segments of the economy. The United States and China have long grasped the importance of this crucial turning-point for the development of our societies. Europe and France cannot turn a blind eye to an emerging area of potential conflict.

That is why the President of the Republic has made space a priority for our defence. We must concentrate our efforts on identifying and characterising unfriendly or hostile acts in the vicinity of our satellites, on continuing to develop our means of operational support, protecting our space assets and discouraging our adversaries from harming them. In response to these challenges, the Armed Forces Ministry has devised an ambitious space defence strategy for the period to 2030, spanning all aspects.

While the renewal of our entire satellite capability is already scheduled under the Military Planning Act, an additional effort will be made to enhance our space situational awareness and acquire initial capabilities in newly identified areas, especially the detection of potentially malicious space activities and the protection of our space assets. We will step up cooperation with our European partners while maintaining our close relationship with the United States. I am also counting on our industrial partners to continue and nurture the relations of trust we have established.

In terms of governance, the President of the Republic has announced the creation of a major space command, attached to the Air Force, whose sole purpose will be to prepare us for these new challenges. The Air Force will thus become the Air and Space Force. It marks a historic turning-point.

In order to meet these challenges and carry out genuine military space operations we will have to strengthen geographical and functional synergies with CNES, which has a tremendous pool of space expertise and is a real asset for France and its defence.

We have everything we need to succeed. I will ensure with the utmost determination that the space defence strategy described in the following pages is implemented. I believe in France, the third largest space power. We have been among the pioneers. We are about to become the vanguard.

Florence Parly

Minister for the armed forces

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EXECUTIVE SUMMARY

A revolution is taking place in the use of space, as in many sectors in which technology plays a decisive role. Affecting commercial, industrial and geostrategic interests, it presents so many challenges, including of a security nature, that France cannot simply ignore it. A space power for decades, France has undeniable assets and our armed forces have been using space for many years, mainly for strategic intelligence purposes and to support land, air and sea operations. Emerging technologies in what is generally referred to as New Space are paving the way not only for new opportunities that should be grasped but also for new threats that need to be addressed. The current French space model needs to be rethought in order to adapt to these disruptions. While the approach to space as an enabler is indeed being modernised, the notion of space as a domain with its own challenges has not yet been fully addressed.

That is the aim of this report, which outlines the future of our space defence in accordance with a roadmap that looks to 2030 and beyond. It is intended to inform interministerial discussions that take place elsewhere.

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The use of outer space is governed by a specific legal framework which guarantees freedom of exploration and use to all. There is no call to revise existing space treaties.

However, our freedom of access to and action in space could be compromised.

The sudden emergence of New Space is tilting the existing balances: disruptive technologies and uses and faster-moving innovation cycles are rapidly changing the criteria on which space power is based. Both a threat and an opportunity, these developments are forcing us to rethink both our industrial model and our governance of space.

Strategic competition is hotting up. Our space capabilities contribute to the strategic knowledge-and-anticipation function, reinforce the credibility of our deterrent and support our operations, whether through observation, telecommunications, signals intelligence or navigational assistance. They contribute to our operational superiority, fully justifying the resources earmarked for them under the Military Planning Act 2019-2025. These capabilities must therefore be secured for the future and renewed. But there is more to be done: French actors in both the public and the private sector must guard against more recent threats, such as the proliferation of space debris, jamming, blinding and directed-energy weapons.

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This new environment implies a space defence strategy founded on the protection of our capabilities. That involves first and foremost improving our space situational awareness (SSA), especially in order to detect and attribute unfriendly or hostile acts in all orbits of interest and defend ourselves against them. Without calling into question the peaceful and responsible use of space, that aim will be pursued within the existing legal framework, especially for self-defence within the meaning of the United Nations Charter. Promoting responsible behaviour and best practices and contributing to the definition of international standards will also form part of the strategy.

The domestic legal framework will also have to be adapted at interministerial level in order to take better account of the specific characteristics of military space operations, the scope of which will be extended (in particular the role of operator, manoeuvres and security requirements). A definition will also be needed of "trusted operators" on which the Ministry may call for services to support operations and ensure their resilience, so that asset acquisition can focus on the most strategic sectors.

That strategy must take advantage of the opportunities offered by New Space. Over the coming years, the use of constellations of

small satellites will help to improve our military capabilities and our resilience in relation to observation, telecommunications and space surveillance. Downstream, processing the mass of data produced will be a major issue: automation and artificial intelligence will be crucial in order to extract maximum value from the Ministry's investments over the period of the Military Planning Act (MPA).

In industrial terms, French companies have technologies that foster the development of these capabilities, whether they operate in a purely domestic or, in many cases, a multinational framework. They must be given support: innovation must be stimulated by a revised system of state governance, and balances within the ecosystem of start-ups, SMEs, intermediate-sized enterprises and major contractors should be reset. For launchers, the current model will be sustained by the reassertion of European preference for institutional launches. European cooperation will be pursued mainly around a Franco-German core based on complementary SSA resources with a view to laying the foundations for an autonomous European space capability in the future. However, this does not rule out the pursuit or development of cooperation with other international partners, especially the United States.

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That strategic ambition will be backed up firstly by a revised doctrine for military space operations based on four functions: space service support, situational awareness, operations support and active space defence. The revision of doctrine must be underpinned by a consolidated assessment of the threats to our capabilities. Another priority must be to strengthen the overall resilience of our armed forces, which must remain capable of acting without space support.

In order to immediately impart fresh impetus, the chain of command for space assets within the Armed Forces Ministry will be adapted in accordance with the principles of joint operational effectiveness, sustainability, coherence of the domain and visibility

of the organisation. A specific space pillar within the Air Force, which could be renamed the Air and Space Force, will be set up in the summer of 2019. The various military space organisations will gradually be brought together within it, following a rationale of fostering closer functional and geographical links with CNES, the National Centre for Space Studies. In addition, a start may already be made on identifying financial and organisational synergies, especially in the management of space programmes and operations, in order to rethink the relationship between the Armed Forces Ministry and CNES. Areas of particular attention for the management of space programmes are the division of commissioning-authority responsibilities and the Ministry's exercise of oversight over CNES, and the refocusing of state expertise on projects (R&T, demonstrators, etc.) where the degree of industrial maturity is not yet sufficient. The defence innovation agency must also provide input into the guidelines for space R&T carried out by CNES and ONERA, the French Aerospace Research Centre.

In terms of capability, it is essential to ensure the long-term viability of assets which provide strategic intelligence and operations support, making greater use of automated mass data processing and building connectivity into future weapons programmes from the outset. Developing a comprehensive SSA capability will be a priority. A number of steps will be taken as of 2019, including studies for the renewal and extension of existing capabilities and services, a specific cooperation initiative with Germany and the evaluation of industrial projects for the observation of space from space. Active and passive measures to protect satellites whose placement in orbit is already scheduled will be stepped up. In addition, a genuine capability for action in space will be acquired by 2030, drawing on feedback from demonstrators developed under MPA 2019-2025.

The constitution of a pool of experts and the creation of attractive career paths are key factors of autonomy and success in helping

to guide and achieve this new ambition. The establishment of a space academy will help to coordinate the necessary training for military personnel and ministry staff operating in the space domain.

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Overall, this space defence strategy marks a turning-point for the future of our armed forces and for France's capacity to act in all domains and maintain its strategic autonomy of assessment and decision. Although we will still need armed forces capable of gaining operational superiority on land, at sea and in the air, as well as in the more recent spheres of cyber and influence, space must henceforth be seen as the fifth domain of action in which our military strategy will be rolled out. We must unflinchingly address that new situation and ensure that in the future France will have the means to defend itself in space.

1 SPACE IS AN ESSENTIAL DOMAIN FOR THE ARMED FORCES BUT ACCESS TO IT IS BECOMING INCREASINGLY CONTESTED

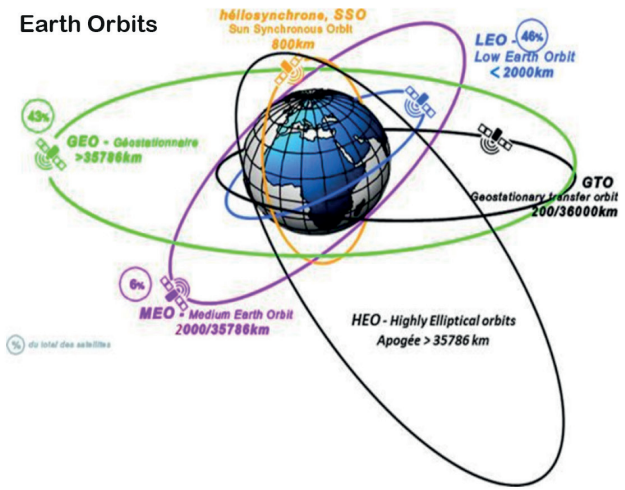
Space makes a vital contribution to our security and to the operation of our economies and societies. Although we are becoming increasingly dependent on space, growing tensions in that area threaten our freedom of access and action.

1.1 Space is a domain in its own right, used until now mainly for strategic purposes and operational support

1.1.1 A specific geography with restrictive physical laws.

The specific conditions that prevail in space make it a domain in its own right, even if there is no clear-cut physical frontier with airspace or Earth's atmosphere. It can essentially be divided into two zones, near-Earth space and outer space. Until around 2040, near space is likely to be the area of particular interest for the armed forces.

Near space is subdivided into three main orbital zones:



- Low Earth Orbits (LEO), with an altitude of 2,000 km or less, mainly used to place observation satellites[1] and telecommunications satellites;
- Medium Earth Orbits (MEO), with an altitude between 2,000 and 35,786 km, mainly used to place radio-navigation satellites for systems such as GPS and Galileo;
- Geostationary Orbits (GEO), a specific type of geosynchronous orbits which are of particular interest for many civilian and military uses, such as telecommunications and early warning satellites, because the satellite is "stationary" in relation to Earth. Retaining the most advantageous slots in these orbits is a major strategic issue.

Further distinctions may be drawn:

- Highly Elliptical Orbits (HEO) are terrestrial orbits whose apogee is greater than 35,786 km. Satellites placed in these orbits have long dwell times close to their apogee and pass close to Earth very quickly at their perigee. They are thus of considerable interest for early warning or communications in high latitudes (as a palliative solution for geostationary satellites for latitudes of over 60°, for example) if their apogee is situated over the poles;
- Geostationary Transfer Orbits are intermediate orbits from which satellites can be placed in geostationary orbit.

Space is a particularly hostile environment in which equipment is subject to extreme temperature variations and ionising radiation.

The risk of collision is also a source of concern. Successive launches, accidents and destructions in orbit have generated pieces of debris[2] that represent so many risks for our space capabilities. Items measuring between one and ten centimetres

1 These satellites are mostly placed in Sun Synchronous Orbits (SSO) so that they always pass over a given point on the Earth's surface at the same local mean solar time.

2 The catalogue to date counts 20,000 pieces of debris larger than 10 centimetres, 350,000 to 750,000 larger than one centimetre and at least 35 million larger than one millimetre. Over 6,000 tons of debris now orbit Earth.

will cause very substantial damage on conjunction with a satellite. Items larger than ten centimetres can completely destroy a satellite, creating large amounts of new debris.

Although the amount of debris tends to stabilise because of natural deorbiting (12 years for an object at an altitude of 500 km) and greater general awareness of the issue, the foreseeable increase in the number of launches multiplies the risk of conjunction. That in turn generates a need for precise knowledge, which is one of the major challenges of space situational awareness, especially as 50% of the debris currently in orbit will still be there in 20 years' time.

1.1.2 A liberal legal framework

The freedom to explore and use outer space, "the province of all mankind", is enshrined in international law on space activities, especially the 1967 Outer Space Treaty[3].

As *Res communis*, outer space is free of access and use, unlike airspace, over which the underlying State exercises full and exclusive sovereignty.

As there is no definition of space for lack of political consensus, a pragmatic approach qualifies any object that has made at least one full orbit as a space object[4]. Under these conditions, access to and use of Earth orbits, including the lowest, are free, leaving States all latitude to carry out the space activities of their choice there.

The legal rules governing space regulate States' practice but also guarantee the freedom of scientific research, meaning that no space application, civilian or military, is prohibited in principle. This regime by nature favours initiative and diversification of both actors and the offer of space services.

3 The catalogue to date counts 20,000 pieces of debris larger than 10 centimetres, 350,000 to 750,000 larger than one centimetre and at least 35 million larger than one millimetre. Over 6,000 tons of debris now orbit Earth.

4 The zone at issue is situated between 80 and 120 km above sea level. While organisations like the FAI regard the Karman line (altitude of 100 km) as the frontier between the atmosphere and space, France, like other space powers, considers it inappropriate, given the present state of space activities, to define and delimit space.

The free use of space is not absolute, however, since it is curtailed by the requirement to respect "the interests of all countries"[5] and by international law. Thus, the use or occupation of space may not result in the creation of a sovereign right in favour of a State exercising that freedom. On this basis, the International Telecommunication Union ensures equitable and fair access to orbital slots and radio-electric frequencies. Some doubt is being cast on this non-appropriation principle at present, since certain States consider, for example, that it does not apply to minerals or other resources that could be extracted from celestial bodies[6]. The prospect of the exploitation of space is an issue for the future that should not be overlooked.

Although international law states that space must be used for peaceful purposes, that does not mean that all military activity in space is prohibited. The Outer Space Treaty permits the militarisation[7] and even weaponisation[8] of Earth orbits, provided that weapons of mass destruction are not deployed there, as well as the use of force, strictly within the framework of the United Nations Charter. However, the Moon, celestial bodies and their orbits are entirely demilitarised[9].

Space activities do not fall within any jurisdiction other than that implied by their attachment to a State or an international organisation. States are free to define the terms of any such attachment, which differ according to nationally prescribed rules.

States are responsible under international law for their national space activities, whether undertaken by government agencies or non-governmental organisations. In accordance with this

5 Outer Space Treaty, Article I.
6 The United States, Luxembourg and the United Arab Emirates, for example, have passed domestic legislation authorising the private exploitation of such resources.
7 Militarisation means the placement in orbit of satellites for military purposes, such as intelligence, navigation and telecommunication satellites (cf. joint concept paper 3.3.13-ESPACE no. 27/DEF/CICDE/DR of 4 February 2014.
8 Weaponisation means the placement in orbit of systems capable of attaining objectives on Earth or in orbit, and not merely systems to support military operations (cf. above-mentioned joint concept paper of 4 February 2014).
9 See Article IV of the Outer Space Treaty and Article 3 of the Agreement of 5 December 1979 (signed but not ratified by France) Governing the Activities of States on the Moon and Other Celestial Bodies.

principle, States are required to authorise and continuously monitor private space activities[10] pursued from their territory or by their nationals, whether individuals or legal entities, acting outside their territory, through measures such as the registration of objects and the authorisation of launches. In order to implement this treaty monitoring obligation, many States have introduced domestic regulatory arrangements with often widely differing content. The regulatory framework in France is established by the Space Operations Act[11], which is essentially commercial and civilian in scope.

1.1.3 A vector of strategic capabilities essential to our operations

France had already identified space as a major factor of power and strategic independence in the 1960s, especially for the development of its nuclear deterrent. Having invested massively in the space sector, it is now one of the few nations capable of developing satellites, placing them in orbit, keeping them on station and exploiting the data collected. France is therefore a genuine space power, both civilian and military.

The armed forces have used space to support their operations since the 1990s, making a decisive contribution to their freedom of action on land, at sea and in the air.

Control over optical or radar observation, signals intelligence, satellite telecommunications and satellite meteorology, navigation and synchronisation is essential to autonomous situational awareness, decision and action and hence a core concern for the armed forces.

Space observation (via the Helios 2, Pléiades and, shortly, CSO satellites) meets the need for non-intrusive intelligence gathering and support for operations and military geography. As part of a geospatial intelligence (GEOINT) system which contributes to autonomous situational awareness by pooling and analysing

10 Public space activities are presumed to be carried out with government consent.
11 Act 2008-518 of 3 June 2008 on space operations.

location-based data from various sources, space observation complements other means of reconnaissance, especially in contested spaces.

Space-based electronic signals intelligence (the ELISA demonstrator and forthcoming CERES satellites) has been defence-specific until now and provides information about adversary activity.

Satellite telecommunications (Syracuse III and forthcoming Syracuse IV satellites) provide secure communications between forces in the field and mainland France and across theatres of operations, regardless of distance and independent of ground relays. They also meet the need for greater connectivity inherent in modern weapons systems and contribute to our armed forces' first-strike capability.

Satellite radio-navigation and synchronisation systems are used in most of the armed forces' weapons, communications and information systems. Our operations have become very heavily dependent on access to these services, as has everyday life in our societies in general (cf. §1.1.4).

Space can also meet other needs for prevention and the protection of our national territory and interests, especially through two capabilities:

- early warning, which contributes to the monitoring of proliferation and ballistic missile activities, ballistic missile defence, aggressor identification, passive defence and space surveillance (cf. §3.3.5);
- maritime surveillance via automatic detection, a potentially dual-use capability which complements existing non-space means of maritime surveillance, whether civilian or military, maritime, airborne or terrestrial.

1.1.4 A key factor for the operation of our economies and societies

Space is a pervasive feature of all human activities, whether domestic, economic, financial, scientific or whatever. In order to meet these core social, even vital needs, it provides four types of data.

Data from observation of the Earth and its atmosphere provide the foundation for weather forecasting and mapping services, the monitoring of natural, climatic and environmental risk, assistance to people in need, border surveillance and defence.

Telecommunications data provide access to TV and telephone networks and the internet in parts of the world without the necessary ground infrastructure (blind spots), helping in particular to bridge the digital divide.

Location data from constellations of satellites in Global Navigation Satellite Systems (GNSS) such as GPS and Galileo are used extensively to locate land, sea, water and air vehicles of all types and have fostered personalised smartphone apps. GNSS signals also include extremely precise and reliable time information and are consequently used everywhere to synchronise digital networks such as banking systems, telecommunications networks and power grids. GNSS are certainly the most widely used satellite systems. Losing them would cause severe disruption to our societies, going far beyond the purely military sphere.

Data from scientific and exploration missions include all the information of fundamental interest that enables us to explore the laws of physics and understand our universe, such as the composition of comets, the environment on Mars, the structure of black holes and the discovery of exoplanets.

In the near future, technological advances will pave the way for new high value-added applications engendered by the link between satellite infrastructure and, for example, the Internet of Things, telemedicine, digital learning and autonomous vehicles. The falling

cost of access to space will also soon open it up to tourism. At the same time, as we have seen, more and more countries are taking an interest in the exploitation of resources on asteroids or in space more generally. Other applications that we cannot yet foresee will appear in the years to come, driven by sectoral needs.

1.2 In a context of fiercer industrial and strategic competition, our freedom of access and action could be compromised

1.2.1 *New Space* is disrupting the existing equilibrium

The space industry has long been the preserve of a handful of big countries, their space agencies and publicly funded companies. That situation was linked to the essentially strategic nature of space activities (few commercial uses), the very substantial investment required and long development cycles.

New Space, originating in the United States, has profoundly changed that landscape. Using methods, technologies, facilities and financial engineering techniques, especially venture capital, developed by the "new economy" in areas such as miniaturisation, electronics, 3D printing and artificial intelligence, it has opened up the traditional space sector, significantly cut costs and democratised access to space.

New Space actors, whether private investors, universities, start-ups or large companies, have taken an innovative approach which involves accelerated decision-taking, innovation in use, greater willingness to take risks, tolerance of failure as a factor of progress and acceptance of lower systems reliability.

The upshot has been the emergence of projects for commercial constellations of dozens or hundreds or even thousands of objects. These in turn open up prospects for observation (higher revisit rate), data transmission (global coverage) and even electromagnetic eavesdropping, hitherto reserved for military applications.

The accelerated development of mass information processing and dissemination completes the emergence of these proposed new uses and services. Here, the digital giants are positioning

themselves as key players in New Space, whether upstream or downstream of the space value chain.

The number of active satellites in orbit (around 2,000 at present) is thus likely to increase substantially over the next few years. Space surveillance and space traffic management are likely to become increasingly important issues. Active debris removal systems are being developed, along with systems capable of making orbital rendezvous in order to repair satellites, refuel them, keep them on station, move or deorbit them. Under cover of civilian objectives, States or private actors can thus openly finance potential anti-satellite technologies.

There are also many initiatives to develop launchers, especially small ones. Financed by private institutions or organisations, over 40 models are currently being developed around the world, with upward of 40 more on the drawing-board.

The opportunities offered by New Space have given decisive new impetus to the space sector. As with the emergence of the internet, a small number of projects will bear fruit but many investments will be written off.

This major shift raises a fundamental question: how will the new actors cohabit with legacy operators who build increasingly sophisticated but expensive satellites which meet institutional needs and are mostly financed by public investment? It will be a crucial question, especially insofar as public investment will continue to be a decisive factor, even for the most innovative New Space projects.

1.2.2 Strategic competition is hotting up, operational contexts are evolving

The 2017 Defence and National Security Strategic Review noted an intensification of competition between powers, increasing the likelihood of state-to-state military confrontation. Countries with long-standing positions in space have also become increasingly dependent on it. As a result they have acquired new vulnerabilities

which they seek to alleviate by means of various strategies to secure pre-eminence, strengthening their means of action in space or embarking on a no-holds-barred policy of ramping up their capability.

At the same time, the operational environment is becoming harsher and military capabilities are being strengthened, taking maximum advantage of information technologies applied to cyber and space. In the naval and air domains, for example, the improvement of space-based surveillance systems and the development of anti-access/area denial (A2/AD) systems are casting doubt on the first-strike capability and freedom of action of our forces in theatres of operation. Our control of the electromagnetic spectrum (contributing to C4 ISTAR) is now strongly contested by potential adversaries who have invested massively in jamming and decoy capabilities which can degrade our capabilities in all domains (land, air, sea and space). Ballistic and cruise missile proliferation also exposes forces in the field to a growing risk. Space itself is becoming an area of possible confrontation in which alternative adversary strategies could be developed, below or beyond the threshold of armed conflict.

Renewed attention should be paid to several parts of the world where tensions run high. Changing strategic dynamics, especially in Asia, are a continuing source of concern, especially as France remains relatively close to these regions, distant from its mainland, through a sovereign presence in its overseas territories in the Pacific and Indian Oceans. Russia is seeking to rebuild a zone of influence on the eastern and northern flanks of Europe, while the Arctic could become a future area of confrontation in a context of international competition for control of its natural resources.

In responding to these new challenges, space will continue to be one of the cornerstones of our operational capabilities, whether for the purposes of deterrence, support to operations or active space defence.

1.2.3 Emerging new threats could compromise our freedom of access and action

The major space powers are currently developing new systems capable not only of protecting their space capabilities but also of carrying out aggressive action against those of their adversaries. Even recently, "unfriendly" activities or demonstrations of power such as ASAT launches, proximity operations and the jamming of location systems have been observed.

Rising space powers have also expressed their interest in developing offensive resources of this type. In addition, countries that have already proved their ability to get into space but do not yet have their own satellites could in the future raise the threat of kinetic or non-kinetic actions in space, deterring countries highly dependent on space from harming them.

All these threats, ranging from the neutralisation to the destruction of an adversary's assets, rely on more or less mature and accessible technologies which may, over the next ten years, be able equally to target ground, communication or space segments and the software parts associated with them.

Cyber threats

Cyber-attacks on the software parts of the different segments of space capability are among the most likely threats, though they require precise knowledge of the target's technical parameters. Difficult to attribute, they may have reversible or irreversible effects including, at the most serious end of the scale, loss of control of payloads or even the platform itself, reducing it to junk.

Electromagnetic jamming

Electromagnetic jamming acts mainly on navigation receivers (GPS, Galileo) or satellite communications receivers. The effects of interference, frequent where satellite communications are

concerned, are generally reversible, though attributing the origin of the interference may be very complicated. Jamming targets the means of communication and the software parts of a satellite system in particular.

Orbital services

The orbital services currently being developed by commercial enterprises and trials of proximity operations such as refuelling and cooperative inspection in the event of failure could be deflected from their purpose and the associated systems could be used as effectors capable of docking with, mooring on, capturing, degrading or displacing a satellite.

Conventional threats

Sabotage, malicious acts against ground infrastructure and the targeting of energy systems remain likely methods of action, albeit not specific to space. They take advantage of all the structural or human fragilities inherent in the ground-based protection of space systems, whether upstream of launch phases or in connection with the operation of ground stations. Their effects are attenuated by the redundancy of ground stations and the identification of vulnerable components to be protected.

Kinetic threats

The United States, Russia, China and now India have developed ground- or air-launched or co-orbital kinetic anti-satellite missile capabilities. Their use would have irreversible and drastic consequences in certain orbits, especially the unique geostationary orbit, generating a large amount of debris.

2 AN AMBITIOUS SPACE DEFENCE POLICY TO ENSURE OUR STRATEGIC AUTONOMY

Faced with the strategic and industrial competition that threatens our freedom of access to and action in space, we must be able

both to protect and defend our space interests and to strengthen our strategic autonomy in space by grasping the technological, industrial and cooperation opportunities which arise in that sphere.

2.1 Respond to threats in new operational contexts

2.1.1 Consolidate and assert our strategy within the existing international legal framework

The assertion of our national space defence strategy forms part of a fresh analysis of the space environment and the threats associated with it, underpinned by recognition that the capabilities of France and its partners in this domain are strategic by nature.

Making a decisive contribution to national and international security and providing essential services to the population, space is a focal point for growing tensions. We must adapt our policy to cope with the emergence of new potential dangers and greater threats and risks.

2.1.1.1 Ambition

In this new environment, our space defence strategy has two strands.

The first is to protect our satellites by enhancing our ability to monitor the space environment so that we can detect and attribute unfriendly or hostile acts in orbits of interest. In order to do so, France will draw on space situational awareness capabilities[12], whether sovereign, developed and operated with other States (European partners, especially Germany), contracted to trusted commercial partners or operated by allies.

The second is to be able to defend our space interests in space against unfriendly, wrongful or aggressive acts, in accordance and in compliance with international law. Our interests are not limited to French military satellites but may include French commercial satellites, some allied satellites and EU satellites.

12 See §3.4.2.

2.1.1.2 Principles of action

Three key success factors will help to consolidate this strategy.

The first is to reassert and define the scope of the guiding principles that must govern the space activities of States or private actors, to which France is committed. These are, firstly, freedom of access to space, followed by the peaceful and responsible– i.e. not deliberately aggressive – use of space[13].

The legal framework for our action must also be robust. International law applies to space, notably the United Nations Charter which governs States' right to use self-defence against armed aggression. The responses to unfriendly, wrongful or aggressive acts must be defined in accordance with the categorisations determined by international law. The guidelines that France will follow in this matter are as follows:

- France reserves the right to take retaliatory measures against an unfriendly act in space;
- France may take counter-measures in response to a wrongful act perpetrated against it with the sole purpose of bringing that act to an end, in compliance with its obligations under international law, such counter-measures being strictly necessary and proportionate to the objective pursued;
- in the event of armed aggression in space, France may avail itself of its right of self-defence.

These principles of action must be backed up by an in-depth strategic and political dialogue with our European and transatlantic partners and closer cooperation with our allies, especially in terms of capabilities. We must also work more closely with our commercial partners in order to make our space capabilities more resilient and guarantee the continuity of the missions they enable us to perform.

13 Taking future orbital services as an example, whether or not they are peaceful will depend not on the systems themselves but on how they are used.

2.1.1.3 International action

France will continue to give its full backing, in the relevant multilateral forums[14], to the pragmatic and effective regulation of space, with a particular focus on standards of behaviour in order to ensure strategic stability and avoid possibilities for misunderstandings or escalation.

Other nations have put forward initiatives to prevent the deployment of weapons in space[15]. France shares the concerns expressed by several of its partners with regard to the effectiveness of such initiatives, especially the difficulty of defining what constitutes a weapon in space and monitoring the enforcement of rules on non-deployment. It therefore gives preference to pragmatic proposals that can be put into effect immediately. In particular, France could support the promotion of a norm prohibiting actions that create pieces of long-lived debris.

A common definition of acts likely to constitute a threat in and from space, rules on States' exposure to international responsability and responses permitted by international law will also be necessary.

In this context, French actors in both the public and the private sector must continue to act in interstate and non-governmental forums to promote responsible behaviour and best practices and contribute to the development of international standards.

2.1.2 Adapt the domestic legal framework to match our ambition

Until the end of the 20th century, the State controlled all space activities carried out in France or with its help. That grip has gradually been relaxed against a background of growing diversification and privatisation. The need to regulate space activities became urgent in the early 2000s in order to ensure that France would not incur responsability and liability for operations over which the State did not exercise effective control[16].

14 COPUOS, First Committee and Disarmament Conference.
15 Cf. in particular the Russian and Chinese proposal for a legally binding treaty (Prevention of the Placement of Weapons in Outer Space - PPWT).
16 See also §1.1.2.

The Space Operations Act addresses this issue by establishing a requirement of prior authorisation of space operations by the civilian authority[17], but it is ill-suited to military operations. Interministerial consultations will have to take place over the period 2019-2025 in order to adjust and update the domestic legal framework.

The surge in private-sector activities in segments that have national security implications (other than Earth observation, already factored in) also militates in favour of an extension of the existing system of prior declaration and appraisal. However, any such adaptation of domestic law will have to strive to maintain the balance between protecting the fundamental interests of the nation and maintaining the competitiveness of the defence technological and industrial base (DTIB).

Lastly, the intrinsic dual nature of the space sector and the need to develop formal partnerships with enterprises endowed with resources that may contribute to the substitution, resilience or redundancy of the armed forces' legacy systems encourage the definition and promotion of the notion of trusted operator, on the basis of criteria such as availability, the integrity of the data provided and confidentiality.

2.2 Grasp opportunities to build up our strategic autonomy

2.2.1 Take advantage of the disruptive technologies and uses associated with *New Space*

2.2.1.1 The space component: satellites and constellations

Supplementing existing or programmed equipment, the armed forces must also take advantage of the uses and services proposed and promised by New Space, mentioned earlier. The potential opportunities that seem to be opening up must be explored with determination. The overall model that is beginning to emerge gives a glimpse of how New Space methods and technologies may coexist with those that have driven the space sector until now. The aim must be to make the most of each approach while preserving specifically military requirements.

2.2.1.2 Downstream: mass data processing

Using computers instead of people to analyse space imagery was unimaginable even a few years ago. But the situation is changing quickly and algorithms can now give good results after a necessary "learning" (data analysis) phase.

Given the long-term constraints on human resources and the increase in the amount of available data, the automatic analysis of space imagery by self-learning algorithms is thus becoming a major issue for the Armed Forces Ministry. In responding to this challenge, artificial intelligence is an essential tool for processing mass space data.

2.2.1.3 New launch options

The cost of placement in orbit is still a key parameter of the space launch industry.

SpaceX has radically changed the commercial playing field with its Falcon reusable launchers and an efficient industrial model based in particular on proximity to the launch pad and assembly facilities. It thus calls into question the position of the legacy players in the industry just as new entrants are on the point of offering their own launch solutions.

ArianeGroup, a long-standing player in the French space industry, is developing the Ariane 6 project, due to come into service in 2020. Designed to guarantee an independent European launch capability for the years to come, the launcher will be viable only if European countries commit to using it for their institutional launches. The Armed Forces Ministry supports Ariane 6 as a guarantor of strategic autonomy.

Rideshare opportunities for light satellites on conventional launchers is another avenue for consolidation[18].

17 The ministry responsible for space, currently the Ministry of Higher Education, Research and Innovation, after appraisal by CNES.

18 This is the idea behind ESA's L3 initiative (Light satellite, Low-cost Launch opportunity), which aims to provide a low-cost launch service for small satellites on either Ariane 6 or Vega.

Small launchers aim to provide a light-satellite launch service that is more responsive than the service offered by conventional launch operators. Consolidation may be expected in the sector, resulting in a number of viable operators. That is why the armed forces will consider the option of using quick-launch capacity, suited to small satellites.

2.2.2 Rethink our industrial model

2.2.2.1 Consolidate our DTIB

The issues at stake in maintaining a European space industry, for both civilian and military purposes, are autonomous access to and use of space (launchers and satellites respectively).

Around 16,000 people are directly employed in the space industry in France, which generated consolidated sales of €4.6 billion in 2017, mostly in the civilian, commercial and institutional sector (CNES, ESA). Defence continues to be a key driver of innovation, however, contributing to the state-backed R&T still needed to keep the players operating in the sector competitive.

France's space sector is mature, spanning the full range of skills from satellite design and construction to launch and operation. Fully integrated into the European space industry, from which it is now indissociable, it has two elements, satellites and launchers, each with its own specific ecosystem.

The major industrial players have gained high-level expertise and achieved commercial success on the back of the institutional funding that has supported the industry's growth. However, two factors cast a shadow over this very positive picture: New Space, which is profoundly changing the industrial ecosystem, and the potential return to the global marketplace of major American players that have hitherto focused exclusively on their domestic market.

2.2.2.2 The satellite industry

The industrial landscape in France is dominated by two major Franco-European contractors, Airbus Defence and Space and

Thales Alenia Space, offering the advantages of an independent industry in a key defence sector.

Many players around the world are now well advanced in the manufacture and marketing of very small satellites, a crucial New Space technology. France lags behind, however, despite having the start-ups, SMEs and intermediate-size companies which should enable it to quickly catch up. Investment is needed in this promising sector[19].

In addition to making satellites, the space industry must also provide a real set of telecommunications and space observation services so that resources can be pooled and the overall resilience of the defence system enhanced. Central government can help to keep companies competitive by offering services which complement the industrial offering. Any excess capacity, such as legacy bandwidth, could be returned to the market where appropriate.

The duplication of industrial skills is another feature of Europe's space satellite industry. Judicious rationalisation or merger on a continental scale would give our industry decisive advantages on the global market for both satellites and the related services.

2.2.2.3 Launchers

The European launcher industry, under the aegis of ESA, is based on ArianeGroup and Avio (Italy), which make the Ariane and Vega launchers respectively, and a commercial operator, Arianespace, which operates them from the assembly and launch base at the Guiana Space Centre.

The international launcher industry is highly subsidised via mainly closed institutional markets. The European market is an exception, since it is open to competition from non-European launchers, which some countries use for their institutional launches. Be that as it may, the preservation of our autonomous access to space currently

19 For example, France is helping Hemeria to develop a national nano-satellite industry.

depends on the long-term sustainability of the European launcher Ariane, the future of which will inevitably involve some cost-cutting.

2.2.2.4 Keeping the lead in technology

Cutting-edge space technologies are eminently dual-use, having important, specifically military implications. Key areas for defence are nano-satellites and constellations, the digitisation of satellite platforms and payloads, optical technologies, technologies which offer operational superiority and those which contribute to the resilience of our operational systems, and orbital services technologies.

For the sector to increase its operational autonomy and export more, certain critical components currently sourced from outside Europe and subject to export restrictions must be financed at national or European level.

2.2.3 Extend cooperation to space operations and open it up to new partners

French military space cooperation over the last 20 years or so has focused mainly on exchanges of capabilities with European partners.

In future it will also apply to space operations, an area in which the US remains a key partner.

The risks to which our capabilities are exposed (cf. §1.2.3) also imply the need, in close cooperation with our allies, to increase redundancy in order to improve resilience.

2.2.3.1 With our European partners

We must seek to share a common vision of the strategic challenges of space with those European partners that are willing and able to do so. That common vision must relate first and foremost to threats in space, our policy and strategy for dealing with them and European autonomy as a goal. It must also be oriented towards the construction of a European space industry founded on mutually agreed dependencies.

Germany

Within Europe, Germany is an essential partner for a more ambitious approach to defence and security. It is therefore crucial to consolidate our relationship in space matters.

Bilateral cooperation is underpinned by observation, in the form of exchanges of French optical and German radar data (Helios and SAR-Lupe now, CSO and SARah in due course). It could be extended in the future to space situational awareness, with the ultimate aim of sharing a coordinated and autonomous spatial situation[20]. The advantage of such cooperation is self-evident for low-orbit surveillance, since France's GRAVES radar and its successor (cf. §3.3.2.1) and Germany's GESTRA surveillance and tracking radar offer complementary capabilities.

New areas of cooperation in relation to observation may be sought and will be pursued, especially in the framework of appraisal of the future Optical Space Component programme (a military Earth observation programme).

Italy

Italy is France's second most important space partner. Historically, our cooperation has concerned exchanges of observation data (optical on the part of France, radar on the part of Italy) and the development of shared telecommunications satellites, both military (SICRAL 2) and dual-use (ATHENA-FIDUS).

UK

There are possibilities for cooperation on space operations with the UK, along with the United States and other partner countries.

2.2.3.2 The European Union

Space has been an area of shared competence between the EU and Member States since the Lisbon Treaty came into force in 2009. EU space programmes have been exclusively civilian to date,

20 The conclusions of the French-German Defence and Security Council meeting in July 2017 stated that "France and Germany [...] agree to cooperate on military space surveillance capabilities in order to share a coordinated spatial situation".

albeit with security-related aspects. The EU could earmark up to €16 billion between 2021 and 2027 for two main programmes, the Copernicus Earth observation system and the Galileo positioning, navigation and timing system. Only limited resources are assigned to the other two programmes, EUSST and GovSatcom.

Looking beyond current projects, a space Europe is needed in order to make a direct contribution to the construction of a Defence Europe and the continent's security. To this end, the French-German axis mentioned earlier must help to draw energies together, especially around a broad-based European SSA project.

The new European Defence Fund (EDF) could also help to finance specifically security-related space capabilities, with a governance system better suited to the requirements of defence programmes than that of the EU space programme. The duplication of industrial skills must be avoided.

2.2.3.3 NATO

At the Brussels Summit in July 2018, the NATO countries recognised the growing importance of space in the strategic and operational environment and decided to frame an overall NATO space policy that would help the allies achieve a more comprehensive and coherent understanding of space issues. There is no call for NATO to develop its own space capabilities, but it can use those made available by its members, who retain sovereign control over them.

2.2.3.4 With our partners outside Europe

United States

The US plays a central role in SSA, since the Space Track system benefits all space satellite operators. Cooperation with the US in this particular area must continue even as technological advances enable Europe to develop its own capabilities, making it a credible partner.

The US is also a key ally for our military space operations.

India

The strategic partnership with India and long-standing cooperation in the civilian space sphere, especially launchers, will be strengthened.

Japan

Our space cooperation with Japan, structured since 2016 by a comprehensive dialogue on space under the aegis of the SGDSN (Secretariat General for Defence and National Security), is being stepped up, especially in space surveillance.

Canada and Australia

France has long maintained a structural partnership with Australia, a front-line strategic player in the Indo-Pacific region. Australia aims to expand its space sector, with which synergies must be sought.

The same applies to Canada, another important player in the space sector.

3 ROADMAP

In order to guarantee France's capacity to act in space, the armed forces must (i) strengthen a space doctrine which establishes the ground rules for and typology of military space operations, (ii) overhaul military space governance, and (iii) ensure that they have appropriate capabilities and human resources.

3.1 Strengthen French space defence doctrine

3.1.1 Military space operations

Military space operations span all activities carried out by or for the Armed Forces Ministry in, from and towards space in order to ensure the availability, tracking, safety and security of national or national-interest space capabilities and services and hence preserve our freedom of discretion, access and action in that domain.

Military space operations consist in operating space capabilities[21] that provide services[22] in support of government authorities and military operations, thus helping to increase the effectiveness of action. They contribute to national security, the robustness of our economy and protection of the population. They also include action taken in space to protect our assets and discourage any aggression.

They are organised around four functions:

- space service support;
- space situational awareness;
- operations support;
- active space defence.

3.1.1.1 Space service support

This function concerns the deployment, implementation and availability of space capabilities. Of the four functions of military space operations, it is the one with the most pronounced dual-use character. It includes the following operations:

- launch and placement;
- launch-pad implementation (currently the Guiana Space Centre);
- keeping satellites in service and in orbit (functions not performed to date by the armed forces for themselves);
- reconstitution of capabilities (restoring, compensating for or replacing a diminished or missing capability, including the possible use of complementary allied or commercial capabilities).

Space service support is a necessary though not sufficient condition for France to keep its status as a space power. The armed forces are thus directly concerned by foreseeable changes to launcher policy in France, and by the future of the Guiana Space Centre.

21 Ground segments, means of transmission and control, space segments, operational resources, skilled personnel.
22 Observation, signals intelligence, communications, positioning, navigation and timing (PNT).

3.1.1.2 Space situational awareness

Control of space situational awareness (SSA) is a prerequisite for the commercial exploitation of space and the conduct of military operations of all kinds.

SSA supplements and interprets information provided by space surveillance and tracking (SST), producing a recognised space picture (RSP). It requires capabilities that guarantee a certain level of strategic autonomy, now partly provided in France by the GRAVES system. SSA meets three distinct needs:

- assessment of the threats that adversary space systems can pose to our satellites, our territory or our forces in the field. SSA is thus essential in order to attribute an internationally wrongful act to a State and permit an appropriate response;
- prevention of risks of collision in space between active satellites and other objects, ensured mainly by SST. While the need to prevent collision is more restrictive than the military need in terms of the size of objects to be detected (very small pieces of debris), it requires neither the same responsiveness nor the same level of national autonomous appraisal, thus offering opportunities for cooperation, especially with European and American partners;
- coordination with other space actors, especially in relation to unintentional jamming.

SSA should therefore be understood as the foundation of military space operations[23].

3.1.1.3 Operations support

This function involves the implementation and operation of payloads (on space platforms) which contribute to the following joint-services functions:

- intelligence, surveillance and reconnaissance (ISR);

23 It lays the foundation for (i) protecting our territory and population, (ii) ensuring compliance with international agreements and treaties, (iii) guaranteeing the security of space manoeuvres, (iv) protecting space capabilities, (v) guaranteeing the continuity of military space activities, and (vi) providing the armed forces with the information needed to plan and carry out their operations.

- early warning and launch tracking;
- surveillance of the geographical, physical and human environment;
- satellite communications (SATCOM);
- positioning, navigation and timing (PNT).

Corresponding to the way in which the armed forces currently use space, space support to operations will continue to be enhanced.

3.1.1.4 Active space defence

Military space operations, previously Earth-centred, must now also be directed towards space and seek under all circumstances to:

- preserve freedom of access to and action in space;
- discourage and thwart action by any ill-intentioned third party.

They span various passive and active measures relating to:

- prevention, taking a comprehensive approach (diplomatic, media, economic, legal, etc.);
- the resilience of all space assets;
- the defence in space of our space assets.

3.1.2 Frame the doctrine for the conduct of space operations

Within the framework established for military space operations, the armed forces must establish a body of doctrine which incorporates changes in the space sector and the following fundamental principles:

- autonomous assessment and decision-taking;
- France as a driver of the space sector in Europe;
- the means to defend our capabilities and ensure compliance with international law, including self-defence.

To ensure coherence and interoperability, the positions of France's allies and partners with regard to space operations will be taken

into consideration when French doctrine is framed, as will feedback from training and exercises carried out with them within NATO or other frameworks[24]. The consideration given to the work carried out by allied States, plus monitoring of the posture of our potential adversaries, are factors which reflect the inevitability of cooperation in space: France cannot act alone in that domain, especially if there is a general deterioration of the situation. The aim is therefore to contribute to the consolidation of an allied military space community, which could include the industrial sector as necessary.

3.1.3 Evaluate the threats affecting our space capabilities

We need a robust evaluation of the threats we face in order to conduct our operations and help us define our capability requirements.

Understanding how a potential adversary can act in space means knowing their doctrine, their capabilities and their willingness to use them.

This space threat assessment must be backed up by better use of available data, especially images.

3.1.4 Enhance our armed forces' capability to operate without space support

As we have seen, access to and use of space for national defence and security purposes are of strategic importance and must be protected in order to contribute to the armed forces' resilience and freedom of action.

Nonetheless, the almost systematic use of space capabilities also raises the issue of a state of dependence which the armed forces must, if necessary, be able to partially surmount in order to continue to carry out their operations[25].

The armed forces must therefore seek to make space services resilient, first and foremost through cooperation that will ensure the redundancy of space assets, but also through complementarity

24 Combined Space Operations or Schriever Wargames.

25 Without satellites the armed forces would be partially blinded, being deprived of essential operational capabilities (cf. supra).

with non-space systems. They will have to maintain capabilities and nurture skills that will enable them to accomplish their missions in conditions where space support has deteriorated. Setting up an exercise in which the use of space assets was ruled out or restricted would be one way of studying the consequences of a deterioration of space services and would help to expand the range of alternative solutions.

3.2 Adapt military space governance to our ambitions

3.2.1 Reorganise the chain of command for space assets within the Armed Forces Ministry in order to achieve our ambitions

The Joint Space Command (Commandement Interarmées de l'Espace, CIE), created under the Chief of the Defence Staff in 2010, was tasked with framing and implementing military space policy, including the identification of military space capability requirements and the command of those capabilities. Its current responsibilities include operational expertise and weapons programmes, the coordination of international cooperation in space matters and the coordination of military space capabilities used by various units under separate chains of command.

Features of the current situation include the fragmentation of effective responsibility for the framing of military space policy, the geographical and functional dispersal of military space facilities and players, and the absence of a single chain of command for space operations.

The Armed Forces Ministry's new ambition implies an overhaul of the current organisation in line with the principles of joint operational efficiency, coherence, visibility and simplicity.

Without impinging on the Chief of the Defence Staff's responsibilities for operations and military planning, the new organisation will need the necessary resources to deal with issues relating to capabilities, human resources, the legal framework, interministerial coordination and international cooperation.

Studies of a revision of the governance system concur that this mission should be entrusted to the Air Force as the only service capable of supporting the constitution of a pool of expertise and guaranteeing the career paths needed to make space an attractive choice. This option also preserves the priority given to operations under the aegis of the Defence Staff while addressing the issues of visibility and coherence. To enhance that visibility, the Air Force will be renamed the Air and Space Force.

Ambition will thus become reality as an approach based on operational support, implemented at different levels under different commands, becomes an approach which recognises space as a domain in its own right, with the same status as the other domains of engagement. Two major factors will ensure overall coherence within this framework:

- the greater consideration given to space at central level,
- the creation of a specific component.

This choice will be implemented as soon as possible, ensuring a transition phase that will guarantee the continuity of our operations in space. The creation of a specific entity based on the current Joint Space Command will be the necessary preliminary step to this reconfiguration.

3.2.2 Rethink the relationship between the Armed Forces Ministry and CNES

The Armed Forces Ministry exercises joint oversight over CNES with the Ministry of Higher Education, Research and Innovation, reflected in the fact, for example, that the head of defence procurement is responsible for Programme 191, "dual (civilian and military) research"[26].

3.2.2.1 Management of programmes

CNES is systematically involved in the conduct of major military space programmes. Drawing on CNES's past experience with space

26 It has a budget of €180 million, of which €150 million is devoted to actions with a defence interest carried out by CNES ("dual research in aerospace").

programmes such as Helios, Spot CSO, CERES and Pléiades, the defence procurement agency (DGA) shares its contracting-authority role with CNES according to the operational area concerned:

- in optical observation, CNES is the delegated contracting authority for the CSO programme because of its expertise in that field;
- in electromagnetic surveillance, the DGA is the contracting authority for the CERES programme;
- in telecommunications, the DGA remains the contracting authority, drawing extensively on the industrial contractor for the Syracuse programme, given that the industry in this sector is mature.

The DGA has also formed integrated programme teams with CNES. They track progress on military space programmes, and decisions are taken jointly.

Nevertheless, consideration must now also be given to the level of maturity achieved by French industry, whose commercial activity often outstrips their institutional activity. Contractors should be allowed greater responsibility. Such a move will both free up expertise and help to focus it on innovative areas requiring substantial investment in research and technology (R&T).

Lastly, the Armed Forces Ministry and CNES will have to establish a closer relationship, taking into account the changes to the Ministry's internal governance. The arrangements for steering that relationship will have to be examined jointly by the armed forces, the DGA and CNES with the aim of producing proposals for renewal.

3.2.2.2 Management of operations

CNES is responsible for operating legacy military satellites with the exception of Syracuse satellites (see above). In that capacity it is responsible for the ground control segment. Given the changing nature of military space operations, the armed forces will have to acquire the necessary skills to operate space objects themselves.

3.2.2.3 Clarify financial resources

At the same time as managing programmes, CNES and DGA prepare technologies for the next generation of satellites. Military superiority implies effective resources using the most innovative solutions (commercial, technological or uses).

Three resources are essential for optimum management of future programmes:

- rich and abundant forward-looking R&T financed by the Armed Forces Ministry and CNES;
- a line of demonstrators to pave the way for the technologies or concepts of the future and, if necessary, consolidate the technologies earmarked for future projects;
- a mature industry to manage development on a fixed-price basis.

As space technologies are dual-use and investment in projects helps to strengthen the industrial fabric, these initiatives form part of the CoSpace policy introduced by the defence, economy and research ministers in 2013.

The CNES "Defence" team, comprising members of the EMA, DGA and CNES, is responsible for guiding the choices to be made, especially as regards the financing split between P144 and P191. In the specific case of research, the DGA also carries out programmes under P144 for the Armed Forces Ministry and has an agreement with CNES, renewed in 2016, which provides for exchanges of common research programmes and working groups on subjects of joint interest.

CNES's R&T programme aims more broadly to improve the effectiveness of telecommunication and observation systems, their onboard intelligence (processors and flight software) and all the building-block technologies for satellite platforms. Most of these generic activities have a considerable dual-use interest [27], which should give CNES's activities in the military sphere greater visibility.

27 In 2016 and 2017, for example, 85% of CNES Orbital Systems R&T programme qualified as dual-use.

3.2.2.4 Strategic and organisational aspects

The Armed Forces Ministry expresses its research options and priorities through its oversight of CNES (exercised jointly with the Ministry of Higher Education, Research and Innovation) and ONERA. These two bodies have internal organisational arrangements which take those options and priorities into account and reflect them in the management of programmes and operations.

3.3 Develop space capabilities in reponse to our ambitions

The use of space resources will range from support for operations on Earth to operations in space in order to defend the capabilities deployed there.

Although a balance will be sought between assets and services for each segment of the space resource, the identification and characterisation capabilities that require the validation and interpretation of data must form part of the assets or trusted partnerships, strictly regulated in legal terms in the event of the use of services.

3.3.1 Secure space operational support capabilities in the long term

The first priority of space strategy is to enhance the capabilities already used to support land, sea and air operations. The aim is thus to upgrade and secure the long-term sustainability of the observation, signals intelligence, space communications and geographical positioning capabilities already available to the armed forces.

The first challenge concerns the intelligence cycle, which needs to be accelerated by reducing satellite response times and facilitating the provision of data collected in theatres of operations. That will require a capability for automatic or on-demand dissemination of images or videos to several users. Artificial intelligence will also play a major role in the processing of mass data gathered in space: the armed forces will be confronted with a "data wall". Processing and automatic object detection require vast and pooled storage capacity, suitable algorithms and substantial computing power. The use of trusted operators in this area should not be ruled out.

Space signals intelligence may be enhanced by other capabilities, especially in the sphere of maritime surveillance and geopositioning.

Space capabilities will also have to meet the challenge of the armed forces' need for greater connectivity, especially in the air (Rafale F4, drones, FCAS project), on land (the Scorpion programme) and at sea (PANG, the new-generation aircraft carrier), which requires a significant increase in voice communication and data transfer capacities due to the proliferation of connected players and faster data flows.

In order to enhance the resilience and responsiveness of their operations, the armed forces will have to study ways of ensuring the continuity of space services for their benefit. That could include tactical satellite launch capabilities. New Space technologies such as nano-satellites, cluster launches and even mini-launchers seem to point towards such a possibility. HAPS (high-altitude pseudo-satellites) are another option for exploration.

3.3.2 Prioritise the development of an SSA capability

Space situational awareness, a pillar of the planned strategy, contributes to the protection of space capabilities. It has three components: surveillance, space-related intelligence and environmental data. It also needs to be backed up by a robust command and control system (C2).

3.3.2.1 Surveillance

The first component of SSA, surveillance has three functions in relation to objects: detection, tracking and characterisation/identification. It must be supplemented by permanent tracking of space launches and objects placed in orbit. This end-to-end tracking contributes to the attribution of an ill-intentioned or hostile act.

Ground-based detection and tracking

Various technologies are used to detect objects from the ground, depending on their altitude.

- *Low Earth orbits (less than 2,000 km)*

France's GRAVES radar is an essential component of its space surveillance system. Its renovation in 2022 will extend its working life and improve its effectiveness.

However, construction of the successor to GRAVES will be brought forward, with a first capability increment in 2025, in order to bring the capability to track new objects of interest (especially debris, as mentioned earlier) into service as soon as possible.

Forming the basis for our low Earth orbit SST architecture, the post-GRAVES capability will be a national asset. It may be strengthened by bilateral cooperation with Germany or draw on the EUSST initiative (though it has not given full satisfaction to date) or some other European financing arrangement such as the European Defence Fund or EDIDP.

SATAM radars for tracking objects in low orbit will be renovated under MPA 2019-2025, with a replacement scheduled for 2030. European cooperation, especially with Germany, or even the purchase of a ground- or space-based service should be among the options to be considered.

- *Medium and geostationary orbits*

A state service and a commercial service currently provide geostationary orbit monitoring and tracking. This configuration, using telescopes shared with private- or public-sector civilian operators, provides feedback which can then inform thinking about the acquisition strategy (national asset, cooperation and service).

The planned upgrades to existing GEO monitoring and tracking systems should enable MEO monitoring and tracking in the near future.

Ground-based characterisation and identification

The need is for a resilient system based on:

- sovereign satellite radar imagery capabilities. Cooperation with Germany should be sought, in addition to any national assets;

- telescopes with adaptive optics in order to obtain high-resolution images of objects in low Earth orbit.

Using a cross-cutting approach to these different aspects of SSA, the planned architectures and resources must take advantage of the Armed Forces Ministry's bases in overseas France, since their geographical position offers natural options for optimisation in relation to orbits and objects detected.

SSA from space

The resources described above correspond to a ground-based system which will have to be subsequently extended to include additional resources in orbit. Observation of space from space, whether for the purposes of detection, tracking, characterisation or identification, helps to get closer to the objects to be observed.

3.3.2.2 Command and control system (C2)

These surveillance assets are building blocks of systems that need to be used in parallel by including them in the military space operations command and control system in order to control their definition and the appropriate levels of confidentiality and sovereignty.

3.3.2.3 Space-related intelligence

Space-related intelligence concerns the characteristics, performance and status of space objects and the capacity of other States to interfere with our national interests in space.

It is prepared by the ministry's intelligence operatives, drawing on all available resources (national sensors or intelligence-sharing with partners).

3.3.2.4 Space environment data

An essential complement to SSA, this mainly comprises space meteorological data. Synergy will be sought with the services offered by the European Union. The data will contribute to assessment of the issues associated with making our space assets more resilient to space risks of natural origin.

3.3.3 Protecting and hardening our space capabilities

From the outset, the development of any weapons system incorporates a detailed analysis of threats and how they may change, from which appropriate measures to protect against them are deduced. Military space systems are no exception: their development currently incorporates protection against potential threats from Earth (electromagnetic aggression, cyber-attack, high-altitude nuclear explosion). They must therefore systematically incorporate responses to emerging threats in space.

The first measure to protect our satellites is based on detailed space situational awareness, considered earlier.

Plans are already in hand for the protection of future defence satellites (Syracuse IV, CERES and CSO). Additional measures must be taken where relevant in order to make them more resilient.

In the longer term, technological initiatives will be taken in order to harden the future generation of satellites.

Observation of the close environment of satellites may also help to strengthen their protection. Capabilities of this type will be implemented on board the Syracuse 4A and 4B satellites in order to detect any approach by another satellite.

3.3.4 Acquire a capability to defend our interests

In order to be able to implement France's space defence strategy and better protect our space capabilities (know and act), it is crucial to give the armed forces the capabilities to defend us in space.

Studies and demonstrators over the period of the Military Planning Act

Earmarking over €3.6 billion for space, MPA 2019-2025 must provide the armed forces over the period with initial capabilities that enable them to carry out operations in space.

A long-term capability by 2030

The efforts made under MPA 2019-2025 must be the springboard for full capability by 2030.

These capabilities will be integrated, as sensors and effectors, into the scope of the future military space operations command and control system, the initial studies for which will begin as of MPA 2019-2025

3.3.5 Contribute to ballistic missile defence (BMD)

3.3.5.1 Context

The threat posed by the proliferation of ballistic missiles is an established fact among both State and non-state actors. The appearance of terminally guided ballistic missiles, which are much more accurate than conventional missiles, will expose the armed forces to a greater threat.

3.3.5.2 State of play

Ballistic missile defence is based on three types of capability:

- early warning (surveillance and detection by satellite and/or radar depending on the missiles' range);
- a command and control system to coordinate information, estimate the impact zone and decide on interception;
- interception capabilities (radar guidance and interceptor missiles).

NATO members' concern for territorial missile defence was addressed through the NATO Ballistic Missile Defence (BMD) programme and policy at the Lisbon Summit in 2010, complementing the Alliance's existing Theatre Ballistic Missile Defence (TBMD). The programme is based on voluntary national contributions, with only command and control being jointly financed. The US is the only power to date with a comprehensive set of territorial BMD resources.

France's contribution to NATO's BMD capabilities is currently based on the SAMP/T land-based medium-range air defence system.

In addition to SAMP/T, in the 2008 Defence and National Security White Paper France stated its intention of acquiring an early warning capability. This need, reasserted within NATO after the decisions taken at the 2010 Lisbon Summit, also features in the 2017 Strategic Review, which identified early warning as a capability to be enhanced.

3.3.5.3 Outlook

A comprehensive early warning capability draws on complementary space- and ground-based components.

For the ground-based aspect, the armed forces have the very long range radar demonstrator handed over in 2016 and currently undergoing trials.

For the space-based component, the SPIRALE space demonstrator was operated in orbit between 2009 and 2011.

3.4 Develop space defence expertise

The growing importance of space also implies a significant human resources element, involving the cultivation of expertise based on three pillars:

- a training resource, the space academy, which coordinates existing training and is open to other ministries and our foreign partners, providing high-level training leading to recognised qualifications;
- specific, varied and well-rewarded career paths from initial recruitment to senior managerial positions;
- an outreach strategy to give the service the necessary long-term visibility, recognition and attractiveness.

3.4.1 A training resource: the space academy

The space academy will nurture space defence expertise and enhance skills at all functional levels. It will act as the ministry's training expert for space.

Initial space training will give recruits or staff already working in the area a core knowledge base and nurture the ministry's space community. A necessary first step, it will be supplemented by the introduction of a training path adapted to each individual's functional level and area of expertise.

Targeted training opportunities will be identified, ranging from short conversion courses to specialist master's degrees within various institutions, especially elite engineering schools under ministry oversight, and provided according to needs and career paths. The academy will coordinate all the training offered.

The space academy's expertise and training courses will be open to partners from other ministries and other countries, especially to support exports of space systems, and to other stakeholders in the sector (CNES, ONERA, industrial firms, other EU Member States, etc.). It may be a prime forum for exchanges and encounters with academic and industrial players in the space sector, with the particular aim of encouraging innovation. Its action in that respect will complement that of a Sp@ce l@b set up with the space command in liaison with the defence innovation agency.

3.4.2 Specific, varied and well-rewarded career paths

There is a need to create and maintain a pool of experts and specialists, backed up by personalised and proactive management.

Because the sector draws on different backgrounds (intelligence, information and communication systems, etc.) and crossover career paths, a cross-cutting approach to the management of space skills and the pool of experts will be needed. That role will be taken by the employer, in liaison with other managers, especially the armed forces, the Directorate of Military Intelligence (DRM) and the Joint Directorate of Infrastructure Networks and Information Systems (DIRISI).

For officers, the creation of a Space specialisation at the Air Force Academy in Salon-de-Provence will provide the necessary structure within the armed forces. The annual intake for the specialisation will include career officers, contract officers and category A civilian personnel with scientific or space expertise. Opportunities for transfers will enable officers from other specialisations to join the sector.

Non-commissioned officers and category B civilian personnel may continue their career within the space sector or return to their original specialisation.

3.4.3 Greater visibility, recognition and attractiveness

The creation of a "space family" within the ministerial employment opportunities template will offer greater visibility and provide significant leverage in order to build up the sector. Positions of interest for space within the ministry will be specially flagged up.

ANNEXES

ANNEX 1
MEMBERSHIP OF THE WORKING GROUP

Under the direction of Mr Martin Briens, head of the Armed Forces Minister's civilian and military office, the Space working group included, around Mr Hervé Grandjean, adviser for industrial affairs:

Armed Forces Ministry

Chief of Defence Staff

Lieutenant General Eric Bellot des Minières, Deputy Chief of Defense Staff "Planning"

Colonel Ludovic Pinon

Colonel François-Yves le Roux

Directorate General of Armaments

General engineer Caroline Laurent, Director of Strategy

Mr Jean-Paul Granier

Chief engineer Jean Reix

Chief engineer Alexandre Lahousse

Directorate General for International Relations and Strategy

Mr Guillaume Schlumberger, Director for Defence Strategy, Counter-Proliferation and Strategic Foresight

Chief engineer Frédéric Planchon

Lieutenant Colonel Alexandre Godefroy (rapporteur of the working group)

Air Force

Brigadier General Dominique Arbiol, Deputy Chief of Air Force Staff "Synthesis"

Colonel Thomas Vinçotte

Lieutenant Colonel Thierry Cattaneo

Joint Space Command

Brigadier General Michel Friedling, Chief of the Joint Space Command

Colonel Thierry Blanc

Colonel Didier Beaumont

Colonel Emmanuel Capliez

Colonel Emmanuel Allain

Captain Jérémie Ayadi

Directorate of Military Intelligence

Colonel Laurence Venat

Colonel Jean-Guillaume Moalic

Armed Forces Inspectorate

Inspector Olivier Pernaudet

Armed Forces General Inspectorate

General engineer Vincent Imbert, General Inspector of the Armed Forces - Armament

General Vincent Carre, General Inspector of the Armed Forces – Air Force

Legal Affairs Directorate

Mrs Claire Legras, director of legal affairs

Major Mickael Dupenloup

Armed Forces Ministry Military Cabinet

Colonel Vincent Giraud

Navy Captain Vianney Droulle

Colonel Matthieu Kessler

Ministry for Europe and Foreign Affairs

Mr Nicolas Roche, Director for Strategic Affairs, Security and Disarmament

Mrs Elisabeth Meyer

ONERA

Mr Jacques Lafaye

CNES

General engineer Lionel Suchet
Lieutenant General (r) Philippe Steininger
Mr Frédéric Pradeilles

ANNEX 2
LISTE DE SIGLES UTILISES

A2/AD	Anti Access/Area Denial
ADR	Active Debris Removal
ASAT	Anti-satellite weapon
BMD	Ballistic Missile Defence
C4/ISTAR	Computerized Command, Control, Communication/Intelligence, Surveillance, Target Acquisition and Reconnaissance
COPUOS	Committee on a Pacific Use of Outer Space (AGNU)
CSO	Optical Space Component
DGA	Directorate General of Armaments
DTIB	Defence Technological and Industrial Base
EDF	European Defence Fund
ELISA	Electronic Intelligence by Satellite
ESA	European Space Agency
FCAS	Future Combat Air System
GGE PAROS	Group of Governmental Experts on the Prevention of an Arms Race in Outer Space
GNSS	Global Navigation Satellite System
GPS	Global Positioning system
HAPS	High Altitude Pseudo Satellite
ISR	Intelligence, Surveillance, Reconnaissance
NATO	North Atlantic Treaty Organisation
PPWT	Treaty on the Prevention of the Placement of Weapons in outer space, Threat or use of force against Outer Space Objects
SATCOM	Satellite Communications
SGDSN	Secretariat General for Defence and National Security

SSA..... Space Situational Awareness
SST..... Space Surveillance and Tracking
STM..... Space Trafic Management

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