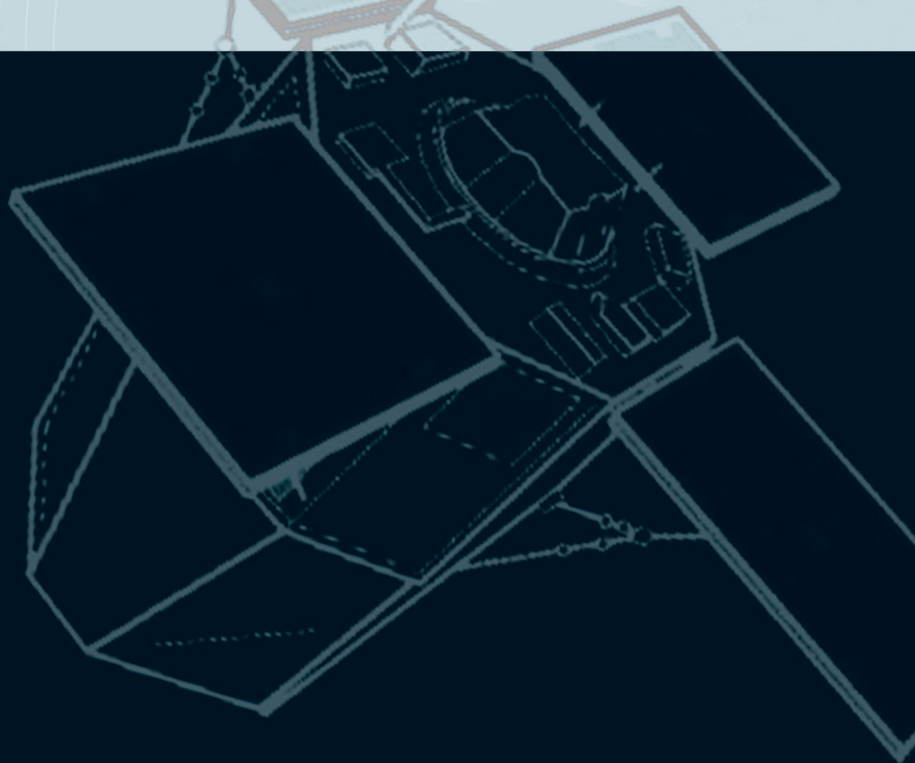


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Space: A New Theater of Conflict?



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Overview

Jean-Christophe Noël

Dear readers,

Vortex has occasionally ventured into space in previous issues, yet the journal quickly returned to the reassuring environment of air and sky to discuss air strategy. This time, however, this ninth issue of *Vortex* is fueled up, takes off, and defies gravity to illuminate the dynamics that shape military space affairs. This was the least that one could expect from a journal whose subtitle is “Studies on Aerospace Military Power.”

The issue opens with an article by I. Sourbès-Verger, which provides a historical overview of military space development and proposes a geopolitical report on space today. Reading this text offers the necessary foundation for fully appreciating and contextualizing the subsequent texts.

This issue is divided into six parts. The first focuses on the history of the militarization of space, with three articles discussing three different moments in this endeavor. The first is written by P. Varnoteaux and recounts the birth of the French space program. The author demonstrates how the State structured itself to embark on the conquest of this new environment. The various technical directorates of the Armed Forces were superseded by a Ministerial Delegation for Armaments (Délégation ministérielle pour l’armement, or DMA). The landscape of French armaments was transformed, with consequences that are still discernible in its current organization.

The second article revisits the history of the French space program in the early 1990s. It narrates the development and implementation of the *Helios* military reconnaissance satellites. The author, General (2S) B. Molard, was a direct witness to this rise to power. He recounts this slow maturation process from an insider’s perspective and does not shy away from any of the obstacles – at times military, at times political – that had to be overcome.

Commander B. Colom-y-Canals broadens the focus in the third article, addressing the issue of observation satellites during the Cold War. U.S. and Soviet satellites naturally dominate the narrative. The author endeavors to demonstrate how their use influenced events by providing intelligence on the opposing side, which was more or less precise but often highly relevant. This original contribution spurred decision-makers to develop increasingly powerful devices.

The second part of this issue discusses current operational aspects. This section comprises four articles. The first is written by G. Penent, who highlights the various challenges currently animating military space affairs. Reviewing the main Western doctrinal documents, the author stresses that the military space domain is now contested, transformed, expanding, manipulated, and, crucially, considered an operational environment. He analyzes the different courses of action now being contemplated to face this new situation.

The second article, which focuses on U.S. geospatial intelligence, is authored by N. Juglard. The author notes the importance of the data revolution in the rise of this type of intelligence. He analyzes the new governance emerging from it, highlighting the necessity of constantly designing and developing software solutions and associated services.

B. Hendrickx then reviews the various Russian capabilities likely to attack satellites in orbit. Readers will be struck by the fact that the origin of these capabilities often dates back to the first decade of this century, demonstrating Russia's intent to prepare for actions in space from as early as that period.

Finally, in the last article of this section, Captain V. Aquilina discusses the use of nuclear energy in space. Numerous countries, such as the United States and China, are interested in this option for the purpose of energy production or spacecraft propulsion. While taking into account the issues of safety, security, and proliferation is indispensable, the recourse to this type of energy could cause a genuine rupture, ensuring an operational advantage to those who master it.

The third part focuses more specifically on the major space powers by discussing their designs and their development. General (2S) P. Legai first analyzes the space challenges in Europe. Faced with increasingly severe international competition, European countries are obliged to rapidly find the best balance between national sovereignty and a collective approach. In addition to possessing high-performance military capabilities, they will need to devise a genuine policy for commercial competitiveness at the continental level.

As Rear Admiral L. Tiller, Director of the European Union Satellite Centre, demonstrates, certain initiatives are functioning effectively. They have supported a specific vision of European autonomy for years and can adapt to political, technological, and security changes. Space can therefore genuinely be a "strategic catalyst" for European security and defense.

General (2S) S. Cholley, for his part, focuses on describing the development of Chinese space power. He asserts that China now meets all the criteria of a fully-fledged space power. Notably, it excels at leveraging the integration of its civilian and military capabilities. It remains to be determined whether its relative isolation in international space affairs or its lack of organizational agility, which is essential in the era of New Space, will unduly hinder this expansion.

In this rapid overview, the United States could not be ignored. Colonel O. Fleury offers an internal view of the U.S. Space Force by presenting its recent evolution. He particularly highlights the manner in which it has revolutionized its acquisition processes by successfully aligning itself more closely with commercial companies. Nevertheless, challenges remain. The desire to use space freely, while simultaneously preventing adversaries from doing so, necessitates, among other things, the conquest of new budgets.

While state rivalries are growing and extending into space, H. Peter notes that no binding, multilateral legal instrument has been adopted since 1979. The author suggests promoting transparency and trust-building measures that fall under the umbrella of soft law. Discussing such measures could allow for the constructive resumption of dialogue and, perhaps eventually, facilitate a progressive evolution of state behavior.

The fourth part offers a collection of more original articles that may encourage the reader to adopt a decentered perspective. How can one discuss a potential war in space without mentioning what is surely the most popular and well-known franchise, namely Star Wars? Commandant T. Morin attempts to do so while highlighting the limitations of the various films for the budding space strategist. These blockbusters undoubtedly say more about the social and political context in which they were written and produced than about the best way to dominate space.

To speak of travelling in space also means undergoing a highly stringent medical examination, the rigor of which would make the military pilot one look like a simple routine check-up with a general practitioner. E. Le Reun provides an overview of these medical aspects, focusing on manned spaceflight and the dangers astronauts must confront. Microgravity, space radiation, and confinement: readers will learn everything about the trials that future volunteers will have to endure when heading towards Mars or even more distant destinations.

Finally, Lieutenant-Colonel V. Quétier concludes this section by exploring how the French Air and Space Force and the U.S. Space Force address the issue of gender inclusion within their units. These two organizations adopt distinctly different approaches, with France notably favoring a logic of strict gender equality and opportunities, while the United States places far greater value on the concept of “wellness.” This article, of course, touches on space, but not exclusively...

The fifth part consists of two interviews. The first is with B. E. Bowen. B. Hainaut interviews him on the content of his book, *Original Sin: Power, Technology and War*

in *Outer Space*, published in 2022, and on various issues currently animating the space strategy community. Readers will be able to gauge the continuing relevance of Clausewitz, even in space.

The second interview, also conducted by B. Hainaut, features A. Saint-Martin and I. Régnauld regarding their book *Une histoire de la conquête spatiale. Des fusées nazies aux astro-capitalistes du New Space* (English: *A History of Space Conquest. From Nazi Rockets to the Astro-Capitalists of New Space*). In this work, published in 2024, the authors decide to “defy a certain number of commonplaces in space history in order to enhance comprehension.” As the interview demonstrates, the result is a narrative whose tone and thesis offer valuable food for thought.

The sixth and final part is devoted, as is the tradition in *Vortex*, to book reviews. J.-P. Maréchal took a particular interest in two books written by French space experts, based on the positions they hold or the work they have carried out. These are *Révolutions spatiales. De von Braun à Elon Musk* (English: *Spatial Revolutions: From von Braun to Elon Musk*) by General (2S) P. Steininger and *La ruée vers l'Espace : Nouveaux enjeux géopolitiques* (English: *The Rush to Space: New Geopolitical Challenges*) by X. Pasco. Readers are encouraged to discover why J.-P. Maréchal appreciated these two books and, of course, to read them.

Finally, the last contribution is provided by Captain B. Hainaut. These two space specialists briefly present ten books, ten “favorites,” that should help novices or enthusiasts quickly deepen their knowledge of strategic space issues. Between reading this ninth issue of *Vortex* and these selected works, one should be able to fully grasp the challenges of today and tomorrow, and understand why the wars of the future will be influenced by the confrontations that take place in space. This will be somewhat in the manner that war in the air influenced war on land and sea during the twentieth century.

The gestation of this issue has been lengthy, much longer than usual, for various reasons. I would like to thank the authors and contributors for their patience, some of whom had to update their texts to reflect current events. I would also like to sincerely thank B. Hainaut who, despite her numerous current projects at the Institut de recherche stratégique de l'École militaire, invested herself from the conception of this issue to ensure its existence. She played a decisive role by proposing themes, suggesting author names, and conceiving other sections that budgetary and size limitations of the issue regrettably prevented from being offered this time. This issue is, to a large extent, her too.

I also must not forget in these acknowledgments P. Vallée and E. Batisse, whose roles, though often behind the scenes, remain essential in ensuring the delivery of a quality product.

Should readers wish to comment on the content of this issue or require any information or propose a submission, the editorial team remains available at the address vortexlarevue@gmail.com.

We wish you an excellent reading.

The Geopolitical Stakes of Space: From Exploration to Security Concerns (1957-2025)

Isabelle Sourbès-Verger

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Introduction

In 1955, a commitment was made by the United States and subsequently the Soviet Union to each launch a satellite as part of a scientific year, the International Geophysical Year (IGY). The objective was to collect data on the upper atmosphere and contribute to measurements taken on Earth to better understand its overall functioning. Simultaneously, the development of a launch vehicle – indispensable for accessing space – and the mastery of satellite launches provided new instruments of power to the states capable of acquiring the required technologies.

In 2025, seventy years later, space is simultaneously occupied by more than 10,000 operational satellites. This environment is now unanimously recognized as “strategic.” It serves the prestige and influence of states. It is decisive for ensuring economic development and monitoring global challenges such as the environment or climate change. It is crucial for the assertion of strategic autonomy, while for the most advanced space powers, its mastery is critical to their national interest. This gradation of uses is determined by the level of expertise of the actors regarding an environment where the cost of access is particularly high. However, there is a consensus on the exceptional role that space plays in terrestrial activities, to the extent that the future security of this unique environment is becoming a growing subject of concern.¹

1. This observation is central to the *National Space Strategy 2025-2040*, published on November 12, 2025. See General Secretariat for Defence and National Security, “[Stratégie nationale spatiale 2025-2040](#),” 12 November 2025.

For two generations, the spread of space activities has demonstrated a gradual, yet limited, expansion in the number of states capable of operating in space. The inequality of national capacities – in terms of the number of satellites, diversity of missions, and types of orbits – remains a constant. Furthermore, the emergence of private actors only reinforces the existing hierarchy within the club of space powers. While space assets are today an integral part of all human activities,² few states control all their uses, either directly or through the industrial actors they support. Simultaneously, the widespread availability of services has led to an increasingly general awareness of the necessity of possessing space assets. This is reflected, depending on resources, through a wide range of means, from the ownership of satellites to simple use as a client.

The geopolitical issues expressed in space are therefore situated at multiple levels. They correspond primarily to the projection of terrestrial interests and rivalries, but they are also manifested in the acquisition of new orbital capacities, the power of which must be assessed in relation to their ability to alter relations on Earth.

I. Space as an Element of Competition in the Cold War (1957-1991)

If the term “geopolitics” is understood in its broadest meaning – namely, the analysis of power relations and rivalries between actors – the specific context of the Cold War, which governed the objectives of space exploration, is decisive in several respects. The direct rivalry between the United States and the Soviet Union on symbolic, political, and strategic levels was indeed the structuring element. The Space Race, as orchestrated by the United States with the stated desire to reclaim the lead, proceeded in tandem with the development of reconnaissance satellites, an essential link in nuclear deterrence. In parallel, U.S. leadership was asserted through services – telecommunications, observation, and navigation – offered to civilian users worldwide, while their military capabilities were simultaneously strengthened. Finally, the decline of the Soviet economy and the questioning of the regime’s military-industrial priorities formalized the decoupling from a U.S. approach that placed Space at the heart of its national interests.

While the terrestrial duopoly was indeed reflected in Space, it must be noted that the stakes extended beyond the framework of mere competition between the two superpowers. Every state on the planet rapidly became concerned by space capabilities that ignored terrestrial borders, offered new infrastructures, and multiplied the means of influence or even domination.

1.1 National Prestige and Ideological Influence (1957-1972)

The Space Age began under the banner of the Soviet Union, much to the dismay of the United States and its allies. A few days after the launch of *Sputnik* on 4 October 1957, the newspaper *Pravda* commented: “The Soviet satellite shines like a star of our scientific and technical victory.” On 14 April 1961, the terminology remained

2. The French use an average of 47 satellites per day; according to “[Aller dans l’espace : rêve ou réalité ?](#),” official website of the French Government, 13 March 2023 [updated 15 March 2023].

very similar when the First Secretary of the Central Committee of the Communist Party, Nikita Khrushchev, declared: “Gagarin’s flight into Space is the triumph of Soviet science and technology. It is a victory for our socialist fatherland.”

During these five years, space successes – the first large scientific laboratory (*Sputnik 3*, launched in 1958), the first space probe (*Luna 1* in 1959), and the first photographs of the far side of the Moon (*Luna 3* in 1959) – fueled Soviet rhetoric. They served to maintain and disseminate the image of the scientific and technological superiority of the Soviet system. The capacity of the *Vostok* and *Soyuz* launchers, direct adaptations of the R-7 Semyorka intercontinental ballistic missile (ICBM), contributed at that time to establishing the superiority of the Soviet Union. Space achievements were intended to bolster national pride and equally, if not more so, to attract states undergoing decolonization.

At the heart of the direct competition for influence between the Soviet and U.S. models, the 1963 flight of Valentina Tereshkova – the first and only woman to go into Space for nearly 20 years – and the first extravehicular activity by Alexei Leonov in 1965 also possessed great diplomatic value. Moments of tension, such as the construction of the Berlin Wall in 1961 and the Cuban Missile Crisis the following year, as well as the initial steps toward stabilizing the nuclear relationship, were part of this specific period of “peaceful coexistence,” according to the Soviet expression, or “competitive coexistence,” in the U.S. phrase.

For the United States, whose scientific and technological excellence had been uncontested since the end of the Second World War, these first Soviet launches represented a brutal challenge. The choice by President Dwight D. Eisenhower to pursue transparent scientific exploration, separate from intercontinental missile programs, proved to be a factor of immediate weakness. Nevertheless, this direction was not called into question. The National Aeronautics and Space Administration (NASA), established in July 1958, gradually integrated the various space launcher competencies developed by the military. For instance, in 1960, the teams at Huntsville, Alabama – initially part of the Army Ballistic Missile Agency and responsible for the Jupiter and subsequently Saturn launchers – became the Marshall Space Flight Center.³

The *Sputnik* episode also served as a catalyst for the enactment of the National Defense Education Act in 1958. Already under discussion in Congress prior to the Soviet satellite launch, this reform of the educational system, intended to train more scientists and engineers, found its justification in national security requirements.

Parallel to this national reorganization, the United States mobilized the network of the U.S. Information Agency (USIA), created as early as 1953 as an instrument of public diplomacy and active in nearly eighty countries.⁴ The results from

3. It was a Juno launcher, derived from the Jupiter ICBM, designed by the German scientist Wernher von Braun, that put Explorer 1, the first American satellite, into orbit on January 31, 1958.

4. The official mission of the USIA was “to understand, inform, and influence foreign public opinion in order to promote the national interests of the United States and to expand dialogue between the United States and the rest of the world;” according to [Executive Order 10477 – Authorizing the Director of the United States Information Agency to exercise certain authority available by law to the Secretary of State and the Director of the Foreign Operations Administration](#), 1 August 1953, section II.

the *Explorer 1* and 3⁵ satellites, as well as the selection of the first astronauts, the “Mercury Seven,”⁶ were widely disseminated. This contrasted with the secrecy surrounding Soviet capabilities. Space was then presented as one of the elements of a global revolution through science and technology, which the United States strove to achieve and from which developing countries could benefit. This approach mirrored the Soviet discourse on a new world built by socialism. It aimed to convince newly independent states to follow the U.S. model, whose technological capacities were also mobilized within the “American way of life” – proudly presented to the entire world and contrasting with the austerity of daily life in the Soviet Union.

In this competitive context, the flight of Yuri Gagarin on 12 April 1961 triggered a radicalization of U.S. policy. By announcing the landing of a man on the Moon and his safe return to Earth before the end of the decade in a speech to Congress on 25 May 1961, President John F. Kennedy formalized the symbolic value of space exploits to demonstrate the superiority of freedom over tyranny to the entire world.⁷

This period, described by the West as the “Space Race,” reached its conclusion with the triumphant success of Neil Armstrong and Buzz Aldrin’s walk on the Moon on 20 July 1969. The live transmission to the thirty or so countries connected to Intelsat and the Eurovision network was reportedly seen by over 500 million viewers. Although the majority were U.S. nationals – between 125 and 150 million, representing nearly 94% of households with a television – and Westerners (between 180 and 220 million), the news of the achievement was relayed worldwide by radio and the press. While strong protest had been voiced since the mid-1960s – regarding civil rights struggles and opposition to the Vietnam War – this episode offered a moment of national unity and an indisputable image of the supremacy of U.S. technology.

The communication policy, meticulously planned since the start of the program⁸ and extensively documented by NASA, achieved its objective: to demonstrate the exceptional capacity of the United States to dedicate such effort and resources to successfully landing a man on the Moon in the name of Humanity. Internationally, the Soviet Union saluted the scientific and technical achievement. China, however, in the midst of the Cultural Revolution, reported the event as an expression of the hegemonic will of the U.S. and Soviet systems.

Three years later, the cancellation of the final missions demonstrated that, once the goal had been reached, the Apollo program had lost its *raison d’être*. On the Soviet side, the automated return of lunar samples saved face. However, the new political direction established by the Kremlin leader, Leonid Brezhnev (1962-1984), no

5. *Explorer 1* was the first American satellite, placed in orbit in February 1958. *Explorer 3*, for its part, was a scientific satellite launched the following March.

6. The term “Mercury Seven” refers to the pilots selected to lead the Mercury missions in the early 1960s. They are also known as the “Original Seven” or “Astronaut Group 1.”

7. “[Special Message to the Congress on Urgent National Needs](#),” *The American Presidency Project*, 25 May 1961.

8. “[Memorandum From the Office of Policy and Plans, Apollo 11 Operations Center, United States Information Agency to the Director \(Shakespeare\)](#),” *Foreign Relations of the United States, 1917-1972*, vol. VIII, Public Diplomacy, 1969-1972, Washington, 6 June 1969.

longer utilized space as a showcase. The primary objective was to achieve strategic parity with the United States.

1.2 The Strategic Dimension of Space in the Nuclear Balance (1955-1985)

Further removed from the spotlight than human spaceflight, the satellites placed into orbit between 1957 and 1972 reveal a different story: that of the close link between space and nuclear capabilities. The most represented category throughout this entire period was, in fact, that of military satellites, particularly observation satellites – as evidenced by the declassification of these programs from 1995 onwards.⁹ These satellites were already identifiable at the time, as they were registered with their identification numbers in lists maintained by the Committee on Space Research (COSPAR).¹⁰

For their initial intelligence satellites, the United States initially resorted to cover names. Until January 1962, the *Corona* photographic observation satellites were designated as “Discoverer”, while the GRAB electronic eavesdropping satellites were named “SOLRAD”. Others were mentioned as “OPS-” or “USA-” followed by numbers, without further details. For their part, the Soviets utilized a generic category, “Kosmos”, comprising both scientific and military satellites.

For U.S. intelligence, the mapping of the Soviet Union was the top priority.¹¹ It was indeed crucial to know the number of intercontinental missile sites and to possess precise data to develop targeting plans. The large number of reconnaissance satellites – more than 200 in fifteen years – is explained by the use of film technology, which necessitated the return of films to Earth; digital transmission only became prevalent from 1976 onwards. The two other major missions at that time were electronic intelligence (ELINT), which allowed for the collection of military signals, and the monitoring of nuclear tests and ballistic missile launches.

For the Soviet Union, the availability of open information regarding U.S. capabilities rendered the development of reconnaissance satellites less of a priority. Moreover, it was opposed in principle to the acquisition of images from space, in line with the refusal it formulated regarding the “Open Skies” policy promoted by President Eisenhower as early as 1955.¹² However, faced with the de facto impossibility of preventing this practice – the satellite orbiting the Earth ignoring terrestrial borders – Moscow resolved to develop its spatial intelligence capabilities. This shift in posture

9. For the Corona, Argon, and Lanyard programs, declassification occurred on February 22, 1995, with [Executive Order 12951 – Release of Imagery Acquired by Space-Based National Intelligence](#). For other programs, declassification came later, in 2005 and 2015.

10. For each launch of an artificial object into space, COSPAR assigns it a “COSPAR identifier” (or “International Space Object Registration Number”) which allows for tracking the number of satellites in orbit. This registration procedure was established in 1958 to differentiate space launches from missile tests, and to address states’ responsibility for any damage caused by their satellites.

11. The United States will launch nearly 145 Corona family satellites, representing almost 20% of the total number of U.S. satellites launched during this period.

12. On July 18, 1955, at the Geneva summit, President Eisenhower proposed to the Soviet Minister of Defense, Nikolai Bulganin, the principle of “mutual aerial observation.” Moscow formally opposed it.

resulted in an impressive number of military satellites launched from the late 1960s until the end of the 1980s – with occasionally two to three satellites per month during periods of crisis.¹³ The existence of eavesdropping constellations and the delay in digital transmission then provided an image of intense militarization, which was extensively exploited by the U.S. Department of Defence before Congress to obtain new funding.¹⁴

Finally, the two superpowers – with the Soviet Union consistently lagging behind – acquired military telecommunication and navigation satellites. In these fields, the pace was set by the United States with the first telecommunication satellite as early as 1962 (*Telstar 1*),¹⁵ followed by the *Transit* family, the first satellite geopositioning system, which became operational from 1964 and was replaced in 1996 by the Global Positioning System (GPS).¹⁶

The discretion surrounding these programs is also explained by the absence of a legal framework until the Outer Space Treaty of 1967. Presented under the auspices of the United Nations, it was part of a perspective supporting international security and the principle of peaceful use that characterized texts of that era.¹⁷ Its major principles established freedom of movement and use for peaceful purposes, non-appropriation, and the absence of sovereignty in space and on celestial bodies. Space was, moreover, described therein as the “province of all mankind.”¹⁸

While it established the principle of equality between all states regarding its uses, the treaty was, in reality, the result of bilateral negotiations between the two superpowers, who were anxious that a reference text should exist before the lunar landing. They therefore intentionally left a margin for interpretation in numerous articles. The status of military satellites, for example, remained ambiguous. Although extensively employed by Moscow and Washington at the time of the treaty’s conclusion, no official status was conferred upon them. They were tacitly considered “peaceful” as long as they possessed no directly offensive capabilities.¹⁹ Their acceptance was ultimately achieved through their direct role in nuclear arms control mechanisms, as they were the only means of enabling confidence-building measures by ensuring the verification of thresholds set by the SALT Treaty of 1972.²⁰

13. See, for example, the launches carried out in October 1973 to ensure coverage in space imagery. Moscow urgently launched nearly six reconnaissance satellites in the space of a few weeks; according to D. A. Day, “[Crisis in space: The 1973 Yom Kippur War and “crisis reconnaissance”](#),” *The Space Review*, 2 October 2023.

14. To support the work of Congressional committees, the Congressional Research Service published, starting in 1966, a very detailed overview of Soviet military satellite launches and programs under the title “Soviet Space Programs.”

15. The USSR launched its first telecommunications satellite, *Molniya 1*, into orbit in 1965.

16. The first Soviet navigation satellites of the Tsiklon family were placed into orbit starting in 1967.

17. Such as the Antarctic Treaty (1959) or the Partial Nuclear Test Ban Treaty (1963).

18. [Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies](#), 27 January 1967, “Article premier.” The English expression – “Province of Mankind” – is slightly different.

19. This viewpoint is not unanimous. Until the end of the 1990s, a number of countries – including India – sought clarification on the legitimacy of the use of military satellites.

20. Strategic Arms Limitation Talks, or “Interim Agreement on Certain Measures Concerning the Limitation of Strategic Offensive Arms.”

Indeed, referred to indirectly in this agreement as “national technical means,” satellites were recognized as contributing to strategic stabilization. As such, they favored a sanctuary of space, since the destruction of satellites would amount to removing the guarantees of an indispensable parity within the context of the doctrine of Mutual Assured Destruction.

Although the International Geophysical Year of 1957-1958 certainly marks the official beginning of space exploration, the political objectives and technical competencies that governed the involvement of the United States and the Soviet Union were directly linked to strategic concerns. These were implicitly present in U.S. rhetoric and decisions. For the USSR, the fact that the space sector was completely integrated into the military-industrial complex under the authority of the VPK²¹ and the Politburo testifies to political priorities with heavy consequences. Bureaucratic inertia²² and the culture of secrecy reinforced internal rivalries while penalizing innovation and severely limiting the development of civilian services.

1.3 The Expansion of Space Activities (1981-1991)

In line with its demonstration of leadership through the benefits of technology, NASA was officially responsible for the cooperation component of U.S. space policy.²³ It thus ensured the training of European and Canadian “rocket scientists,” as well as those from Japan and India.

NASA played a key role in the civilian applications sector. As early as 1961, President Kennedy invited all states to participate in a global satellite communications system – named “Intelsat” – the infrastructure of which was provided by the United States. The Communications Satellite Corporation, a U.S. company, managed this intergovernmental organization. Becoming operational in 1964 and boasting 77 members by 1973, it required participating countries to renounce the creation of any competing system. This clause only began to pose a problem at the end of the 1970s, when France and Germany developed “Symphonie,” an intercontinental link program. In comparison, the response of the Soviet Union, with the creation of the Intersputnik organization highlighted the weakness of its international influence, as its membership was limited to the countries of the Eastern Bloc.

At the same time, the international space scene was gradually opening up.²⁴ As early as 1970, Japan and then China succeeded in their first launches. However, it was only from the middle of the decade that new actors emerged capable of reach-

21. The VPK – or Voenno-Promyshlennaya Komissia – is a commission of the Presidium of the Council of Ministers for matters of military industry.

22. The creation in 1965 of the Ministry of General Mechanical Constructions (MOM), intended to rationalize administrative operations, had only a very limited effect, especially since the space budget remained limited compared to that of the United States.

23. Scientific cooperation agreements have also been made with several countries, such as Brazil, Argentina, Australia, South Africa, Pakistan and Iran for sounding rocket programs with mixed results.

24. France launched its first satellite, Astérix, in 1965. Paris quickly chose to prioritize the European dimension with the European Launcher Development Organisation (ELDO) and then the European Space Agency from 1975 onwards.

ing geostationary orbit, while India succeeded in its first low-earth orbit launch in 1980.²⁵ This phenomenon occurred in parallel with the stagnation of the Soviet space sector. Despite being the only power to possess an inhabited space station and maintaining a military fleet, Soviet international influence was steadily declining.

In this context of a growing hiatus between U.S. and Soviet capabilities, the announcement by President Reagan on 23 March 1983 of the Strategic Defence Initiative (SDI) indirectly formalized the end of the assumption of a sanctified Space.²⁶ The SDI was intended to eliminate the nuclear threat hanging over the U.S. people by providing the country, within at least a decade, with the technological means to render nuclear weapons ineffective and obsolete. In addition to strengthening detection and ground-based interception capabilities, the system was only made possible by the creation of a space shield featuring thousands of small satellites designed to ensure the detection and destruction of warheads in flight. Rapidly nicknamed “Star Wars” by its opponents and the media – alluding to George Lucas’s films, with Return of the Jedi expected later on in May 1983 – the SDI was nevertheless formalized in January 1984 in National Security Decision Directive 119.²⁷

On a strategic level, the objective stated by the SDI was the end of the principle at the heart of nuclear deterrence: the capacity for the attacked state to retaliate and destroy its adversary with a second strike. Although the United States envisaged this project from a defensive perspective, it nonetheless represented a real threat to the Soviet Union, even if its implementation could not be immediate given the disproportionate technological constraints represented by a mandatory 100% interception rate. Furthermore, the election of Mikhail Gorbachev as General Secretary of the Central Committee of the Communist Party of the Soviet Union in March 1985 resulted in new slogans: “Perestroika” (reconstruction) and “Glasnost” (transparency) for domestic policy, alongside a renewed strategic dialogue with the United States aimed at reducing arms control.²⁸ There was, therefore, no out-racing from the Soviet side following the U.S. announcement.

II. The Supremacy of the United States within the Space Club (1991-2014)

From January to February 1991, Operation Desert Storm showcased what observers described as the “first space war.”²⁹ With the collapse of the Soviet Union a few months later, the United States established itself as the sole dominant force. Rus-

25. Japan in 1977 (*Kiku-2*), China in 1984 (*Dong Fang Hong 2*), Europe in 1981 (via the European Space Agency, with the *Meteosat* satellite); according to T. G. Roberts, “[Spaceports of the World](#),” *Aerospace Security*, Center for Strategic and International Studies (CSIS), updated on 31 January 2023.

26. “[Strategic Defense Initiative. President’s Backup Copy: Address on Defense](#),” National Archives and Record Administration, 23 March 1983.

27. “[Strategic Defense Initiative](#),” National Security Decision Directive, no. 119, 6 January 1984.

28. It came up during the summits in Geneva (1985), Reykjavik (1986), Washington (1987) and Moscow (1988).

29. P. Gras, “[Le renseignement spatial pendant la première guerre du Golfe](#),” *Carnets de Vols*, no. 143 (“Le renseignement aérospatial”), 2023, pp. 52-53.

sia was forced to accept their leadership in the field of launchers³⁰ and human spaceflight,³¹ while the other significant space powers, such as Europe and Japan, did not position themselves as competitors. This situation of uncontested hegemony only began to fade in the early 2000s with the increasingly significant display of China's capabilities. In particular, the first flight of a taikonaut in 2003 established it as the third space power in the prestigious field of human spaceflight. As the traditional dominant actor of the spatial order, the United States then opened a new era – that of New Space – while asserting its commitment to control Space to ensure its security.

II.1 Unrivalled Military Capabilities

The first Gulf War in 1991 revealed to the entire world U.S. space capabilities at the service of operations in the conduct of a high-technology warfare. The complete range of satellites, financed by substantial military budgets that have exceeded civilian budgets since 1981,³² was mobilized to cover an extremely broad spectrum of missions: the early warning of Scud missile launches, communications transmission, missile navigation and guidance, analysis of meteorological conditions, intelligence gathering, continuous situational awareness monitoring, or more targeted reconnaissance as needed.

The lessons learnt led to an improvement in alert systems, a wider dissemination of terminals, a greater bandwidth capacity, and enhanced coordination effort with a single point of contact at the level of the theatre of operations. Above all, the design of military space activities evolved by pursuing the strategic dimension and support for operations, and by integrating space capabilities into the design of new military systems.

At the political level, President Bill Clinton's December 1999 *National Security Strategy for a New Century* established access to Space and the guarantee of its use as a vital interest for national security and prosperity.³³ The necessity of possessing capabilities to counter enemy systems likely to threaten the space sector opened the way for potential offensive means in addition to the usual tools of surveillance and passive protection.

30. While delays in the Space Shuttle program reduced commercial launch capacity for foreign customers, the United States developed partnerships between Russian and American companies for the commercialization of the highly reliable and inexpensive Proton launch vehicles, whose development they financed with profit sharing. This policy, sometimes pursued at the expense of the Ariane company, was also adopted by France and then Europe with the creation of Starsem for the commercialization of the Soyuz launch vehicle.

31. Concerned about the risks of social destabilization in Russia, the political authorities sacrificed the International Space Station Freedom (designed with Europe, Canada, and Japan) for cooperation with Russia, which became a major partner and made its experience and technical resources available with the Zarya and Zvezda power and life support modules, initially intended to succeed the Soviet Mir space station, which was deorbited in 2000.

32. In 1990, the U.S. space budget amounted to billions of dollars, including for the entire military space program.

33. [*A National Security Strategy for a New Century*](#), The White House, December 1999, p. 12.

The notion of “Space Control” took on a new dimension with the presidency of George W. Bush, at a time when the second war against Iraq (2003) had demonstrated the decisive contribution of satellites. One year later, the U.S. Air Force published the first Counterspace Operations doctrine intended to guarantee U.S. military superiority in Space, including via offensive means.³⁴ By asserting in the 2006 *National Space Policy* the will to use Space for its strategic advantages in order to consolidate U.S. leadership in all its forms,³⁵ the principles of peaceful use and freedom of movement inscribed in the 1967 treaty found themselves directly challenged. This was, at least, the reading made by China, whose anti-satellite test on 11 January 2007 reflected the risks of weaponization, namely the development of offensive military capabilities in Space.

While China and Russia jointly proposed to the United Nations in 2008 to ban weapons in Space,³⁶ the Obama presidency marked a shift towards transparency and the development of security guarantees in Space, which was still declared of vital interest.³⁷ Then, in 2011, the *National Security Space Strategy* of the Department of Defence considered that “Space is an increasingly congested, contested, and competitive environment,”³⁸ which constitutes a challenge for U.S. leadership. Although the measures envisaged to build a responsible spatial order under the aegis of the United States mention the interest of cooperation, the preparation to defeat possible attacks and to preserve their freedom of action in Space also formed part of the measures envisaged. In 2019, this latter aspect took on a new dimension with the creation of the U.S. Space Force decided by President Donald J. Trump.

II.2 A New Deal in Civilian Space

With the arrival to power of President Bill Clinton in 1993, the United States undertook to capitalize on its technological advances to reinforce its global influence. The evolution of U.S. policy regarding space applications manifested itself through the 1996 opening of the GPS constellation to the public, followed by the end of the voluntary signal degradation for civilian use in 2000. The result was immediate with the boom in the sale of receivers and, above all, of services.

In parallel, the White House attempted to reinforce the position of U.S. operators on the international market. In 1994, it authorized the commercialization of high-resolution (1m) space imagery data and systems before publicly encouraging it in 2003 within the framework of the *Commercial Remote Sensing Space Policy*.³⁹ It had, moreover, proceeded in 2000 with the deregulation of telecommunications, linked to

34. [Counterspace Operations](#), Air Force Doctrine Document 2-2.1, 2 August 2004, 67 p.

35. [U.S. National Space Policy](#), White House, Unclassified version, 6 October 2006, 10 p.

36. At the 2008 Conference on Disarmament, Beijing and Moscow proposed a draft for a [Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force Against Outer Space Objects](#) (PPWT).

37. This dimension is reaffirmed in the 2010 National Space Policy of the United States of America (16 p.).

38. [National Security Space Strategy](#), department of Defense, January 2011, p. i.

39. [U.S. Commercial Remote Sensing Policy](#), National Security Policy Directive (NSPD) 27, 25 April 2003, 7 p.

the establishment of information highways, leading to the progressive privatization of international space organizations, such as Intelsat and Inmarsat.⁴⁰

These measures had a direct effect on European and, to a lesser extent, Japanese space capabilities.⁴¹ Europe, rather oriented towards scientific research and technological competence under the auspices of the European Space Agency (ESA), and then began to develop a more economic approach with the increasing involvement of the European Commission. The 1998 decision to initiate the GMES (Global Monitoring for Environment and Security) Earth observation program, and subsequently a navigation system (Galileo), marked an awareness of the stakes of space for European strategic autonomy, even if competition was fierce.⁴² Finally, with the first operational flight of the *Ariane 5* launcher in June 1996, Europe positioned itself in the expanding market for geostationary orbit launches.

The case of China is different insofar as, excluded from any technology transfer since the report by Senator Chris Cox in 1999 which accused it of espionage for military purposes,⁴³ it could only rely on its own resources. Even if it succeeded in developing South-South cooperation, following the example of Brazil with the China-Brazil Earth Resources Satellite Program,⁴⁴ it largely operates in isolation, as its infrastructure needs and its domestic market fully justify its space investments. Its growing expertise in the fields of telecommunications and observation, but also in human spaceflight (the *Shenzhou-5* spacecraft carrying the first taikonaut in October 2003) and lunar exploration (the first *Chang'e 1* probe, orbiting the Moon in 2007), confirmed the maturity of its space industry and the continuity of the ambitions described in the *White Papers* published since 2000.

One of the originalities of the Chinese sector is the application of five-year plans guaranteeing the continuity of programs and conceived within a logic of catching up with the leading space powers. The reform of state-owned enterprise management (1998) within the framework of China's application to join the World Trade Organization, followed by the reform (2008) promoting civil-military integration to stimulate innovation, resulted in an integrated industrial organization. It is headed by two large conglomerates, CASC and CASIC,⁴⁵ and laboratories of the Academy

40. "[Open-Market Reorganization for the Betterment of International Telecommunications Act](#)," *Public Law* 106-180, 17 March 2000, 14 p.

41. Japan is subject to special measures under the so-called "Super 301" agreement (or "Section 301" of the Trade Act of 1974) with the United States, which obliges it to open its calls for tenders to American manufacturers for the development of its commercial satellites.

42. The choice of a public-private partnership for the development of the Galileo program quickly proved to be a mistake, given the free availability of GPS signals funded by the U.S. government. While it did not jeopardize the program, which represented significant political value for the European Commission, it did cause a delay of several months.

43. C. Cox, "[U.S. National Security and Military/Commercial Concerns With the People's Republic of China](#)," Chamber of Representatives, published on 3 January 1999, declassified version published on 25 May 1999.

44. The program was initiated in 1988 and then supplemented by an agreement in 2002, which led to the shared financing of a series of military reconnaissance satellites, called CBERS.

45. Respectively, the China Aerospace Science and Technology Corporation and the China Aerospace Science and Industry Corporation.

of Sciences, and has seen the more recent appearance of a few joint-stock companies for the commercialization of observation and telecommunication services, and even, since 2014, small launchers.⁴⁶ As for the military component, the People's Liberation Army, responsible for launches and human spaceflight, manages its own programs through the General Armament Department.⁴⁷

II.3 The New Balances

Several moments may be chosen to analyze the changes that have taken place since the beginning of the 21st century.⁴⁸ The emergence of New Space – that is, private entrepreneurs originating from the world of the internet – is often cited. The notion actually encompasses a range of realities but has the merit of accounting for new industrial priorities and logics. These place particular emphasis on innovation and cost reduction, or on the initiative of political power, especially in the United States. Thus, the 2000-2006 period corresponds to the creation of Jeff Bezos's company, Blue Origin, then of SpaceX by Elon Musk, and to NASA's establishment of the Commercial Orbital Transportation Services, which was decisive for the financing of both companies.

In 2015, President Obama's SPACE Act⁴⁹ confirmed the commitment to support the development of actors independent from agencies such as NASA and the Department of Defence. It sought to give a new impetus to the space sector by making it more accessible. It thus specified the particular regulation of commercial human spaceflight and opened new perspectives by granting U.S. candidate companies a right to exploit the resources of celestial bodies, such as asteroids and the Moon. This latter initiative, however, was not without legal controversy. It appeared to contradict the principle of non-appropriation enshrined in the 1967 treaty. Furthermore, it raised ethical questions regarding the preservation of an environment external to the Earth that belongs to the whole of humanity.

If one considers achievements, the main technological advance is the development of the reusable Falcon 9 launchers by SpaceX. While Russia tests the A5 version of the Angara launcher – intended for the past fifteen years to replace the Proton launcher – and while the ESA flew its last ATV⁵⁰ to the International Space Station in 2014, the dynamism of U.S. companies is striking.⁵¹

46. L. Sénéchal-Perrouault, "[A Chinese New Space? Commercial Launch Enterprises Within National Economic Reform](#)," *Entreprises et histoire*, no. 102(1), 2011, pp. 149-171.

47. I. Sourbès-Verger, D. Borel, *Un empire très céleste, la Chine à la conquête de l'espace*, Paris, Dunod, 2008.

48. X. Pasco, *La ruée vers l'espace : Nouveaux enjeux géopolitiques. La guerre du ciel est déclarée...*, Paris, Tallandier, 2024.

49. Developed in "[U.S. Commercial Space Launch Competitiveness Act](#)," *Public Law* 114-90, 25 November 2015.

50. The fact that the ATV-5 is the last example of the fleet of cargo vehicles tasked with supplying the ISS reflects a different policy from that of Japan, which, for its part, continues the flights of the HTV (H-II Transfer Vehicle) with the funding of a successor HTV-X in 2025.

51. Besides the giant SpaceX, the company Rocket Lab has quickly established itself as one of the main providers of space services and offers its Electron launcher, which can be used from American and New Zealand launch pads.

Ultimately, it is in the register of exploration – exclusively supported by public financing – that other space powers demonstrate their success. In 2010, after a seven-year voyage, the Japanese probe Hayabusa returned samples from the asteroid Itokawa to Earth. China, for its part, succeeded in its first moon landing in 2013. Meanwhile, the ESA showcased its technological capabilities in the ambitious Philae scientific mission, which separated from the Rosetta probe to land on the comet Chury in 2014. In the same year, the Indian mission Mangalyaan succeeded in its insertion into orbit around Mars, thereby becoming the first Asian power to reach the Red Planet.

However, the mid-2010s also witnessed significant changes in the security field. The United States underwent a genuine doctrinal shift with the designation of Space as a warfighting domain. This is in response to the perception of growing threats from China, which is perfecting its rendezvous techniques, and from Russia. During the 2014 invasion of Crimea, the Kremlin performed several approach maneuvers with *Kosmos-2499* in proximity to one of the stages of its launcher. This led observers to question the nature of this satellite.⁵² On their side, Moscow and Beijing expressed their concerns regarding U.S. capabilities developed in accordance with Pentagon doctrines and presidential declarations on national security.

While most space powers reinforce their conventional military capabilities and concern themselves with protecting them, discussions within the framework of United Nations Special Committee on the Prevention of an Arms Race in Outer Space⁵³ have stalled. They revolve around the renewed proposal by China and Russia for a ban on weapons in space. On this subject, the United States and its allies point to the absence of a definition for the concept of “weapons” and the impossibility of verifying the effectiveness of the treaty. They further support proposals for a non-binding code of conduct,⁵⁴ such as the one developed by the European Union in 2008.⁵⁵ They also favor the creation of Open-Ended Working Groups (OEWG), which have been commissioned anew for the 2024-2028 period.⁵⁶

Ultimately, an analysis of space expenditure reveals a significant effort by the United States and a growing investment by China, which moves into second position. A third position corresponds to the total of European commitments: national, ESA, and European Union. It must finally be noted that, though often forgotten, Japan is making a space investment that now surpasses that of Russia. This is focused on upgrading its military programs and a confirmed investment in exploration and cooperative human spaceflight.

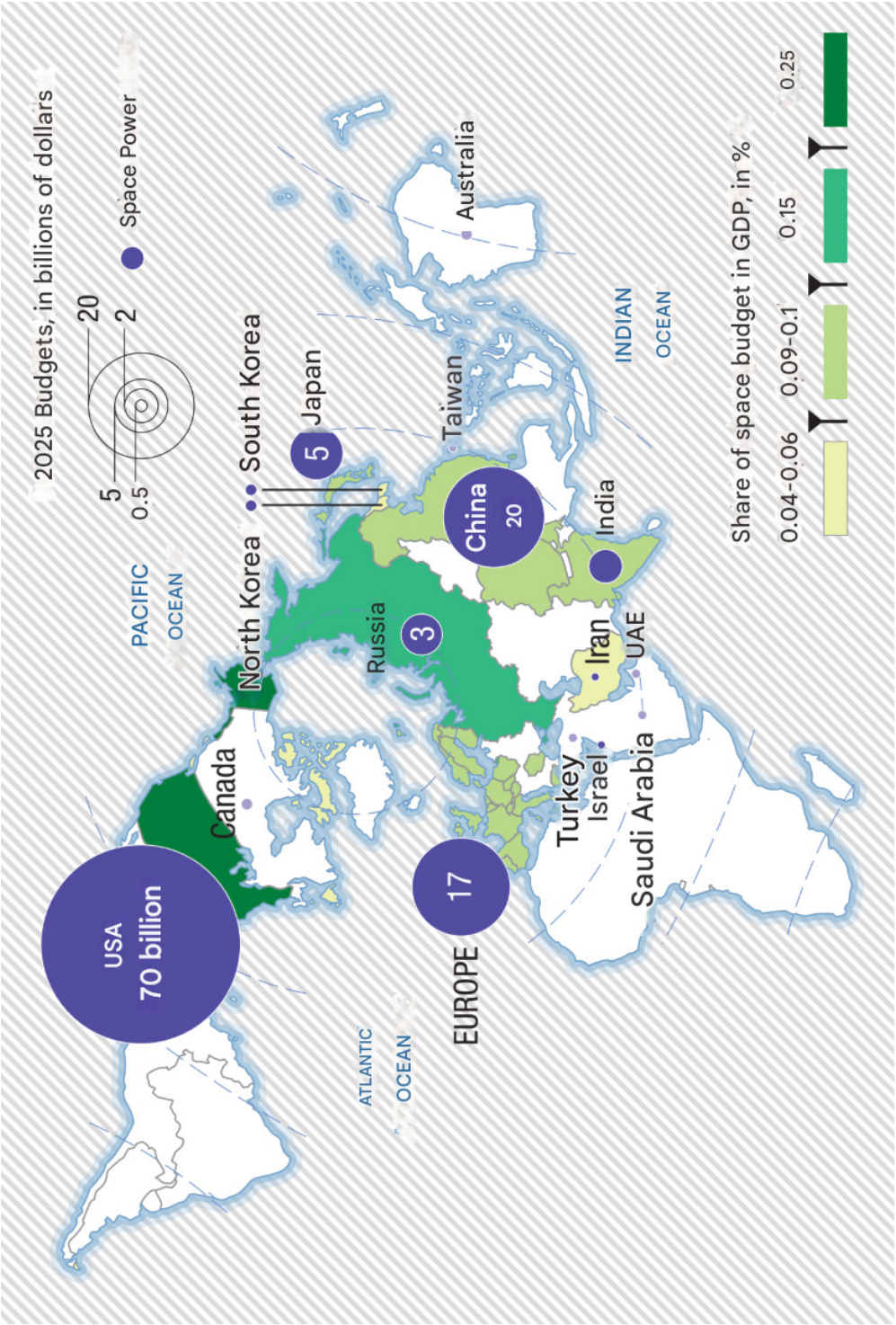
52. A. Zak, “[Kosmos-2499: Is it a spy or an assassin... or both?](#),” *RussianSpaceWeb.com*, 20 September 2023.

53. Better known as PAROS, for “Prevention of an Arms Race in Outer Space”, this ad hoc committee was established following the adoption of a resolution by the United Nations General Assembly in 1981.

54. The defense of soft law against binding multilateral treaty commitments is a fundamental difference today in legal stances between, on the one hand, the initiatives of Westerners and, on the other hand, those of the Russians and Chinese supported by many third states.

55. “[Projet de conclusions du Conseil concernant le projet révisé de code de conduite pour les activités menées dans l'espace extra-atmosphérique](#),” Conseil de l'Union européenne, PESC 1174, CODUN 31, 17 September 2010.

56. B. Hainaut, “[L'établissement de normes de comportement dans l'espace extra-atmosphérique – De la Terre à la Lune, et au-delà](#),” *Étude* No. 110, Institut de recherche stratégique de l'École militaire, November 2023, 66 p.



I. Sourbès-Vergier, *L'Espace*, Documentation Photographique dossier 8168, CNRS Éditions, 2025 (translated by the editor).

III. Continuities and Changes in Space Geopolitics in 2025

Since the mid-2010s, the number of satellites placed into orbit has increased spectacularly. It rose from between 200 and 500 satellites between 2015 and 2019 to more than 1,000 in 2020, 2,500 in 2022, and nearly 3,000 in 2023–2024, and is expected to reach more than 3,000 satellites in 2025.⁵⁷

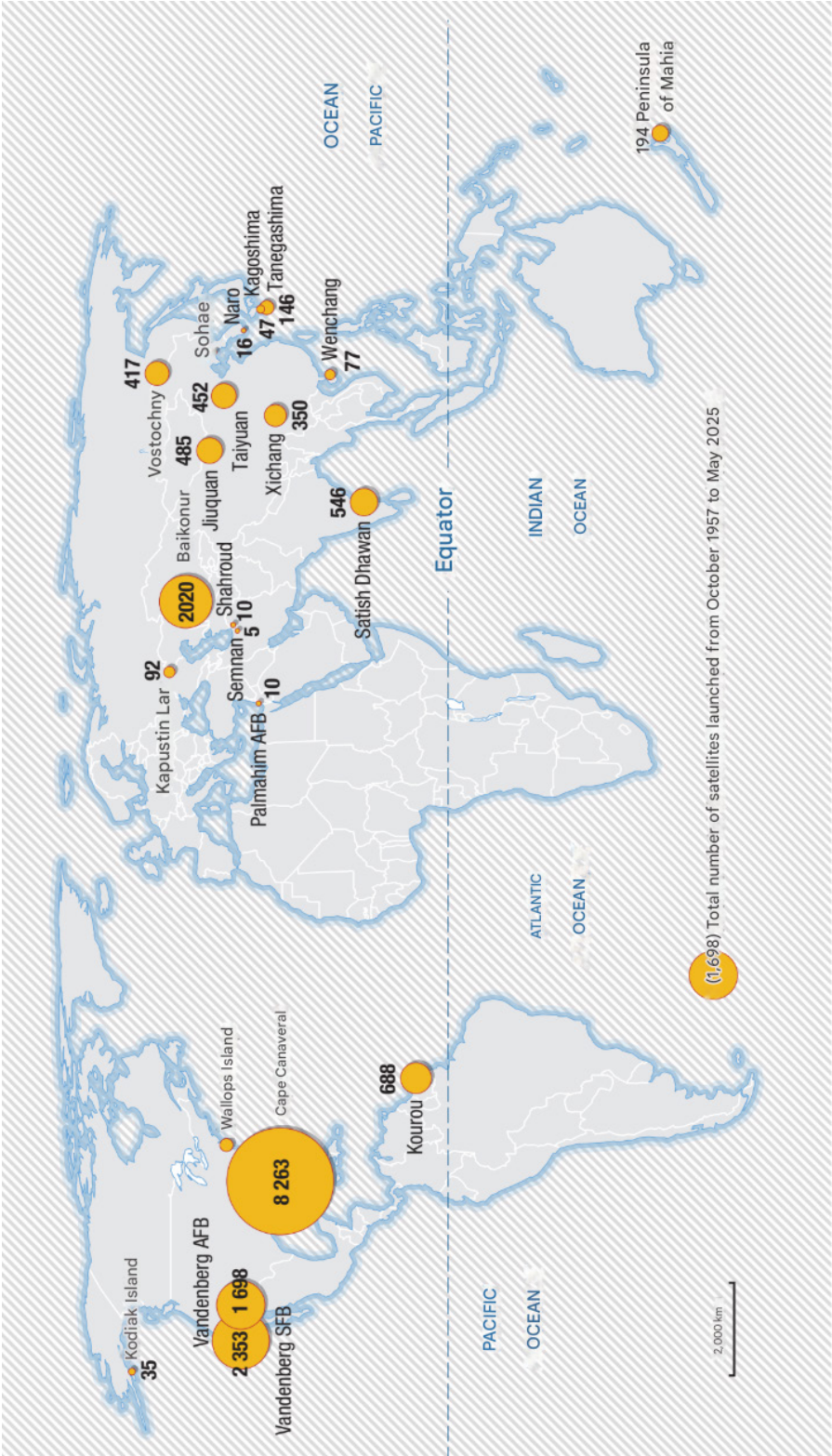
The principal factor of rupture is the deployment of constellations comprising several thousand satellites, particularly for telecommunications, belonging to private actors such as SpaceX. Added to this is the recent development of smaller satellites, weighing below 150 kilograms and descending to only a few kilograms in the case of cubesats.

The increasing occupation of space is therefore the result of two very different phenomena: the presence of a private actor possessing, by 2024, more than half of the satellites in low-earth orbit, and the experimentation with satellite technologies by several dozen newcomers, including states. It also responds to two particular rationales: the desire to acquire a dominant commercial position and the discovery of new capabilities at a lower cost. It therefore immediately raises the question of the coexistence of these approaches, in addition to the traditional methods of conventional satellites in low-earth and geostationary orbits, in an environment where the constraints of celestial mechanics result in an unavoidable interdependence.

III.1 Overview of Actor Capabilities

The map of satellites launched since 1957 reflects the activity of national bases. It does not prejudice the nationality of the satellites placed into orbit, such that one cannot equate the national total with the share in international space activity. Furthermore, this type of representation does not account for evolutions over time, such as the high number of Soviet reconnaissance satellites in the 1960s and 1970s included in the total for Russia, nor the numerous foreign satellites launched from Baikonur after 1995 or, more recently, from Vostochny from 2015 until the invasion of Ukraine. This remark also applies to Kourou in French Guiana, where Ariane accounted for nearly 60% of the commercial launch market from 1986 to 2000, while private or public European satellites seeking the best prices used the Russian Soyuz or SpaceX's Falcon in the 2010s. In contrast, these reservations do not apply to the case of China, which has almost always been kept apart from the global market.

57. Figures may vary depending on the source. These figures come from the personal database of Jonathan McDowell, a recognized expert who cross-references various sources, including data from launch companies. Regularly updated, it is available at "Satellite statistics: Launches," *Planet4589*, updated on 9 October 2025. The official database compiled by the United Nations Office for Outer Space Affairs, on the other hand, only includes declared satellites. The difference between the two databases is approximately 20%.



I. Sourbès-Verger, *L'Espace*, Documentation Photographique dossier 8168, CNRS Éditions, 2025 (translated by the editor).

What the map demonstrates, therefore, is primarily the small number of countries capable of providing access to space. The presence of several bases in Russia,⁵⁸ the United States, and China are also noteworthy. This is due to historical reasons linked to the proximity of ballistic capabilities and space launchers within the strategic context of the Cold War. The evolution of satellite types and commercial concerns results in varying degrees of activity, notably with the development of the much more accessible Wenchang Space Launch Center in China. Finally, the existence of a base on the Māhia Peninsula in New Zealand reflects a new phenomenon: the establishment of private capabilities belonging to the U.S. company Rocket Lab, which is seeking suitable launch sites for its small Electron launcher at lower costs. Nonetheless, despite its international responsibility, New Zealand cannot be considered a space state, as it does not possess the launcher utilized on its territory.

Finally, the map reflects the current superiority of the United States, Russia, and China, as well as the much more diminished role of Europe, India, and Japan. This hierarchy is mirrored in the number of national satellites. Out of a total of 15,000 satellites in orbit (active and inactive) as of December 2024, the United States possesses nearly 8,000, of which 80% are private satellites and 75% belong to the Starlink company alone. The success of the various U.S. governmental measures in favor of private actors is thus well attested. Regarding governmental satellites alone, the United States slightly exceeds China with over 350 satellites, thanks to the importance of their military fleet. Europe and Russia follow, with nearly 200 satellites, a significant proportion of which is represented by navigation satellites, while India and Japan arrive in the final position with 60 to 70 satellites.

The map of budgets corroborates this observation of the United States' dominant share, which represents, on its own, 80% of global public investment. This observation for the year 2025 must be placed in a long-term perspective since, following the end of the Soviet Union in 1991,⁵⁹ U.S. expenditure has at times represented ten times the total of all other space powers. While the civilian space budget, at approximately twenty billion dollars, exceeds the entire European budget, the essential cost lies in the numerous, technologically complex, redundant military programs designed to withstand any type of attack. The U.S. approach deliberately widens the technological gap with its adversaries. Representing less than half of the space budget until 1981, the military share is today closer to two-thirds. With an amount nearing 50 billion, it corresponds to the combined civilian and military budgets of China, Europe, Russia, India, and Japan.

The comparison of budgets is always a delicate exercise, as the expression of national currencies in dollars represents a risk of under- or overvaluation. Furthermore, it is difficult to accurately assess the cost of labor and industrial activity. The Organ-

58. With the collapse of the Soviet Union, the historic Baikonur Cosmodrome ended up in Kazakhstan but was leased by Astana to Moscow, which provided the necessary investments and maintained most of the control.

59. And probably before, but it is very difficult to have an assessment of Soviet spending comparable to U.S. spending.

isation for Economic Co-operation and Development (OECD) has thus proposed a purchasing power parity model, recognizing that the largest share of space costs does not correspond to production itself but rather to facilities, R&D, and the use of complex technologies and materials, whose costs are always high.

In the case of China, this difficulty is increased by the fact that no official declaration of space expenditure exists.⁶⁰ Estimates, based on export prices and comparisons with other technological sectors, vary between 18 and 25 billion dollars depending on the estimated share of military expenditure.

In order to limit these various adverse effects, one solution is to relate known budgets to the Gross National Product of each state, which is also influenced by exchange rate fluctuations and internal cost factors. The result demonstrates the priority level accorded to space expenditure relative to national wealth. In this manner, the United States remains in the top tier, with Russia coming second, followed by North Korea, while Europe, China, India, and Japan are in the same category.

III.2 Continuity and Changes of National Ambitions: The Case of the Moon

The initial framework of early space exploration has left a lasting mark on the collective imagination. The role of the nuclear factor and concerns of national interest, the quest for prestige, and the duopolistic structure remain factors in current space policies, despite the profound changes the world has undergone. However, these enduring elements must not mask the factors of change that are now shaping the international space landscape.

In 2025, space remains a crucial element of the United States' national interest. It contributes significantly to their military superiority and participates in their economic, political, and cultural influence. When President Trump declared during his inauguration speech in January 2025 that he intended to plant the Star-Spangled Banner on Mars, he appropriated this exceptional moment of U.S. grandeur. The Artemis program, planning a return to the Moon, is indeed part of the "Make America Great Again" (MAGA) slogan. However, the ambiguity of Donald Trump's support for the program, as revealed during NASA's latest budgetary decisions, clearly demonstrates the latent contradiction between the desire to achieve a new conquest and the repetition of a glorious act – the only one within the reach of current technology and available funding.

In this framework, the position of China is clearly defined. It takes the place of the Soviet Union as a competitor in the new race to the Moon, with the hope – conscious or unconscious on the part of the United States – that their victory will once again signal the beginning of the adversary's decline. This reframing, however, poses a certain number of difficulties. The competition on Earth between the United States and China is veritably real, but the context is different from that of the Cold War.

⁶⁰. Given that China is announcing a military budget, it is difficult to consider that the logic of secrecy is the only explanation.

Whereas the Soviet Union linked space to its ideal of *homo sovieticus* by denouncing the decadent U.S. consumerist model, China does not pretend to establish itself as a model, nor does its desire for regional influence highlight the notion of leadership. Rather, its space diplomacy practices reflect multilateralism and South-South cooperation, with, for example, the installation of satellite manufacturing lines in Egypt, the sale of satellites to Nicaragua and Venezuela, or the provision of its Beidou navigation constellation as an information corridor for the “Belt and Road Initiative.” Finally, although China integrates space into the “Chinese Dream”⁶¹ – a slogan carried by President Xi Jinping since he came to power in 2012 – it is only one component of the Chinese nation’s rejuvenation ambitions.

The current telescoping of lunar ambitions between China and the United States is also the result of a combination of circumstances linked to the fact that the Moon is the only natural satellite of the Earth and the most accessible destination of any exploration program. Yet the ambitions of each are also different. China is still in its phase of catching up and seeking recognition. Unlike the U.S. discourse of 1969, China cannot present a Chinese man or woman walking on the Moon as humanity’s first step. Therefore, the emphasis is placed on scientific objectives and the principle of broad cooperation open to all. China thus distinguishes itself clearly from the U.S. model, which requires its partners to sign a non-negotiable bilateral agreement, the Artemis Accords, establishing the rules of the game. Furthermore, the insistence on the joint Sino-Russian character of the International Lunar Research Station program is also a sign China’s desire to avoid accusations of national ambitions, even if the *Chang’e* missions – landing and returning samples from the Moon’s near and far sides (a world’s first) – certainly contribute to a great sense of national pride.

Thus, if two models are to confront each other on the Moon, it is not certain that the U.S. approach of commercial resource exploitation will be endorsed at the international level. By highlighting their technological superiority in carrying out a highly complex project and their support for a model of national private enrichment, the United States runs the risk of offending an international public opinion more concerned with meeting the challenges of a sustainable management of the Earth.

The exploration projects also allow for an illustration of the diversity of objectives based on specific characteristics. Europe and Japan thus find themselves confronted with their own perceptions and the particular role of cooperation in their approach.

For Japan, the privileged relationship remains with NASA, to the extent that a Japanese astronaut – the first non-U.S. national – was expected to walk on the Moon in 2024 as part of an agreement.⁶² In addition to cooperation with Europe on the

61. I. Sourbès-Verger, “[La Chine dans l’espace et le rêve chinois](#),” *Monde chinois*, no. 64(4), 2020, pp. 16-35.

62. The Lunar Surface Exploration Implementing Arrangement of April 9, 2024, provides for the delivery of a pressurized lunar rover by Japan and two opportunities for Japanese astronauts to land on the Moon.

I-Hab habitation module of the Gateway (the circumlunar space station) and with Canada on robotics, Japan also diversifies its partnerships with India in a joint mission towards the South Pole, and with the United Arab Emirates following the launch of the Hope Martian probe in 2020 from the Tanegashima Space Center. As for Europe, the contribution to Artemis represented a less attractive objective than Martian missions and sample returns, although it nevertheless attempts to define an original contribution.

Conclusion

The acquisition of space capabilities responds to the desire to demonstrate scientific, technological, and industrial prowess. It therefore serves national pride as much as international image. Even in 2025, the success of exploration programs testifies to the modernity of a state and its recognition within a restricted club. This dimension, which initially concerned the space powers, now extends to a second circle, as shown by the Emirati programs presented as the symbol of the return of Arabic science. This foundational element of the beginnings of the space era remains very much present.

The methods of occupying space also correspond to the installation in space of an infrastructure intended for terrestrial activities. Mastery of all orbits and the systems utilized multiplies the power of direct and indirect intervention – both civilian and military – on Earth. From this perspective, the United States has secured for itself, at the cost of a constant effort, a unique position; this corresponds as much to the expression of a national identity – that of “Manifest Destiny”⁶³ – as to military superiority and a desire to lead. Conversely, Russia finds itself trapped by its Soviet heritage, the disappearance of its ideals, and its incapacity to reform a sector condemned, in a certain sense, to fulfil only a strategic mission.

For Europe, the path is relatively narrow between the achievement of the objectives of an economic and cultural power and the absence of a common national identity. While the existence of major joint programs testifies to a real scientific and industrial capacity, it struggles to carry a genuine political project – a dimension that remains confined to the national spheres of the member states. This weakness also exists in the case of Japan, which is dominated by its political dependence on the United States and is isolated on the Asian stage. The priority given to technological excellence and investments in innovation result in genuine successes, but these cannot serve as a foundation for dynamics other than a diversification of its cooperations.

63. “Manifest Destiny” is rooted in the foundational vision of John Winthrop (1630), citing the City upon a Hill (Matthew 5:14) regarding the exceptional mission of the Puritan community that set out to found the Massachusetts colony under God’s guidance. It was taken up again in 1845 by the journalist John O’Sullivan to justify territorial expansion westward and is found, in its religious and colonial dimensions, in the speeches of numerous American presidents.

The case of China stems from another logic. The needs of its domestic market and the independent development of its competencies constitute the basis of its programs. It now undertakes to enhance its achievements through partnerships, principally with countries of the Global South and Russia. The logic of its development and its technological successes make it the second space power and the only natural competitor to the United States. However, space is only one of its priorities, and its future projects will remain subject to political and economic considerations.

India, finally, remains an original case. In contrast to China, its space competencies are the result of diversified cooperations in direct symmetry with its political posture of non-alignment. Following the priority given to space applications, it is setting itself new objectives in exploration, science, and human spaceflight. It must, however, move beyond its historical model of a hegemonic agency – the Indian Space Research Organisation (ISRO) – to develop an industrial fabric while maintaining cost control.

Israel, Iran, and the two Koreas represent the latest newcomers to a club that has not expanded for more than two decades. In various capacities, they illustrate the long-standing link between space and nuclear capabilities (Iran, North Korea), the desire for even limited autonomy (Israel), and the demonstration of technological maturity (South Korea).

This state-led component of space activities is certainly no longer the only one. At the initiative of the United States, autonomous private actors are now part of the landscape. While remaining closely linked to national policies, they nonetheless testify to their own ambitions, with significant effects on the ways in which Space is used and, perhaps, on the achievement of new ambitions. However, regardless of the nature and nationality of the actors, their cooperative efforts, and the phenomena of competition, all these actors must consider their inevitable interdependence.⁶⁴ Growing concerns regarding risks (debris, traffic problems) and threats (attempts to control Space and the conduct of offensive operations) illustrate the challenges of current and future uses of activities in Space.⁶⁵

64. F. Gaillard-Sborowsky, *Géopolitique de l'espace : à la recherche d'une sécurité spatiale*, Le Cavalier Bleu, 2023.

65. I. Sourbès-Verger, *L'Espace*, Documentation Photographique, dossier 8168, CNRS Éditions, 2025.

HISTORY

The Air Force, the Aeronautical Industry, and the Birth of French Space Activities

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General de Gaulle's return to power in 1958 generated new momentum in many areas, including space exploration, which was not a priority at the time. The situation evolved and became clearer during 1961. The authorities were challenged and pushed by the achievements of the scientists and engineers who had together accomplished France's first space feat in March 1959.² In December 1961, De Gaulle and his government entrusted the former with space policy by creating the National Center for Space Studies (Centre national d'études spatiales, or CNES) and assigned the latter with the development of the first national launch device (*Diamant*). This launch vehicle was to be designed by the Society for the Study and Production of Ballistic Missiles (Société d'études et de réalisation d'engins balistiques, or SEREB), which was already responsible for the construction of ballistic missiles under the authority of the Ministerial Delegation for Armament (Délégation ministérielle pour l'Armement, or DMA). The DMA was set up in April 1961 to coordinate and rationalize military studies, which until then had been in the hands of each of the armed forces' technical departments.³

1. The author would like to thank Jean-Jacques Serra, Doctor of Science and former head of department at the Directorate General of Armament (Direction générale de l'armement, or DGA), for proofreading this article.

2. On 10 and 12 March 1959, two *Véronique* sounding rockets, constructed by the Ballistic and Aerodynamic Research Laboratory (Laboratoire de recherches balistiques et aérodynamiques, or LRBA) of Vernon within the DEFA (see footnote 3), studied the atmospheric layer of the turbopause from Hammaguir (see footnote 19). This was achieved through artificial clouds designed by Jacques Blamont of the Aeronomy Department (Service d'Aéronomie) of the National Center for Scientific Research (Centre national de la recherche scientifique, or CNRS).

3. To conduct their studies, each branch of the armed forces had its own technical department: the Directorate of Armament Studies and Manufacturing (Direction des études et fabrications d'armement, or DEFA) for the Army, the Technical and Industrial Directorate of Aeronautics (Direction technique et industrielle de l'Aéronautique, or DTIA/DTI) for the Air Force, the Central Directorate of Naval Construction and Armaments (Direction centrale des constructions et armes navales, or DCCAN) for the Navy, plus the Powder Service (Service des poudres).

To achieve the first satellite launch in 1965, SEREB engineers could rely on a significant industrial base that had flourished following the Second World War with missile studies. A large number of these missile programs had been developed by the Air Force through various programs. Without this initial phase, the SEREB would have struggled to achieve such rapid success. Within this context, this article aims to highlight the contribution of the aeronautical industry and the Air Force to France's rise to autonomous space access, particularly through missile research.

1. From the German Heritage to the First Air Force Missile Studies

1.1. *The Emergence of Missiles in the Aftermath of the Second World War*

During the Second World War, Germany demonstrated the operational value of self-propelled weapons, whether with the unmanned V1 aircraft or the V2 ballistic missile, employed from June and September 1944 respectively. As the Allies advanced into Germany, they seized German weapons, technologies, and specialists in operations that closely resembled plunder.⁴ The French armed forces were not to be left behind. The Army, Air Force, and Navy established “scientific missions” to repatriate German equipment and specialists.⁵ Military archives now reveal the importance of these actions for the French forces in general and for aviators in particular. For instance, in a confidential memo dated 29 September 1945, the Ministry of Air acknowledged the “extraordinary modernization effort [that must] be undertaken urgently” and mentioned the importance of “mastering German technology in preparation for the cosmic wars of the future.”⁶ There was great lucidity at the time regarding the role that self-propelled weapons – rocket-type devices then designated as “special devices”⁷ – would inevitably play.

1.2. *Effective Official Departments*

While the Air Force, under the impetus of its Technical and Industrial Directorate of Aeronautics (Direction technique et industrielle de l'Aéronautique, or DTIA) and with the approval of its Ministry, gave priority to rebuilding the civil and military aircraft

4. This plundering was organized through, in particular, the American Paperclip and Soviet Osoaviakhim operations. See L. Hunt, *The Paperclip Affair: The Recovery of Nazi Scientists by the Americans*, Paris, Stock, 1995; N. Naimark, *The Russians in Germany: A History of the Soviet Zone of Occupation*, Harvard, Harvard University Press, 1995.

5. R. Hautefeuille, M. Jarry, *Les armes V1 & V2 et les Français*, Rennes, Marines éditions, 2010. See also the documentary “[Main basse sur les savants d'Hitler, le plan secret français](#),” directed by D. Delfaut, produced by Mischia Productions and broadcast on La Chaîne Parlementaire (LCP) in November 2023.

6. SHAA (Air Force Historical Service), series E, box 4398, memo classified “Top Secret,” 29 September 1945.

7. This lucidity is also evident in the specialized press. See, for example, P. Belleruche, “Les bombes à réaction V1 et V2,” *Science et Vie*, No. 332, May 1945; C. Rougeron, “Armes nouvelles et bombardement intercontinental,” *Science et Vie*, No. 339, December 1945, É. Romat, “La super V2. Fusée atomique de bombardement intercontinental,” *Science pour tous*, No. 1, February 1947. Several books also address the issue, notably those by A. Ananoff, *Des premières fusées au V2* (Paris, Elzévir, 1947) and *Les armes de demain* (Paris, Berger-Levrault, 1948) by Albert Ducrocq.

fleet – notably by creating the National Office for Aeronautical Studies and Research (Office national d'études et de recherches aéronautiques, or ONERA)⁸ – it also undertook missile studies. Expectations were significant, as attested by a classified memo from the Chief of the General Staff of the Air Force, General Martial Valin, issued as early as October 1945. According to this memo, future wars could be fought using missiles. The text asserts that, “it is therefore not impossible that tomorrow, air power will be dethroned in favor of special devices such as the V2 war engines.”⁹

The DTIA therefore had an essential role to play. It was responsible for ground-to-air systems as well as the Air Force and Naval Aviation airborne missile programs. Furthermore, its prerogatives also led it to exercise oversight over the aeronautical industry. It thus coordinated a large number of missile programs, ranging from aerial targets to anti-tank missiles for the Army, through to ground-to-ground missiles. It was the Technical Service of Aeronautics (Service technique de l'aéronautique, or STAé)¹⁰ within the DTIA, headed by General Engineer du Merle,¹¹ that played the most important role in the development of missile research after the end of the war.

1.3. The Role of Military Engineer Decker and the STAé/ES

In the summer of 1945, in order to consolidate the spoils recovered in Germany and facilitate the start of studies, with the agreement and support of the DTIA, the STAé created the Special Devices Section (Engins Spéciaux, or STAé/ES), in which military engineer Michel Decker¹² held a leading position. He took part in the famous scientific missions to Germany and was interested in both V1 and V2 technologies, as well as in flying bombs such as the Henschel Hs-293. In October 1944, for instance, he drafted the first “Summary Report on the So-Called V2 Device” for the DTIA authorities.¹³

8. The ONERA, established on 3 May 1946, is a public establishment placed under the authority of the Ministry of Armaments. While not strictly an inter-service center, the Office did not confine itself solely to the aeronautical domain. It also addressed problems related to aerodynamics, propulsion, material resistance, and other fields. It was authorized to call upon private or state-owned industrial firms, institutes, or laboratories. Due to its commitment to space activities, it became the National Office for Aerospace Studies and Research (Office national d'études et de recherches aérospatiales) in 1963.

9. SHAA, E 4298, memo dated 8 October 1945.

10. The origins of the STAé date back to 21 February 1916, when the Technical Aeronautics Section (Direction générale de l'aéronautique) was set up within the Directorate General for Aeronautics (Direction générale de l'aéronautique) to coordinate aeronautical studies. In 1934, the Directorate General of Aeronautics was replaced by the Directorate of Aeronautical Construction (Direction des constructions aériennes), within which the Technical Aeronautics Service (Service technique de l'aéronautique, or STAé) and the Aeronautical Production Service (Service de la production aéronautique, or SPAé) were established. The STAé continued until 1980, when the services were reorganized.

11. Guy du Merle (1908-1993), military air engineer, test pilot, director of the STAé from 1945 to 1948, founder and first director of the National Civil Aviation School (École nationale de l'aviation civile) from 1948 to 1951.

12. Michel Decker (1913-2003), an Air Force officer and military engineer, became head of the Special Devices Section (Engins Spéciaux) of the STAé (STAé/ES) from 1947 to 1954, then chief engineer (1954), technical deputy director (1959) and deputy director at Nord-Aviation, then at the Tactical Devices division of Aérospatiale.

13. Report dated 13 October 1944; in SHAA, 4D 52.

Simultaneously, he considered that simply reproducing German materiel was insufficient. While the German experience certainly needed to be taken into account, Decker believed that innovative studies had to be launched as quickly as possible to develop high-performance weapon systems. At the end of 1945, he drafted a short five-page report. In this report, he advocated for the development of self-propelled devices in close collaboration with the industrial sector. This was intended to accelerate innovation, both in the devices themselves and in their equipment. Furthermore, in his report, Decker established a classification system that continues to be used to designate missile types: AA for “air-to-air,” AS for “air-to-ground,” SA for “ground-to-air,” SS for “ground-to-ground” (with the maritime variant “surface-to-surface”), and CT for “remotely controlled targets.” A preliminary program was conceived on 1 July 1946, having been approved by the Air Force Staff and the office of the Air Ministry. The objective was to swiftly overcome the national delay and to develop innovative techniques. To this end, the DTIA took the initiative to reorganize and support industrial groups capable of investing in rocket research.

2. The Aeronautical Industry as the Foundation of the Space Industry

2.1. The Reorganization of the Aeronautical Industrial Base

In the aftermath of the war, and for several years thereafter, a balance was established between private entities (ECA, Matra),¹⁴ state-owned companies (Arsenal de l’Aéronautique),¹⁵ and mixed-economy nationalized companies (SNCA).¹⁶ Of the latter, only SNCAC, SNCASO, SNCASE, and SNCAN remained in 1945.¹⁷ In 1947, on Decker’s initiative, the “special devices” groups of the SNCA were consolidated in Cannes to form the Cannes Technical Group (Groupe Technique de Cannes, or GTC). This group was placed under the authority of SNCASE, which specialized in special devices thanks to the transfer of qualified employees and engineers. During the 1950s, the GTC became the largest research and experimentation center for rocket-propelled devices in Europe, outside of the Soviet Union.

At the end of the 1950s, new entities were formed. SNCASE merged with SNCASO on 28 February 1957 to form the powerful industrial company Sud-Aviation. As for SNCAN, after absorbing SNCAC in June 1949 and SFECMAS in December 1954, it became Nord-Aviation in January 1958.

14. ECA (Société d’études et de constructions aéronautiques), established in 1936, developed target devices, flight control systems, and other equipment. CAPRA (Compagnie anonyme de production et réalisation aéronautique), founded in 1937, became Matra (Mécanique-Aviation-Traction) in 1941. A new actor in the missile sector appeared in 1957 with Dassault, which established an Engins (Devices) department focused on air-to-ground and ground-to-ground systems.

15. Created in 1934, the Arsenal de l’aéronautique became the Société française d’étude et de construction de matériels aéronautiques spéciaux (SFECMAS) on 31 December 1952.

16. In 1936-1937, in response to German rearmament, six national aeronautical construction companies were set up: North (SNCAN), Centre (SNCAC), West (SNCAN), Southwest (SNCASO), Southeast (SNCASE) and Midi (SNCAM).

17. In 1940-1941, SNCAN was absorbed by SNCASO and SNCAM by SNCASE.

When General de Gaulle returned to power on 1 June 1958 and decided to equip France with ballistic missiles, he could thus rely on significant industrial groups that possessed experience gained from designing a large number of missiles. Numerous equipment manufacturers had also emerged, such as the Société anonyme de télécommunications (SAT, founded in 1932), the Société d'études et de constructions aéronautiques (ECA, 1936), the Société nationale d'étude et de construction de moteurs d'avion (SNECMA, 1945), the Société technique de recherches en industries mécaniques (STRIM, 1946), the Établissement Turck (1946),¹⁸ the Société de fabrication d'instruments de mesure (SFIM, 1947), the Société française d'équipements pour la navigation aérienne (SFENA, 1947), and Hotchkiss-Brandt (1956), among others.

2.2. Experimentations

Of the three branches of the armed forces involved in missile research during the 1950s, the Air Force was undoubtedly the most active in terms of development and testing. However, as it is not possible to cover all programs in this article, the focus will only be on the most important ones in the field of ground-to-air missiles. These missiles were of interest to all branches of the armed forces, which needed to protect themselves against the threat of Soviet bombers. This research would eventually yield the expertise necessary to contribute to the development of powerful missiles and even a satellite launcher.

Among the companies involved, the Arsenal de l'Aéronautique and SNCASE were among the first to respond to ministerial requests. The Arsenal de l'Aéronautique, which became SFECMAS in 1953, initially focused on recovering German materiel (such as the X4 air-to-air missile and the Enzian ground-to-air missile) before embarking on several programs. As early as 1946, the Ars 5101 (Program AA 10) – a reproduction of the German subsonic X4 air-to-air missile – was developed. However, the project was abandoned in 1950 following difficulties with guidance.

As part of the CT 10 program, Arsenal also developed the Ars 5501, a type of aerial target drone remotely controlled by radio and recoverable by parachute, derived from V1 technology. This type of device proved highly useful for anti-aircraft gunnery training and for developing the first ground-to-air missiles. The CT 10 performed its inaugural flight in December 1949 and entered service in May 1952. Capitalizing on this experience, SFECMAS began studying the CT 20 (formerly Ars 5510) in early 1954 to better simulate the flights of subsonic jet fighter aircraft. This device became operational in 1958. In October 1957, the teams at SFECMAS (and later Nord-Aviation) designed the CT 41 Narval, a powerful remotely controlled and recoverable device. Its first tests took place in January 1959. However, since the CT 41 flew at a speed of Mach 2.5, neither the fighter aircraft nor the existing missiles

18. Jean Turck (1911-2016), a radio specialist, founded his eponymous company to manufacture electronic equipment for the armed forces. He was a pioneer in the field of infrared homing devices for the guidance of Matra's air-to-air missiles. When his company joined the SAT in 1957, he became the director of its defense activities.

were able to intercept it. It should be noted that most of the devices belonging to the Air Force (and the Army) were tested at the CIEES in Colomb-Béchar.¹⁹

As for SNCASE, leveraging its extensive aeronautical experience and under the guidance of Louis Marnay,²⁰ it committed to developing the SE 1500 multi-mission droppable device. With an inaugural flight conducted on 7 November 1946, dropped from a *LeO 451*, it became the first French special device to set numerous records. It was the first to be mass-produced, the first to be recoverable by parachute, the first to serve as a target for both Air Force and Navy missiles, and the first to use an anti-jamming optical system in the infrared domain. Finally, it served as a test bed for the SEPR's first rocket engine, the SEPR 2/4.²¹

When SNCAC was integrated into SNCAN (1949), SNCASE acquired the main members of Louis Besson's design office.²² This allowed it to quickly undertake the development of a major long-range ground-to-air missile program for the Air Ministry. This included the two experimental devices SE 4100 (Program SA 10) and SE 4300 (Program SA 11), the ramjet missile SE 4400, and also two ground-to-ground missiles intended for the Army (SE 4200 and SE 4500).²³ The SE 4100 and SE 4300 used liquid propulsion and their development was intended to result in a subsonic interception device with a range of 35 km, comparable to the American Nike Ajax missile. The SE 4100 constituted the first modern French rocket, which served as a test bench for all fundamental technologies, with the exception of inertial guidance. With 78 units launched in 16 different versions, it paved the way for the future *Diamant* satellite launcher. Philippe Jung, an engineer and specialist, would even go so far as to consider the SE 4100 as being "at the origin of the creation of

19. Between 1947 and 1967, the Air Force and Army tested their missiles mainly at the Joint Special Weapons Testing Center (Centre interarmées d'essais d'engins spéciaux, or CIEES) in Colomb-Béchar, in the Algerian Sahara. The CIEES had several firing ranges, including Hammaguir, located 110 km further southwest. It was from this latter site that the first *Véronique* sounding rockets took off in 1950, later followed by the first SEREB ballistic missiles and the first *Diamant* launcher. The navy used its center on the Île du Levant. See P. Varnoteaux, M. Le Fèvre, *Hammaguir. Première base spatiale française*, Paris, Ginkgo, 2024.

20. Louis Marnay (1911-1985) was an engineer at Lioré et Olivier in 1935, then at the design and flight test office in Marignane. Director of the GTC in 1950, he became director of the Missiles and Electronic Space division when Sud-Aviation was created (1957), then deputy director of the Ballistic and Space Systems division when Aérospatiale was created in January 1970. The latter was created through the merger of Nord-Aviation and Sud-Aviation (which had just absorbed the SEREB).

21. The Société d'études de la propulsion par réaction (SEPR) was created at the end of May 1944 and became the first French company to specialize in rocket engine propulsion. In 1969, it merged with SNECMA's Engins Espace division to form the Société européenne de propulsion (SEP), which was joined in 1971 by the industrial activities of LRBA in Vernon.

22. Louis Besson (1914-1996) was an engineer at SNCAC, where he became head of special devices in 1946. He is considered the father of the NC 3500 and SE 4100 ground-to-air missiles and the SE 4200, SE 4300 and SE 4400 ground-to-ground missiles. He then became head of the design office at Sud-Aviation, in the Technical Group in Cannes.

23. The SE 4200 is a tactical missile with a maximum range of 127 km. As for the SE 4500, it was supposed to be capable of carrying a 700 kg nuclear payload with a range of 138 km. However, it was abandoned in October 1956 due to the choice of the *Mirage IV* bomber, which had a greater range.

the essential French space industrial fabric.”²⁴ As for the SE 4300, it became the first ground-to-air missile employed by the Air Force for training purposes.

From 1948 onward, Matra also began missile studies on behalf of the STAé. The objective was to produce an anti-aircraft device available in two versions: the air-to-air R 511 (Program AA 20) and the medium-range ground-to-air R422 and R431 (SA 20). This company was tasked with developing the guidance for a supersonic device using auto-guidance techniques. This constituted an immense challenge for the era since reliable electronic technology did not yet exist. Although Matra did not entirely overcome this challenge, it nonetheless achieved promising results. It developed the first guided supersonic device in Europe with the experimental device M 04. A first generation of auto-guided air-to-air devices was also produced with the R 511. Similarly, on the eve of General de Gaulle’s return to power, Matra’s ground-to-air missiles were among the most advanced programs. The initial successes were achieved thanks to young teams that notably included Roger Pacault,²⁵ who would continue his career at the European Space Research Organisation, Yves Hébel, whom some consider the “father” of Matra’s auto-guided missiles, and Pierre Quétard, a specialist in guidance systems. The latter would assume the directorship of Matra’s Space division from 1962 to 1972 and work on the development of the first satellite, *A1 / Astérix*.

3. Convergence of Political, Scientific, Military, and Industrial Interests

3.1 The Return of Grand Ambitions

General de Gaulle’s arrival in office marked the return of major political ambitions. These ambitions were deemed necessary by him for France to regain the position it deserved in world affairs. Technology and the sciences were among the key elements that contributed to a state’s power. De Gaulle progressively developed a keen interest in supersonic aviation (such as the *Mirage*), nuclear technology, computing, missiles, and telecommunications, among other fields. Consequently, immediately upon his return, the government actively supported scientific and technical programs, in parallel with the institutional and monetary reforms then underway. Funding increased and new structures emerged, such as the Consultative Committee for Scientific and Technical Research (Comité consultatif de la recherche scientifique et technique, or CCRST) and the General Delegation for Scientific and Technical Research (Délégation générale à la recherche scientifique et technique, or DGRST).²⁶

24. P. Varnoteaux, M. Le Fèvre, *Hammaquir. France’s first space base*, op. cit., p. 152.

25. He was promoted to technical director of the Missile Division in 1963.

26. Established on 28 November 1958, the CCRST was a body composed of twelve scientists that federated and consulted numerous research groups before offering its opinion to the government. The CCRST thus emerged as a kind of ‘scientific government’ intended to preside over national scientific policy. The CCRST was responsible for preparing the decisions taken within the Interministerial Council for Scientific Research (Conseil interministériel de la recherche scientifique, or CIRST), a structure placed under the responsibility of the Prime Minister. A General Delegate for Scientific and Technical Research (Délégué général à la recherche scientifique et technique, or DGRST) was also established. The role of this General Delegate was to ensure liaison between the CCRST and the CIRST. Through

Through these structures, the scientists working on space-related issues understood that they now had the attention of the State. Led by the physicists Pierre Auger (Professor of Quantum and Relativistic Physics at the Faculty of Sciences of the University of Paris) and Jean Coulomb (Director General of the National Center for Scientific Research [Centre national de la recherche scientifique] from 1957 to 1962), they convinced the government to establish the Space Research Committee (Comité des recherches spatiales, or CRS) on 7 January 1959. The financial operations of this Committee fell under the purview of the CCRST and the Interministerial Council for Scientific Research (Conseil interministériel de la recherche scientifique, or CIRS). Presided over by Pierre Auger, the Committee was tasked with initiating the deliberations that would ultimately define the national space policy.

At the same time, the CRS coordinated the various activities between scientists and the military through four subcommittees. While scientists were responsible for the “Scientific” subcommittee (chaired by astronomer André Danjon, to oversee programs carried out by sounding rockets) and the “Observation/Guidance” subcommittee (Pierre Marzin, director of the National Telecommunications Research Center [Centre national d’études des télécommunications], for issues relating to space object detection, warhead re-entry, and trajectories), the military controlled the “Devices” subcommittee (General de Pins)²⁷ and the “Firing Program” subcommittee (General Guérin,²⁸ president of the National Defense Scientific Action Committee [Comité d’action scientifique de la Défense nationale, or CASDN]).²⁹

the freedom of action afforded to the General Delegate, they were able to target the most interesting projects and establish priorities. For further information, see G. Ramunni, “La mise en place d’une politique scientifique,” pp. 654-713; in *De Gaulle en son siècle, Tome 3 : Moderniser la France*, Paris, Plon, 1992.

27. Gérard de Pins (1915-1999), Air Force Brigadier General, led missions notably at the Reggane center and then commanded the Mont-de-Marsan base from 1958 to 1960, when he was appointed to the Space Research Committee.

28. Jean-Maurice Guérin (1900-1978) was a student at the École supérieure d’électricité. He first served in the Engineering Corps and then in the signals corps. In 1942-1943, he took part in the Tunisia campaign and the liberation of Corsica. In 1945, he became the Director of Signals at the Central Administration and subsequently commanded signals for the French Occupation Corps in Germany (1948-1950). He served as the chairman of the European Committee of Military Telecommunications at the Atlantic Organization in 1952. He was appointed head of the National Defense Scientific Action Committee (Comité d’action scientifique de la Défense nationale, or CASDN) from 1955 to 1965. Furthermore, he was a member of the Scientific Council of the Atomic Energy Commission (1955-1957), of the Bureau des longitudes (1959-1965), and served as chairman (1955) and then vice-chairman (1963-1965) of the Board of Directors of ONERA.

29. A decree dated 24 May 1948 established the National Defense Scientific Action Committee (Comité d’action scientifique de la Défense nationale, or CASDN), which was common to all three armed forces. This body was tasked with “coordinating, directing, and, where appropriate, initiating scientific research relevant to national defense.” Placed directly under the authority of the President of the Council, it served as “the President of the Council’s permanent information body.” At the national level, it was responsible for centralizing information concerning the activities of all research organizations, both civilian and military. It possessed two key assets: an operational budget and the ability to engage civilian actors.

Upon its creation, the CRS promoted French proposals in international³⁰ and European space research projects.³¹ At the national level, it supported efforts led by scientists and the military concerning the exploration of the upper atmosphere using sounding rockets.³² This exploration covered air currents, turbulence, and ionization, whose characteristics would be important for communications, but also for the structure and dynamics of future launchers, including propulsion, guidance and tracking.³³ At the time the CRS was established, only one experiment had been carried out using the *Véronique* sounding rocket³⁴ in 1954. That experiment achieved mixed success, provoking considerable criticism and leading to the suspension of credits intended to finance the construction of a new rocket (*Véronique AGI*).³⁵ The CASDN, which was responsible for the program,³⁶ intervened and succeeded in restoring funding, thereby authorizing the scientific campaign of March 1959. This campaign, in contrast, yielded spectacular results,³⁷ which allowed France to become a recognized player in the space endeavor. Although politicians were receptive to this success, the major concern of the moment was, nonetheless, the ballistic missile.

3.2 The Issue of the Strategic Ballistic Missile

At the end of the 1950s, missile development was in full swing, even though the government made two major decisions that were unfavorable, primarily for budgetary reasons. The ground-to-air programs were abandoned in August 1958, as the

30. For example, within the framework of the Committee on Space Research (COSPAR), an international scientific group whose objective is to organize scientific work related to space exploration. It was created in October 1958 by the International Council for Science during the International Geophysical Year (AGI). The competition to develop space technology intensified when the United States created NASA at the same time.

31. At the European level, discussions were initiated and culminated on 14 June 1962 in the formation of the European Space Research Organisation (ESRO), with Pierre Auger as its Director General.

32. The exploration of the upper atmosphere accelerated thanks to the AGI. Initiated in the early 1950s by physicists from different countries, it aimed to study the Earth as a whole from 1957-1958, a period during which high solar activity would have a major impact on the Earth's atmosphere. On this occasion, the Americans and Soviets announced in 1955 the launch of the first artificial satellites.

33. L. Sebesta, "Technical choices, political choices: the origins of strategic ground-to-ground ballistic missiles (SSBS) in the international context," pp. 176-196; in D. Pestre (ed.), *Deux siècles d'histoire de l'armement en France*, Paris, CNRS Éditions, 2005.

34. Originally, in 1947-1948, *Véronique* was a research rocket for liquid propulsion, built by the LRBA in Vernon, part of the DEFA of the French Army. Under the impetus and responsibility of the CASDN, it was decided in 1949 to use it as a sounding rocket for exploring the upper atmosphere.

35. On 29 October 1954, a *Véronique* (NA model) carried a radioelectric experiment, designed by the French physicist Étienne Vassy and the German physicist Karl Rawer, to an altitude of 104 km. Nevertheless, it took nearly six months to recover the rocket's nose cone from the Algerian sands; it did, however, yield scientific results. This episode led to the suspension of credits intended to develop the more powerful *Véronique AGI* model, which was designed to exceed an altitude of 200 km. For further information, see P. Varnoteaux, *L'aventure spatiale française. De 1945 à la naissance d'Ariane*, Paris, Nouveau Monde, 2015, pp. 95-100.

36. In 1961, the CASDN military handed over responsibility for sounding rocket launch campaigns to scientists from the Space Research Committee (then to the CNES from 1962 onwards).

37. See footnote 1.

government preferred to purchase the U.S. Hawk ground-to-air missile under license instead. Then, in August 1959, it was then the turn of the tactical ground-to-ground ballistic missile (SSBT) program to be abruptly halted.³⁸ Efforts were now focused on the strategic ground-to-ground ballistic missile (SSBS) – the origin of which dated back to July 1955. The Minister of National Defense had at that time requested the Air Force to launch preliminary studies concerning ballistic, semi-ballistic, and cruise missiles.

Upon his accession to power, de Gaulle decided to design an SSBS with a 3,000 km range. The Société pour l'étude et la réalisation d'engins balistiques (SEREB) was created for this purpose on 17 September 1959. It brought together the era's foremost companies and organizations: Nord-Aviation, Sud-Aviation, SEPR, SNECMA, Dassault, Matra, the Atomic Energy Commission (Commissariat à l'énergie atomique), and ONERA, in addition to the armed forces' technical directorates. The SEREB was given three main objectives: to advance studies on liquid and solid propulsion, to master the atmospheric re-entry of a warhead, and to design experimental devices (test vehicles).

At the time of the SEREB's emergence, numerous difficulties remained to be overcome. These included issues related to propulsion,³⁹ flight control, guidance, warhead re-entry into the atmosphere, and stage separation, among others. The government then considered cooperating more closely with the United States. However, the U.S. State Department abruptly reversed its position and prohibited the transfer of ballistic technologies to France. Exasperated, the French government decided to proceed by relying solely on national expertise and know-how.

4. The Issues of the Launcher and the Space Agency

4.1 Proposals from the SEREB and the DTIA

In December 1959, only a few months after its establishment, the SEREB announced the possibility of orbiting a payload of a few kilograms by assembling several of its test devices then under development. The launcher project was presented in the autumn of 1960. The idea interested the CRS and was appealing to the Air Force. However, the DTIA and the other technical directorates lacked the resources necessary to build the launcher and manufacture satellites. A potential solution lay in

38. In 1958, Nord-Aviation and Sud-Aviation, at the request of the Chiefs of Staff Committee, launched a preliminary design for a tactical ground-to-ground ballistic weapon system (SSBT) capable of carrying a nuclear payload to a range of approximately 100 km.

39. For the strategic ballistic missile, the issue then had to be resolved between the use of liquid and solid propellants. The former offered the advantage of a lighter and more energetic device. Furthermore, liquid propellant engines had been specifically developed for missiles by SNCASE, Matra and *Véronique*. Concerning solid propellants, which were more practical to use, the Direction des poudres (Powder Service) had recently developed new molded propellants without diameter limitation. These included épictète, available from 1954, and especially plastolite and plastolane, which were very high-performance and became available in 1956.

the establishment of a space agency of sorts that would direct all stakeholders. This was the opinion of Air Brigadier General Robert Aubinière, who headed the DTIA at the time.⁴⁰

Aubinière was all the more convinced of the future of space activities because he had seen them begin while directing the firing ranges of the CIEES and had followed them closely. The success of *Véronique AGI* in March 1959 had, in his opinion, “paved the way.”⁴¹ However, upon taking charge of the DTIA in 1960, Aubinière was “astonished [...] to see that space issues were not being addressed at all.” He stated, “I had discussed it with the Air Force; I had even spoken about it with Guillaumat, who was the Minister for Research. I went to see him with Blancard⁴² and I said to him: ‘An official public establishment must be created to implement a space policy.’ [...] We were received horribly poorly by Guillaumat, who [retorted] to us: ‘But there is no need for one; I have created a committee [the Space Research Committee or Comité des Recherches spatiales] and that is sufficient, and furthermore, the aeronautical industry is sufficiently advanced to handle space matters’.”⁴³

Although there was not yet any question of a space agency, political authorities nonetheless sensed the need to better consolidate expertise and avoid rivalry among the technical directorates of the armed forces. Furthermore, the government’s desire to develop a nuclear strike force, dependent on political power rather than the military, no longer aligned with the vision of these same technical directorates, who wished to maintain their independence in tactical and strategic choices concerning their weaponry. Consequently, the DTIA and the Directorate of Armament Studies and Manufacturing (Direction des études et fabrications d’armement, or DEFA) did not welcome the arrival of the SEREB and feared having to abandon studies whose scopes overlapped. To put an end to tensions and rivalries, on 5 April 1961, the government established the Ministerial Delegation for Armament (Délégation ministérielle pour l’armement, or DMA).⁴⁴

40. Robert Aubinière (1912-2001), a graduate of the École polytechnique and Air Force general, was successively director of the Rochefort training base (1954-1956), the CIEES (1957-1959), the École militaire de l’air (1960), the DTIA (1960-1962), Director General of the CNES (1962-1972), then Director General of the ELDO (1972-1975).

41. R. Aubinière: “After the success of 1959, Blamont and I couldn’t stop talking about space; we dreamed of exploration! [...] The *Véronique* rocket undoubtedly helped pave the way;” interview between Robert Aubinière and Philippe Varnoteaux, Paris, 30 November 1996.

42. J. Blancard (1914-2008), a mining engineer, was head of the Ministerial Delegation to the Air Force from 1959 to 1961, which at the time oversaw the DTIA.

43. R. Aubinière, A. Lebeau, *Le général Robert Aubinière. Propos d’un des pères de la conquête spatiale française*, Paris, L’Harmattan, 2008, pp. 90-91.

44. Due to the Cold War, France’s role within the Atlantic Organization, and scientific and technical changes, the technical departments of the armed forces are now under the authority of the DMA, which is responsible for taking a holistic approach to weapons systems. See D. Pestre, “The creation of the DMA and the DRME in 1961: strategic political project or circumstantial construction?,” p. 170; in A. Chatriot, V. Duclert (eds.), *Le gouvernement de la recherche, Histoire d’un engagement politique de Pierre Mendès France au général de Gaulle (1953-1969)*, Paris, La Découverte, 2006. In 1977, the DMA became the Délégation générale pour l’armement (DGA, or General Delegation for Armament)..

4.2 The Turning Point of 1961

While the DMA was being established, the CRS scientists judged that their organization was no longer fit for purpose. If the SEREB were to build a launcher, satellites would be needed, and engineers would have to be trained in space techniques. It therefore became essential to rely on an entity with broader capabilities for action, including financial capacity. Moreover, the international environment was evolving very rapidly. On 12 April 1961, the Soviets sent Yuri Gagarin into space aboard the *Vostok 1* spacecraft. The following 25 May, the United States announced its intention to send personnel to the Moon “before the end of this decade.” It became urgent to take action to prevent France’s definitive decline in status.

Following the failure of General Aubinière’s approach, Pierre Auger of the CRS became involved in turn. He sought a meeting, along with representatives from the SEREB, with President de Gaulle and several of his ministers, notably those responsible for Finance, Posts and Telecommunications, Atomic Energy, Research, and the Civil Service. An interministerial council was organized on 22 July 1961. Auger presented the CNES project, which would require the SEREB’s *Diamant* to launch its first technological satellites. To convince his audience, he emphasized that this would “allow France to enter the international arena.”⁴⁵ Such a discourse naturally convinced General de Gaulle, who was all the more determined given that the SEREB representatives assured the audience of the controlled cost of the launcher, which was to be derived from the test devices. The deal was then sealed.

By Way of Introduction

After passing through Parliament, the law establishing the National Center for Space Studies (Centre national d’études spatiales, or CNES) was signed by de Gaulle on 19 December 1961. As for *Diamant*, its construction, managed by the SEREB under the responsibility of the DMA, was validated during the interministerial council held the day before. Four years later, on 26 November 1965, the SEREB successfully placed the small A1 capsule (named “Armées n°1” and later renamed “Astérix”), produced by Matra, into orbit. This made France the third nation to achieve space access by its own means, following the Soviet Union (1957) and the United States (1958).

A few months later, beginning in March 1966, the CNES initiated a managerial and industrial shift. Faced with the growth of space activities, it fundamentally revised its organizational structure, notably through the creation of the Programs and Planning Directorate and the Development Directorate, to which the Launchers Division was attached. The CNES determined that it needed to emancipate itself from the DMA by assuming responsibility for satellite launchers in order to pursue the national space policy in full independence.

45. For more information on this meeting of 22 July 1961, see P. Varnoteaux, *L’aventure spatiale française...*, op. cit., pp. 221-222.

The CNES also considered that it was now necessary to adopt a “get things done” approach, entrusting project management to industrial firms. Maintaining total control over a program while merely soliciting industries as simple executors, as had been the case with the SEREB, was no longer considered the most efficient solution. On 30 June 1967, Maurice Schumann, Minister of State responsible for Scientific Research and Atomic and Space Issues, entrusted the CNES with the development of the new civil launcher *Diamant B*, with the DMA retaining control only over military devices.

From Air to Space: A Continuum of Operational Capabilities

Bernard Molard

General Bernard Molard (Ret.) had a distinguished career as a fighter pilot in France and in the Royal Air Force (RAF) before joining the “Space” Office of the French Armed Forces Staff, where he was responsible for the first military space-based observation program, Helios. He was appointed Director of the European Satellite Centre in Torrejón (Spain), Executive Secretary to the French Air Force Chief of Staff, then Director of the Air Force Academy in Salon-de-Provence, before joining Alcatel Space and then Astrium¹ as advisor to the CEO on defense and security matters.

Space became the focus of scientific and strategic interest at the end of World War II. The Americans and Soviets became engaged in an all-out competition, starting with the development of increasingly reliable launch vehicles capable of placing active objects into orbit. The Soviets won the first round twice over: after successfully placing the first artificial satellite, *Sputnik 1*, into Earth orbit on October 4, 1957, they were the first to send a man into space a few years later.²

President Kennedy immediately responded by promising his fellow citizens that the first man to walk on the Moon would be an American.³ This was achieved on July 21, 1969, with the Apollo 11 mission. After a three-day journey aboard their spacecraft, the two astronauts, Neil Armstrong and Buzz Aldrin, set foot on the lunar surface and returned safely. This event marked a crucial milestone in the history of space exploration.

1. Alcatel Space and Astrium have now become Thales Alenia Space and Airbus Defence and Space, respectively.

2. On April 12, 1961, at the height of the Cold War, Yuri Gagarin gave the USSR a symbolic victory by becoming the first man to travel into space.

3. On May 25, 1961, in a speech before the U.S. Congress, President John F. Kennedy announced that men would be sent to the Moon before the end of the decade.

The Space Sector in France

Following the establishment of the Commissariat à l'énergie atomique (CEA, Atomic Energy Commission) in October 1945, with the aim of providing France with an autonomous nuclear deterrent and electricity production capacity, General de Gaulle created the Centre national d'études spatiales (CNES, National Center for Space Studies) in 1961.

Significant results were quickly achieved:

- The first component of the “strike force” was airborne. Consisting of a squadron of *Mirage IV* bombers armed with AN-11 atomic bombs⁴ and *Boeing C-135 F* in-flight refueling tankers, it became operational in 1964.
- After a few tests in the Hammaguir desert in Algeria, the first French *Véronique* rocket took off from Kourou, in French Guiana, in April 1968.⁵

The subsequent history of the space sector is a succession of major technological and political milestones. The growing strategic confrontation between the United States and the USSR culminated in 1983 with President Ronald Reagan's Strategic Defense Initiative (SDI), which, in what was the biggest bluff of the century,⁶ made it clear to the Soviets that the battle was lost. The emergence of China and India as space and nuclear powers, along with Japan's significant advances in the construction of launch vehicles and satellites, demonstrated to the whole world that space had become the key to strategic dominance for any major power.

Several European countries then sought to coordinate their efforts in space research in order to reduce their dependence on the United States and the USSR. After several attempted organizations, the European Space Agency (ESA) was founded in 1975, establishing Europe's place in the space sector.⁷

An Operational Vision of the Utility of Space

Although France was slower than others to grasp the importance of the third aerological dimension for military purposes,⁸ it has proved to be very visionary in

4. With a yield of 60 kilotons of TNT, it was five times more powerful than “Little Boy,” the bomb dropped by the United States on Hiroshima on August 6, 1945.

5. The French government's choice of Kourou proved to be particularly wise: over the years, the Guiana Space Center (CSG) has built a reputation for excellence in astronautical circles. It was the *Véronique* (short for “VERnon éleCTRONIQUE”) sounding rocket that inaugurated the launch pad built in Kourou on April 9, 1968.

6. Officially launched on March 23, 1983, by President Ronald Reagan, SDI, dubbed “Star Wars” by the media, aimed to establish a missile defense shield to protect the United States against a large-scale nuclear attack. This ambitious program called for the use of advanced technologies, deployed both from Earth and from space, to intercept and neutralize intercontinental ballistic missiles (ICBMs), such as those launched from submarines.

7. This creation followed the failures of the European Space Research Organisation (ESRO), dedicated to scientific missions, and the European Launcher Development Organisation (ELDO), dedicated to developing the first European launch vehicle. On May 30, 1975, eleven European states signed the European Space Agency Convention, establishing this new organization to replace the previous entities.

8. In 1910, General Foch declared: “Aviation is a sport; for the Army, it is worthless.”

its perception of the utility of the third spatial dimension for monitoring the health of the planet, understanding anomalies, and optimizing the use of its armed forces.

A pragmatic vision of the use of space has inspired the creativity of CNES engineers, who are very attentive to military users, in addition to their original research and development mission.

GROWTH IN TWO PHASES

Countries are divided between those that “know exactly” what is happening on our planet Earth because they control the source of information, and those that “are merely aware” thanks to defense and intelligence cooperation agreements with certain allies. However, these agreements are sometimes undermined depending on the political context at the time.

From the creation of CNES in 1961 to the Gulf War in 1991, the French armed forces began to discover certain space capabilities thanks to satellites they owned outright (telecommunications), to capabilities acquired through civil-military synergy (meteorology, oceanography, navigation), and to commercial agreements (observation) or confidential multilateral exchanges.⁹ But it was the arrival of the *Helios* space-based observation system in 1995 that marked the greatest breakthrough in capabilities in the history of the French space sector.

Phase 1: From the Creation of CNES to the Arrival of the *Helios* Satellites

Two years after the creation of CNES, the Élysée Treaty, a general agreement on Franco-German cooperation, was signed on January 22, 1963, by President Charles de Gaulle and Chancellor Konrad Adenauer. The governments of both countries signed an intergovernmental agreement for the construction, launch, and use of two experimental telecommunications satellites called *Symphonie*.

With no launch capabilities, France and Germany had no choice but to ask the Americans to put their satellites into orbit. The U.S. agreement would be subject to the condition that the program remain at the experimental stage and that no attempt be made to transform these satellites into operational tools. Faced with such demands, France and Germany refused this American demand and decided to join forces to provide Europe with its own launch vehicle. This became the origin of the Ariane program launched at the turn of the 1970s.

The success of the *Symphonie* satellites led to the creation of the *Telecom* program, followed by *Syracuse*.¹⁰ By 1980, the French armed forces had a secure telecommunications system for exchanging classified information between the capital and French Navy vessels operating worldwide. Today, two *Syracuse IV* satellites are in service.

9. The purchase of images from the American *LandSat* and French *Spot* satellites and the exchange of classified images between intelligence services generated the French desire to acquire *Helios*.

10. The SYRACUSE program (“SYstème de RADioCommunication Utilisant un SatellitE” or “Satellite Radio Communication System”) was launched in the mid-1970s, primarily at the request of the French Navy, to communicate with its entire fleet deployed far from France.

In the field of space imaging, CNES quickly understood the value of using space to position an observation satellite for geography, cartography, and environmental monitoring purposes. This marked the beginning of the *Spot* satellite family,¹¹ whose real operational value was first recognized by the French Air Force, as a complement to the aerial images used by the Centre d'exploitation des images de l'armée de l'Air (CEIAA, Air Force Image Processing Center).

At the same time, CNES, the French defense procurement and technology agency DGA and the manufacturers responsible for the *Spot* program were considering the benefits of capitalizing on the program's development to create a more powerful version dedicated to military uses. Called SAMRO for Satellite Militaire de Reconnaissance Optique (Military Optical Reconnaissance Satellite), the first French military reconnaissance satellite program was launched in 1978, but abandoned in 1982 due to a lack of support from the military Staffs and the absence of prospects for European cooperation.

Military Leaders Lukewarm about Helios

The achievements of the SAMRO project were then reinvested in the French civil Earth observation satellite program *Spot 4* and in the military reconnaissance satellite program renamed *Helios* – two satellites developed in synergy, but controlled by two separate image programming and analysis systems.

With regard to the political desire to find a European partner to share the costs of the *Helios I* program, an exchange of letters took place in 1981 between President François Mitterrand and Chancellor Helmut Kohl, in which France proposed that Germany cooperate on the program. Bonn declined the offer, responding courteously that the weather conditions in Central Europe, which was its primary area of interest, meant that priority had to be given to a radar satellite capable of observing in all weather conditions, day and night.

The chiefs of staff of the Army, Navy, and even the Air Force at the time were not enthusiastic, as each feared that this new expenditure, purely political and of no obvious operational value, would be detrimental to their fleets of tanks, submarines, or fighter aircraft. This underestimated the strength of political will, as President Mitterrand and his Defense Minister Charles Hernu would demand the manufacture of the *Helios I* satellite, capable of seeing everything, everywhere on the planet. It was ultimately financed from the nuclear deterrence budget line.¹²

Impatient Political Decision-Makers

Following Germany's refusal, *Helios I* was launched as an all-French industry program. However, the DGA was ordered to continue the search for European part-

11. *Spot* stands for "Satellite Pour l'Observation de la Terre" (Satellite for Earth Observation). The first satellite in a series of seven, *Spot 1* was launched on February 22, 1986.

12. Hence its classification as "classified," both to protect innovative industrial solutions and for its highly strategic use in nuclear deterrence.

ners. Italy finally signed up in 1985, with a 14.1% share of program costs, and Spain joined in 1986, with 7%.

The first challenge facing *Helios I* was industrial, as the DGA's priority was to determine the share of the program to be entrusted to Italian and Spanish industry in proportion to their financial investments, but without jeopardizing the already tight schedule.

However, the greatest challenge facing *Helios I* lay in the area of shared operations, as, for the first time, three partners of different nationalities¹³ would be operating a single classified military satellite. It was the occasion for some generals to discover the subtleties of orbital laws and realize that an observation satellite does not remain stationary above a crisis zone. The fact that the satellite was in low Earth orbit (LEO) meant that it could not immediately satisfy all requests for images, particularly in high-risk areas of the planet.

In order to optimize satellite programming, several shared operation simulation campaigns between government intelligence agencies took place in the basement of the CNES Poincaré building in Toulouse prior to the launch of the first satellite. The three representatives of the national secret services took turns, in complete confidentiality, entering the coordinates of their points of national interest. For several hours, powerful computers optimized the satellite's work schedule in orbit, based on its sequencing capabilities and its inclination, in order to capture as many images as possible, while respecting the rights of each partner according to their share of program funding.

The initial results were not good, as they showed that the *Helios I* system was producing three times fewer images than expected. After a detailed analysis of the results, it was found that many of the individually programmed geographical points were common to all three partners, whose operational needs were often the same. For optimization purposes, International Shared Requests were created. This would be the first lesson learned from the *Helios I* programming campaigns.

Another important lesson emerged concerning the operational management of a collaborative space program. When cooperating on conventional military equipment, each state is free to use its national equipment without having to know how its partners intend to use theirs. Space cooperation is quite different because, as the satellite is unique, sharing its daily use requires a high level of trust, especially when it comes to classified military data. It is therefore crucial to adopt a common intelligence policy in order to manage the satellite's capacity as effectively as possible. This is why regular exchanges are necessary between the intelligence services of cooperating countries in order to optimize satellite programming throughout the life of a military space observation system. Space cooperation on observation and intelligence thus generates transparency and trust. In light of the experience gained, it is now accepted in France that space cooperation brings cooperating states together.

13. These three partners were also particularly demanding customers, as they were strategic intelligence services: the French General Directorate for External Security (DGSE), the Italian Military Intelligence and Security Service (SISMI), and the Spanish National Intelligence Center (CNI).

The *Helios* program also highlighted the concept of a system, which was not yet understood by all military personnel. Each branch of the armed forces had become accustomed to valuing the intrinsic qualities of its equipment – such as tanks, submarines, or aircraft – solely for its own needs. Today, it is clear that each piece of equipment contributes to the effectiveness of an overall defense system.

The final major lesson was that, whenever *Helios* was discussed in the early 1990s,¹⁴ CNES emphasized the spatial dimension of the system, i.e. the satellite and its launcher. However, once in orbit, the satellite disappears forever, while the ground segment of the system remains in the hands of military operators to make the best use of the space system.

Numerous operational specialists¹⁵ and industrialists therefore had to combine their efforts to develop the ground segment of the *Helios I* space observation system. Everything had to be invented from scratch, and software had to be designed to program the satellite and to retrieve, process, archive and exploit digital images in accordance with the requirements of the political and military authorities.

Thanks to the civilian satellite *Spot 1*, in orbit since February 22, 1986, French, Italian, and Spanish image analysts have become familiar with the specific characteristics of space images: their size (covering 60x60km), the immense wealth of information contained in each image, the complexity of human-system interfaces, and the crucial nature of image archiving in order to track an evolving situation over time.

Europe's Awakening Thanks to Chernobyl

When the Chernobyl nuclear power plant accident occurred on April 26, 1986, *Spot 1*, which had just entered orbit, was urgently programmed to observe the extent of the damage and monitor the spread of the radioactive cloud. The satellite's multispectral photographic equipment¹⁶ clearly showed color changes in the vegetation affected by the cloud and, depending on the winds, made it possible to anticipate which crops would be contaminated and should not be consumed, as well as the location of the populations that needed to be sheltered.

The use of the *Spot 1* satellite to monitor the progress of a nuclear disaster was of great interest to members of the Western European Union (WEU).¹⁷ They drafted two reports (named after their rapporteurs, Messrs. Fourré and Malfatti) in which they suggested that Europe should be equipped with an autonomous space surveillance capability so that it could make its own assessment of the reality of a future

14. For the ceremony on July 14, 1995, the idea of parading a model of the *Helios* satellite on the ground was even mooted.

15. Experts from the world of intelligence, but also from the fields of geography, infrastructure, and targeting.

16. *Spot* had three channels in the optical spectrum that allowed it to see the situation in color.

17. The WEU was created by the Brussels Treaty (1948), amended within the broader framework of the Paris Agreements (October 1954). It was considered the armed wing of the European Union. As soon as the EU adopted a Common Security and Defence Policy (CSDP), the need for the WEU disappeared. It was dissolved in June 2011.

environmental accident. It would not be influenced by anyone and could assume its international responsibilities with complete strategic autonomy. These two reports were submitted to the WEU Council in 1988, which, although it found them very interesting, did nothing with them.

On January 17, 1991, as the Gulf War began,¹⁸ Europe had no autonomous means of validating (or invalidating) the information disseminated by the United States. No coalition reconnaissance aircraft was allowed to fly over Kuwait. Europe was completely blind.¹⁹

Within the WEU Council, some permanent representatives recalled the reports produced by Fourré and Malfatti and their recommendations. Within a few months, the WEU Space Observation Centre²⁰ was approved, financed, built in Spain at the Torrejón air base, and inaugurated in 1993. In order to give assurances of non-interference with U.S. intelligence, the first director of the WEU Satellite Centre (SC) was a British national, Mr. Barry Blades.

The Gulf War

As demonstrated by the rapid creation of the WEU SC, the Gulf War had an immediate impact within the WEU, but also in many European capitals. They realized with regret their total dependence on American observation satellites to understand the reality on the ground. Such a situation required total transatlantic trust within the coalition of 35 states that quickly came together to win this lightning war against Iraq and drive the invader out of Kuwait.

During the aerial bombing phase, it is interesting to note that the U.S. Air Force was one of *Spot* Image's biggest customers. In fact, while the deployed American military had access to a large number of high-quality images, albeit several days old, from their high-performance government satellites (*Keyhole* and *Lacrosse*), they were also interested in very recent images from *Spot* satellites, even with lower resolution.

This lesson was integrated into the architecture of the ground segment of the *Helios* system, whose management capabilities for recent archives were enhanced to avoid unnecessary reprogramming of the satellite if the requested information already existed in the archive.

18. The Gulf War took place from August 2, 1990, to February 28, 1991, between Iraq and a coalition of 35 states led by the United States following Iraq's invasion and annexation of Kuwait. It can be divided into two phases: the first, Operation Desert Shield, covering the military buildup and the defense of Saudi Arabia; followed by Operation Desert Storm, the start of combat operations, which began with air and naval bombardment, followed by a ground assault, and ended with the victory of the coalition forces, who managed to drive Iraqi forces out of Kuwait and advance into Iraq.

19. Apart from agreements on the exchange of information from the United States for certain compliant allies.

20. More commonly known as the WEU Satellite Centre (SC).

Preparing for the Launch of Helios

In France, the Ministry of Defense team responsible for the program, CNES engineers, and manufacturers patiently awaited the launch date of *Helios IA*, the program's first satellite, which depended on the availability of the Ariane 4 launcher. French politicians at the time, fascinated by this non-intrusive ability to observe what was happening anywhere on planet Earth, also shared this anticipation.

In line with the political and military lessons learned from the Gulf War, several diplomats at the Quai d'Orsay also wanted to take advantage of the launch of *Helios IA* to persuade WEU Member states to work together to develop an autonomous space observation capability in the coming years.

Thus, even before the first *Helios* satellite was launched and its performance, ten times superior to that of *Spot*, could be exploited, France promised to provide images to WEU Member states via the SC, subject to certain conditions. Called upon involuntarily, the defense ministries in Rome and Madrid took some time to coordinate with their respective foreign ministries.

The first signs of resistance would come mainly from the French Direction du renseignement militaire (DRM, Directorate of Military Intelligence), which was still in the process of being set up. The DRM believed that it should retain control of *Helios* jointly with the Direction générale de la sécurité extérieure (DGSE, Directorate General for External Security). It opposed the political idea of offering valuable data to WEU Member states without compensation.

However, under strong government pressure, the drafting of a Memorandum of Understanding on the provision of *Helios* images to the WEU was quickly completed.²¹ It was signed in Torrejón in 1993, on the day of the inauguration of the WEU SC. Contracts were signed for the installation of *Helios I* image processing stations, the adaptation of SC facilities to receive classified military data, and the accreditation of personnel. The first *Helios* image for the 28 WEU Member states was received.

Phase 2: From *Helios* to the Air and Space Force

Launch of the First Helios IA Military Satellite

For the first time in the history of Kourou and its Jupiter control room, two military officers were seated at Arianespace's "client" stations: the deputy director of the *Helios* program, representing the DGA, and the program officer representing the French Armed Forces General Staff.²² These two military officers were tasked with monitoring the launch preparations and authorizing the destruction of the satellite in the event that Ariane 4 failed to follow its nominal trajectory and risked crashing into the sea.

21. The *Helios* Memorandum of Understanding (MoU) was signed on April 23, 1993, the day the SC was inaugurated.

22. The *Helios* program officer is the author of this article.

The launch of the first Franco-Italian-Spanish defense satellite, *Helios IA*, took place on July 7, 1995. This event, which received extensive press coverage, heralded the dawn of a new era, one in which we could see and know what was happening on Earth, completely independently, legally,²³ and without violating anyone's airspace. This moment marked a fundamental first step in acquiring fully sovereign intelligence capabilities.

The reception of the first image was another challenge that had to demonstrate to the most skeptical the real expertise of our manufacturers. Ultimately, defense personnel would be able to carry out their missions even more effectively.

The First Helios Image in France

In agreement with Admiral Jacques Lanxade,²⁴ then Chief of Staff of the Armed Forces (Chef d'état-major des Armées, or CEMA), the choice for the first *Helios* image fell on the Punggye-ri nuclear test site in North Korea. The CEMA, aware of the political value of this first image, wanted to show it quickly to President Jacques Chirac.

Three images were taken: the first showed the Punggye-ri site, which was being prepared for a nuclear test launch (numerous vehicles and testing equipment, as well as several tents, were clearly visible around "Ground Zero"); the second showed the same site the day after a test (the site is completely empty); and the third showed the site as it appeared the day before the presentation in the president's office.

These images were all of excellent quality. As soon as they were placed on his desk, President Chirac exclaimed: "Are you telling me that a nuclear test is imminent in North Korea?" The director of military intelligence, whose teams had worked through the night, then stepped forward to detail the number of tents visible, the type of vehicles, and the number of military personnel present at the site. The president said to him, "General, these details are your responsibility. I don't need them to understand the situation. Thank you, gentlemen." The *Helios* images spoke for themselves, and the strategic information was in the hands of the head of the armed forces.

Very quickly, the *Helios* center in Creil was inundated with requests from numerous officials wanting to come and see the quality of the satellite images for themselves. However, the fact that they were classified severely limited their distribution. The end of 1995 was marked by a steady increase in the flow of data from the *Helios* system, which proved highly satisfactory for strategic intelligence missions as well as for mapping and targeting. The quality of the images was praised by all French, Italian, and Spanish users.

23. On January 27, 1967, the United Nations unanimously signed a treaty (known as the "1967 Treaty") declaring that the exploration and use of outer space must be carried out in the interests of and for the benefit of humanity, without discrimination between States.

24. Admiral Jacques Lanxade, with his keen insight into the military and political situation, contributed greatly to the establishment of France's nascent space program.

Now it was time to implement the *Helios* MoU signed with the WEU, and facilitate the arrival of the long-awaited first image at the Torrejón SC.²⁵

The First Helios Image in Torrejón

The first *Helios* image selected was of Sarajevo airport. With the war in Bosnia and the siege of Sarajevo having just ended, this site was particularly representative of the full potential of the *Helios* system. After establishing a very strict procedure to protect the transfer of the digital image from Creil to Madrid, the result largely lived up to expectations.²⁶

Since that day in May 1996, the SC has regularly received *Helios* images to help it respond to questions from the WEU Council. For reasons of confidentiality, *Helios* partners prohibit the SC from including the original image in files intended for the Council and WEU member states. The SC is therefore obliged to place an order for a *Spot* image, complemented with details detected on the *Helios* image in order to compile the intelligence file distributed in Brussels.

On December 3, 1996, during the meeting of the WEU Council of Ministers, chaired by France, President Chirac declared: “We must build on the recognized expertise of the Torrejón Satellite Centre to pursue a genuine space ambition for Europe.” The SC was then officially declared operational.

From then on, France, Italy, and Spain enjoyed preferential treatment within the WEU Council, as the other member states finally realized the great value of the information held by these three countries thanks to *Helios*. This was especially true since certain information was still not being shared by the U.S. intelligence services.

The Great Lakes Crisis

The Torrejón SC earned its stripes in 1996 and 1997 during the Great Lakes crisis. Between April and July 1994, hundreds of thousands of Tutsi were victims of the genocide carried out by the Hutu in Rwanda. A massive refugee movement began spontaneously, a humanitarian exodus that the United Nations High Commissioner for Refugees could not anticipate.

From space, it was possible to monitor changes in the number of refugees in the Mugunga camp, but also to see that this camp was close to Lake Kivu and a volcanic crater filled with drinking water. However, 51 other refugee camps were detected with no water nearby and no means of survival. It was therefore urgent for the European Union to address the problem raised by the satellite images.

25. The author of this article was appointed Director of the WEU SC and took up his duties on January 1, 1996. Having led the negotiations on the drafting for the *Helios* MoU, he now had to implement it.

26. I was in my office when the director of operations rushed in and, without even knocking or announcing himself to my assistant, shouted in my ear, “Boss, come, come quickly!” I asked him why he was in such a frenzy. I followed him running to the *Helios* operations room and saw, displayed on the screen, an image of Sarajevo airport. “So what?” I said to him. “Chief, this photo is magnificent! It’s extraordinary! In the UK, our secret services were convinced that if France said that its *Helios* images were classified, it was because they weren’t any good!”

However, Members of the European Parliament were not yet ready to deal with such tragic information. Many elected representatives felt overwhelmed by the tool they had acquired. "Yesterday, we didn't know, and it was easy for us to say, after a tragedy, that if we had known, we could have intervened. [...] Today, thanks to the SC, we have the information, but we are unable to make a joint decision."²⁷

Although weather conditions are not conducive to optical space observation,²⁸ the Torrejón SC nevertheless produced information files on the crisis zone very quickly. In addition to *Helios*, other space-based images were privately acquired. These included optical archive images from Spot, the American *Landsat*, and *Indian Remote Sensing* (IRS) satellites, as well as radar satellite images from the European ERS and Canadian RADARSAT platforms. By merging data from this range of highly complementary sensors, the SC produced reports that were recognized as extremely useful to the international community in the real and tragic context of managing the crisis in the Great Lakes region.

Users Satisfied with Helios IA

As French, Italian, and Spanish users progressively learned how to share data from the first *Helios IA* satellite and develop tools for exploiting high-resolution images, the decision was made to launch the second *Helios IB* satellite into orbit in 1999. A constellation of two satellites opened up a new dimension. The reduction in image access time and the increase in the revisit rate over areas of interest (AOIs) optimized the operational efficiency of the *Helios I* system.

Within military staffs, discussions were also progressing because it was necessary to quickly prepare the successor to *Helios I*, which had an initial lifespan of five years. It was therefore necessary to launch the *Helios II* generation as soon as possible in order to be ready for launch in 2001. For complex reasons²⁹ and despite an operational return on *Helios I* that far exceeded their financial contribution, neither Italy nor Spain were eager to continue their cooperation within the framework of *Helios II*.

A New Franco-German Rapprochement

A new project for rapprochement with Germany was launched at the same time. In line with the 1981 exchange of letters between President Mitterrand and Chancellor Kohl, the aim was to propose a Franco-German optical and radar space observation system based on the *Helios II* and *Osiris* satellites.³⁰ The latter was quickly renamed *Horus* for the subsequent exchanges between Paris and Bonn.

27. Confession by the Portuguese ambassador to the WEU Council.

28. Optical satellite sensors depend on visible light. Without light (at night), or if the observation area is covered by clouds, their images are rendered unusable.

29. Several parliamentary reports refer to the fact that France long concealed from its Italian and Spanish partners the existence of a stowaway aboard *Helios I*, EURACOM, tasked with listening in on Soviet missile defense radars.

30. The French Armed Forces General Staff had included the program, called OSIRIS, in its Multi-Year Military Space Plan (Plan Pluriannuel spatial militaire [PPSM]). OSIRIS was an observation satellite that used radar detection for day and night missions in all weather conditions. This satellite was planned to be in orbit around 2001-2003 to coexist with *Helios II*.

A framework agreement was signed in Baden-Baden but quickly abandoned under pressure from the United States, which threatened to stop transmitting images from its *Keyhole* (optical) and *Lacrosse* (radar) satellites to the BND.³¹

Before being officially informed, France understood that Germany intended to embark on the construction of five small radar satellites built by its own space industry. The *SAR-Lupe* constellation was finally financed, built (by the German company OHB) and launched into orbit in 2007, despite the costs of German reunification. Italy then took a similar decision by launching its program of four small *COSMO-SkyMed* radar satellites, which were launched into orbit in 2008.

European Expansion Falls Through

France's original idea of using the Torrejón Space Center and *Helios* images to create a European dynamic aimed at expressing a common operational need before converging on the European MUSIS program³² had failed. Each country ultimately preferred to invest in its own resources to acquire or enhance its national space industry capacity rather than contribute to the Franco-European project.

This accumulation of national investments is certainly not conducive to optimizing the financial resources of the states. However, it does offer the opportunity to make a large number of optical and radar images available to operational users in these countries thanks to the bilateral exchange agreements that were put in place.³³

The Second Gulf War: Proof of the Lie

What was called the "Second Gulf War" officially began on March 20, 2003, with the invasion of Iraq and the launch of Operation Iraqi Freedom. A coalition led by the United States against Saddam Hussein's Baath Party was formed. Based on information widely disseminated by American television channels and newspapers and illustrated with highly detailed satellite images, the United States claimed that many Iraqi presidential palaces were storage sites for weapons of mass destruction. The reinforced doors of certain buildings and traces left in the sand by tracked vehicles were clearly visible in the photos broadcast in the American media, and several countries were convinced by the accusations made by the United States. France was not one of them.

Unlike the first Gulf War, in 2003 France could use *Helios*. However, armored doors and traces left by tracked vehicles did not appear in any of the images ob-

31. The BND (Bundesnachrichtendienst) is the German Federal Intelligence Service (equivalent to the French DGSE).

32. This European system, called MUSIS (MULTinational Space-based Imaging System), has not been completely abandoned. This is why the successor to *Helios II* was named CSO, for Composante Spatiale Optique (Optical Space Component of the MUSIS system).

33. This was the case, for example, with the Franco-Italian agreement signed in Turin (January 2001), which organized an exchange of access rights between the *Helios II* (optical) and *COSMO-SkyMed* (radar) satellites. The Franco-German agreement signed in Schwerin (July 2002) provided for a similar arrangement, this time between the French *Helios II* and German *SAR-Lupe* (radar) satellites.

tained. President Chirac then announced France's refusal to participate in this second coalition and sent Dominique de Villepin, then Minister of Foreign Affairs, to the United Nations Security Council, where he delivered his famous speech.³⁴ This affair caused quite a stir because it demonstrated the strategic importance of space-based intelligence and the need to possess this capability independently.

Whether by pure coincidence or not, it is worth noting that, immediately after the 2003 crisis, the UK decided to test its first space observation capability by launching a microsatellite called *TopSat 1* at the end of 2005. It worked perfectly and demonstrated the UK's real technological capabilities.

Space Was Still Not a Priority for the French Armed Forces General Staff

The period from 2000 to 2010 was marked by uncertainty regarding space investments and applications. However, on an operational level, space became an everyday reality for forces that used – without always realizing it – valuable meteorological data (*Meteosat* satellites), precise positioning (GPS and *Galileo* satellites), a wealth of space-based imagery (*Helios I* and *II*) and easy communications via secure links (*Syracuse*). But funding for the next generations of satellites (the Composante spatiale optique [CSO] for observation and *Syracuse IV* for telecommunications) was posing problems at Staff level. The decision to transform the technology demonstration microsatellites (*Essaim* and *Elisa*³⁵ for electromagnetic intelligence, then *Spirale*³⁶ for early warning) into full-fledged future programs also had to be considered.

Gradually, space was losing its status as a peaceful and untouched environment, the driving force behind all 1960s dreams. It was becoming an environment that needed to be closely monitored, as numerous hostile actions were beginning to occur there without France being aware of them. In order to track space debris (which had already damaged some French satellites) and to preserve the physical integrity of our satellites in the face of various threats (laser illumination from the ground, “eavesdropping” by hostile satellites, and electromagnetic jamming), it became urgent to develop a French capability to monitor space and protect the orbital relays of French power.

34. “Discours de D. de Villepin, au conseil de sécurité de l’ONU – 14 février 2003,” *Clio-Texte*, February 10, 2021.

35. The constellations of four *Essaim* demonstration microsatellites (telecommunications intelligence, launched in 2004 as passengers on *Helios IIA*) and *Elisa* (radar intelligence, launched in 2011 with the *Pléiades* satellites, successor to *Spot*) made it possible to specify the expected performance of the operational CERES (Capacité de Renseignement Électromagnétique Spatiale, Space-based electromagnetic signal intelligence capability) satellites.

36. SPIRALE (Système Préparatoire Infrarouge pour l’ALerte, Preparatory infrared early warning system) was a demonstrator based on a constellation of two microsatellites. Launched in 2009, this demonstrator performed very well and helped consolidate our valuable database on the IR signature of launchers and strategic missiles.

The National Office for Aerospace Studies and Research (ONERA)³⁷ was at the forefront of space surveillance. In the 2000s, the Agency developed the GRAVES system,³⁸ based on ground-based radars that track and catalog several thousand objects in low and medium orbit on a daily basis.

Despite France's scientific strengths and the convincing results of demonstrators, the Armed Forces General Staff remained cautious. And yet, several crisis situations in which the French armed forces were involved showed our political leaders how space could allow them to monitor the situation completely independently.

At a time when defense budgets were collapsing, French military authorities considered that they had other priorities in terms of investment in new capabilities. Within the Staff itself, some argued that space had no relevance to the conduct of military operations. The then Chief of Staff of the Armed Forces even declared at the French War College: "I no longer have the budget to put gas and a driver in my Jeeps. How could I possibly finance your space toys?"³⁹

The New Political Wake-Up Call

With the support of anxious manufacturers, the situation was presented to policy makers on the defense committees of the National Assembly and Senate, as well as advisors to the President and Prime Minister. They were shown the level of risk of discontinuity in strategic space capabilities if the multi-year military space plan⁴⁰ was not followed. The speeches given by French President Nicolas Sarkozy in Kourou in 2008⁴¹ and in Toulouse in 2011,⁴² as well as the publication of the *White Paper on Defence and National Security* in 2008,⁴³ put space investments back in their rightful place.

It was in this context that the CERES electromagnetic signal intelligence (SIGINT) program⁴⁴ was finally launched, just in time to preserve the human and technological expertise of the engineers and technicians who had worked on the *Essaim* and *Elisa*

37. ONERA (Office National d'Études et de Recherches Aérospatiales), also known as "The French Aerospace Lab," works closely with CNES on all matters related to space research.

38. Stands for "Grand Réseau Adapté à la VEille Spatiale" (Large Network Adapted to Space Surveillance).

39. Statement by General Jean-Louis Georgelin, then Chief of Staff of the Armed Forces, in response to a lecture given by the author of this article in 2008 at the Foch amphitheater (École militaire – Paris).

40. PPSM: France adopted this plan between 1992 and 2010, which made it possible to isolate the funding needed to maintain and develop a genuine space defense and security capability.

41. "[Déclaration de M. Nicolas Sarkozy, Président de la République, sur les défis et priorités de l'industrie spatiale européenne, à Kourou le 11 février 2008](#)," *Vie publique*.

42. "[Déclaration de M. Nicolas Sarkozy, Président de la République, sur le politique spatiale de la France, à Toulouse le 22 novembre 2011](#)," *Vie publique*.

43. *The French White Paper on Defence and National Security. Foreword by Nicolas Sarkozy, President of the French Republic*, Paris, Odile Jacob and La Documentation française, June 2008, 350 p.

44. CERES (Capacité de Renseignement Électromagnétique Spatiale) is a system consisting of three electromagnetic signal intelligence (SIGINT) satellites and a high-performance ground segment, enabling the mapping and analysis of electromagnetic transmitters operating in frequency bands of interest to radar and telecommunications.

demonstrators.⁴⁵ Since 2021, thanks to the CERES constellation, France has become the only European country to have access, day and night, in all weather conditions, to highly confidential information on the density of telecommunications traffic and on the signatures of our adversaries' surveillance and tracking radars.

Conclusion

Today's military decision-makers understand that space-based capabilities are an essential part of an autonomous intelligence policy. In the event of a crisis, the management of military resources requires precise operational positioning of deployed capabilities and careful control of confidential data flows between the area of operations and political decision-makers.

The training of Air Force officers has been adapted to enable them to understand the advantages and specificities of the space environment. Since the early 2000s, the Air Force Academy in Salon-de-Provence has organized a space seminar lasting several days for French officer cadets, which is also open to our allies. As early as 2002, some of the school's directors had already proposed changing the name of the Air Force Academy to the "Air and Space Academy" – which became a reality in 2021.

As part of this renewed interest in space in France, the Joint Space Command was created in 2010. This was a promising step forward, although space remained under the authority of the Chief of Staff of the Armed Forces, who was keen to retain financial control over capability choices.

It was not until 2019 that Space Command was created by Florence Parly, then Minister for the Armed Forces. It was established at the CNES space center in Toulouse, demonstrating the vital need for synergy between civilian and military experts. The responsibility of each party in preparing France for a future space conflict⁴⁶ was thus clearly established.

By decision of the President of the Republic, the Air Force officially became the Air and Space Force on September 11, 2020.⁴⁷ It was the first European Air Force to understand and integrate the powerful potential of the coordinated use of space assets for the security and defense of our citizens, both at the political decision-making level and at the level of our intelligence services and forces deployed in crisis zones.

In Europe, the issue of strategic decision-making autonomy based on space-derived intelligence has long been debated in Brussels. In the name of the famous "no duplication" principle, some states have long considered the American umbrella sufficient to guarantee the security of the European continent.

45. *Essaim* was a constellation of four electromagnetic signal intelligence (SIGINT) microsatellites, launched with *Helios IIA* in 2004 and joined in 2011 by the four microsatellites of the *Elisa* constellation. Together, they enabled the development of the future operational electronic surveillance system CERES.

46. "Dossier – La France face à la guerre dans l'Espace," *Esprit défense*, No. 9, Fall 2023, pp. 30-49.

47. This date was chosen intentionally because it corresponds to the anniversary of the death of Captain Guynemer in 1917, whose motto "Faire face" (Facing Up) was adopted by the French Air Force.

The ongoing Russian-Ukrainian conflict, the recent positions of China and North Korea, and President Trump's regular statements in the United States on his vision of the Atlantic Organization and Europe raise questions. When it comes to the defense of Europe, many ideas are now being explored in Europe from a new perspective. Yesterday's "no duplication" policy is no longer appropriate. Many European States, including non-members of the European Union,⁴⁸ now realize that it is time to join forces.

Space has become the cornerstone of a European multinational system capable of assessing multifaceted risks and threats, deterring potential new aggressors, and demonstrating a certain level of military cohesion to defend a still-fragile Europe in a spirit of solidarity.

48. It would indeed make no sense to discuss the defense of Europe without including the United Kingdom and Norway (as well as Macedonia, Albania, Montenegro, and Turkey), which are members of the Atlantic Organization, but not of the European Union. Similarly, the cases of Austria and Ireland (members of the EU but not of NATO) will have to be considered.

Observation Satellites During the Cold War: An Indispensable Decisional Tool

Baptiste Colom-y-Canals

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Often the subject of fascination, largely unknown to the general public, and exaggeratedly labeled as “spies,” observation satellites played a crucial role in the Cold War. This term covers an entire set of data-collecting platforms, ranging from satellite photography and radiation detection to the monitoring of electromagnetic waves. Their common point, however, is to have been developed in order to attempt to anticipate adversarial intentions and understand their military potential to guard against a surprise nuclear attack. Fairly rapidly, intelligence originating from satellites became essential for political and military decision-makers. By contributing to the knowledge of strategic means and adversarial armaments, they became integrated into foreign policy maneuvers to the point of becoming indispensable. As technology advanced, the capabilities of satellites increased, thereby opening the fields of application for this intelligence.

At the end of the Second World War, the U.S. military captured Wernher von Braun, the engineer behind the V1 and V2 rockets, to initiate its research programs. In May 1946, General Curtis LeMay, deputy to the Chief of the Air Staff for Research and Development, requested a study from RAND on the feasibility of producing a space satellite for the U.S. Army Air Forces (USAAF). This was in response to studies commissioned by the U.S. Army and the U.S. Navy on the subject.¹ RAND

1. J. T. Richelson, *America's Secret Eyes in Space: The U.S. Keyhole Spy Satellite Program*, New York, Harper Collins Publishers, 1990, p. 2.

concluded that it was technically possible to send a satellite into orbit and also highlighted its military utility, particularly in the field of intelligence.² This work served primarily to assert the USAAF's dominance over the U.S. Navy and the U.S. Army regarding space issues and future satellite programs.³ From its inception in 1947, the U.S. Air Force (USAF) took a significant part in research on space programs by commissioning several studies from RAND. The development of a means of space-based intelligence gathering was part of a logical extension for the U.S. of the aerial reconnaissance missions conducted on the borders of the Soviet Union from 1946, and the overflights of the country after 1950.⁴

The principal constraint for launching an observation satellite program was ensuring sufficient image resolution to meet the needs of photographic analysts. Although the USAF leaders still considered the realization of an operational reconnaissance satellite to be premature, they encouraged research on these projects. The difficulties encountered in obtaining intelligence on the USSR were the primary motive for this support. With the reinforcement of Soviet air defense capabilities, it became evident that in the short term, aerial reconnaissance could not continue without risk.

The objective here is not to provide an exhaustive history of the technological evolutions of the sensors used. Instead, it is to attempt to understand for what purposes these various satellites were developed and how national issues may have intervened in the strategic choices behind these programs. It is also of interest to consider the strategic interactions that guided the commissioning of these data collection systems, particularly within the specific context of the Cold War.

It is necessary, firstly, to understand the origins of the needs that pushed both the U.S. and the Soviets to invest substantial funding and, despite the failures encountered, to pursue the development of these complex programs. The results provided by the first space platforms sparked new demands, particularly in the context of the crises that occurred during the Cold War. Finally, the technological advancements spurred by these new needs contributed to extending the field of intelligence-gathering possibilities and to fostering new uses.

Access to U.S. archives, such as the work conducted on various reconnaissance satellite programs and on relations between intelligence agencies in the United States, provides a fairly precise image of the country's use of space. In contrast, Soviet sources are rarer and more difficult to access. The use of archives from Western intelligence agencies helps to provide insight into Soviet programs, but this approach is also subject to limitations. Consequently, this study presents an asymmetry in the

2. Douglas Aircraft Company, "[Preliminary Design of an Experimental World-Circling Spaceship](#)," RAND Corporation, 1946, p. 10 and p. 236.

3. R. M. Denisch, *Eyeing the Red Storm: Eisenhower and the First Attempt to Build a Spy Satellite*, Lincoln, University of Nebraska Press, 2016, p. 87.

4. J. T. Farquar, *A Need to Know: The Role of Air Force Reconnaissance in War Planning, 1945-1953*, Maxwell AFB, Air University Press, 2004, p. 38 and p. 41; R. Cargill Hall, C. D. Laurie (eds.), *Early Cold War Overflights*, Washington D.C., National Reconnaissance Office, 2003, p. 3.

treatment of the two countries, despite the use of research undertaken on Russian documents.⁵

I – A Vital Requirement for National Security

After the USSR acquired nuclear weapons in 1949, the U.S. became preoccupied with ascertaining the state of the Soviet arsenal, specifically the number of nuclear warheads and delivery vehicles, to gauge the evolution of Soviet nuclear potential. They naturally wished to be able to assess this threat as accurately as possible. This search for information became a national security issue for the U.S. – as it did for the Soviets. For the former, the fear of reliving a new “Pearl Harbor,” this time involving nuclear weapons, fueled the development of strategic intelligence-gathering programs. For the latter, the memory of the German surprise attack on 22 June 1941 fostered the same concerns and reactions. By immeasurably amplifying the effects of a surprise attack, nuclear weapons increased the anxiety of political decision-makers on both sides of the Iron Curtain.

The First Programs

In the United States, initial thinking on the use of space to ensure national security led to several studies highlighting the value of satellites for reconnaissance missions. RAND published their “Feedback” report on the use of reconnaissance satellites in March 1954. The authors insisted notably on two key points:

- “1. The earliest possible completion and use of an efficient satellite reconnaissance vehicle is of vital strategic interest to the United States.
2. The satellite operation must be considered and planned on a high policy level.”⁶

Simultaneously, concerns regarding the role of new armaments, particularly nuclear weapons and their delivery systems, prompted President Eisenhower to assemble a commission led by the director of the Massachusetts Institute of Technology, James R. Killian, to study the implications of technological issues for national security.⁷ The first report from this commission, titled “Meeting the Threat from Surprise Attack,” was presented the following year. Faced with the threat of a surprise nuclear attack, it recommended that:

“[The US] must find ways to increase the number of hard facts upon which [their] intelligence estimates are based, to provide better strategic warning, to

5. Such as: V. M. Zubok, *A Failed Empire. The Soviet Union in the Cold War from Stalin to Gorbachev*, New Delhi, University of North Carolina Press, 2009; C. Gelibter, “Renseignement et politique : l’affaire des armes de destruction massive irakiennes. 1979-2003. Analyse comparée France/USA/Russie/ Grande-Bretagne/Allemagne,” *Phd dissertation* under the supervision of Olivier Forcade, Sorbonne Université, Paris, 2025; B. Hendrickx, “[Snooping on Radars: A History of Soviet/Russian Global Signals Intelligence Satellites](#),” *Space Chronicle. Journal of the British Interplanetary Society*, vol. 58, 2005, pp. 1-37.

6. J. E. Lipp, R. M. Salter, “[Project Feedback](#),” RAND Corporation, 1954, p. 149.

7. J. M. House, *A Military History of the Cold War, 1944-1962*, Norman, University of Oklahoma Press, 2012, p. 376.

minimize surprise in the kind of attack, and to reduce the danger of gross overestimation or gross underestimation of the threat. To this end, [the Panel] recommend[s] adoption of a vigorous program for the extensive use, in many intelligence procedures, of the most advanced knowledge in science and technology.”⁸

It was also from 1955 onwards that the USAF believed the Soviets possessed new bombers capable of striking the United States.⁹ This potential threat further amplified the need for new intelligence-gathering platforms to guarantee an accurate evaluation of Soviet military power. The lack of intelligence regarding the new *Myasishchev M-4* (“Bison” in NATO code) fueled the “bomber gap.” The USAF consequently drew alarming conclusions regarding Soviet bombardment capabilities.¹⁰ This episode led President Eisenhower to support the development of the *U-2* aircraft program. Conscious of the value of developing a more permanent solution, he also funded research into a satellite based on the RAND studies.¹¹ The WS-117L program, intended to design military reconnaissance satellites, was born in this context in 1956.

On the Soviet side, Sergei Korolev, director of the Soviet space program, launched studies for the development of a reconnaissance satellite in April 1956. Not possessing the U.S. expertise in photographic technologies, the Soviets encountered more difficulties in developing their first generation of reconnaissance satellites.¹² In January 1960, the leader of the USSR, Nikita Khrushchev, requested those responsible for the space project to accelerate their work so as not to be overtaken by the United States.¹³

Their efforts focused initially on the *Zenit-2* satellite. It utilized the *Vostok* spacecraft as a platform, the capsule of which was equipped with cameras. At the end of the mission, this capsule returned to Earth. The Soviets then recovered the capsule, along with the cameras and film, which were reused with their equipment for a subsequent mission. The *Zenit-2* module was also equipped with a small ELINT (Electronic Intelligence) sensor to record Western radar emissions.¹⁴ Following unsuccessful launches from 1961, the program reached fruition the following year. The Soviets successfully placed their first *Zenit-2* in orbit on 28 July 1962, which returned its images upon its

8. Department of State, S/S–RD Files: Lot 71 D 171. Top Secret; Restricted Data, “[Report by the Technological Capabilities Panel of the Science Advisory Committee](#),” Washington, February 14, 1955.

9. K. Wright, *The Collectors: U.S. and British Cold War Aerial Intelligence Gathering*, Warwick, Helion & Company, 2019, p. 95.

10. J. Prados, *The Soviet Estimates: U.S. Intelligence Analysis and Soviet Strategic Forces*, Princeton, Princeton University Press, 1986, p. 45.

11. R. M. Deniesch, *Eyeing the Red Storm: Eisenhower and the First Attempt to Build a Spy Satellite*, Lincoln, University of Nebraska Press, 2016, p. 69.

12. P. A. Gorin, “Zenit, The Soviet response to Corona,” pp.157-170 (p. 156); in D. A. Day, J. M. Logsdon, B. Latell (eds.), *Eye in the Sky: The Story of the Corona Spy Satellites*, Washington D.C., Smithsonian, 1998.

13. J. Villain, *Satellites espions : histoire de l'espace militaire mondial*, Paris, Vuibert, 2009, p. 122.

14. P. A. Gorin, “Zenit, The Soviet response to Corona,” p. 164; in D. A. Day, J. M. Logsdon, B. Latell (eds.), *Eye in the Sky...*, op. cit.

descent to Earth four days later.¹⁵ Nonetheless, conscious of their technological lag compared to the US, the Soviets launched new research programs.¹⁶

The Sputnik Shock and the Corona Program

On 4 October 1957, the launch of *Sputnik* by the Soviets surprised the U.S. Their vulnerability to Soviet missiles – the “missile gap” – became apparent to all.¹⁷ Under pressure from public opinion and the opposition, President Eisenhower decided to accelerate the WS-117L program. Simultaneously, he tasked the Central Intelligence Agency (CIA) with the rapid development of an intermediate system intended to compensate for collection deficiencies pending the completion of the WS-117L.

The *Corona* program relied on research already conducted to develop a photographic reconnaissance satellite with a capsule for returning film to Earth.¹⁸ In November 1958, the USAF chose to expand the WS-117L project by splitting it into three parts. *Discoverer*, firstly, was presented as a program of scientific research and testing satellites but was intended to serve as a cover for *Corona*. The *Midas* project, secondly, focused on the development of an infrared early-warning satellite designed to detect the launches of intercontinental ballistic missiles.¹⁹ Finally, *Sentry* – which later became *Samos* – was the component intended to commission a reconnaissance satellite capable of transmitting images by radio via a scanner system.²⁰ It also contained an electronic intelligence component aimed at designing an auxiliary payload to collect Soviet radar emissions. With these systems, the U.S. hoped to be able to guard against a Soviet surprise nuclear attack and avoid the aforementioned new “Pearl Harbor” of apocalyptic proportions.

The first launch of a *Discoverer* satellite, on 21 January 1959, was a failure. Furthermore, the interception of Francis G. Powers’s *U-2* on 1 May 1960 constituted a disaster for U.S. intelligence, which lost its primary source of information on the USSR. Fortunately, on 10 August 1960, the satellite’s launch into orbit and the subsequent recovery of its capsule were successfully completed with the 13th *Discoverer* mission. The first *Corona* reconnaissance mission – of the KH-1 class – was conducted with the 14th *Discoverer* on 18 August. After spending just over a day in orbit, the KH-1 photographic capsule returned more than 900 meters of photographic film covering over 4,237,480 km² – representing nearly one-fifth of the

15. J. Haslam, *Near and Distant Neighbours: A New History of Soviet Intelligence*, Oxford, Oxford University Press, 2015, p. 234.

16. E. Grossfeld, “Russia’s Declining Satellite Reconnaissance Capabilities and Its Implications for Security and International Stability,” *International Journal of Intelligence and CounterIntelligence*, 38(1), 8 May 2024, pp. 1-30.

17. J. Prados, *The Soviet Estimates...*, *op. cit.*, p. 63.

18. A. D. Wheelon, “CORONA, A Triumph of American Technology,” pp. 29-47 (p. 33); in D. A. Day, J. M. Logsdon, B. Latell (eds.), *Eye in the Sky...*, *op. cit.*

19. Intercontinental Ballistic Missile (ICBM), meaning a missile with a range of over 5,000 km. *Midas* is an acronym for “Missile Defense Alarm System.”

20. R. M. Deniesch, *Eyeing the Red Storm...*, *op. cit.*, p. 168.

surface area of the Soviet Union.²¹ Although more than 25% of the frames were unusable due to cloud cover, this mission provided more intelligence than the entirety of the *U-2* missions conducted over the USSR.

The Midas and Samos programs, being more ambitious and especially more complex regarding the technologies employed, did not achieve the expected successes. After eleven launch attempts and only two satellites placed in orbit (which did not produce high-quality photographs), the Samos program was discontinued at the end of 1962.²² For its part, Midas represented the first generation of early-warning satellites. However, the program proved far too complex due to the infrared sensors, which lacked reliability once the satellite was in orbit. It was transformed into a testing program in 1961 and paved the way for the development of the Defense Support Program in the 1970s, which would lead to the first operational early-warning satellite system.²³

A Tool for Strategic Surveillance

The intelligence gathered by the Corona satellites allowed Allen Dulles, Director of the CIA (1953-1961; Director of Central Intelligence – DCI), to demonstrate the non-existence of the “missile gap.”²⁴ The photographs from these early missions nonetheless showed the preparation for a large-scale deployment of medium-range ballistic missiles²⁵ from the Baltic Sea to the Black Sea, in proximity to the countries of the Atlantic Organization.²⁶ The intelligence gathered by satellites became one of the primary sources for the establishment of “National Intelligence Estimates” (NIE), which are intelligence evaluations of strategic issues produced by the U.S. intelligence community. U.S. political and military decision-makers could thus follow the evolution of the USSR’s missile arsenal.

The commissioning of the first KH-7 *Gambit* in July 1963, possessing a resolution exceeding 20 cm, contributed to improving the surveillance of Soviet strategic capabilities.²⁷ This clarification led analysts at the National Photographic Interpretation Center²⁸ to revise downwards the estimates regarding the increase in the number of Soviet ICBMs. The Secretary of Defense, Robert McNamara (1961-1968), observed the evolution of the adversarial nuclear potential through the analysis of satellite photographs. He thus realized the inadequacy of the U.S. doctrine of massive retaliation and presented, in February 1965, a new doctrine known as “Mutual Assured Destruction.”²⁹

21. R. Perry, “[A History of Satellite Reconnaissance. Volume I – Corona](#),” National Reconnaissance Office, 1973, p. 100.

22. C. Peebles, *Guardians Strategic Reconnaissance Satellites*, London, Ian Allan LTD, 1987, p. 70.

23. *Ibidem*, p. 310 and J. Villain, *Satellites espions...*, *op. cit.*, p. 158.

24. D. T. Lindgren, *Trust but Verify: Imagery Analysis in the Cold War*, Annapolis, Naval Institute Press, 2000, p. 102.

25. Missiles with a range between 1,000 and 3,500 km.

26. D. T. Lindgren, *Trust but Verify...*, *op. cit.*, p. 107

27. *Ibidem*, p. 108.

28. Created in the early 1960s, the NPIC was attached to the National Imagery and Mapping Agency (now the National Geospatial-Intelligence Agency) in 1996.

29. D. A. Day, “[Little Wizards: Signals intelligence satellites during the Cold War](#),” *The Space Review*, 2021; C. Peebles, *The Guardians...*, *op. cit.*, p. 181 and p. 219.

Parallel to these developments, since the late 1950s, the U.S. launched the GRAB (Galactic Radiation and Background) program to collect signals intelligence on Soviet radars. Five small satellites were launched between 1960 and 1961, but only two reached a stable orbit. By contributing to the mapping of enemy radars, GRAB highlighted the significance of the Soviet air defense system and led to a reassessment of the Strategic Air Command attack plans.³⁰ GRAB demonstrated not only that it was possible to manufacture an ELINT satellite at a lower cost, but above all, the immense benefit of such a platform for this type of intelligence gathering. This lesser-known aspect of satellite intelligence gathering was nonetheless just as important as imagery gathering for both the U.S. and the Soviets. From 1965, the latter also launched SIGINT satellites, including the *Tselina* series. The primary motivation in the development of ELINT satellites was to ascertain the surface-to-air defense systems of the other party.

The Soviets invested in developing their intelligence-gathering capabilities and wished to be able to rival the U.S. before the end of the decade.³¹ It was only from 1967 that they succeeded in obtaining a complete inventory of U.S. strategic installations with sufficiently precise images and in following the changes of these sites.³² The Soviet objective was identical to that of the US: to understand the evolution of the adversarial nuclear potential and to monitor the slightest sign that might announce the beginning of a surprise attack against the USSR. The fear of a devastating U.S. first strike was, in fact, omnipresent among Soviet leaders.³³

During the Cold War, it was very difficult for both the United States and the USSR to know precisely the intentions of the adversary. With the fear of a surprise strategic attack, early warning intelligence became as crucial as it was potentially extremely short-lived. It then became vital for political leaders to estimate as precisely as possible the adversary's capabilities to attempt to anticipate the other's actions. The improvement in the surveillance capabilities of reconnaissance satellites thus contributed to reducing the risk of escalation in the event of a crisis. Political leaders gained a more precise understanding of the reality of enemy capabilities, making them less open to interpretation.³⁴

II – Toward a Tool for Crisis Management?

The Cold War was marked by a succession of regional crises which, given the direct or indirect involvement of the two superpowers, could rapidly become global.

30. D. A. Day, "[A flower in the polar sky: the POPPY signals intelligence satellite and ocean surveillance](#)," *The Space Review*, 28 April 2008. During the Cold War, the SAC was responsible for the land and air components of American deterrence. On its history, see M. G. Deaile, "[Strategic Air Command: A History of Adaptation throughout the Cold War](#)," *Vortex. Studies on Air and Space Power*, No. 6, July 2024, pp. 341-355.

31. E. Grossfeld, "Russia's declining...", *op. cit.*

32. J. Haslam, *Near and Distant...*, *op. cit.*, p. 235.

33. V. M. Zubok, *A Failed Empire...*, *op. cit.*, p. 136, 205, and 271.

34. W. Muszynski-Sulima, "[Cold War in Space: Reconnaissance satellites and US-Soviet Security Competition](#)," *European Journal of American Studies*, No. 18-2/2023.

Offering the possibility of collecting images without the risk of interception, the satellite appeared to be an ideal and promising platform for these reconnaissance missions.

The Value of Strategic Surveillance in Times of Crisis

During the Cuban Missile Crisis in the autumn of 1962, observation satellites did not play a direct role in the confrontation between Moscow and Washington. It was essentially the *U-2*, the *RF-8 Crusader*, and the *RF-101 Voodoo* that returned photographs of the Soviet missile sites.³⁵ The U.S. did, however, attempt to employ the *Corona* program to gather information on the island. A *KH-4* satellite, launched at the end of September, was used to take photographs, but the few images captured were not of high quality, while cloud cover obscured a substantial portion of Cuban territory. The footage did not allow for the identification of military installations, nor for the detection of anomalies in Cuban activity.³⁶

The delay in recovering photographic capsules, the low resolution of the cameras, and the impossibility of pointing at a precise location demonstrated at that time the limitations of the observation satellite in crisis management.³⁷ This generation of satellites was preprogramed and placed in a specific orbit in order to take photographs over a particular region at a precise time to optimize the lighting on the targeted objective. With such constraints, it became very difficult to synchronize the passages of the satellite over different geographical locations and to ensure the surveillance of several regions of the world simultaneously.

Conversely, the images captured over the USSR by the *Corona* satellites allowed President Kennedy's advisers to monitor the alert level and the movements of adversarial forces. They were thus in a position to reassure the U.S. president that the Kremlin did not intend to trigger a war – which bolstered Kennedy in the conduct of his policy.³⁸

For their part, the Soviets also had reconnaissance satellites in orbit by the autumn of 1962 and appear to have resorted to *Cosmos-9* to evaluate U.S. movements, which was recovered on 1 October, followed by *Cosmos-10* (17-21 October).³⁹ However, no source allows for the precise determination of the use the Soviets made of the intelligence gathered by their reconnaissance satellites during this crisis. Given the problems with image resolution and cloud cover encountered by the US, the utility of such data remains questionable.

35. W. B. Ecker, K. V. Jack, *Blue Moon over Cuba: Aerial Reconnaissance during the Cuban Missile Crisis*, Oxford, Osprey Publishing, 2012.

36. J. W. Caddell, "[Corona over Cuba: The Missile Crisis and the Early Limitations of Satellite Imagery Intelligence](#)," *Intelligence and National Security*, Vol. 31, No. 3, 2016, pp. 416-438.

37. C. Peebles, *The Corona Project America's First Spy Satellite*, Annapolis, Naval Institute Press, 1997, p. 140.

38. E. R. May, "Strategic Intelligence and U.S. Security: The Contribution of Corona," pp. 21-28 (p. 26); and D. A. Day, J. M. Logsdon, B. Latell (eds.), *Eye in the Sky: The Story of the Corona Spy Satellites*, Washington D.C., Smithsonian, 1998.

39. C. Peebles, *The Guardians...*, *op. cit.*, p. 153.

Recognizing the importance of an observation satellite that could be utilized in the monitoring of crises, the CIA worked from 1963 onwards on a project for an “observation satellite endowed with a real-time image transmission capability.”⁴⁰ This technology relied notably on the research conducted within the framework of the USAF Samos program.

A Requirement that Becomes Crucial and Indispensable

The escalating tensions in the Middle East in 1967 pushed the U.S. to monitor this region closely. To this end, a *Corona* satellite had been in orbit since 9 May and conducted a 64-day mission. A KH-7 was launched on 4 June, the eve of the start of the Six-Day War, but its photographs were not usable on Earth until 30 June – nearly two weeks after the fighting had ended.⁴¹ President Lyndon B. Johnson then lamented the delay in retrieving the footage, which prevented the monitoring of troop movements on the ground and the ensuring of precise tracking of the conflict.⁴² This constituted the major problem that prevented the full utilization of the potential of reconnaissance satellites in crisis situations.

During the Prague Spring crisis in 1968, the U.S. monitored the activity of the Warsaw Pact forces. Intelligence agencies reported increasing concentrations of Soviet units near the Czechoslovak border from May onwards.⁴³ Although a Soviet intervention constituted the prevailing hypothesis from that date onward, analysts did not perceive signs suggesting immediate action.⁴⁴ A KH-8 was launched on 6 August, and its footage, recovered nine days later, revealed no significant changes. On 7 August, a KH-4B was placed into orbit, but the return of its capsule was not expected for another twenty days. The Director of the CIA, Richard Helms, was thus only able to inform President Johnson of the intervention by Warsaw Pact forces ten hours before they crossed the border, on the night of 20 to 21 August.⁴⁵ The satellite footage, when recovered several days later, revealed all the Soviet preparations indicating their next movements.⁴⁶ However, having arrived too late, this intelligence no longer possessed any value.

Far from discrediting the observation satellite program, these events pushed the CIA and the National Reconnaissance Office (NRO)⁴⁷ to strengthen their research on

40. R. Helms, *A Look Over My Shoulder: A Life in the Central Intelligence Agency*, New York, Random House, 2003, p. 264. The operational rationale for this project is also shared by the USIB to feed into its National Intelligence Estimates.

41. J. T. Richelson, *America's Secret Eyes in Space...*, *op. cit.*, p. 96.

42. D. A. Day, J. M. Logsdon, B. Latell, “Corona and the U.S. Presidents,” pp. 173-180 (p. 179); in D. A. Day, J. M. Logsdon, B. Latell (eds.), *Eye in the Sky...*, *op. cit.*

43. CIA-RDP80B01495R001300130019-7, CIA, Memorandum for the DCI: “[Post Mortem on Czech Crisis](#),” 22 November 1968.

44. M. Truong, “The CIA and Strategic Warning: The 1968 Soviet-Led Invasion of Czechoslovakia,” CIA, Langley, 2009, p. 7.

45. CIA-RDP80B01495R001300130019-7, *op. cit.*

46. J. T. Richelson, *America's Secret Eyes in Space...*, *op. cit.*, p. 98.

47. The NRO is an intelligence agency responsible for overseeing U.S. satellite programs and operations. It provides other major agencies in the intelligence community with information obtained from its sensors.

real-time satellite image transmission projects to provide early warning intelligence in the event of a crisis. These led to the funding of the first equipment testing programs in 1969.⁴⁸ For its part, following the failure of the Samos program, the USAF continued its research through the “Film Read-Out Gambit” (FROG) project, based on the KH-7 *Gambit* satellite.⁴⁹ This involved developing a system capable of digitizing images taken by the Gambit platform cameras with a laser. Simultaneously, from 1967, the NRO funded smaller programs in the hope that they could be completed more quickly. It specifically wished to acquire a real-time image transmission satellite to complement the KH-9 *Hexagon* satellites then under development. One of these was the “Spin Scan,” which was intended to be carried on a KH-9 as a sub-satellite and activated in case of need.⁵⁰

The rise in tensions between China and the Soviet Union once again highlighted the requirements for rapid data transmission. The Soviets increased their launches of photographic satellites and compensated for the constraints linked to film recovery by multiplying short missions (approximately eight days) to monitor Chinese army units. The photographs taken reassured the Politburo by showing that it was not a large-scale offensive.⁵¹ On the U.S. side, three KH-8 and two KH-4B satellites followed one another to cover the Sino-Soviet border and monitor the fighting. The conflict nonetheless highlighted the need for a satellite capable of ensuring very regular coverage of a zone during a crisis. The two satellite models that overflowed the zone, equipped with very precise cameras, had a narrow swath and therefore a wide interval between passes over the same area;⁵² this did not allow for the detection of brief events, nor for the ensuring of sufficiently regular surveillance over a specific point.⁵³

The October 1973 War: A Turning Point?

Competing with the more ambitious FROG (USAF) and ZAMAN (a CIA project that culminated in the KH-11) programs, the “Spin Scan” project was slow to materialize before ultimately being canceled. While the KH-9 *Hexagon* entered service in 1971, the United States still possessed no satellites capable of providing real-time imagery during a crisis. Such satellites nonetheless appeared to be the only means capable of regularly and securely providing intelligence, offering details on the intentions of a foreign country.

48. D. A. Day, “[The long road to near-real-time satellite reconnaissance: a chronology](#),” *The Space Review*, 9 June 2025.

49. D. A. Day, “[FROG: The Film Read Out GAMBIT program](#),” *The Space Review*, 7 February 2022.

50. D. A. Day, “[Spinning towards the future: crisis response from space](#),” *The Space Review*, 3 July 2023.

51. C. Peebles, *The Guardians...*, *op. cit.*, p. 159.

52. The swath corresponds to the actual width of the area captured in the image. The more precise the image capture device can produce, the narrower the swath. For satellites in near-polar orbits, the satellite’s trajectory appears to have a westward component due to the Earth’s rotation. This apparent movement of the satellite allows the sensor’s swath to observe a new region with each successive pass of the satellite. The narrower the swath, the longer the orbital cycle, thus increasing the monitoring interval of the covered area.

53. J. T. Richelson, *America’s Secret Eyes in Space...*, *op. cit.*, p. 101.

In the summer of 1973, during a meeting of the Washington Special Actions Group (WSAG) – which brought together the principal senior U.S. diplomatic and military advisers to discuss the evolution of the situation in Vietnam – Henry Kissinger, the National Security Adviser, raised the stakes regarding the absence of such a capability for U.S. security.⁵⁴ He discovered, to his astonishment, that satellites could not procure imagery intelligence capable of covering a crisis. A 30-day delay was required before a satellite could perform a pass over an area. Only three reconnaissance satellite launches were planned for the year (with a single satellite in reserve), while the KH-11 satellites, transmitting near-real-time images, were not expected before 1976.⁵⁵ Kissinger concluded with dismay: “But the conditions of an emergency can’t be programed. I am talking about one vehicle which we could launch in an emergency situation to take a look at it. Suppose there were a Middle East crisis. We don’t have a vehicle to send up. [...] I have nightmares about the danger of someone taking a run at us.”⁵⁶ His comments illustrate the importance that U.S. decision-makers attached to satellite imagery for managing crises during the Cold War.

After the sixth KH-9 (SV-6) returned its final capsule on 25 September 1973,⁵⁷ a KH-8 with high-resolution cameras was launched on the following 27 September. This was the only U.S. reconnaissance satellite in orbit when, on 6 October, a new Arab-Israeli war began. For their part, the Soviets had a satellite – *Cosmos-596* positioned in an orbit that allowed it to fly over the battlefield on the Golan Heights and the Sinai Peninsula. It returned to Earth only two days after its launch, and its photographs revealed heavy losses on both sides. Moscow then decided to launch an observation satellite every four to six days to maintain a satellite constantly over the region and thus recover images within a regular interval of a few days.⁵⁸ Caught off guard by the outbreak of the war, the NRO had the first photographic capsule of the KH-8 returned on 7 October. However, for lack of additional capabilities, an intelligence-gathering mission had to be carried out by an *SR-71* in order to obtain an accurate picture of the situation.⁵⁹ The second and final capsule of the KH-8 in orbit was retained, pending the launch of a new satellite. The latter, a KH-9 (SV-7) launched on 10 November, was only operational after the end of hostilities.⁶⁰

Alongside the problems encountered by the US, the Soviets compensated for the difficulties linked to film recovery delays by sending more satellites into orbit than

54. D. A. Day, “[Crisis in space: The 1973 Yom Kippur War and ‘crisis reconnaissance’](#),” *The Space Review*, 2 October 2023.

55. National Archives, Nixon Presidential Materials, NSC Files, NSC Institutional Files (H-Files), Box H-116, “[WSAG Meeting Minutes](#),” Originals, 1973. Top Secret; Sensitive; Codeword. The meeting was held in the White House Situation Room.

56. *Ibidem*.

57. NRO Archives FOIA, F-2022-00212_C05141839, Report for the Hexagon program satellite vehicle number six, 9 November 1973. The last capsule was recovered on September 25th and the satellite was deorbited on October 12th.

58. C. Peebles, *The Guardians...*, *op. cit.*, p. 161.

59. D. A. Day, “Crisis in space...,” *op. cit.*

60. “[Hexagon \(KH-9\) mapping camera program and evolution](#),” National Reconnaissance Office, 1982, pp. 349-351.

usual. They utilized those they had in reserve to obtain more frequent updates of their intelligence. This coverage of the Middle East was, moreover, complemented by an ELINT-gathering satellite launched at the beginning of October.⁶¹

The crisis highlighted once again the deficiencies of U.S. satellite coverage during events that could tip into a nuclear confrontation. Furthermore, the numerical inferiority of U.S. intelligence-gathering capabilities compared to those of the Soviets accentuated the need to deploy a reconnaissance satellite capable of supporting the United States' political posture during a crisis. In this regard, the October 1973 war represents a genuine turning point where the observation satellite emerged as an essential and indispensable tool for managing an international crisis with discernment. This episode reinforced the urgency of developing a satellite for image transmission to Earth by a means more suited to crisis management than capsules.

III – Indispensable Intelligence in Every Field

Despite the failures of the Samos program – a project for an observation satellite capable of transmitting its images by radio – the USAF and the CIA worked on projects for satellites capable of transmitting their footage in real-time from the mid-1960s onwards.⁶² These projects culminated in the launch of the first KH-11 in 1976. Being less technologically advanced in electro-optical sensors, the Soviets did not deploy their first satellite of this type until 1982 – designated “*Terilen*” or “*Yantar-4KS1*.”⁶³ With the increase in regional crises, this requirement for near-immediate image intelligence appeared as a necessity for political decision-makers as well as for military leaders.

An Instrument Ever More Indispensable for Ensuring National Security

Following the signing of the treaties resulting from the Strategic Arms Limitation Talks (SALT) between the United States and the USSR in 1972, the two countries mutually recognized the right to monitor their strategic arsenals with their “National Technical Means.”⁶⁴ This expression, agreed upon between the two parties, referred – without mentioning them publicly – to optical reconnaissance and electromagnetic intelligence satellites. It also provided the opportunity to maintain secrecy regarding the exact capabilities of each party's collection systems. The KH-9 “*Big Bird*,” the third of which was launched by the U.S. on 7 July 1972, was tasked with verifying the Soviets' compliance with the treaties and monitoring their military activity.⁶⁵

Its resolution allowed it to monitor the earthworks of Soviet missile sites, from which image interpreters extrapolated the technical capabilities of the ICBMs de-

61. CIA-RDP79T00936A011800010011-4, “[The President's Daily Brief](#),” 12 October 1973, p. 7.

62. D. A. Day, “[The long road to near-real-time satellite reconnaissance: a chronology](#),” *The Space Review*, 9 June 2025; D. A. Day, “[FROG: The Film Read Out GAMBIT program](#),” *The Space Review*, 7 February 2022.

63. B. Hendrickx, “[Soviet television reconnaissance satellites](#),” *The Space Review*, 5 September 2023.

64. C. Peebles, *The Guardians...*, *op. cit.*, p. 111.

65. J. T. Richelson, *America's Secret Eyes in Space...*, *op. cit.*, p. 112.

ployed there.⁶⁶ Analysts at the National Intelligence Photographic Center (NIPC) could also monitor the Warsaw Pact's conventional forces and the commissioning of new types of bombers – such as the *Tu-26* (the future *Tu-22M Backfire*). David Lindgren, a consultant to the CIA, even estimated that the Soviets were testing U.S. satellite imagery capabilities by operating at the limits of the capacities fixed by the treaties.⁶⁷ Ultimately, the intelligence gathered by satellites appeared as a means of safeguarding peace and proved indispensable for the conception and maintaining of arms control agreements – for both the U.S. as much as for the Soviets.⁶⁸

The United States also utilized satellites to intercept the signals from the missiles' onboard instruments during launch tests to determine their technical specifications. To optimize this type of intelligence gathering, they developed the Rhyolite program, specifically dedicated to the collection of telemetric data.⁶⁹ Thanks to this system, they could follow the evolution of Soviet launchers, almost in real-time, and even before they were declared operational. However, the Soviets eventually noticed this and began to jam emissions during tests, leaving U.S. analysts without data on the new R-36 missile (NATO code: SS-18). In order for the Soviets to agree to stop this jamming, President Carter was obliged to explain that the monitoring of these signals was fundamental to ensure the proper respect of arms control agreements and for the smooth progression of the SALT II negotiations.⁷⁰

However, satellite imagery could not help analysts to accurately estimate the number of nuclear warheads that the Soviets possessed. Satellite imagery could nonetheless be employed to extrapolate launcher capabilities and obtain an indication of the number of warheads that a single missile could carry.⁷¹ Nevertheless, the development of intermediate-range missiles, some of which were mobile, complicated the detection of these weapons.

The CIA was also interested in the development of radar satellites, given that cloud cover over the Soviet Union reduced the yield of photographs. In 1976, George H. W. Bush, then Director of the CIA, launched a program to develop a reconnaissance satellite capable of providing radar imagery, which culminated in 1988 in the launch of the first *Lacrosse* satellite.⁷² This system was capable of ensuring the surveillance of mobile missiles, which the Soviets moved by night to escape the KH-11, while also providing a solution for monitoring strategic targets despite cloud cover.

66. *Ibidem*, p. 110 and FOIA, DOC_0000969823, CIA, “[Intelligence report on the Soviet SS-11 force: role and strategic implications](#),” September 1973.

67. D. T. Lindgren, *Trust but Verify...*, *op. cit.*, p. 137.

68. A. Bateman, “Trust but verify: Satellite reconnaissance, secrecy and arms control during the Cold War,” *Journal of Strategic Studies*, Vol. 46(1), 2023, pp. 1-25.

69. C. Peebles, *The Guardians...*, *op. cit.*, p. 199; D. A. Day, “[Stealing secrets from the ether: missile and satellite telemetry interception during the Cold War](#),” *The Space Review*, 17 January 2022.

70. D. Lindgren, *Trust but Verify...*, *op. cit.*, p. 149; D. A. Day, “[Arms control and satellites: early issues concerning national technical means](#),” *The Space Review*, 10 October 2022.

71. A. Bateman, “Trust but verify...,” *op. cit.*, p. 21.

72. J. T. Richelson, *America's Secret Eyes in Space...*, *op. cit.*, p. 220 and 221.

Finally, the 1980s marked the establishment of satellite imagery as an indispensable means for monitoring the evolution of conventional and strategic arsenals. During this decade, the U.S. had on average at least two KH-11s in orbit, generally accompanied by a KH-8 and a KH-9, ensuring continuous surveillance of the USSR and crisis zones.⁷³

Toward a Broader Military Utilization

From the beginning of the 1960s, reconnaissance satellites were used by both the United States and the USSR to design target dossiers and strike plans of nuclear forces. Due to the technological limitations of early collection systems that utilized return capsules, this strategic planning mission remained the primary one for the armed forces. For this purpose, the U.S. notably collected intelligence on Soviet radars and surface-to-air defense sites through images captured by their reconnaissance satellites. However, this intelligence gathering was achieved primarily through their ELINT means.⁷⁴

The first project developed for this intelligence gathering was the GRAB (Galactic Radiation and Background) satellite series, developed by the U.S. Navy's research laboratory. The first of the series commenced its mission on 5 July 1960. Its data were mainly exploited by the National Security Agency and the SAC, despite it being initially a U.S. Navy program. The two GRAB satellites that reached orbit provided significant intelligence on Soviet air defense radars. These initial results encouraged the U.S. to pursue ELINT collection. They developed the POPPY program, the satellites of which were used between 1962 and 1977.⁷⁵ Alongside GRAB and POPPY, other programs were also launched, including the P-11, developed by the USAF from 1963.⁷⁶

The Vietnam War accentuated the requirements for electromagnetic intelligence. From 1968, the NRO's ELINT satellites were used to collect data on radars and surface-to-air defense sites in North Vietnam.⁷⁷ This information was cross-referenced with satellite imagery, despite the cloud cover that obscured much of Vietnam. For the first time, intelligence initially collected for strategic planning was used in the conduct of tactical operations.

At the end of 1972, within the framework of its operations to mine the port of Haiphong, the U.S. Navy wished to be able to observe the movements of Soviet

73. *Ibidem*, p. 199.

74. D. A. Day, "[The wizard war in orbit \(part 3\) – SIGINT satellites go to war](#)," *The Space Review*, 5 July 2016.

75. D. A. Day, "[A flower in the polar sky: the POPPY signals intelligence satellite and ocean surveillance](#)," *The Space Review*, 28 April 2008; R. L. Potts, "[History of the Poppy satellite system](#)," National Reconnaissance Office, 1978, pp. 4-7.

76. D. A. Day, "[Wizards redux: revisiting the P-11 signals intelligence satellites](#)," *The Space Review*, 7 September 2021.

77. "[The SIGINT Satellite Story](#)," National Reconnaissance Office, 1994, p. 114.

vessels heading toward that port.⁷⁸ However, none of the NRO's ELINT satellites had been initially designed for this type of research. The U.S. Navy's intelligence needs regarding the Soviet navy were therefore added to the missions of the POPPY program. From that moment, maritime surveillance became the primary mission of these satellites.⁷⁹ After 1977, the PARCAE satellites thus succeeded the POPPY series within the framework of the Naval Ocean Surveillance System.

The USSR, for its part, favored another solution by resorting to radar. However, this detector required energy that could only be provided by a nuclear reactor, complicating the realization of its Radar Ocean Reconnaissance Satellite (RORSAT). Its goal was to succeed in detecting the movements of vessels at sea and to provide targeting data for naval forces. This program was integrated into the Soviet Navy's doctrine, whose primary mission was to strike U.S. aircraft carrier groups with its missiles. The first RORSAT satellite was launched in December 1967 but only became truly operational in May 1974.⁸⁰ The exploitation of its data was carried out by the naval intelligence division of the GRU,⁸¹ which transmitted coordinates to surface forces and naval aviation through a communication network.

The Soviets also developed an ELINT collection capability from the beginning of the 1960s to monitor the evolutions of the air defenses of the Atlantic Organization countries in Europe and China. After conducting tests with small satellites carried as auxiliary payloads on the *Zenit* series, they launched the Tselina program, specifically dedicated to SIGINT collection⁸² and intended to track the adversarial electronic order of battle.

The principal obstacle to the use of satellite intelligence at the operational and tactical levels lies in its transmission within a sufficiently short timeframe to be usable. The launch on 19 December 1976 of the first KH-11, capable of retransmitting images to the ground in near real time, constituted a genuine capability breakthrough in this regard. It utilized electronic sensors (Charge-Coupled Devices – CCD) that transmitted digital data to the ground.⁸³ This method of operation led to an extension of the lifespan of satellites but, above all, freed analysts from their dependence on film returns, as with previous systems. With a constellation of several KH-11s, the U.S. was able to ensure more regular surveillance of crisis zones and the Soviet strategic arsenal.

This innovation also opened the use of satellite photography to other purposes, notably applied at tactical levels. The close advisers of President Ford (1974-1977)

78. D. A. Day, "[And the sky full of stars: American signals intelligence satellites and the Vietnam War](#)," *The Space Review*, 12 February 2018.

79. D. A. Day, "[Spybirds: POPPY 8 and the dawn of satellite ocean surveillance](#)," *The Space Review*, 10 May 2021.

80. C. Peebles, *The Guardians...*, *op. cit.*, p. 278.

81. Glavnoïe Razvėdyvatel'noïe Oupravlėniė, Soviet military intelligence.

82. B. Hendrickx, "Snooping on Radars..." *op. cit.* Unfortunately, there are very few sources on Soviet SIGINT satellites.

83. W. E. Burrows, *Deep Black: The Startling Truth behind America's Top-Secret Spy Satellites*, New York, Berkley Books, 1988, p. 243.

were, moreover, convinced that the use of satellite intelligence could revolutionize the way military operations were conducted by making armaments more effective.⁸⁴ However, the development of a system for transmitting data from satellites to terminals capable of processing these digital data was indispensable for the judicious use of this intelligence at the operational and tactical levels. The KH-11s were deployed in 1979 during the hostage crisis at the U.S. embassy in Tehran and to monitor the situation during the Soviet invasion of Afghanistan in December of the same year.⁸⁵ The lower resolution of the first KH-11s nonetheless encouraged the continued service of the KH-9 units, which carried capsules but whose optics produced more precise photographs.⁸⁶

Conclusion

During the Cold War, the U.S. and the Soviets developed means of satellite reconnaissance in order to acquire an early warning system. This was intended to be able to prevent a new strategic attack comparable to those that both countries suffered during the Second World War. Nuclear weapons, by considerably amplifying the consequences of a strategic surprise, spurred research into satellite programs. Political and military leaders viewed this new mode of intelligence gathering as the only one capable of fully guaranteeing national security. Similarly, the risk that a local crisis could escalate into a nuclear confrontation pushed political leaders to demand increasingly regular and precise surveillance, capable of following the slightest changes. This context, specific to the Cold War, was the primary catalyst for the evolution of reconnaissance satellites.

This strategic need, which was initially the sole data collection mission of satellites, gradually broadened as sensors and transmission means were perfected. SIGINT data collecting capabilities followed the same dynamic: strategic intelligence needs for the SAC (Security Action Center), the U.S. Navy, and the Soviet Navy drove the launch of the first programs, before their scope was broadened in light of their successes. However, as Agathe Rabant highlights in her dissertation, the United States and the USSR became highly dependent on satellite intelligence, with risks of an imbalance in data collection. Satellite intelligence was favored over other sources, which could lead to biases in its use.⁸⁷

In the field of International Relations, historian John Lewis Gaddis pursues the idea that reconnaissance satellites played a decisive role in easing relations between the U.S. and the Soviets during the Cold War.⁸⁸ Wawrzyniec Muszyński-Sulima ex-

84. A. Bateman, "Trust but verify...", *op. cit.*, p. 19.

85. A. Rabant, "Le renseignement satellitaire américain et soviétique dans la Guerre froide (1957-1979)," *Master's thesis* under the supervision of Olivier Forcade, Sorbonne Université, Paris, 2025, p. 91 and 93.

86. C. Peebles, *The Guardians...*, *op. cit.*, p. 119.

87. A. Rabant, "Le renseignement satellitaire américain...", *op. cit.*, p. 69.

88. J. L. Gaddis, *Long Peace: Inquiries into the history of the Cold War*, New York, Oxford University Press, 1987, p. 216.

plains, for his part, that technological intelligence-gathering capabilities contributed to a detente in relations between the two Great Powers by dispelling unknowns about each other's military and nuclear potential.⁸⁹ By dispelling the uncertainties of political leaders concerning the strategic forces of the adversary and the evolution of crises, reconnaissance satellites contributed to establishing a climate of stability.⁹⁰

Nevertheless, from the 1980s onwards, they became tools of power, whether to guarantee the status quo of a situation or to influence a country deprived of such intelligence-gathering capabilities. The Soviet surveillance of the South African military nuclear program in 1977 sufficiently intrigued Moscow for it to contact Washington via its embassy to transmit the data that one of its reconnaissance satellites had captured over the Kalahari Desert.⁹¹ On the other hand, the U.S. used their reconnaissance satellites to track the evolutions of the French nuclear program after 1960.⁹²

In another situation, the United States transmitted their intelligence gathered by satellites on Libyan forces in Chad to support France during Operation Manta (1983) until President François Mitterrand's policies diverged from U.S. interests.⁹³ Moreover, this episode demonstrated to the French president the necessity of possessing this capability in their own right in order to conduct a sovereign and independent foreign policy. The importance of satellite intelligence-gathering capabilities was definitively demonstrated during the Gulf War in 1991. Thanks to their transmission systems, the U.S. was capable of utilizing the data gathered by their various satellites at the tactical level and in near-real-time.⁹⁴ The diversity of satellite intelligence-gathering means contributed to the smooth conduct of operations.

89. W. Muszyński-Sulima, "Cold War in Space...", *op. cit.*, p. 15.

90. J. Lewis Gaddis, *Long Peace...*, *op. cit.*, p. 233.

91. C. Gelibter, "Renseignement et politique...", *op. cit.*, p. 339.

92. J. T. Richelson, *Spying on the Bomb: American Nuclear Intelligence from Nazi Germany to Iran and North Korea*, New York, W. W. Norton & Company, 2006, p. 212.

93. B. Colom-y-Canals, "Le renseignement aérien en France 1945-1994," *PhD dissertation* under the supervision of Olivier Forcade, Université Paris IV, Paris, 2016, p. 440 and 441.

94. J. P. Coyne, *Airpower in the Gulf*, Arlington, Air Force Association, 1992, p. 121; V. Rousset, *La guerre à ciel ouvert. Irak, 1991*, Vincennes, Addim, 1996, p. 127.

OPERATIONAL ASPECTS

The Public Release of Defense Space Strategies: Lessons and Outlook

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Space strategy seems poised for a bright future. Although still lacking a firm theoretical definition,¹ it is now taking shape on a substantially renewed empirical base. For observers who have long lamented the lack of historical experience and practices to inform their analyses, particularly in comparison with other domains, the recent proliferation of official strategic documents offers an unprecedented body of material.

The phenomenon – whose main stages are outlined in the table below – originated in the Euro-Atlantic area, which is the focus of this paper. It has given rise to a new type of “strategic review,” like France’s 2019 *Space Defense Strategy*. These reviews translate, specifically within the space domain, the orientations often defined in broader framework documents such as France’s 2017 *Defense and National Security Strategic Review*. In some cases, they delegate the clarification of doctrinal and capability aspects to other documents or works, the Multi-Year Military Programming Law (Loi de programmation militaire, LPM) being one example. This trend is also reflected in the establishment of specialized organizations – such as France’s Space Command (Commandement de l’Espace, CDE) –, which embody these strategies, concentrate national military space expertise, and implement their governments’ ambitions.

1. See J. J. Klein, *Fight for the Final Frontier: Irregular Warfare in Space*, Annapolis, U.S. Naval Institute, 2023; B. E. Bowen, *War in Space: Strategy, Spacepower, Geopolitics*, Edinburgh University Press, 2023; J. J. Klein, *Space Warfare: Strategy, Principles and Policy*, 2nd edition, London, Routledge, 2025.

Country / Organization	Date	Origin	Document	Date	Structure
NATO	2019	Member countries	<i>Overarching Space Policy</i> (declassified in 2022)	2020	NATO Space Center
France	2019	Ministry for the Armed Forces	<i>Space Defense Strategy</i>	2019	French Space Command (CDE)
Italy	2019	Presidency of the Council of Ministers	<i>National Security Strategy for Space</i>	2019 2020	Space Policy Office Space Operations Command
USA	2020	US Department of Defense	<i>Defense Space Strategy</i>	2019 2020	US Space Command US Space Force
Portugal	2021	Ministry of National Defense	<i>Estratégia da Defesa Nacional para o Espaço 2020-2030</i>	/	/
Combined Space Operations	2021	Participating countries (Germany, Australia, Canada, United States, France, New Zealand, United Kingdom)	<i>Vision 2031</i>	/	/
United Kingdom	2022	Ministry of Defence	<i>Defence Space Strategy: Operationalizing the Space Domain</i>	2021	UK Space Command
Canada	2022	Royal Canadian Air Force (RCAF)	<i>RCAF Strategy for Space Mission Assurance</i>	2022	3 Canadian Space Division
Australia	2022	Department of Defense	<i>Defense Space Strategy</i>	2022	Defense Space Command
Luxembourg	2022	Ministry of Foreign and European Affairs, Directorate of Defense	<i>Defense Space Strategy</i>	/	/
Netherlands	2022	Ministry of Defense	<i>Defense Space Agenda</i>	2022	Defense Space Security Center
Spain	2022	Air and Space Force	<i>Estrategia Espacial del Ejército del Aire y del Espacio</i>	2024	Mando del Espacio
South Korea	2022	Ministry of National Defense	<i>National Defense Space Strategy</i>	2021	Space Operations Command
Japan	2023	Space Development Strategy Headquarters	<i>Space Security Initiative</i>	2020	Space Operations Group
European Union	2023	Member states, based on a joint proposal from the European Commission and the EEAS	<i>EU Space Strategy for Security and Defense</i>	/	/
Sweden	2024	Ministry of Defense	<i>Defense and Security Space Strategy</i>	/	/
Germany	2025	Federal Ministry of Defence and Federal Foreign Office	<i>Space Safety and Security Strategy</i>	2021	Bundeswehr Space Command

Far from losing momentum in 2025, the trend is expected to grow and to diversify geographically.² It should also be extended, within a shorter or longer timeframe, depending on the country, through a second generation of documents, intended at minimum to keep pace with the political, media and administrative tempo characteristic of this kind of exercise. These may take the form of adaptations, updates or interim progress reviews of their implementation.³ And for a good reason: Space, and space for defense even more so, has historically been organized in most countries around one or more specialized communities working in closed circles and separating “those who know and do not speak” from “those who speak and do not know.” However, today’s public disclosure of space strategies gives public debate and other stakeholders an unprecedented opportunity for engagement and participation.

The exercise clearly follows broader logics⁴ and also finds parallels in other specialized domains.⁵ It is most often structured around cross-government efforts to define a space strategy as an instrument of global power, extending beyond the strict confines of defense.⁶ Nevertheless, it appears here as characteristic of three transformations:

- 1/ Although the process is unfolding at different stages across countries, this type of exercise reflects emerging awareness of the opportunities, threats and challenges associated with space. This domain is now recognized as a new theater of conflict, warranting substantial adaptation efforts.
- 2/ In the face of attempts at disinformation or manipulation, and for the purposes of both internal and external communication, the exercise illustrates

2. The table presented here, organized according to the main criterion of publishing a dedicated defense or security space strategy, is not exhaustive. Some countries have established specialized organizations with various responsibilities without yet producing an official strategy document. This is the case of India, which created a Defense Space Agency in 2019, and Peru, which has operated a *Comando Espacial y Ciberspacial* since 2023. In other instances, relevant content may already be incorporated – more or less concisely – into overarching strategies, framework reviews or doctrinal documents, without the need for a dedicated approach. Strategies may also still be under development or awaiting formal approval. Germany, for example, which has relied on the Bundeswehr Space Command since 2021, announced in its 2023 *National Security Strategy* its intention to publish a *Space Security Strategy* focused on protection and defense, resilience and military space operations. This commitment was finally fulfilled in November 2025. For a comprehensive overview, subject to state contributions, see the “[Space Security Portal](#)” of the United Nations Institute for Disarmament Research (UNIDIR).

3. For example, see U.S. Department of Defense, [Space Policy Review and Strategy on Protection of Satellites](#), September 2023, whose publication is primarily intended to meet legal and regulatory obligations imposed by the U.S. Congress.

4. É. de Durand, “Planification de défense : la belle Arlésienne ?,” pp. 479-498; in S. Taillat, J. Henrotin, O. Schmitt, *Guerre et stratégie : Approches, concepts*, Paris, Presses universitaires de France, 2015.

5. Including cyberspace, the seabed, artificial intelligence, and higher airspace.

6. See, for example, the [National Space Strategy](#) made public by the British government in September 2021, the [United States Space Priorities Framework](#) and [Strategic Framework for Space Diplomacy](#), respectively released by the White House and the U.S. Department of State in December 2021 and May 2023, or the [German Federal Government’s Space Strategy](#) published in September 2023 by the German Ministry for the Economy. France also released in November 2025 a *National Space Strategy 2025-2040* setting out the objectives defined in the [National Strategic Review 2025](#).

the need to make even a minimal effort to provide explanations and ensure transparency, in order to secure the support of parliaments, national opinion and the international community.

3/ In today's increasingly challenging strategic context and in response to a general lack of familiarity with and cultural adaptation to the space environment, this process ultimately reflects the need to improve strategic understanding among political and military decision-makers and to prepare mindsets.

This paper therefore sets out to provide a concise overview of national space strategies for defense and security. It draws on official documents published by Western countries, because they are emblematic and comparable, representative texts from other actors are largely unavailable. While acknowledging the specific nature of the exercise, which is anchored in its temporal context, governed by specific codes as an instrument of public diplomacy, and subject to requirements and constraints that vary from one country to another, the aim here is to analyze the content of these strategies in order to identify areas of convergence, highlight potential tensions and propose future prospects.

1/ Five Shades of Strategic Competition

Recognition of the rapidly evolving strategic context of today's space environment is the stated starting point behind the current wave of dedicated defense reviews. Being a means of formulating an inherently political position, the related "awareness-raising" exercise obviously does not aim to provide an "objective" analysis of the situation in the scientific sense of the term. Rather, it seeks to renew understanding of the challenges involved and to build a new consensus by facilitating dialogue among the various stakeholders. It also serves to justify to political authorities and public opinion the urgent need to adapt security and defense policies, while simultaneously promoting certain actions to third parties – partners and competitors alike. While the descriptive content may vary according to the tone or priorities of each document, it is interesting to note that official strategies generally converge in defining Space as a domain shaped by five major, structuring, and mutually reinforcing tensions.

Contested Space

In recent years, Space has witnessed a multiplication of behaviors that, at best, can be described as "ambiguous," "unfriendly," "dangerous," "hostile" or even "irresponsible." The Netherlands notes that "threats in and from Space have increased."⁷ The member states of the European Union (EU) emphasize that "irresponsible and hostile behaviors in the space domain have intensified in recent years, increasing the risk of spillover effects upon European citizens, organizations, industries, and businesses."⁸ In addition to becoming more widespread, this trend is also accelerating

7. Ministry of Defense, *Defense Space Agenda*, 25 November 2022, p. 25.

8. General Secretariat of the Council, *Council Conclusions on the EU Space Strategy for Security and Defense*, 14512/23, Brussels, 13 November 2023, p. 5.

under pressure from ill-intentioned actors, whose public identification is handled differently and selectively from one country to another.⁹

These developments mark the end of a certain vision of Space as a relative “sanctuary.” Western countries that were capable of controlling it could once use it freely, as a military enabler, or even as a genuine differentiator of power.¹⁰ They now recognize that Space has become an “increasingly contested domain” – a concept that originated in the United States in the mid-2010s, has since been gradually adopted by all actors, and was formally endorsed by the EU in 2022.¹¹ France, for its part, more readily speaks of Space as an “area of possible confrontation,”¹² while the United States has fully embraced the idea of space as a “warfighting domain.”¹³

Whatever terminology is used, two inseparable characteristics are generally associated with the emergence of what is commonly referred to as “counterspace.” Firstly, the behaviors in question span the full spectrum of possible modes of action, whether from the ground or in space. Their effects may be reversible or irreversible – anti-satellite missile tests, proximity maneuvers in orbit, covert deployments, jamming, dazzling, cyberattacks, and so on. As Luxembourg notes in its *Defense Space Strategy*, “[t]he range of threats to satellites continues to grow, from neutralization to complete destruction.”¹⁴

Secondly, these activities deliberately play on “threshold effects” by provoking and exploiting dilemmas of interpretation – how to track, detect and attribute ambiguous actions – and of reaction – how to respond to actions that remain below the threshold of retaliation and open conflict. They are in fact fully integrated into the range of tools used for strategic signaling, intimidation, the imposition of *faits accomplis*, denial of access and even coercion. As Australia notes, “grey-zone activities in Space represent a complex threat for Defense because they can exploit shortcomings in international legal frameworks and, as a result, constrain or delay response options.”¹⁵

Space as an Operational Domain

“Contested” Space can be seen as a consequence of the growing dependence of both Western societies and armed forces on space systems. As noted in the UK

9. See, for example, Defense Intelligence Agency, *Challenges to Security in Space: Space Reliance in an Era of Competition and Expansion*, 12 April 2022, which is particularly representative of the maximalist approach – explicitly citing China, Russia, Iran and North Korea.

10. B. R. Posen, “*Command of the Commons: The Military Foundation of U.S. Hegemony*,” *International Security*, Vol. 28, No. 1, summer 2003, pp. 5-46.

11. General Secretariat of the Council, *A Strategic Compass for Security and Defense – For a European Union that protects its citizens, values and interests and contributes to international peace and security*, 7371/22, Brussels, May 21, 2022. Also see Joint Communication of the European Commission and the High Representative of the Union for Foreign Affairs and Security Policy, *EU Space Strategy for Security and Defense*, JOIN(2023), Brussels, 10 March 2023.

12. French Ministry for the Armed Forces, *Space Defense Strategy*, 25 July 2019, p. 24.

13. U.S. Department of Defense, *Defense Space Strategy Summary*, 17 June 2020, p. 3.

14. Ministry for Europe and Foreign Affairs, Defense Directorate, *Defense Space Strategy*, 28 February 2022, p. 15.

15. Department of Defense, *Australia's Defense Space Strategy*, 2022, p. 10.

Defense Space Strategy, “adversaries understand our reliance on space services and [...] are increasingly able to exploit the vulnerability of satellites [...] threatening our strategic stability and security.”¹⁶

This dependence, although synonymous with vulnerability, should not lead to renunciation. However, to be accepted, it requires an awareness of the advantages it provides and the opportunities it creates. This point has been recognized by Japan, which aims to “radically expand” its use of space systems for national security.¹⁷ The same is true for Germany, which, in its *National Security Strategy*, now expresses its intention to embrace the “strategic dimension” of Space, which has become indispensable for many spheres of civilian life and increasingly significant for the armed forces.¹⁸ Here, Berlin follows in the footsteps of NATO, which, as early as 2019, declared Space as an operational domain, on a par with the traditional ones. The Alliance has made its integration a priority across its core tasks and in all its operations, missions and other activities.¹⁹ The EU has also set the example, issuing a similar statement in November 2023.²⁰ It has formally acknowledged the potential offered by satellites for security and defense and stated its intention to make fuller and more effective use of its dual-use space program.²¹

This general effort by Western states to reassert the fundamental role of space systems is illustrated by the widespread revival of investment aimed at strengthening, modernizing and renewing capabilities in areas such as communications, navigation and intelligence.²² It is also reflected in the creation of specialized organizations responsible for conducting “military space operations.” These entities are tasked with ensuring the availability and responsiveness of the various resources and guaranteeing their effective integration into the armed forces, in support of the various governmental authorities and from a multi-domain perspective. Finally, this effort is leading to actions to enhance coordination and interoperability at the inter-allied level.²³ The Combined Space Operations (CSPO) initiative, for example, brings together Australia, Canada, France, Germany, Italy, Japan, New Zealand, Norway, the United Kingdom and the United States. The British strategy thus underlines the importance of “integration between do-

16. Ministry of Defense, *Defense Space Strategy: Operationalizing the Space Domain*, 1 February 2022, p. 11.

17. Space Development Strategy Headquarters, Prime Minister’s Office, *Space Security Initiative*, June 2023, p. 8.

18. Federal Government, *Robust. Resilient. Sustainable. Integrated Security for Germany. National Security Strategy*, 2023, p. 62. See also Federal Ministry of Defence and Federal Foreign Office, *Space Safety and Security Strategy*, November 2025.

19. North Atlantic Treaty Organization, *NATO’s overarching Space Policy*, January 2022.

20. General Secretariat of the Council, *Council Conclusions on the EU Space Strategy for Security and Defense*, *op. cit.*, p. 6.

21. *Ibidem*, pp. 16-22.

22. A spectacular example of this trend being Germany’s commitment to invest 35 billion euros over 2030 on military space capabilities. See “[Pistorius: Russia and China are our direct neighbors in space](#),” 25 September 2025 (in German)

23. U.S. Space Force, *International Partnership Strategy: Strength Through Partnership*, 3 July 2025.

mains and across Defence, and across government, with international partners and the commercial, research and scientific sectors.”²⁴

However, this effort is neither unique nor confined to Western countries. Similar initiatives are being pursued by nations such as Russia and China, which until now have since accustomed to predominantly asymmetric strategies. Without this being regarded as incompatible, they are now reassessing the benefit, relevance and feasibility of better integrating space capabilities into their own operations. According to NATO, “potential adversaries are increasing their own use of space, thereby extending their ability to project power over greater distances, with increased precision, speed and effectiveness.”²⁵ This process of learning and catching up is variable. It is particularly marked in the case of China, which today possesses the second largest satellite fleet in the world. Beijing would even appear to hold a dominant position in the field of space-based observation systems, an area in which the United States fears a risk of being overtaken, is concerned about the threats facing its armed forces and questions its ability to counter these developments.²⁶

Transformed Space

These changes are also occurring in a dynamic environment where historical balances and hierarchies of power are being disrupted by the rise of “New Space.” While the disruptive potential of this sector has long been recognized,²⁷ the awareness of its implications for security and defense has emerged more recently. Yet, the consequences are ambivalent. As France notes:

“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.”²⁸

The technological and industrial transformations currently underway are indeed opening up new prospects for the exploitation of orbits. They enable an accelerated development of capabilities and expertise, which, if properly managed, could allow certain countries to catch up. For many states, and even international organizations such as NATO and the EU, this potential argues in favor of developing dedicated sub-strategies.²⁹ It also justifies internal reorganizations, including the establishment of specific entities tasked with accelerating defense innovation, harnessing innovation from the civilian sphere and facilitating access to technologies developed in the commercial sector. Finally, this potential is prompting a multiplication of “syner-

24. Ministry of Defence, *Defence Space Strategy: Operationalizing the Space Domain*, op. cit., p. 16.

25. North Atlantic Treaty Organization, *NATO's overarching Space Policy*, op. cit.

26. U.S. Department of Defense, *Space Policy Review and Strategy on Protection of Satellites*, op. cit., p. 2 and pp. 10-11.

27. As an example, Communication of the European Commission, *Space Strategy for Europe*, COM (2016)705, Brussels, 18 October 2016.

28. French Ministry for the Armed Forces, *Space Defense Strategy*, op. cit., p. 9.

29. U.S. Department of Defense, *Commercial Space Integration Strategy*, 2 April 2024; NATO, *Commercial Space Strategy*, June 2025.

gies” and collaborations with the commercial sector, with the aim of rebalancing capability mixes and developing new contractual relations and “trusted” partnerships.³⁰

Yet these transformations also trigger fears of falling behind, as they maintain, or even widen, the technological, operational and strategic gap between the most advanced powers and the rest of the world. This risk, which could even materialize between partners and allies, is particularly illustrated by the unprecedented and radical effort underway to transform the satellite architectures inherited from the Cold War. While the constellation venture has so far been punctuated with failures, the unlimited investment capacities and technological advances in the New Space sector are starting a veritable “race for resilience.” Relying particularly on numbers and redundancy to ensure the survivability and continuity of space services, the objective is to complicate adversaries’ counterspace calculations and to rebalance the highly unfavorable offensive/defensive ratio in the space domain – characterized by its vastness, hostility, extreme fragility and deep asymmetries of reliance. The prospect of these massive projects reaching completion in the United States and China, respectively by the end of this decade and the middle of the next, also raises questions about space traffic management. They underscore the exposure of the most heavily used orbits to the risks of collision, “chain reaction” debris events (Kessler syndrome) and the saturation of limited strategic resources (frequencies and orbital slots). In so doing, these new “proliferated” architectures raise concerns about a de facto territorialization of Space, restricting freedom of access and use of space on a “first come, first served” basis. Furthermore, they offer vast potential for strengthening conventional capabilities – reinforcing and accelerating operational cycles, particularly in targeting – but with the risk of entering a new cycle of countermeasures and retaliation, or even an uncontrolled escalation to extremes.³¹

Expanding Space

Official strategies generally limit their scope to Earth’s orbits, typically divided into low Earth orbit (LEO), medium Earth orbit (MEO) and geostationary orbit (GEO). France’s *Space Defense Strategy* is very clear on this point: “Until around 2040, near space is likely to be the area of particular interest for the armed forces.”³²

They nonetheless underline the need to adopt a dynamic approach consistent with the very concept of military space operations. Such an approach may be motivated by the need to diversify dependencies, minimize the risk of surprise, or achieve strategic circumvention by exploiting new and emerging areas of competition. Such exploitation would take place across the various historical orbital zones and in interaction with other operational domains. As Japan notes, “the scope of space security is likely to expand beyond earth orbit to the region between the Earth and the Moon (cis-lunar

30. French Ministry for the Armed Forces, *Space Defense Strategy*, *op. cit.*, p. 31.

31. W. J. Hennigan, “[The Warning: What One Russian Satellite Tells Us About the Threat of Nuclear Weapons in An Unstable World](#),” *The New York Times*, 5 December 2024.

32. French Ministry for the Armed Forces, *Space Defense Strategy*, *op. cit.*, p. 14.

region),”³³ while France calls for a better understanding of “the operational ambitions for higher airspace operations”³⁴ and a deeper analysis of the requirements related to spaceplanes.³⁵ The United States, whose corpus of public documents supplementing its strategic review is the most extensive, notes that “the entirety of economic and military space activities is confined to the geocentric regime; however, commercial investments and new technologies have the potential to expand the reach of vital National space interests to the cislunar regime and beyond in the near future.”³⁶ It also warns of the operational risk of “defining space based on a lower physical boundary [that] neglects the domain’s vast expanse and dynamic character.”³⁷

The strategies also converge on the idea that the other components of a space system, particularly the ground segment, including ground stations and command and control centers, should be taken into account. Two main trends can be observed in this regard. The first involves shrinking the terrestrial footprint, either by restricting the use of uncontrolled infrastructure and reducing the associated vulnerabilities (for example, repatriating facilities to controlled territory or routing data via inter-satellite links, etc.), or by creating an in-orbit “data transport layer” to accelerate the decision-making cycle and thus improve operational support. Although these new proliferated architectures may not be accessible to all, they represent an opportunity to be seized. The other trend, which seems contradictory, consists of densifying and consolidating a ground network spread across the entire planet. This process is unfolding in a context where ground infrastructure is integral to the overall performance of a space program, in terms of coverage, responsiveness and resilience. It also coincides with the expansion of space – and counterspace – capabilities. Norway, Sweden and Australia, which each leverage their geographical assets, particularly as an advantage in relations with their partners, are striking examples of this second trend. Sweden, with its unique sites for satellite launches (Esrange space center) and for monitoring and operations (Kiruna station), highlights the potential benefits of its geographical proximity to the Arctic Circle for the space operations of its partners.³⁸

Manipulated Space

In this context of profound transformation, stakeholders lack the points of reference they need to guide their actions. According to the U.S. Department of Defense, not only does it have “limited operational experience with conflict beginning in or extending into space,” but “international understanding and agreement of what

33. Space Development Strategy Headquarters, Prime Minister’s Office, *Space Security Initiative*, *op. cit.*, p. 2.

34. Journal officiel de la République française (Official Journal of the French Republic), *Loi n°2023-703 du 1er août 2023 relative à la programmation militaire pour les années 2024 à 2030*, p. 37.

35. *Ibidem*, p. 44.

36. U.S. Space Force, *Spacepower: Doctrine for Space Forces*, Space Capstone Publication, June 2020, p. 14. See also U.S. Space Force, *Space Force Doctrine Document – I: The Space Force*, April 2025, p. 20.

37. U.S. Space Force, *Spacepower*, *op. cit.*, p. 10.

38. Ministry of Defense, *The role of space in a new security situation: Sweden’s defense and security strategy for space*, July 2024, p. 12 and p. 37.

constitutes unsafe, irresponsible, or threatening behavior in space is nascent.”³⁹ The CSPO participating countries similarly note that the current situation of disruption, which in itself heightens the risk of miscalculation, is compounded by “the lack of widely accepted norms of responsible behavior and historical practice.”⁴⁰ Hence their support for the initiatives launched by the United Kingdom in multilateral fora to “reduce space threats and ensure continued access to the space domain.”⁴¹

At the same time, since states lack proven coordination mechanisms and appropriate channels of communication, some deliberately adopt opaque postures. These naturally run counter to the efforts made by those who publish their strategies in order to promote transparency and confidence and contribute to “clarifying intents.”⁴² In these circumstances, it becomes highly tempting to exploit or manipulate a right that is widely regarded as “free,”⁴³ whether to justify one’s own activities, denounce those of others or influence practices and ultimately achieve strategic objectives. Russia and China never miss an opportunity to condemn official strategies that define Space as an operational domain or envisage it as a possible theater of military confrontation.⁴⁴ Both countries reject the urgency of establishing “norms of responsible behavior,” which they also accuse of serving as instruments of discrimination and domination. In their view, such documents are destabilizing, since they amount to accepting, or even justifying, the inevitability of conflict in Space.

Since 2008, Moscow – supported by Beijing – has promoted a draft legally-binding treaty to prohibit the placement “of weapons in Outer Space.” This initiative, supplemented since 2014 by the political undertaking not to be the first to deploy such weapons, has consistently faced opposition from Western countries, as reflected in their strategic reviews. In France, the initiative has raised questions regarding its “effectiveness [...], especially the difficulty of defining what constitutes a weapon in space and monitoring the enforcement of rules on non-deployment.”⁴⁵ Its obvious shortcomings – evidenced by Russia’s destructive ground-based anti-satellite test against one of its own satellites in November 2021⁴⁶ – and the persistent contradiction between its declared diplomatic positions and the activities observed in orbit – including, according to the United Kingdom, Moscow’s deployment of systems and subsystems that “may have a destructive capability”⁴⁷ and, as mentioned by several

39. U.S. Department of Defense, *Defense Space Strategy Summary*, op. cit., p. 4.

40. Combined Space Operations, *Vision 2031*, February 2022.

41. Ministry of Defence, *Defence Space Strategy: Operationalizing the Space Domain*, op. cit., p. 13.

42. General Secretariat of the Council, *Council Conclusions on the EU Space Strategy for Security and Defense*, op. cit., p. 7.

43. French Ministry for the Armed Forces, *Space Defense Strategy*, op. cit., p. 16.

44. See the discussions held from 2022 to 2023 alongside the Conference on Disarmament within the framework of the open-ended working group on reducing space threats through norms, rules and principles of responsible behaviors: Office for Disarmament Affairs, “[Open-Ended Working Group on Reducing Space Threats](#),” United Nations.

45. French Ministry for the Armed Forces, *Space Defense Strategy*, op. cit., p. 29.

46. General Secretariat of the Council, *Council Conclusions on the EU Space Strategy for Security and Defense*, op. cit., p. 5 and pp. 25-26.

47. Ministry of Defense, *Defense Space Strategy: Operationalizing the Space Domain*, op. cit., p. 11.

actors, including French President Emmanuel Macron, “Russian particularly shocking threat of nuclear weapons in space”⁴⁸ – have cast doubts on Russia’s sincerity. They have done little more, moreover, to strengthen its credibility.

2/ Varying Approaches to Deterrence

Not all of the documents discussed are of equal merit. The aim here is not to distinguish between “good” and “bad” strategies, which would be meaningless, but rather to emphasize that strategic thinking is primarily determined by its “starting point”⁴⁹ and that publicly released documents do not necessarily share the same objective. Despite numerous points of convergence, these strategies have been developed by actors positioned differently within the international environment and their own administrative-political ecosystems, leading to diverging assessments of the nature and utility of the public exercise being undertaken. Thus, these strategies reflect varying interests, constraints and limitations. Most remain at an initial stage of defining responses to the challenges faced. Others, however, stand out for their more assertive ambitions, revealing not only the ability to conceive of Space as a source and vector of power (spacepower), but also the goal of influencing the strategic calculations of other powers.

“Win the War Before the War”: Deterring the Adversary

The first major point of divergence – and a source of tension – concerns the extent to which the various strategies acknowledge that the worsening situation is part of a long-term structural trend requiring adaptation. This effort entails recognizing changes that are beyond our control. It should not, however, lead to the passive acceptance of this “new normal” (with the risk of trivialization), but rather to demonstrating willingness to seize every opportunity to safeguard one’s interests through deterrence.

From this perspective, adaptation must be twofold. Faced with the multiplication of ambiguous behaviors, the first objective is to avoid creating zones of impunity for the actors who engage in them. The strategic effects of such actions, even when conducted in peacetime, could create precedents. France’s *Space Defense Strategy* provides the most advanced example of what could be described as a “deterrence posture” (posture de découragement). It set out the guidelines that France will follow in response to acts deemed “unfriendly,” “wrongful” acts perpetrated against it, or in the event of “armed aggression.”⁵⁰ It expresses the ambition to develop a range of appropriate “active defense” capabilities, in addition to other instruments (declarations, diplomacy, economic levers, partnerships, etc.) to defend its interests.⁵¹ It also under-

48. [Discours du Président de la République sur la stratégie spatiale nationale depuis le Commandement de l’espace à Toulouse](#), 12 November 2025 (in French).

49. L. Freedman, *Strategy: A History*, Oxford, Oxford University Press, 2013, p. xi.

50. French Ministry of the Armed Forces, *Space Defense Strategy*, *op. cit.*, pp. 28-29.

51. *Ibidem*, p. 42.

lines that these interests are not limited to French military satellites alone.⁵² Finally, it signals France's determination not to allow hostile actions to go unanswered, to respond in an appropriate and proportionate manner, and ultimately to "win the war before the war."⁵³

Faced with the risk of escalation, the next objective is to avoid confrontation in Space, a domain in which Western countries could find themselves at a disadvantage against competitors who are less dependent on satellites for their security and prosperity. The most complete official articulation of this reasoning is arguably found in the "competitive endurance" approach developed by the U.S. Space Force in 2023. Presented as an "operational hypothesis", "below the threshold of open conflict,"⁵⁴ it underlines the dilemmas facing Space-dependent actors targeted by asymmetric strategies: "Our adversaries must never be desperate enough or emboldened enough to pursue destructive combat operations in space. The goal [...] is to achieve space superiority when necessary while also maintaining the safety, security, stability, and long-term sustainability of the space domain."⁵⁵

Si Vis Pacem, Para Bellum: Accepting the Risk of Escalation

The relationship to escalation is precisely the second source of tension that emerges from an analysis of the documents. The challenge lies in defining and sharing tolerance thresholds for acts of concealment, destabilization and intimidation. Managing escalation refers to the defender's ability – while remaining mindful of the risk of build-up – to accept to engage in a power struggle when red lines are crossed and, if necessary, to move into a new phase of strategic competition to counter an adversary who has underestimated their resolve. Here, the risk lies in leaving the initiative to the adversary. Overall, official strategies address the question of "managing escalation" primarily from the angle of example and restraint – to increase the political cost of any hostile action and facilitate its condemnation – or cooperation – to show that any attack against one actor is an action against several. These approaches are, it is true, within reach of all actors and represent essential components of the strategic review process. Resilience through numbers – to demonstrate the capacity to absorb an attack and convince the adversary that it will not achieve its goal –, is also a recurring theme. While difficult and costly to implement from a capability standpoint, and by definition a long-term endeavor, it can nonetheless be developed through cooperation and commercial partnerships.

For these tools to be credible, they must form part of a broader, integrated approach that combines not only diplomatic, economic and informational measures,

52. *Ibidem*, p. 28.

53. French Defense Staff, *Strategic Vision of the Chief of the Defense Staff*, October 2021. Interestingly enough, and perfect example of strategic emulation, echoes of this four-tier reasoning are found in the newly released German *Space Safety and Security Strategy*, *op. cit.* See notably p. 40.

54. Office of the Chief of Space Operations, *White Paper on Competitive Endurance: A Proposed Theory of Success for the U.S. Space Force*, January 2024, p. 6.

55. *Ibidem*, p. 4.

but also more assertive ones. On this point, actors tend to favor ambiguity, expressing their intention to “protect and defend” their space infrastructure without going into detail. Italy thus underscores its intention to “acquir[e] new tracking and identification capabilities and increase[e] the resilience of space infrastructures in order to reduce the effects of potential attacks and develop self-defense measures.”⁵⁶ For its part, Canada places the emphasis on “mission assurance” and “defensive operations,” adding that priority will be given to “non-debris causing measures and reversible effects.”⁵⁷ France stands out in this regard, not only because of the “active defense” posture it more openly asserts, but above all because of the transparency surrounding its capabilities. The openness of the “Space” section of the 2024-2030 Multi-Year Defense Spending Law, which sets out France’s ambitions in particular for “action in Space” and “from Space”⁵⁸ remains quite unique, even compared with the United States. As a result, it does not go unnoticed.⁵⁹

Taking Multi-Domain Dynamics into Account

A third identifiable area of tension concerns the multi-domain dimension. Most of the documents address this topic cautiously, and it is only discernible through indirect phrasing or within more operational contexts.

“Horizontal escalation” is the first challenge, i.e. escalation occurring in another domain (air, land, sea, cyber) or field (diplomatic, economic, informational), in order to protect and defend space interests. Although escalation is seldom addressed explicitly in the documents reviewed, and more often echoes earlier texts,⁶⁰ it is never excluded, and is sometimes implied in the “appropriate” measures habitually outlined using standard formulations. The possibility of extending the geographical scope of deterrence against an adversary, either as a complement to or in the absence of dedicated levers within a given domain, constitutes a classic form of calculated strategic ambiguity. At the same time, the actors recognize the importance of adopting tailored deterrence postures. They also appear to understand the specific challenges of manipulation posed by cross-domain deterrence, and the need to manage the associated risks of misperception and overreaction.

The second challenge is that of escalation within the space domain itself, primarily to protect and defend forces on the ground. The role of satellites in supporting operations is increasingly vital, and the prospect of a return to high-intensity conflict, against the backdrop of the war in Ukraine, serves as a reminder of the importance of adopting integrated approaches to coordinating maneuvers across oth-

56. Presidency of the Council of Ministers, *National security strategy for space*, 2019, p. 5.

57. Royal Canadian Air Force, *RCAF Strategy on Space Mission Assurance*, March 2022, p. 3.

58. Also see General Secretariat for Defense and National Security, *National Strategic Review 2025*, July 2025, p. 76.

59. Notwithstanding the numerous approximations reflected in the study, on this “French singularity” and on the difference it reveals with the United States, see Makena Young, “*The Evolution of French Space Security*,” *Report of the CSIS Aerospace Security Project*, March 2024.

60. See, for example, The White House, *National Security Strategy of the United States of America*, 18 December 2017, p. 31.

er domains. In these circumstances, ensuring one's own freedom of action while denying the adversary the same advantage if necessary, is essential. The United States – which is concerned about the ramp-up of China's military space program – is, not surprisingly, the country that addresses this issue most openly. "Protecting the Joint Force from Adversary Hostile Uses of Space" has become an increasingly assertive and publicly stated objective.⁶¹ Naturally, terms with "offensive" connotations, or explicit references to "space weapons," have not yet appeared in public documents and are still approached with linguistic caution in official statements – even though the lines are beginning to shift.⁶² However, the expression "space superiority" is widely accepted. As part of the U.S. Space Force's "competitive endurance" approach, space superiority is defined as the ability to "employ space capabilities in support of military objectives while also preventing adversaries from using their own."⁶³

Conclusion: No Totem, No Taboo

With the general framework now established, three main lessons emerge from defense and security space strategies published.

First, there is an obvious point: between today and the first "new generation" official strategies – those of NATO (publicly released in 2022), France, and the United States – seven years have passed. During this time, events appear to have accelerated: the number of active satellites has risen from 2,500 to more than 10,000; genuine infrastructures comprising hundreds or thousands of satellites have been placed in orbit; and the world's largest operator is no longer a state, but a private company. Yet, this entry into an unprecedented era of massification and diversification of Space uses has not diminished the degree of convergence among the various documents discussed in this paper, whether older or more recent. Even though new strategies are expected and updates have been announced for the coming months, it is unlikely that they will reverse the general dynamic already underway. This is the process of operationalization and, ultimately, the normalization of space as an operational domain like any other, one that involves the same challenges of control and operational support as the others. At most, forthcoming strategies may differ in the channels deemed most suitable to ensure the acceleration of this process and its effective adoption at every level.

61. U.S. Department of Defense, *Space Policy Review and Strategy on Protection of Satellites*, *op. cit.*, pp. 10-11.

62. T. Hitchens, "[Time for Space Force to 'clearly say' it needs 'weapons in space': SPACECOM head](#)," *Breaking Defense*, 8 April 2025.

63. Office of the Chief of Space Operations, *White Paper on Competitive Endurance: A Proposed Theory of Success for the U.S. Space Force*, *op. cit.*, p. 2. Also see T. Hitchens, "[Space Force gets loud and proud about warfighting role: 2024 in review](#)," *Breaking Defense*, 27 December 2024.

Second, there are no totems. This normalization – which is both a long-standing and global trend,⁶⁴ although embraced and expressed more decisively by some strategies than others – does not aim to erase the singularity of the Space environment. Recognizing that no domain is unique – nor inherently more or less conducive to international cooperation or to the risk of conflict than the others – does not mean that space should not be given specific attention. All the Western actors discussed in this paper share the view that Space is a highly fragile environment, marked by growing phenomena. For example, it is difficult to predict the interdependencies and interconnections between interests and activities that render escalation dynamics particularly complex. These actors may diverge on the level of risk they are prepared to bear, both individually and collectively, to influence an adversary's calculations and defend their interests. They also differ, of course, in terms of their maturity and investment capacity. The gradual emergence of a two-tier Space order, separating those with sovereign access to a constellation and its ecosystem from those without, could ultimately compromise their ability to build and maintain strategic alignments between themselves. The main challenge in implementing strategies – particularly for Europeans if they wish to remain a relevant space power capable of maintaining a form of autonomy while guaranteeing their freedom to use space – will be to avoid a misalignment between political objectives and available resources. They will either have to readjust the former with realism, or supplement the latter with additional assets.

Lastly, there should be no taboo. Confidentiality has long complicated the way States communicate on their defense space policy. Yet, these new strategies can be seen as an unprecedented effort to align words with actions and an opportunity to collectively deepen understanding of the complex realities involved in maintaining the stability and security of space activities. In this regard, there is no doubt that a gap remains with part of the international community, which continues to assert that space should be used for “exclusively peaceful purposes” (i.e. non-military), even though national activities demonstrate the opposite. These actors – whether out of strategic opportunism, indifference, or dogmatism – contest the very premises of these documents: that the risk of conflict in Space is growing, and that preventing it must therefore be the priority. They reject their pragmatic approach, which they regard as an unacceptable legitimization of “space weapons.” Consequently, they refuse to engage in a nonetheless essential discussion on military space operations, considering that it would amount to recognizing a form, deemed unacceptable, of “responsible weaponization of space” and to hastening the prospect of conflict in Space. This is a problematic and worrying situation at a time when risks of misunderstanding and uncontrolled escalation have never been higher.

64. B. E. Bowen, *Original Sin: Power, Technology and War in Outer Space*, London, Hurst, 2022.

The Impact of Commercial Data and Solutions on U.S. Geospatial Intelligence (GEOINT)

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Introduction

The revolution in Geospatial Intelligence, or GEOINT, which began mainly in the 2000s with the conflicts in Iraq and Afghanistan, has gathered speed during the war in Ukraine and the significant contribution of commercially sourced spatial data. The Russian invasion in February 2022 was closely monitored in near real time thanks to commercial satellite data available to the public. In the early days of the conflict, convoys of Russian military vehicles were spotted near Hostomel airport, 60km northwest of Kyiv, by the commercial imaging company Maxar. The images were picked up by media outlets around the world.¹

1. “[Guerre en Ukraine : des images satellites montrent un immense convoi militaire russe près de Kiev](#),” *Le Monde* with AFP, 1 March 2022.



Satellite image taken by Maxar on February 28, 2022, showing Hostomel Airport, believed to be the main gathering and logistics point for the Russian offensive toward the Ukrainian capital, Kyiv, in February 2022.

EO image © Maxar 2022, Artificial Intelligence © Safran.AI 2022, Analysis © Victor Mangin.

Defined as “the exploitation and analysis of imagery and geospatial information to describe and visualize physical factors and geolocated activities on Earth,”² the development of GEOINT as a recognized branch of the armed forces is the result of several decades of technological progress in imaging from various sensors (optical, infrared, radar, video, etc.), doctrinal advances, and operational experience following the announcement of the Revolution in Military Affairs after the first Gulf War.³ Although the concept originated in the United States, the French Direction du renseignement militaire (DRM, Directorate of Military Intelligence) also adopted it in 2015. In this article, GEOINT is limited to its American definition and is understood as a process of merging geolocated and georeferenced information, with satellite imagery as the foundation on which additional layers of information can be added.

The U.S. geospatial sector was once dominated by legacy sensors and systems whose operation was based on methodical planning, but which were often slow to react and difficult to adapt to new forms of conflict. It has recently evolved with New Space and the growing emergence of the private sector. This evolution is reflected in the massive use of commercial data and solutions (I), the importance of which has been particularly highlighted during the war in Ukraine (II). In response to these

2. P. Boulanger, *GEOspatial INTelligence : Geoint, un outil géopolitique d'aide à la décision*, Paris, Armand Colin, 2024.

3. *Ibidem*.

changes, a new dynamic is at work within government agencies. They are adapting their business models and working methods to support the constant development of software solutions and associated services in response to ever-changing threats (III).

I. The Growing Use of Commercial Satellite Data to Complement Government-owned Sensors

The Growth and Diversity of Geospatial Data for Military Intelligence

GEOINT has undergone significant changes since its emergence in the United States in the 2000s under the auspices of the National Geospatial-Intelligence Agency (NGA). This agency collects, analyzes, and disseminates geospatial data for national security purposes. Created in 1996, the National Imagery and Mapping Agency (NIMA), which became the NGA in 2003,⁴ has seen its missions expand with the evolution of threats, increasingly integrating advanced technologies to automate the collection of satellite imagery, the production of digital mapping, and the analysis of Big Data from the seabed to the lunar surface. With an annual budget that is classified but estimated at over \$5 billion, the NGA currently has approximately 15,000 employees,⁵ 25% of whom⁶ are deployed within the Combatant Commands (COCOMs).⁷ They support the armed forces in the collection and use of geospatial data as close as possible to the theaters of operations.

According to the current organization of the Department of Defense (DoD)⁸ and the Intelligence Community (IC), the National Reconnaissance Office (NRO) is responsible for managing sovereign satellite-based systems, but also for purchasing satellite images from commercial satellites. The NGA, meanwhile, is responsible for sensor tasking, acquiring analysis capabilities, and producing finalized geospatial intelligence. While the centralization of commercial data acquisition by the NRO offers undeniable financial advantages, it also generates tensions within the geospatial community.⁹ Today the NGA and NRO must defend their place within the military space community, where some of their activities now appear to be facing competition from initiatives by the U.S. Space Force in particular. Officials from the Department of the Air Force – to which the Space Force reports – justify their intervention by citing the urgent need at operational and tactical levels to receive satellite data and enriched information more quickly in order to deal with strategic competitors such as China and Russia.¹⁰ In response to these criticisms, the new National System for

4. *Ibidem*.

5. *Ibidem*.

6. “GEOINT 2024 Keynote by VADM Frank Whitworth, USN, Director, National Geospatial-Intelligence Agency,” U.S. Geospatial Intelligence Foundation, *YouTube*, 6 May 2024.

7. The DoD has 11 Combatant Commands. See “[Combatant Commands](#),” *official website* of the DoD.

8. By presidential decree of 5 September 2025, the U.S. DoD became the Department of War.

9. T. Hitchens, “[Air Force greenlights baseline for new NRO-Space Force satellites to track ground targets](#),” *Breaking Defense*, 29 August 2024.

10. T. Hitchens, “[Space Force, IC’s battle over commercial ISR reignites as appropriators add fuel](#),” *Breaking Defense*, 22 March 2024.

Geospatial Intelligence's Joint Mission Management Center, presented by Admiral Whitworth in May 2024 as the "Space Intelligence Hub" of the future, is seen by the NGA as the tool that will enable better coordination of all geospatial data collection carried out by DoD agencies, private operators, and U.S. allies.¹¹

This competition is not new and reveals an ongoing duel between two imperatives of intelligence and the provision of geospatial data. On the one hand, there is a demand for in-depth analysis over the long term. On the other hand, there is a need to meet immediate requirements imposed by the pace of operations and the return of high-intensity conflict with the war in Ukraine, responses that are facilitated by the widespread availability of commercial imagery at the tactical level.

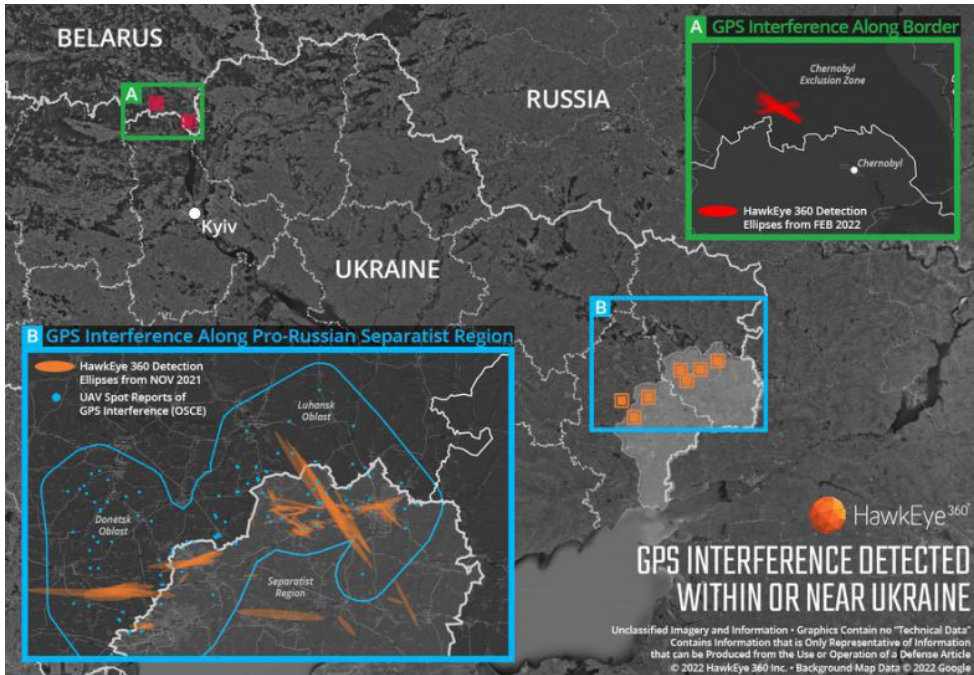
The Decisive Contribution of Commercial Satellite Data

The New Space phenomenon, which emerged at the beginning of the 21st century, marks the emergence and growth of the commercial space industry thanks to the drastic reduction in satellite launch costs and the proliferation of platforms in orbit. Whether it be very high-resolution electro-optical (EO) imaging systems with revisit frequencies of up to 12 times per day,¹² synthetic aperture radar (SAR) satellites providing images that can detect activity at night or under heavy cloud cover, radio frequency (RF) satellites to detect the movements of ships, troops, or GPS jamming, and soon infrared, hyperspectral or GMTI (Ground Moving Target Indication) satellite data,¹³ geospatial intelligence is no longer sourced solely from state actors, but also from a multitude of private-sector providers. While the number of privately-owned satellites in orbit has multiplied tenfold since the 1990s, the diversity and quality of sensors and their revisit capabilities have also increased significantly. In response to these changes, the space sector in the United States is gradually restructuring to create a new architecture supported by government agencies and implemented through partnerships with the private sector.

11. C. Albon, "[National Geospatial-Intelligence Agency creating space intel hub](#)," *C4ISRNet*, 6 May 2024.

12. M. van Ryswyk, "[Planet's New Rapid Revisit Platform to Capture Up to 12 Images per Day](#)," *Planet*, 9 June 2020.

13. T. Hitchens, "[EXCLUSIVE: GMTI emerges as new front in Space Force-NGA turf battle](#)," *Breaking Defense*, 8 April 2024.



HawkEye 360's RF satellites detected an increase in GPS interference in Ukraine and Russia in the months leading up to the Russian invasion.

© HawkEye 360, 2022.

Complementing government-owned capabilities, the massive collection of geo-located commercial data adds a new dimension to GEOINT.¹⁴ The lack of sovereign satellite capabilities has not limited Ukraine's ability to obtain image-based intelligence independently. From the outset of the conflict, Ukraine's Minister of Digital Transformation sought to increase its access to satellite data by mobilizing not only its government partners, but also commercial providers directly.¹⁵ A significant amount of sovereign and commercial geospatial data shared by its allies has greatly helped Ukraine defend itself against the Russian invasion. "With the NRO [National Reconnaissance Office], we immediately doubled the amount of commercial imagery we purchased for Ukraine," said Dave Gauthier in 2022, then director of commercial operations at the NGA. At the same time, the operational availability of the first U.S. commercial SAR data was increasing for the benefit of theaters of operations.¹⁶

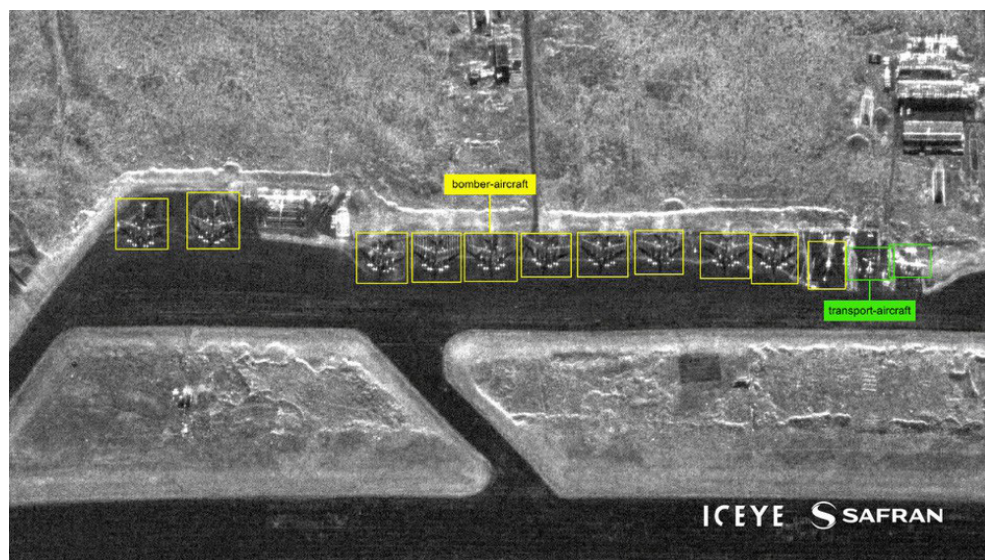
14. With the publication in 2021 of its *National System for Geospatial Intelligence Enterprise Commercial GEOINT Strategy*, the NGA even talks about "considering commercial data as an equal playing field to national capabilities." Quoted in C. Biesecker, "[New Strategy Elevates Commercial GEOINT, Gets Everyone On Same Page, NGA Official Says](#)," *Defense Daily*, 12 January 2021.

15. L. Minisini, "[Mykhailo Fedorov, chef de guerre numérique en Ukraine](#)," *Le Monde*, 9 March 2022.

16. S. Erwin, "[As Russia prepared to invade, U.S. opened commercial imagery pipeline to Ukraine](#)," *Space News*, 6 April 2022.

Nevertheless, while commercial data has the advantage of being easier to share with allies and partners, access via government platforms depends on U.S. goodwill.¹⁷ Three years after Russian forces invaded Ukraine, the Trump administration's decision to halt, even temporarily, the sharing of geospatial intelligence in March 2025 dealt a severe blow to the Ukrainian armed forces.¹⁸

However, the speed with which the images and services have reached Ukrainian units has demonstrated the rapid response and benefits of commercial geospatial intelligence in armed conflicts. American companies Maxar, BlackSky, Planet (EO), Capella, Umbra, ICEYE US (SAR), and HawkEye 360 (RF) contribute to supplying geospatial data in direct or indirect support of the Ukrainian government. The latter even signed an agreement in 2022 with the Finnish company ICEYE to transfer the entire capabilities of one of its SAR satellites for the exclusive use of Kyiv. Ukrainian military intelligence makes extensive use of ICEYE satellite imagery, according to one official speaking in June 2024: "Our specialists have taken a total of 4,173 images of enemy targets."¹⁹



ICEYE SAR satellite image from 30 December 2022. It highlights the relocation of Russian *Tu-95* strategic bombers from Engels Air Base to Olenegorsk Air Base in the Murmansk Oblast, following the first Ukrainian strikes on Russia.

SAR image © ICEYE 2022, Artificial Intelligence © Safran.AI 2022, Analysis © Victor Mangin.

17. The NGA's G-EGD program, which gives users in the field direct access to unclassified commercial optical and radar imagery, currently has 6,000 subscribers within the Ukrainian forces.

18. E. Vincent, E. Grynspan, "[Guerre en Ukraine : la 'pause' du renseignement américain à l'égard de Kiev, un défi inédit pour la coopération entre les alliés](#)," *Le Monde*, 7 March 2025.

19. A. Protz, "[Ukraine's Defense Intelligence says 'people's satellite' helped to destroy thousands of Russian targets – photos](#)," *Ukrainska Pravda*, 26 June 2024.

The U.S. acquisition strategy demonstrates the strong complementarity between government-owned and commercial satellite data, which are often merged within the same geospatial platform. The U.S. geospatial community is taking full advantage of its sovereign capabilities and also diversifying its sources of supply by turning to commercial players in order to benefit from a greater volume and a better information refresh rate. The ability to obtain native resolution of less than 30cm remains, to this day, the ultimate difference between commercial and sovereign capabilities. However, a new challenge has emerged: the volume of information made available by the proliferation of sensors is increasing, while the human resources available to process it remain constant. Intelligence specialists are struggling to extract all the relevant information buried in the mass of raw data.

II. The Recent Adoption of Automatic Geospatial Data Processing Capabilities for Operational Purposes

Overcoming the Data Wall with Big Data and Artificial Intelligence (AI): Promising Initial Operational Results Now Being Scaled Up

Although the processing of large amounts of heterogeneous data represents an opportunity for the adaptation of Big Data and AI, the U.S. intelligence community has been slow to adopt these new technologies on a large scale for its own benefit. The DoD, and in particular the U.S. Air Force (USAF), quickly focused on data analysis and visualization through automation, augmentation, and artificial intelligence – also known as “Triple A” – but their adoption for operational purposes (intelligence or targeting) remains slow, particularly within the Distributed Common Ground System (DCGS),²⁰ the USAF’s primary system for analyzing and exploiting Intelligence, Surveillance, and Reconnaissance (ISR) assets.

Despite numerous experiments, the DoD’s AI budget remains stagnant (\$1.8 billion for FY24 and FY25)²¹ and few concrete initiatives have reached the stage of industrial production in the field of AI. Alongside the ASPEN program,²² focused on integrating AI models into image analyst operating systems, the flagship Maven Smart System (MSS) program developed by a consortium of American companies, including Big Data and AI specialist Palantir, stands out as an exception. Launched in 2017 as a pilot project managed by the Pentagon, MSS was designed to analyze video data from USAF *Predator* UAVs. It became a Program of Record in 2022 jointly

20. The DCGS collects, processes, exploits, and disseminates intelligence from various ISR platforms, including satellites, aircraft, and ground sensors. It forms the backbone of USAF intelligence operations, providing critical support to the armed forces by analyzing data in near real time to produce actionable intelligence. The DCGS integrates different forms of intelligence, including signals intelligence (SIGINT), imagery intelligence (IMINT), and geospatial intelligence (GEOINT), among others. See “[Fact Sheets – Air Force Distributed Common Ground System](#),” official website of the U.S. Air Force.

21. B. Vincent, “[Why the Pentagon didn’t request higher funding for AI in fiscal 2025](#),” *Defense Scoop*, 11 March 2024.

22. S. Erwin, “[Geospatial intelligence gets smart](#),” *Space News*, 7 May 2024.

managed by the NGA and the CDAO.²³ Maven's main goal is to improve the speed and accuracy of targeting on the battlefield. It is an AI-based decision support tool²⁴ capable of processing sensor data from various drone and satellite sources (179 in total).²⁵ Through this interface, users can select computer vision algorithms tailored to specific cases to help U.S. Army targeting experts identify and select military targets.²⁶ Widely used within U.S. Central Command and U.S. European Command, this software is also deployed in Ukraine in an adapted version and benefits from user feedback in the field. This operational use has accelerated Maven's roadmap,²⁷ and its adoption by the Supreme Allied Commander Europe has facilitated its rapid acquisition by NATO, with deployment planned at Supreme Headquarters Allied Powers Europe (SHAPE) in 2025.²⁸ Maven could therefore become an interoperability standard for the intelligence community within the Alliance, which is a cause of concern for French industry and military officials.²⁹

Automatic satellite image analysis technologies, which rely on AI techniques, particularly computer vision and deep learning, are gradually maturing. They are now ready to be industrialized and scaled up. In the field of automatic satellite image processing, for example, pre-trained AI algorithms³⁰ are currently achieving performance rates that are very close to the capabilities of human analysts. Far from replacing operators, these technologies assist certain intelligence specialists, such as image interpreters, in performing repetitive tasks such as the automatic detection and recognition of known and relatively unchanging objects of military interest (aircraft, ships, or armored vehicles). The aim is to speed up the processing of large amounts of information and allow analysts to focus on tasks with higher added value.

23. Chief Data and Artificial Intelligence Office, which reports to the Pentagon. A Program of Record refers to a planned and funded effort to provide new, improved, or continuing capability in equipment, weapons, information systems, or services in response to an approved requirement.

24. E. Probasco, "[Building the Tech Coalition. How Project Maven and the U.S. 18th Airborne Corps Operationalized Software and Artificial Intelligence for the Department of Defense.](#)" *The Center for Security and Emerging Technology*, August 2024. One of the metrics of success for Project Maven is enabling a team of 20 analysts specializing in targeting to identify 1,000 targets per hour, the equivalent of work that required more than 2,000 analysts a few years earlier during Operation Iraqi Freedom in 2003.

25. S. Freedberg, "[Success begets challenges: NGA struggles to meet rising demand for Maven AI.](#)" *Breaking Defense*, September 2024.

26. General Michael Kurilla is a senior U.S. military officer, currently head of U.S. Central Command. Prior to this position, he commanded the 18th Airborne Division and was instrumental in his division's involvement in the development of the Maven project.

27. D. E. Sanger, "[In Ukraine, New American Technology Won the Day. Until It Was Overwhelmed.](#)" *New York Times*, 24 April 2024.

28. "[NATO acquires AI-enabled Warfighting System.](#)" NATO, SHAPE Public Affairs Office, 14 April 2025.

29. M. Fauroux, E. Trujillo, "[Après le choix de Palantir à l'OTAN, la grande inquiétude des industriels et militaires français.](#)" *La Lettre*, 24 June 2025.

30. Comparable, in its Industry 4.0 version, to a Ford car assembly line. Achieving very high levels of algorithmic performance relies on mastering each link in the production chain, from the massive, laborious, and often costly (illustrated by a recent NGA tender worth \$708 million) annotation of data representative of operational cases, to the training and configuration of a set of complex algorithms and their operational validation in close collaboration with end users.

AI research continues to advance with promising applications for the military geospatial community. Studies on algorithm frugality should result in the ability to maintain the same level of performance with less training data, less computing power, and lower energy consumption. This will allow algorithms to be implemented closer to satellite sensors or drones (edge computing), further accelerating the OODA loop.³¹ Another avenue of research is also beginning to prove its worth: synthetic data simulating the characteristics of real data. While current technologies do not yet offer the same levels of performance as real data, they do enable companies to overcome the difficulty of building sufficiently varied training databases. Finally, in light of the success of ChatGPT, the CDAO recently signed a contract with the four leading American frontier AI companies (Anthropic, Google, OpenAI, and xAI)³² to deploy their capabilities within the DoD, with potential applications in the field of GEOINT, such as the contextualization of multiple layers of heterogeneous data.

The quality of data representing cases of military interest, along with data diversity and accessibility, still constitute the cornerstone in the development of robust and reliable artificial intelligence. The USAF highlights the risk of “model drift” in pre-trained algorithms, which limits their operational adoption: “Because models are trained a priori on data (and simulations) in an anticipatory fashion, AI-based systems encounter situations in the real world that are incompatible with training feature distributions and parameterization of employed algorithms. The result is degradation to model performance that can negatively impact mission effectiveness and safety.”³³ To address this issue, the DoD is seeking to develop internal AI software so that military specialists can quickly retrain, test, and redeploy AI models developed locally to meet mission requirements. While sovereign control of the value chain ensures complete traceability of training data, it requires significant human resources (annotators, data scientists, etc.) and technical resources (computing power, etc.) for what are, after all, highly specialized operational effects.

The key to getting people to adopt artificial intelligence is making sure that AI is trustworthy and understandable. It needs to be tailored to operational situations to generate the most value in a true “man-machine teaming” (MMT) setup, where people retain a central role. However, the large-scale deployment of AI technologies depends on the availability of appropriate digital skills and infrastructure.

31. Observe, Orient, Decide, Act; theorized by Colonel John Boyd in “A Discourse on Winning and Losing” (August 1987).

32. “[CDAO Announces Partnerships with Frontier AI Companies to Address National Security Mission Areas](#),” official website of the Chief Digital and Artificial Intelligence Office, press release, 14 July 2025.

33. J. Harper, “[Air Force provides more details about plans for ‘battle management’ of AI](#),” *Defense Scoop*, 5 March 2024.

Digital Skills and Infrastructure Required to Facilitate Large-Scale Deployment of Commercial Solutions

Network management and the integration of new technologies into an open, interoperable architecture that is accessible at multiple levels are major priorities for the U.S. armed forces. The DoD is currently facing growing challenges in terms of geospatial data management and exploitation, and varying levels of confidentiality and security within multiple GEOINT platforms. There is an urgent need to “de-silo” classified and unclassified networks in order to facilitate information sharing within U.S. government agencies, within NATO, and with allies and partners in the field.

The adoption of the cloud for business applications is progressing, but organizational reluctance and security constraints remain significant obstacles to the rapid deployment of commercial solutions in sovereign clouds.³⁴ Deployment on secure local infrastructures remains the norm. Following the abandonment of the JEDI mega-contract in 2021,³⁵ the DoD has not developed a unified cloud approach, and each branch of the military awards contracts to different U.S. providers (mainly AWS for the USAF, but also Google, Microsoft, etc.). The DoD and contractors (Second Front, Palantir, etc.) are seeking to make certified platforms accessible to developers in order to reduce software accreditation cycles and costs. These accelerated certification tools should also facilitate the continuous integration of constantly maturing solutions (the initial version and frequent updates) into government clouds with different levels of confidentiality. In September 2024, the NGA launched a pilot program called the “AGAIM initiative,” which aims to standardize the accreditation of computer vision models to facilitate their widespread adoption within the GEOINT community.³⁶

Beyond the data that forms the foundation in the form of geodigital layers, GEOINT also relies on a set of Geographic Information Systems (GIS). Developing skills related to digital tools therefore remains essential for the ongoing adaptation of the armed forces. The recruitment, training and retention of data specialists, network architects and geomatics experts are essential for establishing infrastructures capable of effectively centralizing geospatial databases, structuring them within platforms where government and commercial data are merged, developing internally or supporting the deployment of capabilities, and finally ensuring their rapid and secure dissemination to end users. For example, the ATAK (Android Tactical Assault Kit) geospatial solution,³⁷ developed by the Air Force Research Laboratory (AFRL)³⁸ and managed by TAK Product Center, aggregates various business applications devel-

34. E. Harding, “[Move Over JARVIS, Meet OSCAR Open-Source, Cloud-Based, AI-Enabled Reporting for the Intelligence Community](#),” *Center for Strategic and International Studies* (CSIS), 19 January 2022.

35. J. Harrington, “[The Pentagon Issues Order 66 to Terminate JEDI](#),” CSIS, 2021.

36. B. Vincent, “[NGA launches new pilot program to standardize computer vision model accreditation](#),” *Defense Scoop*, August 2024.

37. “[Android Team Awareness Kit or ATAK / CivTAK](#),” *official website of TAK*.

38. “[Tactical Assault Kit](#),” *Air Force Research Lab*, 2025.

oped by the government and industry for the benefit of a community of users at the tactical level. Based on an open architecture (via the integration of plugins)³⁹ and interoperable, ATAK has a standardized library of validated applications available for large-scale use. It allows different users to quickly access new software and updates.

Financial constraints and a lack of human resources in the armed forces reinforce the urgency of rapid digital transformation, as well as the need to develop and retain the skills essential to this evolution. The transformation of digital infrastructure must also be accompanied by new types of public-private partnerships (PPPs). The aim is to develop new business models, accelerate contract awards for innovative solutions, and develop new, more agile working methods in order to respond to constantly changing threats and growing international competition.

III. New PPP Models to Facilitate the Integration of Innovation Into Geospatial Defense Programs

New Business Models With Industry

The momentum of New Space has led to the gradual implementation of a new industrial ecosystem associated with the development of new business models. As part of its *Commercial GEOINT Strategy*⁴⁰ published in 2021, the NGA has actively established partnerships with the private sector to access a wider range of geospatial data sources. These collaborations have significantly improved its own geospatial intelligence capabilities by diversifying data sources and integrating cutting-edge technologies. In a second phase, the NGA began outsourcing its capabilities to collect satellite data, as well as to analyze and merge the data to create high value-added geospatial products. Capitalizing on the initial success of the Economic Indicator Monitoring (EIM) program launched in 2019, the NGA has awarded contracts since early 2025 under two programs, called LUNO A and LUNO B, with a total value of \$490 million.⁴¹ Their objective is to leverage commercial data and AI algorithms to multiply economic and military intelligence capabilities for the benefit of the DoD.

In 2023, the Space Force also began providing operational planning products to theaters of operations, through the “global data marketplace.” This pilot project, called TacSRT, seeks to develop intelligence products tailored to the urgent needs of COCOMs at the tactical level. Between January and April 2024, the Space Force claims to have built up an ecosystem of 30 companies that have contributed to 40 projects for 25 U.S. agencies, including U.S. Africa Command and U.S. Southern Command. The total cost was \$8 million. “Since January, TacSRT has lever-

39. A plugin is a software extension that adds additional functionality to the core application. ATAK is a situational awareness management platform primarily used by the armed forces, emergency services, and other groups that need to coordinate operations in the field.

40. “[National System for Geospatial Intelligence Enterprise Commercial GEOINT Strategy 2021-2025](#),” official website of the NGA, 2021.

41. C. Biesecker, “[NGA Selects 10 Vendors to Compete Under \\$290M Luno A Global Monitoring Program](#),” *Via Satellite*, 16 September 2024.

aged the global data marketplace to accomplish 40 unique efforts, with each effort incorporating at least two commercial vendors, resulting in the delivery of over 200 value-added operational planning products,” the Space Force declared.

More Flexible Contract Terms to Integrate Innovation More Quickly

Admittedly, there are many examples illustrating the DoD’s difficulty in adopting commercial solutions rather than developing often specific capabilities in-house. Furthermore, American startups financed by venture capital funds face real obstacles in crossing “death valley.”⁴² Nevertheless, the DoD is seeking to facilitate the financing of innovation, reduce contracting cycles and offer greater agility to meet its urgent needs. LUNO contracts, for example, represent a more flexible and less prescriptive contractual approach on the part of the U.S. government: “We envision tasking for the insights we desire, and letting industry provide us with the best mix of sources and analytics required to deliver the insight,”⁴³ says Admiral Whitworth, director of the NGA. More flexible contracting also involves partnerships between DoD agencies, such as the Defense Innovation Unit.⁴⁴ The primary mission of this unit is to accelerate the adoption of commercial and dual-use technologies within the department. It has a reputation for contracting in less than 90 days. The NGA was able to leverage this unique entity to sign a maritime surveillance contract for the U.S. Indo-Pacific Command in less than six months.

Within the Maven program, a more agile contractual approach has facilitated aggregation, rapid competition between private companies and continuous updating of AI algorithms and the human-machine interface (HMI). Maven uses the full range of contracts offered by the DoD⁴⁵ to award contracts, share data, test with operational personnel, etc. This process was managed by the prime contractor, ECS Federal, which acted as commercial application integrator, leveraging feedback from warfighters and program managers to identify and rapidly integrate the best capabilities on the market. ECS Federal successfully onboarded (and also offboarded) a group of companies, including large corporations (AWS, IBM, Maxar, Microsoft, Raytheon, etc.), as well as Palantir, which was subsequently promoted to co-prime contractor with ECS.⁴⁶ This contractual approach also enabled smaller companies such as Black Cape, Clarifai, and CrowdAI to participate in the development of the solution.

42. The so-called “death valley” curve represents a crucial phase in the early stages of a new venture, when substantial efforts have been invested in the project, but sufficient revenue has not yet been generated. In the defense sector, the “death valley” represents this critical transition phase from R&D to industrial production in order to obtain adequate funding to scale up, e.g. through integration into a major program.

43. S. Erwin, “[NGA plans new procurement of commercial Earth monitoring services](#),” *Space News*, 23 May 2023.

44. “[Accelerating Commercial Technology for National Security](#),” *official website* of the Defense Innovation Unit.

45. The Cooperative Research and Development Agency, Other Transaction Authorities, Partnership Intermediary Agreement, among other examples.

46. E. Probasco, “[Building the Tech Coalition...](#),” *op. cit.*

The Importance of Agile and Iterative Co-development With Specialized Operational Units

Rapid advances in GEOINT technologies, particularly in the context of the war in Ukraine, are prompting state actors to ensure the continuous development of new military software capabilities within weapons programs. In a dynamic environment where operations are increasingly conducted using scalable software capable of adapting to constantly changing threats, it is becoming crucial to involve warfighters in technical development in order to benefit from their feedback from the field.

In the United States, iterative co-development with innovation specialists, weapons program management experts, and warfighters highlights the crucial importance of bringing together different areas of expertise in the development of innovative military capabilities. For example, MSS was co-developed over time with the 18th Airborne Division during Scarlet Dragon exercises, which simulate the search and identification of potential targets by artillery units. These maneuvers made it possible to refine MSS developments in short, iterative 90-day cycles by bringing together warfighters and developers. The U.S. Army's TITAN program benefits from Soldier Touchpoints – technical and operational workshops dedicated to manufacturers in order to collect user feedback and build a roadmap with all stakeholders. These approaches show how the direct integration of geospatial data specialists into operational units can significantly improve the acquisition and sharing of geospatial capabilities for better decision-making in the field.

Conclusion

Since its emergence in the United States in the 2000s, GEOINT has undergone profound changes. The U.S. acquisition strategy illustrates the transition to a model where geospatial data is no longer the sole preserve of the state. Private actors now play an increasingly important role, providing data, technologies, and specialized services that are rapidly scaling up thanks to promising early initiatives. Public-private partnerships have fostered growth and innovation in the commercial space industry, encouraging the development of new technologies and expanding the applications of geospatial data for the benefit of the armed forces. The growing importance of specialized skills in digital transformation and the management of geospatial, cyber and commercial data available from open sources highlights the critical importance of this expertise in modern military operations.

Tensions between key players in the geospatial sector illustrate the operational, organizational, and budgetary trade-offs at the heart of discussions on how the U.S. geospatial intelligence community should evolve to respond to ever-changing threats. Under the Biden administration, the White House National Space Council was already actively working to resolve this debate on “roles and missions,” particularly between the Space Force and the NGA. The appointment of Dr. Troy Meink as Secretary of the Air Force in May 2025 could give the Space Force a further boost, as President Trump is seen as an ally of this new military branch. He supported its creation during his first term in office.

Russia's Anti-Satellite Projects

Bart Hendrickx

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Russia has been working on a variety of systems capable of attacking enemy satellites in orbit, ranging from conventional kinetic anti-satellite (ASAT) weapons to state-of-the-art laser and electronic warfare systems. Back in the days of the Cold War, the Soviet Union was the only country to have an operational anti-satellite program, namely a co-orbital ASAT system named “IS” (a Russian acronym for “satellite destroyer”), which performed numerous intercepts of specially launched target satellites. Plans for a plethora of new ASAT weapons were shelved after the collapse of the USSR in 1991, but interest in counterspace weapons picked up after the turn of the century. While there is no evidence for a single decision to start a concerted ASAT effort, it is notable that many of Russia’s new ASAT projects got underway around the beginning of the last decade. The renewed interest may at least in part have been sparked by tests of ASAT weapons by China and the United States in 2007 and 2008.

Russia has not publicly acknowledged the existence of all these projects, but a significant amount of information on them can be gleaned from open-source intelligence, mainly through thorough analysis of online procurement and court documents as well as company annual reports, patents and technical articles. This article aims to present these different ASAT systems.

Direct-Ascent ASAT Systems

The Nudol System

Direct-ascent ASAT systems are ground-based missiles that intercept targets without themselves being placed into orbit. Russia possesses at least one such sys-

tem, named Nudol and also designated 14Ts033. The program officially started on August 10, 2009 with a contract signed between the Ministry of Defense and the Almaz-Antei concern.

The key element of the system is a two-stage solid-fuel missile called 14A042, which is fired from a transporter erector launcher. The individual stages are built by NPO Iskra, but overall integration of the vehicle is in the hands of OKB Novator, which belongs to the Almaz-Antei group and has produced a wide range of surface-to-air and cruise missiles. The missile carries a multispectral homing system designated 14Sh129, developed jointly by the Design Bureau of Precision Machine Building (KB Tochmash) and the State Institute of Applied Optics (GIPO). Indications are that it destroys its target simply by colliding with it, not by detonating an explosive charge in its vicinity.

The transporter-erector launcher (TEL) is the 12-wheeled MZKT-79291 of the Minsk Wheel Tractor Factory (MZKT) in Belarus. It is capable of carrying a maximum load of 50 tons. In its configuration for Nudol, it has two missile launch tubes. The mass of the launch tubes is not known, but this does imply that the launch mass of Nudol's 14A042 rocket is probably somewhere in the 15 to 20 ton range. The TEL is seen in a patent that can be positively linked to Nudol as well as in a calendar published by Almaz-Antei.



Transporter-erector launcher carrying two 14A042 rockets.
Source: Almaz-Antei.

Nudol is based at the Plesetsk launch site in northwestern Russia, which is used for both military space launches and test flights of intercontinental ballistic missiles. A total of about 10 suborbital test flights were flown between 2014 and 2020, none of which were aimed against targets in space.

Nudol performed its first anti-satellite test on November 15, 2021. The first signs that such a test had taken place came in the morning hours when a large debris field was detected in low Earth orbit by U.S. space tracking systems. It turned out that this had resulted from the break-up of a defunct Soviet-era Tselina-D electronic intelligence satellite (*Kosmos-1408*), which had been in a 465x490 km orbit with an inclination of 82.56°. Several hours later, U.S. Space Command issued a statement saying that Russia had conducted an ASAT test that had generated more than 1,500 pieces of trackable debris and was likely to produce hundreds of thousands of pieces of smaller orbital debris. The initial assessment was that the debris would remain in orbit for years and potentially for decades, posing a significant risk to the satellites of many countries as well as the International Space Station. The Russian Ministry of Defense confirmed the test without giving any specific details and denied that it presented a threat to orbiting satellites, underlining that China, the United States and India had conducted similar tests earlier.

For a long time, there was much debate among analysts over whether Nudol was primarily an anti-missile system with a complementary counterspace role or vice versa. More specifically, there was much speculation that Nudol may become part of the new A-235 system that is intended to protect the Moscow region against ballistic missile attacks. All indications are now that Nudol is a dedicated anti-satellite system with no anti-missile role at all. While the November 2021 test was not officially linked to Nudol by the Russians, some Russian officials have acknowledged the existence of the system, characterizing it specifically as an ASAT system. Even the index used for the Nudol rocket (14A02) is indicative of that. 14A designators are typically used for space launch vehicles (for instance, 14A14 is the Soyuz-2 rocket).

There have been no further Nudol tests since the November 2021 mission. Speaking to reporters not long after the test, Dmitriy Rogozin, then head of the Russian Space Agency, said he thought it was unlikely the Russian military would perform another one in the future. Rogozin actually hinted he was unhappy with the test and the fact that it had created a large debris cloud in orbit. It would seem that the agency had not been given any advance notice of the test, which was an exclusively military operation aimed against a decommissioned military satellite.

Considering all the negative reactions to the test and the fact that any debris generated by such tests can also jeopardize Russian satellites, it is indeed unlikely that more Nudol test flights will be conducted, at least not against targets in orbit. Following ten tests with phantom targets and one (obviously successful) test with a live target, it must be assumed that Nudol is considered an operational system and is now on standby at the Plesetsk launch site, ready to be used whenever Russia would consider that necessary.¹

1. [Nudol thread](#) on the NASA Spaceflight Forum.

The Anti-Ballistic Missile Systems

While Nudol appears to be a dedicated anti-satellite system, there are at least two anti-missile systems that may have an added counterspace role. One is the S-500 system, also known by the names Prometei and Triumfator-M. In 2020, Sergei Surovikin, the commander of the Russian Aerospace Forces, said that the S-500 system is aimed against both “aerodynamic targets” (including drones and hypersonic vehicles) and “ballistic targets.” Its main goal, he said, is to destroy medium-range ballistic missiles, but if needed it can also intercept ICBM-launched warheads in the terminal stage. He added that in the future it will also be able to destroy low orbiting satellites and “space-based attack systems,” a possible reference to America’s X-37B military space planes. Little has been revealed about S-500 system, but available information suggests that it includes the 40N6M missile (with a reported range of 400 kilometers) for use against aircraft and cruise missiles and the more powerful 77N6-N and 77N6-N1 (with an estimated range of 500-600 kilometers) to counter ballistic missiles and satellites. All these missiles are products of a company named MKB Fakel. There is contradictory information on the current status of the S-500 system. One or more elements of it may be operational, but whether any of them are capable of hitting satellites is unknown.

Another anti-ballistic missile system with possible ASAT applications is called Aerostat. Its prime contractor is Almaz-Antei, which received a government contract for the project on July 12, 2013. One openly available court document describes Aerostat as a “long-range intercept complex for the anti-missile defense of the Russian Federation” and identifies the missile to be used as 106T6. As can be learned from other documents, the missile’s development was assigned to the Moscow Institute of Thermal Technology (further referred to here as the MIT Corporation), which is responsible for Russia’s solid-fuel intercontinental ballistic missiles, the latest of those being Topol-M and Yars. The multispectral homing system is 14Sh129, the same type used by Nudol.

Most likely, the 106T6 missile is a multistage rocket based on the Topol-M and Yars ICBMs and adapted to serve as an anti-ballistic missile system. It may become the long-range component of Moscow’s A-235 ABM system, capable of intercepting ICBMs during the mid-course phase of flight. The homing head could be delivered to its target by what is referred to in literature of the MIT Corporation as a “kick stage,” a solid-fuel upper stage whose thrust can be regulated to increase its accuracy. A similar kick stage is under development for Start-1M, a fleet of lightweight space launch vehicles that the MIT Corporation plans to build on the basis of decommissioned Topol-M ICBMs.

A long-range ABM system like Aerostat would also have an inherent ASAT capability. A number of technical articles that may be related to Aerostat (without mentioning its name) suggest that satellites are indeed among its potential targets. Being much more powerful than the S-500 or the Nudol missiles, an ICBM-based ABM system would be capable of knocking out targets in significantly higher orbits, such as U.S. radar reconnaissance satellites orbiting the Earth at an altitude of around 1,000 km.

It is unclear in what stage of development Aerostat currently is. It is known that a test launch of a Soviet-era Topol ICBM from the Kapustin Yar range near Volgograd in December 2017 tested elements of Aerostat, but further details are absent. Almaz-Antei was awarded a new contract for the project on April 26, 2018. The work known to have been performed under that new contract carries the label “NIR,” which is Russian short for the research phase of a project that precedes actual systems development (referred to as “OKR”.) This may indicate that at least some systems encountered technical problems that forced designers back to the drawing boards.²

Co-orbital ASAT Systems

Co-orbital ASAT systems are counterspace weapons that approach and destroy their targets after having been placed into orbit themselves. Unlike direct-ascent systems, which can strike their targets with no advance warning, co-orbital systems can usually be tracked before reaching their targets, potentially allowing the enemy satellite to perform evasive maneuvers. Despite that drawback, Russia is believed to have developed at least two such weapons under projects named Nivelir and Burevestnik, both of which were initiated in September 2011. Satellites belonging to both projects have likely been tested in orbit in the past decade, demonstrating the ability not only to rendezvous with other satellites in space, but also to destroy them.

The Nivelir Project

Nivelir appears to be a program with multiple objectives. One of the elements of the project is a satellite code-named 14F150, developed by NPO Lavochkin. Probably weighing around 500 kg, five of these satellites are believed to have been launched from Plesetsk since 2017 under the cover names *Kosmos-2519*, *2542*, *2558*, *2576* and *2588*. The first three were launched by the Soyuz-2-1v rocket and the last two by a heavier Soyuz-2-1b launch vehicle. Official Russian launch announcements suggest the 14F150 satellites are used both for Earth remote sensing and observations of other satellites. Analysis of Russian sources shows that they have both a hyperspectral camera and a panchromatic telescope to perform these missions. The four last 14F150 satellites have caused quite some consternation in Pentagon circles by being placed into orbits closely matching those of U.S. optical reconnaissance satellites. Three of them (*Kosmos-2558*, *2576* and *2588*) are still in orbit at the time of writing, observing the American satellites from distances ranging between about 40 and 200 kilometers.

The first two 14F150 satellites (*Kosmos-2519* and *2542*) each deployed a smaller subsatellite (*Kosmos-2521* and *2543*) that rendezvoused with other Russian satellites in orbit. During those approaches, they each ejected what U.S. intelligence sources have described as a “high-speed projectile” that can destroy other satellites in space.

2. B. Hendrickx, “[Aerostat: a Russian long-range anti-ballistic missile system with possible counterspace capabilities](#),” *The Space Review*, 11 October 2021; [Aerostat thread](#) on the NASA Spaceflight Forum.

While this did not actually happen during the two tests, Russia definitely demonstrated its capability of doing so. *Kosmos-2558* deployed a similar subsatellite in June 2025 which may very well carry an identical projectile. If the same armed subsatellites are also on board *Kosmos-2576* and *2588*, Russia currently has three satellites in orbit that can theoretically knock out U.S. reconnaissance satellites flying in their vicinity.

The subsatellites and their projectiles are most likely products of the Central Scientific Research Institute of Chemistry and Mechanics (TsNIIKhM), which unlike most Russian satellite manufacturers operates outside the structure of the Russian space agency Roscosmos. In the Soviet days, the institute was mainly engaged in developing solid propellants and explosives, including the explosive charges carried by the IS “killer” satellites. TsNIIKhM is known to be the prime contractor for Nivelir, with NPO Lavochkin acting as a subcontractor.³

The Burevestnik Project

Burevestnik, not to be confused with an identically named nuclear-powered cruise missile, is believed to be a dedicated ASAT project. Its objective is probably to launch small interceptor satellites with rockets that are fired from modified MiG-31BM fighter jets. Unlike rockets launched from fixed sites, these can reach a wide variety of orbital inclinations and be prepared for launch away from the prying eyes of reconnaissance satellites. The overall project coordinator is the Design Bureau of Machine Building (NPK KBM), with TsNIIKhM in charge of building the interceptor satellites, which may share design features with the Nivelir subsatellites. There is some evidence that they will destroy their targets by detonating explosive charges in their vicinity, in similar fashion to the Soviet-era IS interceptors. Despite TsNIIKhM's own expertise in that field, it seems to have outsourced work on the payload to the Krasnoarmeisk Scientific Research Institute of Mechanization (KNIIM). The three-stage solid-fuel rocket needed to place the satellites into orbit is referred to in documents as “Product 293” and is manufactured by NPO Iskra.

Two *MiG-31BM* jets with tail numbers 81 and 82 were photographed by aircraft spotters at the Flight Research Institute (LII) in Zhukovskiy near Moscow in 2018-2020 while performing test flights with the black “293” missile suspended under their bellies.

3. B. Hendrickx, “[Russia’s secret satellite builder](#),” *The Space Review*, 6 May 2019; B. Hendrickx, “Project Nivelir: Russia’s inspection satellites,” [part 1](#) and [part 2](#), *The Space Review*, 28 April 2025 and 5 May 2025; [Nivelir thread](#) on the NASA Spaceflight Forum.



A MiG-31BM fighter jet with the “293” missile attached to its belly.

Source: Alex Snow.

While the “293” air-launched rocket has not seen any launches yet, it *is* possible that one or more experimental Burevestnik satellites have already been placed into orbit by conventional ground-based rockets. Three small satellites carried as co-passengers by the Rokot launch vehicle in 2013-2015 (*Kosmos-2491*, *2499* and *2504*) appear to have been prototype versions of the Burevestnik satellites. The latter two performed rendezvous and proximity operations with the rocket’s Briz-KM upper stage. Other possible candidates are *Kosmos-2535* and *2536*, launched together in 2019. One of the satellites shed considerable amounts of debris, possibly pointing to some kind of test of an explosive device.

Operational flights are likely to be staged from the airport of the Plesetsk cosmodrome, where construction work in support of the Burevestnik project began in late 2019. The latest satellite photography of Plesetsk shows that an extension to the existing runway has been completed as well as a hangar that may house one or more *MiG-31BM* jets. However, work on other infrastructure for Burevestnik at the launch site appears to be behind schedule.⁴

Laser ASAT Systems

One of the main disadvantages of kinetic ASAT weapons is that they produce a significant amount of space debris that can pose a hazard to the attacking side’s own satellite fleet. There are, however, ways of disabling satellites without physically

4. B. Hendrickx, “[Burevestnik: a Russian air-launched anti-satellite system](#),” *The Space Review*, 17 April 2020; [Burevestnik thread](#) on the NASA Spaceflight Forum.

destroying them. One of these is to use laser beams to dazzle or blind optical systems needed to orient satellites or image targets of interest on the ground. Dazzling causes sensors to temporarily lose their imaging capability by swamping them with light that is brighter than what they are trying to image. Blinding inflicts permanent damage to such systems. Since imaging sensors are very sensitive to light, only relatively low power levels are needed to achieve these goals.

Russia has been working on three such laser systems, one airborne system and two ground-based systems. Their goal is to interfere with the operations of low-orbiting reconnaissance satellites attempting to make detailed images of Russian territory. Development of the airborne system, called Sokol-Eshelon, officially started on December 23, 2002 with the signing of a government contract between the Ministry of Defense and NPO Almaz, which belongs to the Almaz-Antei concern. In press interviews given in 2010 and 2014, the project's chief designer said it was considered part of Russia's response to America's withdrawal from the Anti-Ballistic Missile Treaty in June 2002 and was designed to "counter air-based and space-based reconnaissance assets in the infrared part of the spectrum," an apparent reference to dazzling and/or blinding. Advantages of airborne laser ASAT systems are that they have more flexibility in the choice of targets and that the laser is not hampered by weather conditions.

Initially, Sokol-Eshelon used a modified *Ilyushin-76MD* transport aircraft originally built for an unrelated Soviet-era laser project. The aircraft has also been called the *Beriyev A-60*, because it was modified for that purpose by the Beriyev design bureau in Taganrog. It flew a number of test flights in the first decade of this century, including one in which it aimed a laser beam at a Japanese geodetic satellite, taking advantage of the presence of corner reflectors on the satellite to test the targeting system against a satellite in a known orbital path.



The *Beriyev A-60* aircraft modified for Sokol-Eshelon.
Source: Mikhail Mizikaev RovSpotters Team.

A new *Ilyushin-76* aircraft (a modified *Il-76MD-90A*) was officially handed over to the Ministry of Defense in April 2015 to continue test flights under the project, but at that point still needed to be outfitted with the laser complex. According to online court documentation, the Sokol-Eshelon contract was annulled in October 2020, indicating that the project was discontinued after a nearly 20-year effort.⁵

One of the ground-based laser ASAT systems is called Kalina and is situated on the Chapal mountain near Storozhevaya in the North Caucasus. It is part of a complex named Krona that includes both optical and radar systems for space surveillance. Kalina officially started on November 3, 2011 with a contract awarded to the Scientific and Industrial Corporation “Precision Instrument Systems” (NPK SPP), the prime contractor.

Evidence for Kalina being a laser ASAT system comes from several sources. First, a bank guarantee document placed online in January 2014 described Kalina’s goal as “the creation of a channel for the functional suppression of electro-optical systems of satellites... using solid-state lasers and a transmit/receive adaptive optics system.” Second, NPK SPP’s annual report for 2013 mentioned its involvement in the development of “laser systems for electro-optical warfare.” Third, another official document described Kalina as a “space security complex,” the same term used to describe the Burevestnik ASAT project.

Satellite imagery shows that construction of Kalina got underway in 2019, which clearly was many years behind schedule. It was built right next to a large rectangular building that has been part of Krona for many years and which houses a telescope and a lidar system. The new features that appeared in recent years are a smaller observatory and a tunnel connecting it with the existing lidar building.



Google Earth image of the Kalina laser facility.

5. [Sokol-Eshelon thread](#) on the NASA Spaceflight Forum.

As can be learned from online documentation, Kalina's laser system was placed inside the existing building and the laser beams are routed through the tunnel to a telescope with a one-meter mirror that is installed in the new observatory. Kalina has an adaptive optics system that compensates for atmospheric turbulence to produce images of the target that are sharp and detailed enough to make sure that the laser beams can subsequently be accurately aimed at the object's optical systems. Judging from the available documents, this aiming is done manually by an operator who can simultaneously see the target's image and the emitted laser beam and then select a spot on the target that needs to be "illuminated." The system can also be used in daylight by filtering out background light.

Although the external structures of Kalina are in place, the satellite imagery does not reveal anything about the work going on inside. Online court documentation makes it possible to determine that Kalina was not yet operational by the end of 2022. Its current status is unknown.⁶

Another ground-based laser system with a counterspace role is a mobile complex unveiled by President Vladimir Putin in his State of the Union address in March 2018 and subsequently named Peresvet by popular vote. Videos released by the Ministry of Defense show the white laser system mounted in the aft section of a truck consisting of a tractor unit and a semi-trailer.



The Peresvet anti-satellite laser system.
Source: Russian Ministry of Defense.

Although Putin did not reveal any details about Peresvet in his 2018 address, its counterspace objectives became clear in subsequent years through analysis of publicly available online documents and have since been acknowledged by Russian officials. The roots of the project go back to 2010, when the Ministry of Defense

6. B. Hendrickx, "[Kalina: a ground-based laser to dazzle imaging satellites](#)," *The Space Review*, 5 July 2022.

assigned it to the Russian Federal Nuclear Center – All-Russian Scientific Research Institute of Experimental Physics (RFYaTs-VNIIEF), which has done extensive research in the field of laser technology. The project's internal name appears to be Stuzha-RN and the system is also referred to with the military index 14Ts034.

Peresvet is co-deployed with Russian road-mobile intercontinental ballistic missiles and its objective is to conceal their movements through what the Russians call “the functional suppression” of electro-optical reconnaissance satellites. Whether that means dazzling or blinding of optical sensors is open to interpretation, although the former looks more likely. Preventing spy satellites from tracking mobile ICBM complexes would come in handy if there were signs of an imminent attack on Russia's ICBM arsenal or if Russia itself had the intention to launch a nuclear first strike on another nation.

One recent article in a Russian military journal disclosed that Peresvet can target satellites orbiting between altitudes of 200 and 1,000 km. Its capabilities seem to have been geared to U.S. KENNEN reconnaissance satellites flying in highly elliptical orbits (roughly 260x1,000 km). Only two of those are currently still in orbit and later generations have been placed into lower, more circular orbits. However, Peresvet was conceived well before those newer satellites began flying.

In late 2019, Defense Minister Sergei Shoigu announced that Peresvet had been declared operational at five missile divisions on December 1, 2019. Shelters for the Peresvet trucks with the code-name 2146 have been spotted on Google Earth at ICBM garrisons near Teikovo, Novosibirsk, Barnaul, Yoshkar-Ola and Nizhniy Tagil. These garrisons operate both the Topol-M and Yars ICBMs.

Since Peresvet is now considered operational, it has seemingly overcome significant technical challenges such as the development of sophisticated adaptive optics and pointing control systems to aim laser beams at fast moving orbiting targets. It is possible that a number of low-orbiting experimental military satellites launched by Russia since 2021 have served as test targets for Peresvet.⁷

Electronic Warfare Systems

Another non-destructive way of attacking satellites is through electronic warfare (EW) in the radio part of the electromagnetic spectrum. Electronic warfare has gained tremendous significance in Russia's military doctrine over the past fifteen years or so. The country has consistently invested in electronic warfare modernization and fielded a variety of new EW systems to augment the capabilities of all service branches. They are probably perceived as a relatively inexpensive, asymmetric response to Western military technological development and have proved to be very effective in the current war in Ukraine. Russia's space-related EW systems fall into two categories. One is intended to interfere with the operations of communications and navigation satellites. The other aims to prevent radar reconnaissance satellites from taking pictures of areas of interest in Russia.

7. B. Hendrickx, “[Peresvet: a Russian mobile laser system to dazzle enemy satellites](#),” *The Space Review*, 15 June 2020; [Peresvet thread](#) on the NASA Spaceflight Forum.

Interfering With Communications and Navigation Satellites

The first category can further be subdivided into downlink jammers and uplink jammers. Downlink jammers are designed to affect satellite communication user terminals and GPS receivers in a local area. They must therefore be within the field of view of the receiving terminal's antenna. Russia has several such systems, but these fall outside the scope of this article. What will be discussed here are uplink jammers, which interfere with the satellites themselves, affecting services for all users in the satellite reception area.

One type is a mobile system called Tirada. A first-generation version named Tirada-1 was introduced back in the Soviet days and one of its elements (Tirada-1D) may still be operational today. A follow-on project called Tirada-2 was started on December 19, 2001 with a contract awarded to the Vladimir Design Bureau of Radio Communications (VKBR, Vladimir is a town some 200 km east of Moscow). Several official Russian sources have confirmed that it is specifically designed to counter communications satellites. Some of the wording used in official statements would suggest that, if necessary, Tirada-2 could be used to inflict permanent damage to on-board satellite communications systems, but it is impossible to verify whether this is really the case and no such incidents have been reported so far. A more likely scenario is that Tirada-2 overwhelms the electronic protection systems of satellites, forcing them to spend all their electrical power on trying to counter the jamming signals and thus temporarily robbing them of the ability to relay signals to the ground.

Official documents mention four iterations of the system called Tirada-2S, Tirada-2.2, Tirada-2.3 and Tirada-2.4, all of which were under development before 2010. They, along with their Soviet-era predecessor, are presumably designed to cover different parts of the radio spectrum. The letters "D" and "S" seen in Tirada-1D and Tirada-2S likely refer to the fact that they target satellites operating in the decimeter (UHF) and centimeter (SHF) frequency bands, corresponding to 300 MHz-3 GHz and 3 GHz-30 GHz respectively. So far, there are no positively identified pictures of Tirada-2 jammers, but there are some indications that it is the vehicle seen in the image below.



Possible view of a Tirada-2 jammer.
Source: NPP Inprokom.

After many years of delays, Tirada-2S seems to have reached at least some level of operational capability. In December 2018, the Ministry of Defense published a statement on its website saying that it would enter service in Russia's Central Military District the following year and underlined its ability to "completely disable communications satellites." During a military exhibition in August 2018, it was publicly announced that the Ministry of Defense had placed an order for the delivery of Tirada-2.3 complexes beginning later that year. As can be determined from procurement documentation, government contracts for the production of Tirada-2.2 and 2.4 complexes were signed in October 2019. It is not clear whether Tirada-2.2, 2.3 and 2.4 are currently operational, but it does seem that Tirada-2 type jammers are being used on the battlefield in Ukraine. Ukrainian forces claim to have destroyed two of them in July 2023 and January 2024.

Another mobile EW system called Bylina-MM is designed to jam communications satellites operating in the "millimeter band" (EHF, corresponding to 30-300 GHz). It is just one component of a much broader EW project (Bylina) assigned to the Central Scientific Research Institute of Economics, Informatics and Control Systems (TsNII EISU) on November 3, 2011. The main goal of Bylina probably is to develop a highly automated mobile EW command and control system that uses artificial intelligence to select and recognize targets (not only satellites) and issue relevant orders to EW units in the field. Bylina-MM would appear to be only one of those. Work on Bylina-MM was subcontracted to the Moscow Radiotechnical Scientific Research Institute (MNIRTI) on January 10, 2012. One MNIRTI publication identifies several U.S. and NATO communications satellites that can be targeted by Bylina-MM. As can be inferred from another source, it will focus more specifically on satellites using the Ka-band (the preferred band for high-performance geostationary communications satellites) and V-band, which is used for crosslink communications between U.S. Air Force Milstar satellites, one of the confirmed targets of Bylina-MM. The current status of the project is unknown.

Serving a similar purpose is a network of stationary EW systems known as Tobol (also designated 14Ts227). It consists of seven complexes that are co-located with infrastructure of Russia's space tracking network. Code-named 8282, these are situated near Shcholkovo (Moscow region), Ulan-Ude (Republic of Buryatiya), Ussuriysk (Primorskiy region), Yeniseisk (Siberia), Pionerskiy (Kaliningrad region) and Armavir (Krasnodar region). Although none of them are configured exactly the same, most have a combination of bigger and smaller parabolic antennas. All indications are that all seven complexes are fully operational.



Map and Google Earth image of the Tobol complex near Ulan-Ude.

A decision to press ahead with Tobol seems to have been made in 2010, with a contract for development awarded to Russian Space Systems on May 3, 2012. One official Russian document that was temporarily available online described Tobol as being an electronic warfare system for “space-related purposes.” Confirmation of its counterspace role came in early 2023 when the Washington Post obtained secret Pentagon documents leaked by an employee of the U.S. National Guard. These revealed that Russia had used the Tobol complexes near Shcholkovo, Pionerskiy and Armavir in a 25-day experiment to disrupt communications via SpaceX’s low-orbiting Starlink satellites in Ukraine’s Bakhmut region.

Since Tobol was conceived long before Starlink, it is clear though that it was not specifically designed to counter only that satellite constellation. In fact, it appears to be a multifunctional system that can be used for a variety of purposes. The Tobol site in Pionerskiy has been linked to the jamming of GPS signals in the Baltic Region, which began in late 2023 and has affected commercial air traffic in the region. Open-source analysis has traced the source of the jamming to the Kaliningrad region, with the Tobol complex considered a prime suspect. The same complex may also have been involved in disrupting the relay of Ukrainian TV broadcasts via several European geostationary communications satellites in the first half of 2024. A report published by the International Telecommunications Union in July 2024 named Kaliningrad as one of the places to which the jamming had been geolocated.

Preventing Radar Satellites From Taking Images

Another target for Russian mobile EW complexes are radar reconnaissance satellites that can make high-resolution images of the ground in any conditions, even at night and through cloud cover. The purpose of the EW systems is to prevent these satellites from making images as they fly over Russian territory (in very much the same way as Peresvet and Kalina dazzle optical reconnaissance satellites while making passes over Russia). One such system is called Krasukha, which consists of two types of mobile radar jammers called Krasukha-2 and Krasukha-4. Development of these began back in the 1990s, but they weren’t declared ready for serial production until early 2011. The prime contractor for both is VNII Gradient, which belongs to the Radio Electronics Technologies (KRET) holding.

While the two systems seem to be mainly aimed at jamming airborne radar systems, Krasukha-4 is also widely reported to have the ability to interfere with observations of radar reconnaissance satellites. A former version of KRET’s website described it as a “mobile electronic warfare system to suppress spy satellites, ground-based radars and AWACS airborne systems,” adding that it can “fully cover an object from radar detection at 150-300 km” by creating “powerful jamming at fundamental radar frequencies.” In May 2015, an anonymous military official was quoted as saying that Krasukha-4 was being successfully used against U.S. radar reconnaissance satellites of the *Lacrosse* type.



The Krasukha-4 radar jammer.
Source: Voennoye obozreniye.

Although Krasukha-2 and 4 are still being upgraded, VNII Gradient has also been working on a more advanced radar suppression system called Divnomorye, assigned to KRET on December 20, 2012. Annual reports published by KRET have called Divnomorye a system for “the electronic suppression of airborne and space-based assets.” In May 2018 unnamed sources within the Ministry of Defense were quoted as saying that Divnomorye was expected to begin operational deployment later in that year and would combine the functions of both Krasukha-2 and Krasukha-4.⁸

Finally, Russia is also believed to be working on a capability to conduct electronic warfare *from* space. KB Arsenal in Saint-Petersburg is known to be working on a satellite called Ekipazh (also designated 14F350) under a contract awarded by the Ministry of Defense on August 13, 2014. It will be powered by a thermionic nuclear reactor developed by the Krasnaya Zvezda company. Articles published by KB Arsenal in 2014-2016 described the use of such nuclear-powered satellites to conduct electronic warfare against objects in space and on the ground. One court document specifically linked Ekipazh to electronic warfare. Despite the fact that the project has been underway for ten years, there are currently no signs that the launch of this satellite is imminent.⁹

A Possible Nuclear ASAT

In February 2024, White House officials asserted that Russia is developing a space-based anti-satellite system that would violate the 1967 Outer Space Treaty, which prohibits the deployment of weapons of mass destruction in orbit. They later confirmed media speculation that it is a nuclear-armed weapon, but provided little

8. B. Hendrickx, “[Russia gears up for electronic warfare in space \(part 1\)](#),” *The Space Review*, 26 October 2020; B. Hendrickx, “[Russia gears up for electronic warfare in space \(part 2\)](#),” *The Space Review*, 2 November 2020; [Thread](#) on Russian space-related electronic warfare projects on the NASA Spaceflight Forum.

9. B. Hendrickx, “[Ekipazh: Russia’s top-secret nuclear-powered satellite](#),” *The Space Review*, 7 October 2019; [Ekipazh thread](#) on the NASA Spaceflight Forum.

further detail. Press reports claim that the weapon would produce a nuclear electromagnetic pulse and a flood of highly charged particles that could potentially cripple a vast swath of commercial and government satellites orbiting the Earth. Russia vehemently denied the U.S. allegations.

US officials have remained vague on how far the development of the weapon has advanced, divulging only that it is not considered an imminent threat. They did hint that unspecified elements of the weapon system may already be undergoing testing aboard a secret military satellite that Russia placed into an orbit rarely used by other spacecraft, one where it is exposed to a higher than usual radiation levels. The satellite can be identified as *Kosmos-2553*, launched into a 2,000 km high orbit on February 5, 2022. As can be determined from various sources, it has the military index 14F01 and belongs to a program named Neutron that was assigned in 2011 to NPO Mashinostroyeniya. This company has so far built only radar observation satellites called Kondor that are used for a mix of civilian and military purposes.

Available evidence actually suggests that Neutron is a dedicated military radar observation satellite based on Kondor. The little information on the satellite that can be extracted from open sources suggests that it shares design features with Kondor. Moreover, the satellite repeats its ground track with an accuracy of about one kilometer every four days, which is ideal for interferometric synthetic aperture radar imaging, a technique that requires a satellite to pass over exactly the same region at different times and obtain images from slightly different viewing angles to generate 3D maps of features on Earth. There are no clear signs that *Kosmos-2553* has anything to do with the development of a space-based nuclear weapon. Whatever its purpose, it no longer appears to be operational. Visual and radar observations show that the satellite has been tumbling in orbit since November 2024, suggesting that it either went out of control or was deliberately de-activated.

Some analysts have reacted skeptically to the U.S. allegations, questioning the benefits that such a weapon would have. While a nuclear explosion in space is the only effective way of knocking out entire constellations of satellites (like SpaceX's Starlink), it would also disable a significant portion of Russia's own satellite fleet. The only logic behind the deployment of such a weapon would seem to be its use as a deterrent or as a last-ditch weapon in case all other options are exhausted. Questions have also been raised about the wisdom of actually orbiting a nuclear weapon, which makes it more vulnerable to detection or even attack. Nuclear weapons can just as well be delivered to space by intermediate or intercontinental ballistic missiles flying on suborbital trajectories. That is the way both the United States and the Soviet Union conducted a number of high-altitude nuclear explosions between 1958 and 1962 before they were banned.

Since the U.S. has not shared any of the intelligence on the purported nuclear weapon, it is hard to say if it is really under development. What can be deduced from academic literature is that Russia is conducting research on high-altitude nuclear explosions and their effects on the space environment. This research is not limited to theoretical calculations and computer simulations, but is also being done in the form

of experiments in plasma chambers. Still, that is not necessarily indicative of any active work on a space-based nuclear weapon.¹⁰

Analysis of academic literature also indicates that Russia is exploring the possibility of deploying anti-satellite plasma and electromagnetic pulse weapons that would mimic some of the effects of nuclear explosions without having the same devastating effects. While studies of plasma weapons so far appear to be purely theoretical, work on electromagnetic pulse weapons, particularly in the ultra-wide band range, may have reached a stage where space-based experiments have been or will be performed in the near future.¹¹

Conclusion

Despite repeated calls by Russia in recent years to impose a ban on space weapons, there is ample evidence that the country itself has been working on an impressive array of ASAT systems. Many of them have clearly suffered significant delays, probably due to a mix of technical and economic problems. Western-imposed economic sanctions in particular have had a major impact on Russia's space industry, which remains highly reliant on imported electronic components.

Still, several direct-ascent and co-orbital ASAT weapons have already been tested and a number of laser and electronic warfare ASAT systems have reached operational status. The latter two types are most likely already being actively employed against foreign reconnaissance and communications satellites. Since they are non-destructive and only temporarily prevent those satellites from carrying out their duties, they can be used almost covertly, making it hard for the enemy to point the finger at Russia. On the other hand, kinetic direct-ascent and co-orbital ASAT weapons such as Nudol, Nivelir and Burevestnik are designed to physically destroy enemy satellites. Their use against Western satellites would be impossible to conceal and would most likely be considered an act of war, possibly leading to the invocation of NATO's Article 5. In 2021, this was rewritten to include the space domain, meaning that an attack on a NATO member's space assets could incur a response from across the alliance. Russia currently has the means to launch such attacks against low-orbiting satellites. The Nudol missile is probably on operational standby at the Plesetsk cosmodrome and three Nivelir satellites possibly armed with ASAT projectiles are orbiting close to a trio of American optical reconnaissance satellites. The question is if Russia merely sees such systems as deterrents or actually intends to use them, whether provoked or not. There is no doubt though that Russia has a counterspace capability unmatched by that of any other nation in the world, whatever the country's motives for that may be.¹²

10. B. Hendrickx, "[Russian research on space nukes and alternative counterspace weapons \(part 1\)](#)," *The Space Review*, 13 May 2024.

11. B. Hendrickx, "[Russian research on space nukes and alternative counterspace weapons \(part 2\)](#)," *The Space Review*, 20 May 2024.

12. For a good overview of worldwide ASAT projects, see annual reports published by the [Secure World Foundation](#) and the [Center for Strategic & International Studies](#).

The Use of Nuclear Energy in Space: Interests, Challenges, and Prospects For Military Space

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In a context where the space domain is moving toward an increased need for energy, particularly for civilian exploration programs to the Moon and Mars, space nuclear energy, which is particularly suited to such challenges, also has a military interest, especially for missions to support forces and operate in Space. The use of nuclear power in Space could eventually become a technological differentiator as well as a decisive factor of operational superiority for the armed forces.

With the intention of taking advantage of such promises, the United States and the USSR committed to national programs in the 1960s, which for the Soviet case led to the deployment of 33 ocean observation satellites equipped with thermonuclear generators between 1970 and 1988. Despite promising successes, the various projects were abandoned for technical and financial reasons.

Today, as nuclear power appears to be returning to energy policies, its potential use in Space is generating renewed interest among certain space powers. Russia, benefiting from expertise acquired in the 1970s, has been working since 2010 on the development of a nuclear-powered space tug. It is officially intended to support the country's exploration program, but its dual, civil and military nature cannot be ruled out. In 2017, the China Aerospace Science and Technology Corporation (CASC), the leading Chinese manufacturer of satellites, launchers, and missiles, published a roadmap for 2040 which mentioned the development of spacecraft with a nuclear propulsion system. In December 2021, the United States unveiled its national strategy on the use of nuclear energy in Space. It has also been engaged since 2015 in the development of a nuclear reactor, the Fission Surface Power (FSP), which is intended to deliver approximately 10 kWe (kilowatts of electrical power) for ten years

on the surface of the Moon or Mars from 2031. In July 2023, the UK Space Agency published its roadmap for space exploration, presenting nuclear power as one of its areas of focus. It also commissioned a preliminary study from Rolls-Royce at the same time for the sizing of a nuclear-electric reactor that could be used on the surface of the Moon or other celestial bodies. More recently, Italy and Germany have finally announced their intention to position themselves in favor of the development of a space nuclear reactor.

Despite its dual nuclear and space expertise, France remains to date the only space power on the sidelines of the dynamics observed elsewhere in the world. However, the national and European context appears favorable for the emergence of a debate on the subject. The creation of the Space subsidiary of the French industrial company Framatome, alongside the studies commissioned in 2023 by the European Space Agency (ESA) to the French Alternative Energies and Atomic Energy Commission (CEA), attests to a growing interest in this subject. Could the future national space strategy, whose publication is expected in autumn 2025, formalize a French ambition in this area?

Operational Applications of Space Nuclear Power

As solar panels reach their theoretical limit of development, the space deployment of a nuclear reactor offers a glimpse of operational opportunities. These are both civil and military and are found in the fields of spacecraft propulsion and energy production.

Propulsion

The nuclear propulsion of spacecraft can be either thermal, also known as ‘calorific,’ or electric, referred to as ‘electrogenic.’ In the former case, the nuclear reactor heats liquid hydrogen, which is then ejected through a nozzle to provide propulsion for the spacecraft, whether it be a satellite, space tug, or even the upper stage of a launcher. The thrust produced is considerably increased compared to a conventional mode of propulsion. For exploration missions, such a process would drastically reduce the duration of interplanetary travel. With this mode of propulsion, the journey to Mars, currently estimated to take almost nine months, could be completed in 45 days. From a military perspective, for “active defense” missions, such as those that patrol and surveillance spacecraft like YODA¹ are preparing to carry out, the swiftness offered by thermal nuclear propulsion would allow a patrol craft to move quickly and unpredictably toward a target. This would considerably reduce the time taken to implement the OODA loop (Observe, Orient, Decide, Act).

In the case of nuclear-electric propulsion, the nuclear reactor powers an electric engine that ejects ions at high velocity. Unlike thermal propulsion, the electric vari-

1. YODA (Yeux en Orbite pour un Démonstrateur Agile, or in English: Eyes in Orbit for an Agile Demonstrator) is a French Space Command program aimed at sending two patrol satellites into geostationary orbit to test active defense missions.

ant produces a low thrust but over a longer period of time. Although the duration of a mission to Mars would not be significantly shortened, the autonomy that the electric variant provides appears relevant for missions that require constant mobility. This would facilitate deep space exploration. In the military domain, this longevity and potential permanent mobility could be used by patrol craft on the geostationary orbit to ensure permanent surveillance of their environment. More generally, whether with an electric or thermal variant, a military spacecraft with nuclear propulsion can adopt a less predictable trajectory. This is because it is unconstrained by some of the physical limitations on mobility and temporality imposed by conventional propulsion.

Despite such operational advantages, a nuclear-propelled vehicle remains dependent on the quantity of propellants available. Indeed, the hydrogen for the calorific variant and the plasma for the electrogenic version will be consumed more quickly than the nuclear fuel. Although nuclear propulsion provides a much greater autonomy to a spacecraft than a conventional mode of propulsion, it is already necessary to study the relevance of refueling propellants in orbit. This would extend the vehicle's operational lifespan according to its remaining reserve of nuclear fuel.

Finally, these prospects must not obscure significant technological hurdles, such as the cooling of the nuclear reactor, which are linked in particular to the absence of a radiative environment in Space. To compensate for this environmental constraint, large radiators will have to be deployed. This would considerably increase the weight of the reactor, which is estimated at several tons if the ambition to deliver several hundred kWe were to be pursued. Furthermore, the thermoelectric efficiency – the transformation of heat into electricity – poses other challenges. While the efficiency rate of a ground-based nuclear power plant is approximately 33%, this could be considerably reduced once in orbit.

Energy Production

Today, the production of onboard energy using nuclear power sources relies primarily on radioisotope heater units (RHU²) and radioisotope thermoelectric generators (RTG³). This technology has been mastered primarily by Russia and the United States since the 1960s. Such systems, which can be grouped under the term “radioisotope generator” given that they operate on plutonium-238 or americium-241, have powered exploration probes such as *Pioneer*, *Voyager*, *Perseverance*, and, more recently, *New Horizons*. However, the power emitted by RTGs and RHUs, of the order of a few tens of watts, hinders the emergence of disruptive applications, both civil and military. While the principle of energy abundance should not be sought through RTGs and RHUs, these generators could serve a “survival” mode for satellites of interest due to their robustness, compactness, and autonomy from the sun. As a result, the permanent distribution of energy could power the batteries of a satellite unable to maintain its attitude and its exposure to the sun following a technical problem or an adverse attack, allowing operators to retain remote control while they deal with the damage.

2. Radioisotope Heater Unit.

3. Radioisotope Thermoelectric Generator.

For their part, nuclear reactors offer an increased amount of energy, in the order of a few tens or even hundreds of kilowatts.⁴ On the surface of a celestial body, a nuclear reactor would support civilian missions of exploration, the colonization of the Moon, and the exploitation of its resources. The emergence of a lunar economy would become feasible because mining extraction infrastructures or life-support bases could operate continuously and without a theoretical power limit. This would be possible as they would no longer be dependent on solar energy. In the military domain, and particularly for operational support missions, a nuclear reactor could be carried on board to power energy-intensive systems. One such example is an observation satellite equipped with a synthetic aperture radar (SAR) sensor. The emission of electromagnetic radiation, which is inherent to the operation of a SAR sensor, in fact requires a significant amount of energy. Satellites in this category, operating thanks to solar panels, must take breaks between capturing images in order to recharge their batteries in particular. These constraints would be eliminated by a nuclear reactor capable of continuously delivering the energy required for the mission. The constraints related to the radiative environment or to energy conversion, mentioned above, will nevertheless have to be considered.

In the longer term, the transfer of energy via microwaves or lasers could also be pursued. On the one hand, from Space to Earth, a process whose feasibility was demonstrated by the California Institute of Technology in June 2023; on the other hand, from Space to Space. While the first application could support ground operations, notably by providing energy to forward-deployed military bases, the second could transmit energy to traditional satellites in order to contribute to the conduct of their missions. Such applications are not without considerable technical challenges, whether related to in-orbit pointing or the dispersion of energy between the emitter and the receiver.

An International Context Favorable to the Use of Nuclear Energy in Space

In light of the operational prospects offered by the use of nuclear energy in space, a competition appears to be developing between the main powers, notably the United States, China, and Russia. For its part, Europe is positioning itself through national initiatives led by the United Kingdom, Italy and, more recently, Germany. Despite its dual nuclear and space expertise, France still appears to be largely on the sidelines of current dynamics.

A Leading Trio

The United States of America

As early as 1960, the United States showed an interest in space nuclear power, investing nearly \$10 billion over ten years to develop a thermal nuclear propulsion system. Abandoned for budgetary reasons, this program, named NERVA (Nuclear

4. To note, the 2,500m² of solar panels on the International Space Station provide approximately 110 kWe.

Engine for Rocket Vehicle Applications), nevertheless culminated in a ground test in 1969 that was almost ready for flight-testing. At the same time, NASA was working on the development of an experimental satellite equipped with a fission reactor. Launched in 1965, SNAPSHOT (Space Nuclear Auxiliary Power Shot) operated for 43 days before suffering a technical failure. In 1972, following the Apollo program, NASA's resources were reduced, cutting off a portion of the experimental programs' funding. This budget cut ultimately led to the abandonment of U.S. ambitions in the field of space nuclear energy. Only the use of radioisotope generators has endured, particularly for powering the batteries of exploration probes or rovers such as *Pioneer*, *Voyager*, *Cassini*, and *Perseverance*. The United States nevertheless decided to close its Savannah River laboratory in 1988, which was dedicated to the manufacture of plutonium-238 – a material essential for the operation of RTGs and RHUs. After sourcing Russian plutonium-238 until the early 2010s, the U.S. Department of Energy finally relaunched a production line capable of meeting domestic demand.⁵

In December 2020, in light of the return to the Moon, the United States renewed its interest in space nuclear reactors and published its “Memorandum on the National Strategy for Space Nuclear Power and Propulsion” under *Space Policy Directive 6*, which is the equivalent of a dedicated roadmap. This agenda aims, on the one hand, to rebuild national capacities for processing the nuclear fuel required for the operation of space systems and, on the other, to conduct an initial test of a surface nuclear power system dedicated to lunar missions by 2030. In 2021, a presidential decree supported this momentum by defining a framework for cooperation between the Department of Defense (DoD) and NASA, as embodied until recently by the Demonstration Rocket for Agile Cislunar Operations (DRACO) project. The latter is a thermal nuclear propulsion demonstrator developed jointly by the Defense Advanced Research Projects Agency (DARPA) and NASA. Despite funding of up to \$500 million and numerous technical milestones being reached, the project, which was due to culminate in an orbital demonstration in 2027, was abandoned in May 2025. Although the official reasons have not been stated, the project suffered from the context of NASA's budget cuts and a growing lack of enthusiasm for thermal nuclear propulsion in favor of the electric variant, which is considered easier to implement. Numerous experts also highlight the inadequacy of ground testing capabilities and the additional costs that would need to be considered in order to successfully process the radioactive substances contained in engine exhaust gases. History could be repeating itself after the abandonment of the NERVA program in the 1960s.

Despite these delays, the discontinuation of DRACO does not signify a lack of U.S. interest in space nuclear power. Jared Isaacman, who was initially considered for the position of NASA Administrator before being excluded by the White House, announced in April 2025, during a Senate hearing that he wanted to make nuclear power his priority if he were to take the helm of the U.S. agency. Furthermore, the surface nuclear programs are continuing. Since 2015, NASA has been working on the development of a reactor, initially named “Kilopower” and then “Fission

5. I. Hanine, “[The DoE delivers American plutonium-238 to NASA](#),” *Sfen*, 16 August 2023.

Surface Power” (FSP) in 2018, capable of delivering approximately 10 kWe for ten years on the surface of the Moon or Mars from 2031. The preliminary studies are expected to lead to the imminent awarding of a one-billion-dollar contract for the reactor’s design, construction, and testing. Finally, the U.S. Air Force Research Laboratory’s (AFRL) Space Vehicle Directorate launched the JETSON (Joint Emergent Technology Supplying On-Orbit Nuclear) program for the period 2023-2025 to consider the implementation of an onboard fission reactor and to study a space system integrating RTGs. Contracts worth a total of \$60 million were awarded in 2023 to Lockheed Martin, Westinghouse, and Intuitive Machine for preliminary studies, with the three companies already being involved in NASA’s FSP.

To date, encouraged by a proactive public policy and motivated by lunar and even Martian ambitions, the U.S. space sector appears to be the most invested in the development of nuclear technologies. As proof of U.S. dynamism and the gravitational center that its ecosystem constitutes, the international “Nuclear Energy Space and Defense Tech” summit has been held in Mar-a-Lago since 2024, bringing together a large number of actors in the field each year.

The People’s Republic of China

In 2017, CASC, China’s leading space industry player, published a roadmap mentioning the development of space shuttles with nuclear propulsion by 2040. This was validated at the time by the Ministry of Science and Technology. While this is not a dedicated strategy similar to that of the United States with its *Space Policy Directive*, the roadmap nevertheless reflects a clear political and industrial commitment to space nuclear power. Such orientations are part of an intense agenda of extra-planetary explorations. On the one hand, China is pursuing the International Lunar Research Station (ILRS) program, which is due to culminate in 2035 with the installation of a manned base on the Moon’s South Pole. On the other hand, Beijing makes no secret of its ambitions for a manned flight to Mars, without, however, defining precise milestones. Could the year 2049, which will mark the centenary of the declaration of the People’s Republic, be the year of China’s first manned mission to Mars? Such programs will require a considerable amount of energy, whether on the surface to support life-support bases or to extract mineral resources, or in orbit, to transit to Mars and to ensure the logistical link to Earth.

In February 2024, an article published in the Chinese scientific journal *Scientia Sinica Technologica* reported on the first ground tests of a concept for a lithium-cooled space nuclear reactor. With a projected mass of eight tons and capable of delivering an electrical power of 1.5 MWe, this reactor’s capabilities would far surpass those of NASA’s FSP with its approximately ten kWe. Although the viability of such a project, which still officially lacks industrial support, remains questionable, particularly in view of the announced performance figures, it offers an opportunity to accumulate experience while awaiting a structuring national program. This need to consolidate national efforts also appears to be confirmed in the same scientific publication, where one can read in the conclusion:

“Although there is still a certain gap between the Chinese R&D base for the development of space nuclear reactors and those of the United States, Russia, or other countries, it is estimated that the demonstration of space nuclear reactors can be achieved in the near future, by coordinating national efforts and resources.”⁶

As China openly aspires to be the world’s leading space power in 2045, Beijing will necessarily have to structure its industrial policy on space nuclear power in the near future. To achieve this, the temptation to call on its Russian neighbor could be great, particularly in view of Moscow’s expertise in this field. As a reminder, the Chinese lunar rover Yutu-2, launched in 2018, is powered by a Russian radioisotope nuclear power source. As proof of this growing connivance between the two countries, the Chinese and Russian space agencies signed a cooperation agreement in May 2025 for the deployment of a nuclear reactor on the Moon’s surface in 2035 as part of the ILRS.

Russia

Between 1967 and 1988, while engaged in the Space race with the United States, the Soviets sent 33 RORSAT ocean surveillance satellites into low Earth orbit. The “BE-5” and subsequently “TOPAZ” nuclear reactors, carried aboard these radar imaging satellites, were capable of delivering 2 to 5 kWe of power for 3 to 5 years. Despite several operational incidents, discussed below, this remains to date the most successful space nuclear program in history. In 1994, six second-generation TOPAZ reactors were even sent to the United States during perestroika, where they were subjected to ground tests by U.S., British, French, and Russian personnel. While the tests were indeed successful, the program was not continued by Russia, nor was it purchased by Western countries. Russia nevertheless continued its programs of radioisotope generators (RTG-RHU) for its exploration missions for the purpose of energy production.

In the field of propulsion, the USSR worked between 1965 and 1980 on the development of a thermal nuclear engine. Named RD-0410, this engine, with performance equivalent to the U.S. NERVA, was intended to equip a Proton launcher’s upper stage for possible exploration missions to Mars. Despite conclusive ground tests, the project was halted for financial and political reasons.

After the restructuring of its space sector following the dissolution of the USSR, Russia is showing renewed ambitions in nuclear power and announced in 2010 the development of the Transport and Energy Module (TEM), named “Zeus,” from 2022. This space tug with electric nuclear propulsion, with an announced power of 500 kWe, is officially intended to support scientific exploration missions of the solar system from 2030 onwards. Developed by the company KB Arsenal, which was involved in the past in the development of TOPAZ, this program remains largely clas-

6. Y. Wu, C. Liu, M. Jin, *et al.*, “[Design and R&D of megawatt lithium-cooled space nuclear reactor](#),” *Scientia Sinica technology*, Vol. 54, Issue 3, February 2024, pp. 365-376. Original text in Mandarin automatically translated.

sified despite its officially civilian ambitions. In fact, the TEM's performance could make the vehicle a space nuclear power plant, capable of providing the necessary power for the implementation of directed energy weapons, such as powerful lasers,⁷ via energy transfer to other satellites. As proof of the program's dual-use nature, KB Arsenal launched a study in 2017 aimed at defining the module's military applications.⁸ Furthermore, Russia does not seem to be completely abandoning the expertise acquired from the RORSAT satellites. In 2014, the Russian Ministry of Defense is said to have awarded a \$147 million contract to KB Arsenal and Krasnaia Zvezda, a Rosatom subsidiary, for the development of a satellite equipped with an onboard nuclear reactor, as part of a program named "Ekipazh."⁹ During the 2019 Moscow International Aerospace Salon (MAKS), the two companies mentioned the possibility of carrying a second-generation TOPAZ reactor. The characteristics, missions and status of Ekipazh remain classified to this day.

On a political level, announcements frequently highlight that space nuclear power is of interest to leaders. In late March 2025, Dmitry Bakanov, the new Director General of the Russian space agency and state corporation Roscosmos, announced that space nuclear power is one of his priorities, on par with the manned flight program. Two weeks later, Roscosmos signed a strategic cooperation agreement with the Kurchatov Institute's National Research Centre, which specializes in fundamental research on nuclear technologies. The two entities will form a council and implement the Russian space nuclear program "Space Atom."

Despite the political and scientific proactiveness displayed, the viability of the Russian space nuclear agenda should nonetheless be viewed with caution. For example, the budget allocated to the Zeus program, officially announced for 2030, is not believed to have exceeded \$57 million since 2010. In an interview given in May 2022 to the television channel Russia 24, the former Director of the Russian space agency Roscosmos, Dmitry Rogozin (Yury Borisov's predecessor), stated that his agency did not have sufficient financial resources to successfully carry out the program. Likely aware of these difficulties, the Kremlin, in an instruction given by Vladimir Putin in March 2024, tasked the government with allocating funds for the development of space nuclear energy by 15 June 2024.¹⁰

With the Russian space budget experiencing structural erosion, marked by a 26% decline between 2014 and 2023,¹¹ and with international sanctions following the invasion of Ukraine depriving the sector of a large part of its revenue, Russia could be tempted to move closer to China to implement its ambitions in the field of space

7. ["Russia Says Its Nuclear-Powered Space Tug Can Detect, Disable & Shoot Down Enemy Spacecraft From Orbit,"](#) *The Eurasian Times*, 9 July 2021.

8. A. Zak, ["Russia reveals a formidable nuclear-powered tug,"](#) *Russian Space Web*, 11 July 2024.

9. ["Topic: LB Arsenal's project,"](#) *NASA Spaceflight*.

10. ["Putin asked to allocate funds for the development of space nuclear energy,"](#) *Kosmos News*, 12 April 2024.

11. P. Luzin, ["Russia Space Spending for 2023,"](#) *Eurasia Daily Monitor*, Vol. 20, No. 25, February 10, 2023. The Russian space budget is estimated at \$3.7 billion in 2023, compared to \$5 billion in 2014.

nuclear power. In 2021, Beijing and Moscow announced the creation of an international scientific station on the surface of the Moon (ILRS) by 2035. In this context, the use of nuclear energy appears to be favored, as artist's impressions seem to suggest. While Beijing must structure its expertise in space nuclear power and Moscow has long-standing mastery but limited funding capacity, a rapprochement in this area seems highly likely in the near future.

Dynamics in Europe

The United Kingdom

European dynamics in the field of space nuclear power are largely driven by the United Kingdom. In its technology roadmap for space exploration published in July 2023,¹² the UK Space Agency makes extensive mention of its interest in using nuclear power, whether through fission reactors or RTG-RHUs. In November 2022, the ESA announced the launch of the ENDURE program, for European Devices Using Radioisotopes Energy. Led by the UK and funded to the tune of 25 million euros, this program aims to provide Europe with radioisotope generators (RTG-RHU) by 2030, with a view to supporting exploration missions. However, the amount of energy produced by RTG-RHUs, which is in the order of a few tens of watts, appears insufficient to open up the field to disruptive military space applications. Moreover, RTG-RHUs require the establishment of a complex radioisotope manufacturing chain. While the Russians and the U.S. have been using plutonium-238 since the 1960s, the United Kingdom seeks to innovate by turning to americium-241, which is supposed to be easier to produce despite having a $\frac{3}{4}$ lower energy density. In 2019, the UK Space Agency announced the funding of 20 million euros for a laboratory dedicated to the production of this radioisotope. However, it will take several years to produce enough material to power the first generator.

Not wishing to limit its ambitions to radioisotope generators alone, the UK Space Agency awarded a first contract of 3.4 million euros to Rolls-Royce in 2023 for the development of a lunar surface nuclear reactor demonstrator. London could therefore eventually establish itself as the European leader in space nuclear power, with its capabilities being put to use for NASA's international Artemis program, which aims to return humans to the Moon and establish a sustainable presence there. This program, which is still largely funded and led by the United States, is expected to eventually integrate significant international technological and financial participation.

Italy

In December 2024, the Italian Space Agency and its energy research equivalent announced the launch of the SELENE project (Sistema Energetico Lunare con l'Energia Nucleare), which aims to develop a compact space nuclear reactor for future lunar bases and, more generally, for exploration missions. This three-year project will also benefit from the support of the Politecnico di Milano and Thales Alenia Space

12. "[Space Exploration Technology Roadmap](#)," *UK Space Agency*, 11 September 2023.

Italy. Although it is still too early to envisage the industrialization of SELENE, the work conducted will at least make it possible to invest in new technological fields and invigorate the Italian space and nuclear ecosystem.

This announcement is part of a context of rising Italian space power, as evidenced by numerous initiatives such as the post-Covid recovery plan, which earmarks two billion euros for the sector; the Iride multi-sensor observation constellation project; and a tripling of Rome's contribution to the ESA budget in less than ten years. As a signatory of the Artemis Accords and already involved in the U.S. lunar program with Thales Alenia Space, Italy could aspire – like the United Kingdom – to position itself as a provider of technological components.

Germany

While Germany has historically remained on the sidelines of research work related to the use of nuclear energy in space, the Deutsches Zentrum für Luft- und Raumfahrt (DLR) – the German space agency – announced in July 2025 at the International Space Exploration Coordination Group (ISECG) – a forum for exchange between space agencies – that it had secured funding to launch research for the development of a surface reactor within the framework of the ESA. The very brief nature of this announcement does not currently make it possible to gain a clear understanding of Germany's strategy.

European Space Agency

In June 2022, the European Space Agency (ESA) entrusted the Belgian company Tractebel with leading the European PULSAR project. The project aims, on one hand, to study the space applications of radioisotope generators powered by plutonium-238 and, on the other, to establish a radioisotope fuel supply chain. Given the costs involved in setting up such a supply chain, Europe will eventually have to choose between the solution led by the United Kingdom, based on americium-241, and the one being studied by Belgium, in conjunction with the CEA, ArianeGroup, and Airbus Defence and Space.

Furthermore, in June 2023, the ESA entrusted two feasibility studies on nuclear propulsion and its variants, electric (Alumni study) and thermal (Rocketroll study), to industrial companies and research organizations, such as the CEA and ArianeGroup. These one-year studies, funded to the tune of 500,000 euros, are intended to “inform a roadmap for the possible development of technological components and a demonstrator by 2035.”¹³

While the interest in using nuclear energy in space is not ignored, it is still too early to talk about a European strategy in this area. This is particularly evident in the choices that remain to be made for the power supply of RTG-RHUs and the preliminary nature of studies in the field of propulsion. The ESA is still in a phase of reflection and foresight. Given the difficulties Europe is encountering in launching

13. “[CEA commits to nuclear space propulsion in Europe](#),” *Press & Media*, CEA, 20 June 2023.

a manned flight program – despite its position on space cargo at the previous ESA interministerial summit – there are still many uncertainties about the follow-up to the Alumni and Rocketroll studies. If decisions are made, particularly at the next 2025 ministerial meeting to be held in Germany in November, it seems clear that they will primarily focus on civilian applications, in favor of collaborations such as the one proposed within the framework of Artemis.

France: A Credible Player Remaining on the Sidelines

Between 1982 and 1989, the Centre national d'études spatiales (English: National Centre for Space Studies, or CNES), the CEA, and the Direction générale de l'armement (English: Directorate General of Armament, or DGA) studied the development of a space electronuclear generator. Known as "ERATO," this system was based on a 500 kg liquid metal-cooled reactor, capable of delivering between 20 kW and 200 kW of electrical power. Having remained at the drawing board stage, ERATO, which hinted at both civilian and military applications, remains to date the most advanced French space nuclear project. This was followed by studies between 1995 and 1998 on thermal nuclear propulsion (MAPS project, for Moteur Atomique de Propulsion Spatiale, or English: Atomic Motor for Space Propulsion), then, in 2008, work on a gas-cooled electronuclear generator (OPUS project for Optimized Propulsion Unit System).

Had such work been continued, France, in view of its dual nuclear and space expertise, could have become a pioneering nation. Today, due to a lack of a dedicated roadmap, it remains on the sidelines of the dynamics and competition unfolding around the world. Despite this observation, the industrial and scientific community seems ready to invest in the field. In fact, in October 2023, the company Framatome – already involved in a consortium for the U.S. civil space nuclear program and in the ESA's Alumni project – announced the creation of a subsidiary dedicated to space. While the latter appears to be initially focused on the U.S. market, it could respond to national ambitions in the future.

Furthermore, the national nuclear sector is undergoing a full-scale revival. This is evidenced by the construction of six to fourteen EPR reactors by 2037, the "France Relance 2030" program, the allocation of 1.2 billion euros for civil nuclear power, the various small modular reactor projects, as well as, finally, the launch of the new-generation aircraft carrier and the new nuclear submarine ballistic missile launcher (SNLE 3G) – both of which will integrate onboard nuclear reactors. In this context, potential synergies with programs that have already been initiated would be worth leveraging. For example, the French start-up Naarea is currently developing a small surface-based nuclear reactor with fast neutrons and molten salts, which is expected to produce up to 40 kWe. Even if numerous technical challenges remain, the use of a small modular reactor for space could already be studied.

Given the extremely sensitive nature of nuclear power and the issues raised in terms of safety, security, and proliferation, the emergence of a structuring program that can meet civilian and military operational needs cannot be based solely on an in-

dustrial initiative. While awaiting a political direction, the French space and nuclear ecosystem is showing a growing interest in this subject and appears ready to mobilize its expertise. Although the cost of entry remains to be precisely assessed, France is legitimately positioned to catch up with its main competitors and – given its dual nuclear and space expertise – even establish itself as a unifying country, bringing the European sector with it. Thus, the publication of the national space strategy, expected in autumn 2025, will probably be an opportunity to formalize ambitions in space nuclear power.

Safety, Security, and Proliferation Issues to Consider

Whether during the phases of construction, transport to the launch pad, launch, operation, or decommissioning of a space nuclear reactor, safety, security, and proliferation issues must, of course, be taken into account.

Operational Safety and Security

In 1978, the Soviet RORSAT ocean surveillance satellite *Cosmos-954*, which was equipped with a BE-5 nuclear reactor, disintegrated in the atmosphere. This accident, which was the result of an anomaly in the satellite's attitude control system, caused the dispersal of radioactive substances over Canada, requiring a decontamination effort covering more than 124,000 km². The dispute between Moscow and Ottawa was then settled amicably. Initially designed to disintegrate in the atmosphere, the BE-5 nuclear reactors were subsequently modified to separate from the satellite during end-of-life operations and then be sent to an altitude of 800 kilometers to eliminate any risk of natural return to Earth for at least 400 years. At the end of this period, the decay of radioactivity should allow a risk-free return into the atmosphere. Despite this safeguard measure, in August 1982, the *Cosmos-1402* RORSAT reactor was incorrectly ejected and fell back in February 1983 over the South Atlantic, with no radiological consequences for the population.

Based on such lessons learned, many accidents could be avoided today. Technical progress since the 1980s and increased awareness of nuclear issues have led to the emergence of safer, but naturally more expensive, solutions. At launch, it should be noted that a nuclear reactor would not contain radioactive fission products since its divergence would be carried out in orbit. Furthermore, in order to further mitigate the risks, launching from a maritime platform could prove to be relevant. Finally, from an operational standpoint, a minimum altitude for maintaining the satellite's position could be prioritized, particularly to guard against a natural fall back into the atmosphere. These possibilities should, however, be considered with caution, particularly in view of the in-depth technical studies they require. Indeed, the technical constraints remain considerable, if only to carry out the reactor's divergence in orbit.

Eventually, it will be necessary to incorporate the technical choices made in terms of safety into a new national and international regulatory framework. While the United States seems to have already made the shift by updating its authorization

process for launching space objects carrying nuclear power sources, France - given its status as a launch state with the Guiana Space Centre (CSG) – has not yet reformed its law on space operations in this regard. Finally, on an international level, the legal framework remains permissive, as no text currently regulates the launch of space objects using nuclear power.

Fuel Supply Chain and Nuclear Proliferation Risks

The development of space systems carrying nuclear power sources raises proliferation risks. In the past, the BE-5 or TOPAZ reactors launched by the Soviet Union relied on military-grade uranium, enriched to 95% in isotope 235.¹⁴ By comparison, the uranium-235 enrichment level of fuel used in a nuclear power plant is around 3 to 5%. While very high enrichment in fissile material allows the reactor's size to be drastically reduced, it requires facilities and a supply chain generally used for military applications. From an operational standpoint, such a choice, which imposes increased security on the infrastructure used during the reactor's development and launch, would imply significant additional costs. Furthermore, resorting to highly enriched uranium, whose production is closely monitored by the International Atomic Energy Agency (IAEA), exposes a country to potential accusations of fissile material proliferation.

In light of this observation, recent programs, particularly U.S. ones such as the FSP or DRACO, now favor uranium enriched up to 20%. Although low-enriched uranium leads to an increase in the reactor's mass, the United States has officially favored its use in their space nuclear roadmap, without, however, definitively ruling out the use of highly enriched uranium, particularly if its use is deemed essential and no alternative has been demonstrated to achieve the intended objectives.

The fact remains that establishing a dedicated material production supply chain requires significant technical and financial resources. The simple decision to opt for one level of enrichment or one isotope over another will only be the starting point of a process spanning several years.¹⁵ As a reminder, a Martian rover RTG such as NASA's *Perseverance*, launched in July 2020, contains five kilograms of Pu-238, an isotope whose production is estimated at just over one kilogram per year worldwide.

Conclusion

Aware of the potential of nuclear power, many space powers – first and foremost the United States, China, and Russia – are engaging in dual-use programs that seek to support both civilian and military missions. Although it is still too early to con-

14. Uranium enrichment is a process by which the isotopic content of an element relative to a specific isotope is increased. When the isotope 235 content does not exceed 20%, it is referred to as low-enriched uranium (LEU). Uranium is said to be “highly enriched when the uranium-235 content exceeds 20%. Finally, uranium is generally referred to as “weapons-grade” when its uranium-235 enrichment exceeds 85%. In France, its production was halted in 1996 in the context of nuclear disarmament.

15. R. Mugnier, “[NASA's Mars rover will run on American plutonium](#),” *Usbek&Rica*, 31 July 2020.

firm the relevance of such approaches, they do, at the very least, make it possible to explore a field that portends significant breakthroughs for space operations. While numerous technical and regulatory challenges remain, the operational superiority that the use of nuclear power in space could offer has motivated these countries to engage in exploratory programs. In comparison, France, which holds a considerable comparative advantage in view of its dual nuclear and space expertise, embodies a certain paradox by remaining on the sidelines of the competition that is gradually developing in the field. Yet, history reminds us that missing a technological turning point can have lasting consequences. In light of this observation, the precept displayed in large characters in the Chinese laboratory that conducted tests of a space nuclear reactor in 2023 is enough to awaken consciences: “Innovate or perish. No excuses.”¹⁶

16. Precept written in Mandarin in the hangar used for ground testing of the nuclear reactor. The image can be found here: S. Chen, “[Starship rival: Chinese scientists build prototype engine for nuclear-powered spaceship to Mars](#),” *South China Morning Post*, 19 March 2024.

GEOPOLITICS, CASE STUDIES

National and European Challenges in Space: Strategic Autonomy and the Crucial Balance Between National and European Policies

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In March 2025, Philippe Baptiste, France's Minister of Higher Education and former Chairman and CEO of the French space agency (CNES), explained that "the space sector plays a central role in contemporary geopolitical dynamics."¹ He added that "the arrival of new private players and political decisions on the other side of the Atlantic have changed the game, creating both technological opportunities and strategic uncertainties. This new international landscape is forcing Europe to question the future of its partnerships, including with the United States, as well as the implications this holds for its defense and economic partnerships. The European space industry faces an existential risk if it fails to adapt: it must embark on a profound transition with a long-term vision while ensuring that all players move forward in unison in the current context of high fragmentation within the European sector."

In the face of increased international competition in the space sector, Europe is struggling to maintain its sovereignty and autonomy in terms of military capabilities, innovation and competitiveness. The difficulty posed by finding appropriate and re-

1. A. Guigné, F. Delvert, "[Perspectives Spatiales 2025 : enjeux et orientations stratégiques pour l'Europe spatiale](#)," ASTRES, 21 March 2025.

liable partners for cooperation calls for greater solidarity within the European Union (EU), ESA and between their respective member states.

Meanwhile, sovereign resources and national competitiveness must be preserved in order to uphold a collective approach. In this context, the EU has full legitimacy, including by treaty,² to define a space policy – with assistance from ESA for its technical implementation – and to address urgent challenges regarding climate change, technological innovation, sustainability and competitiveness. A European legislative framework appears essential in order to protect European players in the space sector.

Thus, the major challenges for Europe in the space sector primarily regard the imperative need for independence (I). It is essential for Europe to find the best balance between national and collective approaches (II), as well as to consider the challenges that European space policy is set to face (III). Finally, the extent to which a legislative and regulatory framework can contribute to the stated objectives must be determined.

I. The Imperative Need for European Space Independence

After being faced with a significant increase in international competition over the past decade, Europe is seeking to (re)gain its sovereignty and competitiveness in the space sector. Its priority is to strengthen its sovereignty in the military field, to maintain its level of excellence in terms of research and innovation in order to develop its commercial competitiveness and to establish balanced cooperation with reliable partners. Recent shifts in the Trump administration³ have largely highlighted the risks of overly committed cooperation and dependence on a partner that was previously considered reliable. In addition, having the European Commission fund and steer major space programs could help increase Europe's competitiveness.

The Military Sector

The EU is well aware of the strategic nature of space in the military domain. In the face of increasing risks in the space sector, the EU is prioritizing robust governance and protective measures to preserve its space capabilities. Therefore, Europe's main focus is to reduce its technological dependencies, advance research and innovation, strengthen supply chains to support its security and competitiveness, as well as maintain partnerships with allies that share its values. Space is also a key operational domain, alongside land, sea, air and cyberspace. It is a crucial force multiplier for military missions and operations. By developing space services for member state governments, the EU is strengthening its decision-making autonomy and freedom of action in terms of security and defense, while preserving the civilian nature of flagship programs such as Copernicus and Galileo. In this context, ESA can play a

2. *Confer* footnote No. 20.

3. D. Chrétien, "[Budget de la NASA coupé, missions annulées : l'Agence Spatiale Européenne nous répond sur l'avenir de la science du climat](#)," *Futura-Sciences*, 9 September 2025.

decisive role thanks to its technical, technological and R&D aptitudes, by designing and developing dual capabilities that will ensure that the space policies of both the EU and its member states are implemented.

With regard to France, a 2021 National Assembly report presented a three-level model for structuring military space strategy, which also applies to the civilian sector. Three levels of sovereignty were highlighted:⁴

- “**The sovereign core**”: strategic capabilities, such as communication and observation satellites, are entirely controlled by the state, thereby ensuring their availability in all circumstances;
- “**The extended core**”: this level includes capabilities provided by trusted partners, be it through international cooperation or private companies;
- “**Additional capabilities**”: this final level includes civil services and strategic partnerships, to be used in times of crisis without permanent access being guaranteed.

Research and Innovation

With regard to research and innovation to support commercial competitiveness: “Driven by the rise of private players and technological innovation, New Space is shaking up the balance of power in space. Between ambitions for sovereignty, industrial competitiveness and a still-fragile legal framework, France and Europe are seeking their place in this new orbital orders.”⁵

During the Cold War, only the major powers – i.e. the United States, the Soviet Union (which later became Russia), Europe and China – had access to space. At the end of the 2000s, a new model emerged: New Space. This term, which became popular in the 2010s, refers to a profound transformation of the space sector driven by private players. This “space 2.0” embodies a new era that is more open, more competitive and resolutely market-oriented.

This new model is characterized by profitability, flexibility and reusable resources. The new rules of the space game are based on miniaturized satellites, recoverable and reusable launch vehicles and accelerated industrial production. The emergence of private players such as SpaceX, Blue Origin and Virgin Galactic has democratized access to space. Today, more than 1,000 companies in the space sector are based in the United States. In France, the space ecosystem is emerging, with innovative start-ups such as Altitude, HyPrSpace, Sirius Space Services, Opus Aerospace, MaiaSpace, Prométhée Earth Intelligence and Unseenlabs.

Thus, the space sector is becoming a strategic economic driver. The Clinton administration made key decisions – by liberalizing high-resolution commercial satel-

4. “[“New space” : les défis stratégiques de la privatisation de l’Espace](#),” France’s Institute for Advanced National Defense Studies (IHEDN), 19 May 2025.

5. *Ibidem*.

lites in 1994, which made the Global Positioning System (GPS) available in 1996, etc. – that paved the way for private competition in space.⁶

France’s “National Space Strategy,” which was requested by François Bayrou for the end of 2025,⁷ must address resilience and security challenges in an increasingly unstable international environment. “Space is both an essential field of scientific investigation and a strategic environment of the highest order. It directly influences our security and defense while offering great economic and industrial opportunities,” France’s former Prime Minister explained.

European Cooperation

In light of these observations and in order to address the challenges that have been highlighted,⁸ several courses of action can be outlined when it comes to cooperation. Upon presenting ESA’s annual review for 2024, Director General of ESA Josef Aschbacher recalled that Europe’s greatest successes in space were founded upon international cooperation. The Ariane program is one of the most emblematic examples. Thus, cooperation remains more relevant than ever. In France, Lionel Suchet (CNES) emphasized that space is a key diplomatic tool and that France participates in nearly all of the major agencies’ missions (NASA, JAXA, etc.), carrying out projects that no country could tackle alone. He went on to issue a warning against the risks of intra-European fragmentation: while each nation considers space as a lever for sovereignty and growth, close coordination is required on all levels to ensure overall consistency.

While identifying areas of cooperation between European players remains crucial, healthy competition must also be maintained. This is essential in order to strengthen the European space sector in the face of new shifts in the global balance. Greater cohesion is needed between European manufacturers, agencies and governments. The current fragmentation must be overcome in favor of a more coordinated approach. Harmonizing Europe’s space policy and the creation of a genuine internal market for the space sector are the first levers to be used in order to give manufacturers greater visibility and a sufficiently vast market.⁹

A European strategy for international cooperation – validated by EU member states – would also help expand ESA and Europe’s global footprint. This will involve improving collaboration with EU institutions through the gradual “renationalization” of certain member states’ space policies. In other words, certain roles need to be clarified: the European Commission must lay out a common political impetus and ESA must redirect its focus toward the technical execution of space programs. Revising the principle of “geographical return” – which distributes activities between

6. X. Pasco, “[L’adaptation de la politique spatiale américaine aux changements internationaux](#),” *Réalités Industrielles*, Annales des Mines, May 2012, pp. 75-81.

7. “[Stratégie spatiale nationale](#),” official website of the French government, 6 March 2025.

8. A. Guigné, F. Delvert, “[Perspectives Spatiales 2025...](#),” *op. cit.*

9. “[A Space Strategy for Europe](#),” European Commission, 26 October 2016.

countries in a fair manner – could favor overall performance and the emergence of integrated industrial champions.

A form of balance must therefore be struck in order to preserve sovereignty, while taking advantage of the opportunities offered by private companies. Sufficient support from public authorities is essential. Each state must clearly define the areas in which it is willing to depend on private actors and those over which it wishes to retain sovereign control. Europe thus faces a twofold challenge: maintaining its competitiveness in the space sector while meeting its sovereignty needs.

II. Preferring a Collective Approach Over the Temptation of Retreating Into Nationalism

Conserving sovereign national capabilities is a legitimate priority, one that must complement a collective approach. The world's major spacefaring nations (the United States, China and India) are advancing rapidly in the fields of exploration, science, commerce, defense and competitiveness overall. Faced with these major competitors, Europe must remain united, show solidarity, complementarity and pursue harmonious cooperation, with support from ESA, all while leaving room for competitiveness within the EU.

In the event of America's disengagement, French and European space capabilities would not be able to meet the needs of a high-intensity conflict, nor would they be able to compensate for the shortcomings of their allies – particularly when it comes to supporting Ukraine.¹⁰ Regarding military capabilities, Europe features a number of dependencies and faults. The United States' military spending for space is nearly fifteen times higher than Europe's, despite the two having GDPs of similar magnitudes. Given the crucial importance of optical observation for conducting military operations, complete national autonomy in this field is essential. This can be achieved by improving the revisit rate of the various tools that are currently available. Due to the proliferation of ballistic threats, France must also develop an autonomous early warning capability to detect missile launches (ballistic and hypersonic). For the time being, France remains entirely dependent on foreign capabilities. Immediate support for Eutelsat OneWeb is therefore crucial, given the presence of capabilities such as Starlink.

Another essential strategic condition is access to space.¹¹ This remains the essential foundation underlying space autonomy and constitutes a priority in France's space policy. As such, the launch rate of the Ariane 6 program should be increased in order to reach its full annual capacity. This will help reduce costs per launch in particular.¹² European exclusivity will have to be put in place for institutional launches.

10. R. Tavanti, A. Sauzay, "[Puissance spatiale, le réveil de la France](#)," *Action note* by Institut Montaigne, 11 June 2025.

11. "[Ariane, moteur de l'autonomie spatiale européenne](#)," *official website* of the French Ministry of Higher Education and Research, 10 July 2024.

12. R. Tavanti, A. Sauzay, "[Puissance spatiale, le réveil de la France](#)," *op. cit.*

Meanwhile, France will need to maintain its leadership in terms of launchers, in order to cope with a possible increase in launch rates in Europe without having to depend on non-European actors. In addition to increasing the industrial capacity of Ariane 6, an operational and scalable mini-launcher will also be needed by 2030. This approach will require national control over reusable technologies, so as to achieve a significant reduction in costs. In this regard, the “France 2030” public plan – which aims to accelerate the transformation of key sectors of the economy through innovation – may prove useful depending on the priorities that are pursued, with support from CNES to provide technologies that will help France stand out. France clearly aims to maintain its preeminent position.

France – and, by extension, Europe – plays a major role in the space sector thanks to various investments made since 1961, particularly in the industrial sector.¹³ CNES plays a key role in this regard, the most recent example of which is “France 2030.” Nevertheless, major groups are currently facing difficulties following the collapse of the private geostationary satellite market, as a result of competition from Starlink in the U.S. These groups are aware of the significant efforts required to remain competitive. As a result, major European groups are considering merging their space activities, following the example set by Airbus and Thales.

In Europe,¹⁴ government-run and sovereign resources (i.e. a “heritage core”) are non-negotiable. However, the question of these solely national space resources and their self-sufficiency arises in the context of high-intensity conflict. It is clear that it would be advisable to consider supplementing them with other means, such as commercial services, partnerships, or forms of cooperation that are as reliable as possible and, above all, to determine how the EU can provide essential complementary capabilities. The challenge is therefore to find a balance between national and collective resources.

In this context – and building upon the relevant suggestions made by Institut Montaigne,¹⁵ which clearly illustrate what ESA is proposing –, the creation of an incremental multi-sensor constellation, within a common framework of industries and capabilities, would allow for a collective system to be established. The constellation would be focused on image-based intelligence, featuring radar, visible optical, thermal infrared and hyperspectral observation capabilities. This type of architecture could also carry sensors for early warning or space surveillance. It would also need to ensure the algorithmic integration and fusion of data from heterogeneous sensors – i.e. areas in which artificial intelligence technologies are becoming essential. When distributed across numerous satellites and kept open to new technologies, this type of capability could meet the new requirements for resilience and redundancy in space defense architectures – while allowing for quick and efficient deployment.

13. “[France et Europe : quelles politiques spatiales ?](#),” *Vie publique*, 20 September 2022. 1961 marks the year of CNES’ creation, which is considered to be the birth of the French space program.

14. M. Salini, “[La politique spatiale de l’Union : un succès sous-estimé](#),” *Schuman Papers*, No. 611, Robert Schuman Foundation, 18 October 2021.

15. R. Tavanti, A. Sauzay, “[Puissance spatiale, le réveil de la France](#),” *op. cit.*

The implementation of this approach could begin with IRIS², with new generations and new layers being developed as part of the program's ongoing evolution.¹⁶ This is exactly what Andrius Kubilius, the European Commission's Commissioner for Defense and Space, is proposing by joining forces with ESA to build the future Earth Observation Governmental Service (EOGS). ESA would thereby be acting strictly within the framework of its convention and area of technical expertise for the design, development and implementation of space and ground segments.

Furthermore, the space sector's role as an operational pillar will depend on our ability to ensure the security and resilience of its infrastructure, starting with space surveillance. The aim of this type of surveillance is to understand space as an environment: to detect and track objects in orbit, identify them and understand their maneuvers, control risks and anticipate potential threats. In this area, France and Europe boast significant capabilities, yet remain dependent on U.S. data.

In parallel, the strategic impact of the IRIS² program at the European level will complement the GovSatcom initiative.¹⁷ Finally, Galileo constitutes a means of breaking free from GPS technology, by allowing receivers compatible with the Public Regulated Service signal to be integrated more swiftly. It also allows us to develop complementary technologies to ensure the resilience of our positioning, navigation and timing (PNT) capabilities.

Space is often viewed as a unified way of helping Europe progress. ESA, which was founded in 1975, has played a key role in developing Europe's space program.¹⁸ The principle dubbed "geographical return" provides for investments in each member state, in the form of industrial contracts that are proportional to their contribution toward the agency's projects. Admittedly, this principle proved highly effective at the start of the space age. However, it now needs to be adapted to avoid overlaps in Europe's strengths, given that the continent's industrial fabric is already dense and that competition with the United States, China and India is increasing. The aim here is to improve European competitiveness. Thus, the European Commission's financing and management of major space programs should favor competition rather than the principle of geographical return.¹⁹

The EU can therefore draw upon ESA's expertise – as the executive arm of a European policy steered by the Union itself – to monitor and develop major programs on an operational level, while retaining its own rules on management and procurement. ESA can also continue to finance and manage certain specific programs.

16. The IRIS² program – Infrastructure for Resilience, Interconnectivity and Security by Satellite – aims to deploy a secure communications constellation, primarily in low Earth orbit (LEO).

17. Under the European Union's program for 2021-2027, the initiative on government satellite communications (GovSatcom) aims to provide member states and EU security actors with guaranteed access to secure satellite communications.

18. [Convention of the European Space Agency](#), 30 May 1975.

19. *Confer* Lionel Suchet's article, Chairman and CEO of CNES: "[Spatial, l'Europe à la reconquête de son indépendance](#)," *Polytechnique insights*, 28 May 2025.

III. The Challenges Facing European Space Policy

Europe's space policy²⁰ aims to address some of the most pressing modern challenges, primarily by combating climate change, stimulating technological innovation and offering socio-economic benefits to European citizens. Space technologies, data and services have become indispensable in the lives of EU citizens.

More specifically, the EU's space policy seeks to implement the European Green Deal,²¹ help Europe adapt to the digital age, support the European way of life and build a stronger Europe on the world stage. This policy encompasses the EU space program, as well as existing synergies with space research and innovation initiatives (e.g. Horizon Europe) in order to support access to space and the competitiveness of space systems. Horizon Europe builds upon the Strategic Research and Innovation Agenda for Space Research, which supports competitiveness, with funding from the EU and the InvestEU program. The EU's space policy aims to foster the emergence of a new space ecosystem, by encouraging entrepreneurship and promoting Europe's space industry. Examples include the Cassini initiative for space entrepreneurship and the action plan on synergies between the civil, defense and space industries.

Regarding Europe's space policy, the 2021-2027 multiannual financial framework includes regulations for the EU and ESA's space program. It allocates €14.88 billion for its implementation. The program's main objectives are: to contribute toward job creation, growth and investment in Europe; to play a crucial role in supporting the dual transition toward a green and digital economic model; to strengthen the EU's strategic autonomy; to provide strong support for science and research; and to contribute toward security, defense and industry. As for the 2028-2034 financial framework, it mentions a €134 billion budget for defense and space, without specifying the share allocated to space initiatives.

Sovereignty and Launchers

In 2025, during the 13th edition of "Perspectives Spatiales" titled "Challenges and strategic directions for Europe in space,"²² space sovereignty was presented as a major imperative. The main challenge in this regard is to guarantee sovereign access to space, while enabling Europe to assert itself as a competitive player alongside the United States and China. In the face of temptation to use foreign launchers, which would compromise Europe's independence, Ariane remains an essential means for maintaining Europe's autonomous access to space. Furthermore, dependence on non-European players would pose critical risks in terms of security.

20. The Treaty on the Functioning of the European Union (TFEU) defines the EU's role in space policy under Articles 4 and 189. In particular, the TFEU gives the EU the power to develop a European space policy and to take measures to implement it in the form of a European space program.

21. "[Le pacte vert pour l'Europe. Notre ambition : être le premier continent neutre pour le climat](#)," European Commission.

22. A. Guigné, F. Delvert, "[Perspectives Spatiales 2025...](#)," *op. cit.* This event brought politicians, industrialists, military personnel and experts together. It explored the central issues for Europe's future in space, in light of the geopolitical and industrial transformations currently underway.

The European Commission has issued warnings regarding the fragility of Europe's space sector in the absence of a coherent, coordinated and ambitious industrial strategy – given how far behind the European space industry is in its transformation. Another major challenge is the investment gap with other powers, as Europe invests up to five times less in space than the United States or China do.

Access to space remains a high priority for all extra-atmospheric activities. Ariane 6 constitutes an essential basis for ensuring European sovereignty. However, this economic model requires clear institutional support. It is imperative that a viable economic model be sustained through sufficiently large orders and institutional funding. However, the central issue is Europe's actual needs in terms of launchers in the coming years, in order to avoid turning toward foreign players and to guarantee Europe's autonomy in a highly competitive environment. The idea of establishing a long-term European preference for institutional programs has emerged as a strategic response to support the continent's space industry. Regarding access to space, European cooperation plays a crucial role in ensuring the continent's independence.

In terms of technology, Europe must further accelerate its efforts in order to catch up with its competitors. This is particularly true of reusable launchers, which need to be developed to ensure sustainable competitiveness against SpaceX and new players in the field. In addition, the emergence of new technological segments, particularly orbital infrastructure, must be anticipated in order to avoid dependence upon external powers.

IRIS²

Regarding other parts of the space sector, key initiatives for secure communications must be promoted, such as the IRIS² program. This initiative represents a new paradigm for Europe in space – marking the EU's desire to strengthen its strategic autonomy – and complements the Copernicus and Galileo programs. IRIS² is based on innovative governance and a public-private partnership (PPP) approach. It represents a direct response to the rise of competing constellations, such as Starlink. With a budget of €10.6 billion over twelve years, IRIS² is based on three strategic pillars: *sovereignty* (secure infrastructure and 100% European components), *innovation* (integration of 5G, thereby setting IRIS² apart from competing constellations such as Starlink) and European industrial *competitiveness*. Rapid operational implementation is crucial: the project must be industrialized without delay and a user base (states, agencies and companies) must be built up to ensure its economic viability. Thus, IRIS² embodies a key goal: to mobilize the EU on structuring projects that combine strategic autonomy and industrial opportunities.

Security

In 2019, NATO declared that space is finally a fully fledged military operational domain.²³ The future of European defense programs is also central for ensuring

23. [Approche de l'OTAN concernant l'Espace](#), NATO, 30 July 2025.

the continent's strategic autonomy. Thus, the intrinsic dual nature of a large portion of space capabilities must be acknowledged. Furthermore, growing dependence on space services raises the question of resilience. Our orbital infrastructure must be able to withstand attacks (e.g. cyberattacks and jamming) and other threats (e.g. solar disturbances and orbital debris). Climate change is also a major factor in the security landscape; in this regard, the Copernicus Earth observation program plays a key role in civil security and crisis anticipation. The war in Ukraine has illustrated the critical role of space assets on the battlefield: telecommunications, observation and positioning satellites have been used to ensure communication, intelligence gathering and precision strikes.

Regarding security issues in the civil domain, the “ESA Strategy 2040” – developed with member states and presented on March 20, 2025²⁴ – outlines a more autonomous and stronger European space program. In addition to protecting the planet and the climate, it aims to achieve secure and resilient communications, technological independence and economic growth. In the context of its convention, ESA can play a key role in addressing challenges relating to resilience and international security, in accordance with the decisions made by its member states.

Sustainability

Finally, six major challenges must be addressed to ensure long-term sustainability: improving our knowledge and monitoring of space, establishing harmonized international regulations (to avoid regulatory dumping²⁵ from one country to another), adapting the insurance framework, promoting technical standardization, developing in-orbit intervention technologies (deorbiting, maintenance, etc.) and supporting small innovative players through proactive public policies.

While Europe is struggling to compete in terms of its market share in New Space, it can aspire to become a global regulatory leader on sustainability issues. Europe supports a model in which it drives the responsible and sustainable use of space, thereby avoiding being subjected to a framework dictated solely by other powers. While regulation should not stifle the growth of an emerging market (such as in-orbit services [IOSs]), global coordination is essential to avoid chaos and preserve space as a common resource.

IV. The Need For a Regulatory and Protective Framework in Europe

In terms of legislation and regulation, given the desire of major spacefaring nations to avoid having their activities restricted and regulated, significant progress still needs to be made in order to prevent outer space from becoming a lawless frontier. The EU is setting the tone with the EU Space Act.²⁶ Its aim is to promote the devel-

24. “[ESA Strategy 2040](#),” European Space Agency.

25. The practice of selling on foreign markets at prices lower than those charged on the domestic market.

26. “[EU Space Act: Strengthening Safety, Resilience and Sustainability in Space](#),” European Commission, 25 June 2025.

opment of sustainable space activities in Europe and prevent non-European players from engaging in unreasonable commercial activities on the continent.

This type of legislation is essential for the future regulation of space activities. France is leading the way – as is Italy – with its *French Space Operations Act* (FSOA),²⁷ which is designed to limit the amount of debris in orbit and regulate the atmospheric re-entry of space systems. However, the FSOA only applies to actors operating on or launching their space systems from French territory. The idea behind the EU Space Act is therefore to extend this type of regulation to Europe: new European legislation would take precedence over national laws.

The primary purpose of the EU Space Act is to support the development of a reasonable space program in Europe. The second is to prevent non-European actors from developing commercial activities on the continent by using space resources that are deemed unreasonable. Of course, it will be necessary to offer citizens equivalent alternative services. The EU Space Act will therefore require all space operators to carry out in-depth risk assessments throughout their satellites' life cycles, while applying cybersecurity rules and incident reporting tailored to the space sector. These laws seek to stimulate market access and enhance space security. They will feature a set of measures that aim to make the European space sector cleaner, safer and more competitive, both in Europe and on export markets. European space regulations are currently fragmented, with a variety of different national approaches. This fragmented context hinders innovation, reduces Europe's market share and generates additional costs. A clear and harmonized framework at the European level will ensure security, resilience and environmental responsibility throughout the EU, while helping businesses to grow and expand abroad.

The EU Space Act²⁸ thereby seeks to reduce administrative formalities, protect space assets and create fair and predictable competitive conditions for businesses. This proposal is based on three pillars:

(i) *Security*: Space is becoming increasingly saturated. Today, there are 11,000 satellites in orbit, with another 50,000 expected to be launched over the next decade. What's more, more than 128 million pieces of debris of all sizes are already present in space, which significantly increases the risk of collisions. A cascade of accidents could occur, rendering key orbits unusable and cutting off access to vital satellite services. To prevent this, the EU Space Act will introduce measures to improve the tracking of space objects and to limit new debris, along with requirements for the safe disposal of satellites at the end of their life cycles.

(ii) *Resilience*: Space is becoming a contested environment. Space infrastructure faces growing threats from electronic interference and cyberattacks targeting satellites, ground stations and communication links. These attacks can result in the loss of satellites or the disruption of critical services. The EU Space Act will therefore

27. Act No. 2008-518 of 3 June 2008 relating to [space operations \(Loi sur les Opérations Spatiales – LOS\)](#).

28. “[Législation Spatiale de l’UE : améliorer l’accès au marché et la sécurité spatiale](#),” European Commission, 25 June 2025.

require all space operators to carry out thorough risk assessments throughout their satellites' life cycles, applying cybersecurity rules and incident reporting tailored to the space sector.

(iii) *Sustainability*: As space activities are growing, it is becoming vital to manage resources, CO₂ emissions and debris. Measuring environmental impacts enables the industry to reduce its footprint and support the EU's sustainability. The EU Space Act will establish common rules for measuring this type of impact. These rules will ensure consistent verified data and encourage innovation in areas such as in-orbit servicing, in order to extend the life of satellites and reduce debris.

These new rules would apply to EU space assets, national space assets and third-country operators offering services in Europe. Regulatory requirements will be tailored to the size and maturity of each company and measured against the risks at hand.

Support will be provided to offset any additional costs linked to the space industry. This includes capacity building, access to testing facilities and helping space operators prepare their license applications. This scheme will support small and medium-sized companies in particular. The Commission has also put forward a vision in which the European space economy addresses the changing global space economy and the challenges posed by international competition and geopolitical tensions.

Space represents a fast-growing market that contributes to EU's competitiveness. It encompasses the European space industry (manufacturing and services), space services in many market sectors, climate and environment-related sectors (from agriculture to energy), transport, insurance, banking, security and defense. The proposed legislation is set to enter the usual legislative procedure, with negotiations in the European Parliament and the Council.

The development of a European Space Act has been agreed upon as a structuring factor for the future, but raises questions regarding the sector's competitiveness. Industrialists wonder whether this approach will truly optimize public and private investment at the European level, while providing Europe with a competitive framework vis-à-vis international giants. Following the American model, the EU Space Act is intended as a means of consolidating a unified internal market, harmonizing rules for all players and avoiding competition-induced distortions between countries.

Increasingly fierce international competition in the space sector – combined with a desire on behalf of European countries to develop their own space capabilities – means that European decision-makers must strike the right balance between national sovereignty and a collective approach. Europe's priority is therefore to strengthen both its cohesion and sovereignty in the military field, maintain its level of excellence in research and build a genuine commercial competitiveness policy at the continental level. In addition to defense and research, a third pillar has emerged – one that not only responds to institutional logic, but also to the rules of the open economy. Thus, the digital revolution and enormous quantities of Earth observation data

have paved the way for a vast range of applications, attracting new private investors who are willing to take greater risks.

In a severely deteriorated geopolitical context, the European defense sector is turning to space. In recent years, defense companies have stepped up their involvement in space projects, prompting calls for greater coordination and investment at the EU level. Outer space also appears to be a new arena for conflict. The space race – and the ideological and dominance-related qualities it once took on – may well have been rekindled. Yet this time, technological capabilities are far superior to those available during the Cold War.

This opens the door to new competition for securing space resources.²⁹ It also raises the question of adapting international space law to this new context and the multiple challenges it entails.

Given Europe's budgetary situation, which is particularly constrained due to public debt, our decision-makers will have to confirm whether the space sector is one of their top priorities.

29. P. Legai, "[L'accès aux ressources minières et énergétiques spatiales](#)," Notes from IFRI, the French Institute of International Relations, 30 May 2023.

SatCen – Europe’s Eyes in the Sky: A Strategic Asset for Security, Defence, and Space

Louis Tillier

Rear Admiral Louis Tillier has been Director of the EU Satellite Centre (SatCen) since June 1, 2024. A telecommunications engineer and former Deputy Director, he brings extensive operational experience and expertise in European space cooperation, gained through key roles as commanding officer on operational units, at the French Space Command and in EU and NATO working groups.

I. European Strategic Autonomy in a Shifting Geopolitical Landscape

In May 2025, speaking in Aachen, Commission President Ursula von der Leyen set a clear course for Europe’s future: “Pax Europaea and an Independent Europe. We cannot allow ourselves to be thrown off course by the seismic changes that we are facing.” Her message placed readiness, resilience, and above all, independence at the forefront of the European project.

Just two months later, during the EU Defence Night, the newly appointed European Commissioner for Defence and Space, Andrius Kubilius, reinforced the point: “We Europeans have to ramp up our defence capabilities... and for that we need to build our own independent capacities.”

The return of war to the European continent, exemplified by Russia’s ongoing aggression against Ukraine, alongside escalating conflicts in the Middle East and Africa, has overturned assumptions of global stability. The international security environment – on land, at sea, in cyberspace, and in space – is deteriorating rapidly. In this context, strategic autonomy is no longer a distant aspiration but an operational necessity.

Aligned with the *Strategic Compass*,¹ which calls for the EU to act swiftly and decisively in response to emerging threats, the European Union Satellite Centre (SatCen) stands as a cornerstone of this ambition. Established by the Council under the Common Foreign and Security Policy (CFSP), SatCen is more than a service provider: it is a strategic enabler, delivering autonomous situational awareness to the Union and its member states, and contributing the development of a common strategic culture. Former High Representative Josep Borrell summarised the Agency’s role as: “[You are] the eyes of Europe... Thanks to SatCen, EU institutions and member states have access to fast, top-level, autonomous and reliable analyses, helping us to take better, informed decisions.” Today, this ability to maintain situational awareness and strategic foresight is more essential than ever before.

II. European Autonomy in Action: SatCen’s Strategic Role since 1992

SatCen’s origins date back to 1991, when the Western European Union (WEU) responded to the lessons of the Gulf War by deciding to establish a satellite data interpretation centre. On June 27, 1991, at a ministerial meeting in Vianden, Luxembourg, the WEU’s Foreign and Defence Ministers approved the creation of the Centre; on 19 November, Torrejón Airbase near Madrid was chosen as its headquarters.

Initially, its mission was to deliver actionable geospatial intelligence (GEOINT) to support European security and defence. Advocates like Horst Holthoff, then WEU Deputy Secretary, recognised the strategic value of an independent imagery exploitation capability.

By 1996, SatCen was operational, supporting arms dismantlement verification in Kosovo. In 2002, the WEU’s capability was transferred to the EU, and the Centre became the European Union Satellite Centre. The following year, the EU launched its first military and civilian Common Security and Defence Policy (CSDP) missions, with SatCen providing GEOINT support to EUFOR Althea in Bosnia and Herzegovina.



SatCen Archives: Analysts at Workstations, 1996
© SatCen

1. “[A Strategic Compass for a stronger EU security and defence in the next decade](#),” Council of the European Union, 21 March 2022.

In 2004, Council conclusions on “European Space Policy: ESDP and Space” formally recognised SatCen’s contribution to early warning, crisis management, and intelligence. Over time, it has expanded its role across EU institutions, missions, and operations, while strengthening cooperation with partners and organizations.

Today, SatCen continues to support EU decision-making by delivering geospatial intelligence (GEOINT) products and services based on space assets and collateral data, including satellite and aerial imagery. The center also plays a key role in seeking synergies between the Union’s various activities, in particular through its participation in the Copernicus program, which has been approved by the member states.



Support to Crisis Situations: Kabul International Airport during the Crisis in August 2021, Afghanistan
© Worldview-3.

From its WEU roots to its current role in the CFSP/CSDP framework, SatCen exemplifies the value of long-term strategic investment at the hands of EU member states.

III. SatCen’s Unique Mission and Growing Relevance in EU Policy

SatCen’s mandate is to deliver timely, accurate, and actionable geospatial analysis in support of EU decision-making under the CFSP and CSDP. Its work covers a wide spectrum, including crisis management, non-proliferation, border security, humanitarian aid, maritime surveillance, support to EU missions and operations, and climate-related security. The resulting products are shared with EU bodies and all 27 member states, strengthening both situational awareness and a shared strategic

culture. SatCen's services can also extend to strategic partners and third states – such as the United Nations (UN) and the Organisation for the Prohibition of Chemical Weapons (OPCW) – upon member states approval.

SatCen's operational tempo has surged over the last decade. In 2024 alone, SatCen produced 6,000 reports – 63% in direct support to CFSP – prioritised through the High Representative. Support to EU missions and operations accounted for 22% of those reports (up from 4% in 2019), with growing contributions to EUNAVFOR IRINI, ASPIDES, ATALANTA, EUMM Georgia, and the EU Mission in Armenia.



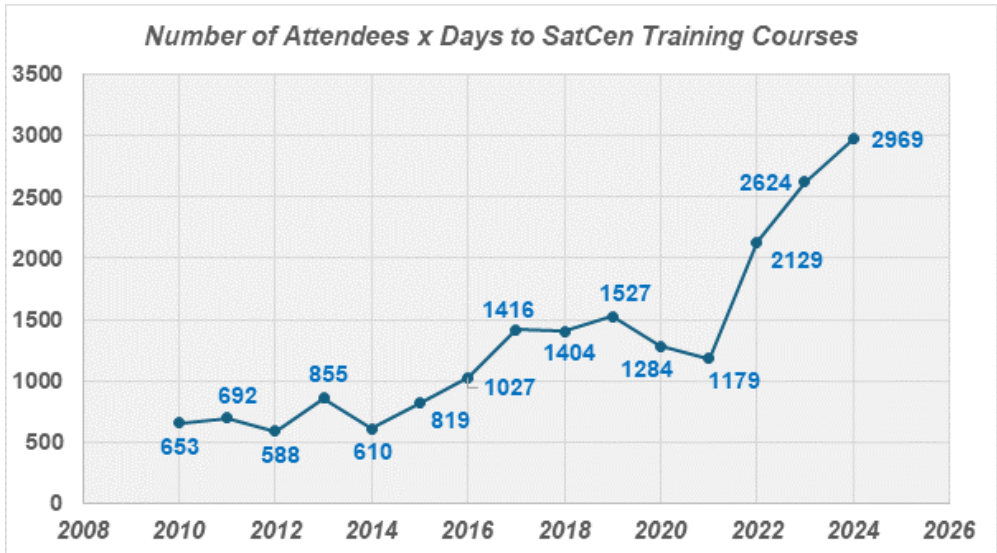
Monitoring of Suspicious Vessel in Support to EU Missions and Operations, 2020
© Worldview-2

The Centre has also doubled its support to Frontex (the European Border and Coast Guard Agency) since 2019, now at 18% of production, with a decade of Copernicus Border Surveillance Service (CBSS) cooperation marked in July of this year.

To meet growing demand, SatCen has embraced digital transformation. Its classified IT platform, the first EU SECRET cloud accessible via the EU Operational Network (EOW), enables secure, real-time interaction with users. This shift from “static” document delivery to Intelligence as a Service (INTaaS) enhances responsiveness and user engagement. The platform integrates AI detection tools, interactive catalogues, and direct communication systems, supporting both EU institutions and national intelligence entities.

SatCen is also investing in future capabilities. It is integrating AI and Big Data analytics to automate detections in satellite imagery, while exploring edge computing and on-board processing for near-real-time alerts. Alongside these technological advances, SatCen's training unit promotes a common analytical approach across the

EU security ecosystem, offering training support to SatCen staff as well as member states, EU institutions, agencies and bodies and to the beneficiaries of the Centre's products and services, both at SatCen premises and in situ. Together, these innovations are evolving SatCen from a traditional product provider into a dynamic, service-driven knowledge hub for member states.



Beyond operations, SatCen contributes to EU strategic autonomy by maximizing synergies with the European Commission, the European Defence Agency (EDA), and the European Space Agency (ESA). It plays a pivotal role – as Entrusted Entity – in the Copernicus Service for Support to EU External and Security Actions (SESA) and participates in cutting-edge research initiatives like Horizon Europe.

In addition to its operational mandate, the strategic relevance of the European Union Satellite Centre (SatCen) has become increasingly clear. This is reflected not only in the surging demand for its geospatial intelligence (GEOINT) products and services, but also in the explicit recognition of its role in the EU's most important strategic documents.

SatCen's role is explicitly embedded in core EU strategic documents. Following Russia's 2022 invasion of Ukraine, the Council of the European Union formally adopted the *Strategic Compass for Security and Defence*, which included a clear objective: "Strengthen the EU Satellite Centre in order to boost our autonomous geo-spatial intelligence capacity." The document emphasized the need to enhance the Union's ability to anticipate threats and secure access to contested domains – the high seas, airspace, outer space, and cyberspace – where SatCen's capabilities are indispensable.

SatCen's relevance extends into the maritime domain, where the *EU Maritime Security Strategy* (EU MSS) encourages cross-sectoral cooperation between civilian and military actors, explicitly including SatCen as a key instrument.² Similarly,

2. "[Maritime Security](#)," European Council & Council of the European Union.

the security and defence implications of climate change – as outlined in the Joint Communication of 28 June 2023, titled “A New Outlook on the Climate and Security Nexus: Addressing the Impact of Climate Change and Environmental Degradation on Peace, Security and Defence”³ – highlight the need for evidence-based analysis and foresight, areas where SatCen’s capabilities are increasingly leveraged.

The Joint Communication on the *EU Space Strategy for Security and Defence* (EU SSSD), published on 10 March 2023, further underscores SatCen’s unique role in ensuring autonomous EU decision-making.⁴ It recognizes the Centre’s contribution to CFSP/CSDP and its alignment with broader EU priorities in space, security, and defence.

Finally, the Council conclusions reaffirm SatCen’s status as an “instrumental European autonomous capability,” providing GEOINT products and services derived from space assets and collateral data.⁵ They also encourage the strengthening of the Single Intelligence Analysis Capacity (SIAC), welcoming SatCen’s support in enhancing strategic understanding of space threats and counterspace operations.

IV. Developing EU’s Strategic Autonomy with Member States

SatCen is not only a success story of operational excellence – it is a unique achievement of the CFSP. Over the past three decades, SatCen’s evolution has paralleled the EU’s rising ambitions in space, security, and defense.

A notable initiative on the horizon is the potential future Earth Observation Governmental Service (EOGS), complementing the EU Space Program with a capability directly supporting EU’s security and defense. The EOGS would provide secure, autonomous Earth observation capabilities for governmental users, enhancing the EU’s situational awareness and ability to respond during crises. The pilot project, already launched, is testing a preliminary service and governance model that member states can trust. Its goal is to harness space data to support autonomous European decision-making in security and defense. This initiative is not just technical – it is strategic, aiming to reinforce Europe’s preparedness and responsiveness in a volatile global environment. SatCen’s participation could ensure that this prospective service benefits from the Centre’s proven operational experience, advanced technical expertise, and established user base. It will be an accelerator to its future implementation by building the potential EOGS on an already operational and trusted agency.

In his strategic report on EU preparedness, President Sauli Niinistö emphasized the importance of enhanced situational awareness, stating:

3. “[Une nouvelle approche du lien entre climat et sécurité : tenir compte de l’incidence du changement climatique et de la dégradation de l’environnement sur la paix, la sécurité et la défense](#),” Communication to the European Parliament and the Council, 28 June 2023.

4. “[EU space strategy for security and defence](#),” European Council & Council of the European Union.

5. “[Space: Council approves conclusions on the EU space strategy for security and defence](#),” Council of the European Union, 14 November 2023.

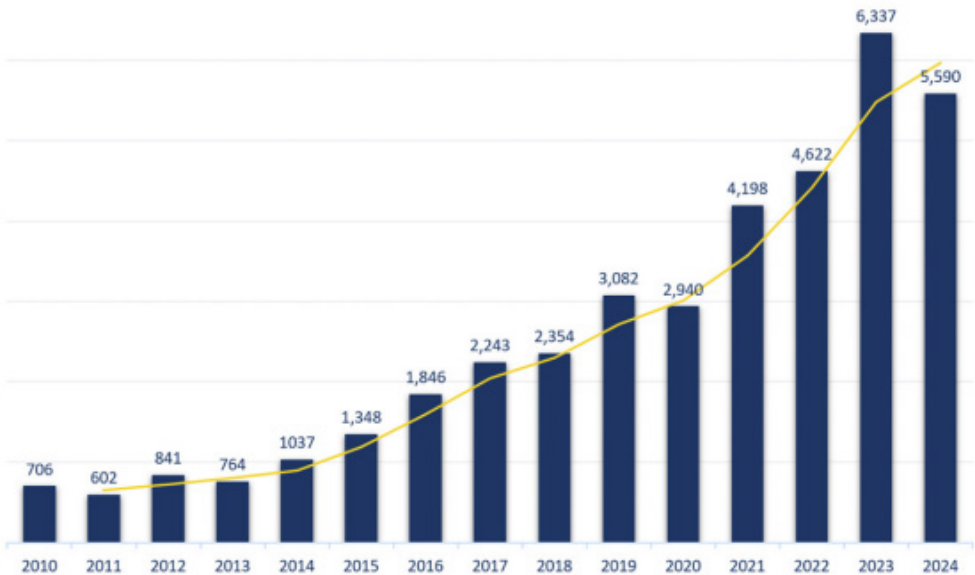
“Geospatial intelligence structures, such as the EU Satellite Centre (EU SatCen), are essential to support autonomous decision-making and the action of the EU and member states for security and defense [...]. There is a need to enhance space-based situational awareness toward more autonomy, accuracy and timeliness. To complement and reinforce existing and planned capabilities, the EU and member states could develop a dedicated EU Earth-Observation governmental service.”⁶

The report underscores the need for highly reactive capabilities to deliver reliable satellite imagery swiftly and securely, and calls for enhanced space-based situational awareness with greater autonomy, accuracy, and timeliness.

According to the EU SSSD, member states should play a central role in defining and implementing the future EOGS, with SatCen’s expertise at the heart of the initiative. The Centre’s GEOINT expertise, secure dissemination infrastructure, and operational track record position it as the primary implementation tool. The current Multiannual Financial Framework funds this initial phase, with a fully operational service envisaged for the next cycle. Commissioner Kubitius has called the proposed long-term budget “historic and extremely ambitious... Defense and space spending will increase five-fold.”

V. Challenges and Mid Term Developments

SatCen’s production has grown nearly tenfold over the past decade, with increasing demand for more complex, faster, and more precise outputs – over 90% now delivered within 24 hours of image acquisition.



Annual Nominal Output of Geospatial Intelligence products 2015-2024.

6. “[L’ancien président finlandais Niinistö remet son rapport sur le renforcement de la préparation civile et militaire de l’Europe](#),” European Commission, 30 October 2024.

To remain ahead of these evolving challenges – and to meet the expectations set out in the *EU Strategic Compass* and the EU SSSD – member states have approved an ambitious development plan. This plan is designed to further expand the Centre’s operational capabilities in the coming years, ensuring it can both sustain its intense, demand-driven and growing operational activity and continue to deliver state-of-the-art geospatial intelligence services that meet the needs of the EU and its member states.

Central to this effort is a commitment to investing in IT, expanding the Centre’s pool of expert staff, and assuring sustainable access to data. These investments are not only about maintaining operational excellence; they are also about building a resilient and scalable foundation for the future.

Moreover, this development plan contributes to the broader goal of establishing a strong European ecosystem in Earth observation for security and defence. It promotes cross-sectoral collaboration, fosters synergies with the European Commission, and supports capability development initiatives that will be essential for Europe’s strategic autonomy in the years ahead.

In the words of former HR/VP Josep Borell, “We need a truly integrated foreign policy that combines the power of EU member states and the potential of their joint action, with the coordinated mobilisation of EU instruments.” The most pressing challenge is to build a truly integrated approach that brings political tools together with security and defence capabilities. In an increasingly hostile and complex geopolitical landscape, decision-makers need access to every layer of information to grasp the full picture. SatCen, with its unique expertise and capabilities, remains ready to deliver timely, relevant, and actionable analysis – empowering member states and bridging the gap between intelligence and strategic foresight.

VI. Looking Forward

In a contested geopolitical environment, SatCen will expand its AI, automation, and analysis capabilities while reinforcing training and support for member states. As a strategic initiative, the potential future EOGS could provide an essential contribution to strengthening Europe’s foresight in the security and defense domain. It is one of the strategic enablers that will support Europe’s ability to scale up as a geopolitical and sovereign actor in defence.

The Centre will remain Europe’s “eyes in the sky,” providing decision-makers – from the High Representative to national authorities – with a shared platform for dialogue and access to critical information and intelligence. This support spans the full spectrum, from high-level political decisions to operational needs on the ground. It focuses on CSDP, directly interacting with defence intelligence services. Moreover, the EU has developed an Integrated Approach to External Conflicts and Crises, using all available policies and instruments at its hands. SatCen, part of this ecosystem, is unique to support an integrated situational awareness. Be-

yond its core task supporting CFSP and CSDP, and working mainly for defence actors, it already supports EU's action on illegal migration, cross-border crimes, humanitarian aid, protection of cultural heritage, and climate security to name a few, developing multiple layers of understanding in areas of conflicts and crises. As global transitions add complexity on top of geopolitical challenges, SatCen is a unique tool that has important development opportunities, always working under member states control.

After 33 years, SatCen stands as arguably the EU's most active forum at the intersection of security, defense, and space. It is a true success story – a force multiplier that delivers more value to every member state than the sum of their individual contributions.



SatCen Headquarters Torrejón de Ardoz.

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Conclusion: SatCen – A strategic Asset in the EU's Toolbox

From its origins in the WEU to its current position as the EU's operational GEOINT agency, SatCen has consistently adapted to political, technological, and security shifts, leveraging space as a key “strategic enabler” for security and defence. Today, it is embedded in the EU's most important policy frameworks – from the *Strategic Compass* to the EU SSSD – and directly supports priorities such as space resilience, maritime security, climate-security foresight, and critical infrastructure protection.

In an era where information dominance shapes strategic influence, SatCen is more than a technical facility – it is a political instrument of European autonomy. Its continued evolution, underpinned by member states' trust and investment, will be vital to ensuring the EU can navigate crises, anticipate threats, and act decisively in an increasingly contested world.

China: From a World Power to a Global Power

Serge Cholley¹

General (Ret.) Serge Cholley spent a significant portion of his career in the field of intelligence. He held several posts abroad, notably as the “Air” attaché at the French embassy in Beijing between 1993 and 1996, before becoming the head of the French military mission in China from 2012 to 2014. After leaving the institution, he joined the French company Eutelsat as the Director Defence and Security (2020-2025).

On 2 November 2009, during the celebrations of the 60th anniversary of the creation of the People’s Liberation Army Air Force (PLAAF), of which he was the commander, General Xu Qiliang (许其亮) asserted in an article published by the army daily newspaper that “it is imperative for the PLAAF to develop offensive and defensive means in space. The competition between armed forces is moving toward the space domain. This is historically inevitable and constitutes an unstoppable development. We must build space weaponry that responds to the interests of our nation and to the demands brought on by the development of the space era. Superiority in space can allow a nation to control warzones, both on land and at sea, while securing a strategic advantage. Only power can protect peace.”

This declaration was not made by just any general officer of the People’s Liberation Army (PLA). General Xu is a close associate of Xi Jinping (习近平), the General Secretary of the CCP, who is known to have accumulated the highest functions following the 18th Congress of the Chinese Communist Party (CCP) in 2012. On that occasion, Xi was indeed appointed Chairman of the Central Military Commission (CMC) and President of the People’s Republic of China (PRC). This close relationship between the two men dates back to their simultaneous postings in the province of Fujian (福建) and subsequently in the municipality of Shanghai (上海). It led General

1. This title is a reference to a book published by the author of this article in 2012: S. Cholley, *Les ambitions spatiales de la Chine : d’une puissance mondiale vers une puissance globale*, Paris, Éditions de l’EMS, 2012, 83 p.

Xu Qiliang to the highest level of the Chinese military hierarchy. He thus became the first aviator promoted to Vice-Chairman of the CMC in 2013, a function he held until 2023.

This duo played a decisive role in the dynamic experienced by the Chinese space sector over the past decade. The two men moved beyond the limited posture of their predecessors, who merely expressed their intentions without truly obtaining capabilities. On the contrary, Xi Jinping and General Xu have mobilized military and civilian resources to reach the end of their ambitions. China then established itself as the second-ranking space power in the world and as the most serious competitor to the United States of America.²

The Means of Its Ambitions

A space power is all too often judged by the general public in the light of its most spectacular achievements: human spaceflights, lunar and Martian missions, or indeed its budget. According to these three criteria, the Soviet Union and the United States long led the race. The U.S. finally pulled ahead and definitively won by sending the first man to the Moon in 1969.

For its part, China only succeeded in launching its first satellite in 1970, thirteen years after *Sputnik*. This delay in accessing space is explained notably by the upheavals caused by the Great Leap Forward (1958-1960) and the Cultural Revolution (1966-1976). These were two political campaigns that ravaged the intellectual and industrial potential of the country. It is also understood by China's isolation on the international stage, despite the efforts of Premier Zhou Enlai (周恩来, 1949-1976), who tirelessly sought to shield the space sector from the revolutionary folly of Mao Zedong (毛泽东).

The death of Mao on 9 September 1976 brought a relative end to this troubled period. The Chinese leadership then decided to embark upon a modernization policy, symbolized by Deng Xiaoping's "Four Modernizations" (四个现代化) program. It concerned the industrial and agricultural sectors as much as those of science and defense. This rise to power goes hand in hand with the regionalization and subsequently internationalization of Chinese ambitions. Today, these reveal China's desire to become the world's leading power. The military plays an essential role in this project. It has received particular political and budgetary attention since Xi Jinping came to power in 2012.

In the space sector, this ambition relies on increased budgets. However, these remain particularly difficult to evaluate in their entirety due to the opacity of the accounts published in China. The inherently dual civilian-military character of space activities adds to this lack of clarity. Furthermore, the private sector has largely moved into a field that was for a very long time the exclusive domain of states. Finally, it is necessary to take into account purchasing power parity and R&D invest-

2. "[Space Economy Report – 2022](#)," *Rapport*, Euroconsult Group, January 2022.

ments. Chinese researchers, engineers, and technicians are far less expensive than their Western counterparts. The equation is therefore insoluble given the documents available in open sources.

Nevertheless, it is possible to get a better understanding by focusing on the public funds dedicated to a particular activity. In 2024, according to the firm Novaspace, out of the 27 billion dollars of public funds invested in space exploration worldwide, the United States spent 63% (17 billion dollars), China 22% (nearly six billion), and the European Space Agency (ESA) only 6% (1.6 billion). At the same time, Euroconsult, estimates that the Chinese space budget represents between 20 and 25 billion dollars per year. French expert Philippe Coué pushes this figure to 30 billion.³ This amount can again be compared to the seven billion dollars paid annually by European states to the ESA. Coué concludes that China has become the second space power in the world, which now appears highly probable.

A Complete Space Power

Five inseparable fields of action appear decisive in judging the rank of a space power. These encompass (i) research, development, and the industrial production of launchers and satellites; (ii) access to all Earth orbits and beyond from adapted and resilient spaceports; (iii) the operation of launchers and satellites; (iv) surveillance of exo-atmospheric space to independently identify and understand events therein; and (v) capabilities for action within and from space.

The Manufacturers

China's space program is directly linked to its nuclear ambitions. In May 1958, Mao Zedong (毛泽东) formalized the “two bombs, one satellite” (两弹一星) program. This was intended to enable the development of both fission and fusion nuclear weapons, the first scientific demonstration satellite, *Dong Fang Hong 1* (DFH-1, 东方红一号 or “The East is Red”), as well as associated missiles and launchers.

Despite statements in which he denied the importance of nuclear weapons,⁴ General Douglas MacArthur's failed initiatives to use the atomic bomb during the Korean War (1950-1953) led Mao to reconsider his position. After Stalin refused to provide assistance for the development of a Chinese bomb and ballistic missiles, Mao eventually secured the decisive support of Khrushchev in 1954. He was thus able to launch his ballistic and nuclear programs, even though Moscow's support gradually diminished from 1958 before ceasing with the China-Soviet split of 1960.

It was during this period that the CCP Central Committee decided to create the academies that would form the CASC (China Aerospace Science and Technology Corporation; 中國航天科技集團公司) and the CASIC (China Aerospace Science

3. C. Durand-Parenti, “[Conquête spatiale : ‘Les Chinois pourraient totalement dépasser les Américains dans dix ans’](#),” *Le Point*, 7 June 2024.

4. In 1946, Mao reportedly told U.S. journalist Anna Louise Strong that “the atomic bomb is a paper tiger.”

The Introduction of So-Called “Private” Actors

Whether it is the Kaituoze (开拓者, or “Explorer”) launchers from CASIC and the Kuaizhou (快舟, or “Fast Vessel”) from ExSpace,⁶ or the ShuangQuXian (双曲线, or “Hyperbola”) and ZhuQue (朱雀, or “Phoenix”) constructed respectively by the “private” companies iSpace⁷ and Landspace, or even the Lanjian Hangtian (蓝箭航天) from the prestigious Tsinghua (Qinghua) University (清华大学),⁸ they all have one common trait: being derived from military ballistic missiles.

However, entrusting the design of a ballistic missile, in whole or in part, to “private” actors entails a high risk of undermining the credibility of China’s deterrent force in the event of failure. It seems unlikely that the Central Military Commission (CMC) would accept such a risk. Conversely, as the PLA has a long tradition of dual-purpose activities, particularly in funding part of its operating costs, it is likely that these “private” companies are directly linked to military units. This is often the case in other industrial sectors. Furthermore, the components of space launchers are likely taken from the Chinese army’s inventories.

This close relationship between these “start-ups” and the Chinese armed forces was considerably strengthened in 2014 with the Chinese authorities’ announcement of the opening of the space sector to private companies.⁹ It is nonetheless marred by numerous cases of corruption. Xi Jinping’s decision to profoundly reform the Chinese military is a response, in particular, to his desire to put an end to this situation. Several senior cadres of the Second Artillery Corps (第二炮兵部队), the military branch responsible for the deployment of nuclear and conventional ballistic missiles, fell victim to this. The corps was even dissolved in 2016 and became the Rocket Force (中国人民解放军火箭军), responsible solely for nuclear deterrence. This restructuring did not, however, end the corruption problems. Admiral Wang Houbin (王厚斌), commanding the PLA Rocket Force since 2023, thus appears on the list of general officers who were victims of the recent purges of October 2025.¹⁰

In parallel, the PLA Strategic Support Force (中国人民解放军战略支援部队), created in December 2015 and responsible for military operations in the space and cyber environments as well as in the informational and electromagnetic fields, was dissolved on 19 April 2024. Several of its generals were dismissed. An Aerospace Force (军事航天部队) succeeded it, placed under the direct authority of the CMC, with the exclusive mission of acting in space to obtain military superiority. China

6. ExSpace belongs to the China Space Sanjiang Group Corporation – formerly “Base 066” (a very military name!) which is a subsidiary of CASIC.

7. Also known as Beijing Interstellar Glory Space Technology Ltd. or StarCraft Glory. For this work, iSpace benefits from the support of CASC and the State Administration for Science, Technology and Industry of National Defense.

8. Tsinghua University benefited from the support of the CASC from the outset.

9. H. Boyd, E. Green, M. Nouwens, “[Space: China’s commercial space sector](#),” International Institute for Strategic Studies (IISS), 21 August 2025.

10. T. Wong, “[Chinese Communist Party expels top generals in sweeping military crackdown](#),” BBC, 17 October 2025.

thus became the only country in the world – alongside the United States – to possess a space army ranked at the same level as the Army, Navy, or Air Force. Officially motivated by the lessons of the war in Ukraine, this new command allows Xi Jinping to control the lucrative business activities of the generals more closely and to purge the cadres who might weaken his power.

Foreign Contribution

The collapse of the USSR accelerated Chinese R&D and the manufacturing sector. During this period, China was able to recruit former Soviet talents and acquire high-level technologies. Paradoxically, it was U.S. companies that would unintentionally contribute to the success of Long March launchers on the commercial flight market.

Indeed, at the turn of the 1990s, the Long March series suffered a string of failures. Excessive vibrations caused the destruction of the launchers. This prevented satellites from being placed in orbit or reaching their operational orbits. China was unable to demonstrate the reliability of their European, Russian, or U.S. competitors. Nevertheless, the Australian communications operator Optus and the Hong Kong operator Apstar were receptive to the low prices offered by Beijing. They respectively ordered the *Optus B2* and *Apstar 2* satellites from the U.S. manufacturer Hughes Aircraft Company. At the same time, Intelsat purchased its 708 satellites from the U.S. manufacturer Loral Space and Communications. All of these spacecraft were to be launched by China using a Long March 2E (in 1992 and 1995 for the first two) and a Long March 3B in 1996 for the third. While all ended in failure, they marked a turning point.

The U.S. administration accused Hughes and Loral of one hundred and twenty-three violations of the Arms Control Export Act and the International Traffic in Arms Regulations. These charges resulted from exchanges between Chinese and American. According to federal judges, the information transmitted by the two companies contributed to the improved reliability of Chinese space launchers and ballistic missiles. China's nuclear deterrence was thereby strengthened. Loral and Hughes were subsequently handed sanctions of 14 and 32 million dollars respectively. These represented the two largest fines imposed by the federal government to that date.¹¹

In 1999, the report of the Select Committee on U.S. National Security and Military/Commercial Concerns with the People's Republic of China – more commonly known as the “Cox Commission”¹² – concluded that Beijing “has stolen or otherwise illegally obtained U.S. missile and space technology that improves the PRC's mili-

11. R. Merle, “[Hughes, Boeing Settle With U.S.](#),” *The Washington Post*, 5 March 2003.

12. “[Report of the Select Committee on U.S. National Security and Military/Commercial Concerns with the People's Republic of China](#),” Report no. 105-851, Chamber of Representatives, 105th Congress, 2nd session, 3 January 1999.

tary and intelligence capabilities.”¹³ Its findings prompted significant legislative and administrative reforms in the United States. They also led to severe restrictions on the export of satellite components to China.

In addition to these restrictions was the law adopted in 2011 by U.S. Congress – also called the “Wolf Amendment.” This prohibits the National Aeronautics and Space Administration (NASA) from using government funds to engage in direct bilateral cooperation with the Chinese government or organizations affiliated with China.¹⁴

While the doors of China-U.S. space cooperation have closed, the war in Ukraine has likely fully opened those with Russia. This occurs even though Beijing has since far surpassed Moscow in the space sector. While niches remain where Russia maintains superiority, such as in the field of engine technology, Xi’s support for the Russian war economy through the delivery of electronic components most likely benefits Chinese space manufacturers. This, at least, is what can be deduced in view of the concessions made by Putin to Kim Jong-un for the benefit of the North Korean space program.¹⁵

Spaceports

China has established a redundant terrestrial infrastructure, which significantly diminishes its vulnerability in comparison with other space powers possessing only a single launch base. The latter are subject to an interruption of their space program in the event of an accident or an attack.

The Jiuquan Satellite Launch Center (酒泉卫星发射中心) – or “Test and Training Base No. 20” (中國人民解放軍第二十試驗訓練基地) according to its military name¹⁶ – is the oldest of these facilities. Located in Inner Mongolia within the Gobi Desert, it serves as a site for launches into polar orbits and for human spaceflights. Furthermore, the Taiyuan Satellite Launch Center (太原卫星发射中心) – or “Test and Training Base No. 25” (中國人民解放軍第二十五試驗訓練基地)¹⁷ – operated by military unit 63710 (中國人民解放軍63710部隊), is situated in Shanxi Province. It is employed for the placement of satellites into sun-synchronous and polar orbits. These two bases were originally constructed for ballistic missile test firings, thereby conferring upon them a confidential nature. The access granted to these sites for so-called “private” actors effectively attests to their persistent connection with China’s military.

13. *Ibidem*, p. xii.

14. D. Hart, D. Cheng, “[Should the Wolf Amendment be repealed?](#),” *Debate Series*, Center for Space Policy and Strategy, July 2025, 13 p.

15. “[En Russie, Vladimir Poutine et Kim Jong-un échangent une poignée de main au cosmodrome de Vostotchny](#),” *Huffington Post*, 13 September 2023.

16. C. Chih-te, L. Jianpeng, “[Étude sur le développement fonctionnel de la Force de soutien stratégique du PCC et son impact sur la guerre de l’information en Chine](#),” *Army Bi-monthly*, Vol. 57, No. 580, December 2021, pp. 67-93.

17. *Ibidem*.

The Xichang Satellite Launch Center (西昌卫星发射中心) – or “Test and Training Base No. 27” (中國人民解放軍第二十七試驗訓練基地)¹⁸ – is operated by military unit 63790 (中國人民解放軍63790部隊). Situated in Sichuan Province, it is the facility closest to the equator and is intended for launches into geostationary orbit. Having been constructed in a relatively populated region, it is expected to undergo a significant reduction in its activities in favor of the Wenchang site (文昌卫星发射中心) on Hainan Island. Having entered into operational service in 2016, this site benefits from maritime access and the slingshot effect for launches into geostationary and polar orbits. This gives it the advantage comparable to that of the European spaceport at Kourou in French Guiana.

Launcher Operators

The inventory presented below of the Long March launchers alone, alongside the number of launches conducted in China, illustrates the formidable progress achieved over the last three decades. Beijing has definitively overtaken Russia and Europe¹⁹ and is resolutely committed to a trajectory intended to catch up with the United States. In 2023 and 2024, China conducted 66 recorded launches and could reach, or even exceed, the symbolic threshold of 100 launches in 2025.

Satellite Operators through the Positioning and Navigation System: Beidou vs. Galileo

In 1996, a European delegation traveled to China to discuss China-European cooperation regarding a Global Navigation Satellite System (GNSS) intended to compete with the U.S. Global Positioning System (GPS). The latter had entered full operational service the previous year for military use.²⁰ For its part, the Galileo program, a European initiative, was designed to provide universal coverage similar to that of GPS and was to consist of approximately twenty satellites in medium Earth orbit. It also aimed to reduce dependence on the United States.

However, at that time, China was developing its own satellite positioning program, named Beidou (北斗) or “Compass.” This program originally had a regional focus – encompassing China and its neighboring countries – and was designed to transmit two signals: one for military purposes and the other, less precise, for civilian use. The first version of the system relied on four DFH-3 telecommunication satellites in geostationary orbit – comprising two operational units and two in reserve – offering significantly lower accuracy than the GPS. Given the limitations of these initial results, China welcomed the European proposal and demonstrated significant involvement.²¹

18. *Ibidem*.

19. The latter suffered from the difficult transition between the two generations of Ariane 5 and 6, the setbacks of the Vega launcher, as well as the cessation of Soyuz launches from Kourou following the Russian invasion of Ukraine and the sanctions against Moscow.

20. GPS will not be fully open to civilian activities until 2000.

21. Author’s professional exchanges.

The French Embassy in China expressed its astonishment at the time and voiced concerns regarding China's true intentions. Indeed, the effectiveness of GPS had been fully demonstrated when the first satellite-guided munitions were deployed by U.S. aviation during Operation Desert Storm in 1991. This shift in the military paradigm had not escaped the attention of the Chinese authorities, who would not accept dependence on a third party, even a European one. They sought to preserve their autonomy at any cost.²²

Opposition from several EU member states delayed the launch date of Galileo. These states understood neither the strategic interest in embarking on a multi-billion-euro program to replicate GPS, whose services were free, nor the necessity of ending dependence on the United States. China took advantage of these hesitations to join the program at a negligible cost relative to the stakes. It then accessed all the information of interest before withdrawing, subsequently engaging in a battle over useful frequencies.

A few years later, in April 2007, the second version of Beidou, comprising five geostationary satellites and thirty satellites in medium Earth orbit, was launched and became officially operational in 2012. The first Galileo satellites, by then entirely European, were not launched until 2014, seven years after the Chinese version. The first operational services were provided in December 2016. The sole consolation in this episode is that both systems rely on rubidium atomic clocks provided by the Swiss company SpectraTime. The company reserved its most high-performance versions for the Galileo program. The European constellation thus distinguishes itself from its Chinese and Indian competitors²³ through the redundancy of its rubidium clocks. It utilizes masers capable of maintaining accuracy within one billionth of a second for several days, compared to only a few hours for its competitors. This advantage mechanically reduces the number of ground stations required to ensure the synchronization and resetting of the systems.²⁴

A third version of Beidou with global reach – comprising twenty-seven satellites in medium Earth orbit, five in geostationary orbit, and three in inclined geosynchronous orbit – was declared operational in 2020. It is officially presented as providing greater precision and integrity.

The Chinese GNSS is thus part of President Xi's "project of the century" (世纪项目), better known as the "Belt and Road Initiative" (一带一路, or "One Belt One Road"). The new satellite telecommunications constellations currently being deployed in low Earth orbit also contribute to this project.²⁵

22. Author's private archives.

23. From 2013, India deployed its own GNSS constellation – the "Indian Regional Navigation Satellite System" – the last of which was launched in January 2025. It has eleven satellites.

24. F. Delaye, "[Au cœur de Galileo bat une horloge suisse](#)," *Bilan*, 16 October 2011.

25. "[China's space cooperation endeavors benefit BRI partner countries](#)," The State Council, The People's Republic of China, 16 October 2023.

Satellite Operators via Space Telecommunication Constellations: In Pursuit of Starlink

When billionaire Elon Musk announced his intention in 2015 to “revolutionize the satellite side of things just as [he has] done with the rocket side of things,”²⁶ the shock within the space community was comparable to the “*Sputnik* moment” of 1957. His company, SpaceX, and its Starlink constellation provide the most accomplished definition of what is known today as New Space. To offer an analogy, this new model of the space industry is akin to the transition from haute couture to ready-to-wear in the textile industry, featuring mass production and the associated economies of scale. The concept is to produce faster, cheaper, and in greater numbers, in the same manner that China has successfully adapted in other domains.

A study published in 2022 provided a highly pertinent illustration to explain the dynamics at work in the New Space sector: “Like the automobile a hundred years ago, space is discovering ‘Fordism’ and its effects on the demand for launchers and satellites. This revolution takes place within favorable institutional and legislative contexts, where civilian-military duality is fully in play.”²⁷ Supported by the federal government and the Department of Defense, this industrial and organizational evolution serves the “Space Dominance” of the United States and the mastery of information highways. For these reasons, viewed from Beijing’s perspective, this initiative represents an obstacle to President Xi’s “project of the century.”

Furthermore, the space-based internet service proposed by Elon Musk serves his own ambitions in the field of autonomous vehicles. Much like Tesla electric cars, this has significant consequences for the automotive industry. For China, an entire industrial sector deemed strategic faces the threat of falling behind, even as it has only just assumed global leadership. Beijing cannot remain passive, especially since vacant spaces in low Earth orbit are limited due to the number of space objects that will cross paths and the associated risk of collision.

This physical congestion logically has repercussions on the question of frequencies. According to experts, it is only possible to deploy two or three constellations per frequency band.²⁸ The U.S. Starlink and French OneWeb (of the company Eutelsat) architectures – which operate in the Ku-band – are already operational. Another U.S. mega-constellation led by Amazon, named “Kuiper,” is on the verge of being launched. Finally, the Canadian Telesat project – the future of which remains uncertain – and the European IRIS² program, planned for the 2030s, operate in the Ka-band. It is therefore becoming urgent for Beijing to launch its own constellation(s).

26. T. Bishop, “[How Elon Musk plans to get to Mars, via Seattle: What the SpaceX founder said at that private event](#),” *Geek Wire*, 19 January 2015.

27. A. Dagicour, J. Gatin, A. Zahiri (dir.), “[Le fordisme spatial et l’Europe](#),” *Report*, Mines Paris, PSL, 2022-2023, 82 p.

28. *Audition, ouverte à la presse, de Mme Eva Barneke, directrice générale d’Eutelsat sur l’europe de la défense et les coopérations européennes (cycle “Europe de la défense”)*. Meeting minutes no. 54 of the National Defense and Armed Forces Committee, Ordinary Session 2024-2025, 26 March 2025.

As is its custom, China initially issues a flurry of announcements suggesting that start-ups will lead these projects. This solution is hardly credible given the necessary investments, as a constellation represents a cost of several billion euros. Furthermore, it involves sovereign interests and frequency rights, which are both scarce and strictly regulated. The media mention the development of constellations with various names, such as Guowang (国网), Zhongguo Xingwang (中国星网), Qianfan (千帆星座),²⁹ G60, Spacesail, Honghu, Hongyuan (虹云),³⁰ or Hongyan (鸿雁).³¹

In practice, however, all indicators suggest that China will retain only two constellations. The first will be Guowang (“national network”), which is effectively identical to Zhongguo Xingwang (“Chinese satellite network”). This constellation serves governmental purposes and is operated by the China Satellite Network Group Corporation, an entity linked to the CASC. The second will be Qianfan (“thousand sails,” formerly known as G60 or Spacesail), produced by the company Shanghai Spacecom Satellite Technology (SSST) for commercial use.

Observers have been struck by the similarity between the user terminals for Qianfan and those of Starlink. The hypothesis of technological theft cannot be ruled out.³² However, the Chinese industry has proved highly competitive in the field of receiving antennas. Consequently, the possibility that China subcontracts all or part of the Starlink terminals is an alternative hypothesis to consider, despite the constraints imposed by the U.S. administration.

Another question concerns the number of satellites announced for each constellation. For Qianfan, a target of 12,000 satellites is mentioned, with the first 18 having been launched in August 2024. This figure is comparable to the one advanced by Starlink. The very low altitude (500 km) of Elon Musk’s mega-constellation requires a large number of satellites to ensure coverage at all points on the globe. Conversely, Qianfan’s altitude (approximately 1,200 km) could achieve similar coverage with fewer than 1,000 satellites. This order of magnitude is similar to that announced by Eutelsat for OneWeb, whose 640 satellites at an altitude of 1,200 km are sufficient to cover the entire Earth. As these three constellations operate in the Ku-band, their sheer numbers could overwhelm the competition, despite the international rules established by the International Telecommunication Union.³³

29. “[La constellation des mille voiles : les étoiles et les mers de l’avenir des communications Internet par satellite de la Chine](#),” *Xinhuanet*, 9 March 2024.

30. *Ibidem*.

31. A. Jones, “[China is developing plans for a 13,000-satellite megaconstellation](#),” *Space News*, 21 April 2021.

32. Article 7 of the Chinese National Intelligence Law promulgated in June 2017 stipulates that “every organization or citizen must, in accordance with the law, support, assist and cooperate with national intelligence work and keep secret any national intelligence work of which they have knowledge,” in G. Jamet, “[Les services de renseignement et de sécurité en République populaire de Chine : un instrument essentiel de survie et d’hégémonie](#),” *Asia Focus* #100, Asia program, Institut de Relations Internationales et Stratégiques (IRIS), January 2019, 16 p.

33. The International Telecommunication Union is the organization authorized by the United Nations to establish standards and rules for telecommunications.

For the Guowang constellation, intended for government use, 13,000 satellites have been announced. Neither their altitude nor their frequency band is currently known, although the first ten satellites were launched in December 2024. This juxtaposition of two constellations – one commercial and the other governmental – is reminiscent of the European IRIS² project. IRIS² will consist of 264 low Earth orbit satellites for governmental activities (Ka-band) and OneWeb's 640 low Earth orbit satellites for commercial activities (Ku-band).³⁴

Faced with these projections, the stakes for Europe are considerable. OneWeb today and IRIS² tomorrow risk being overshadowed. On one side, there are Starlink and Kuiper, which seek to win the connectivity market in Western countries. On the other side, there is Qianfan and Guowang, which aim for the connectivity of member, observer, or partner countries of the Shanghai Cooperation Organization or BRICS+. Beijing is already announcing agreements regarding Qianfan with Brazil, Thailand, and Malaysia.³⁵

On this subject, only a united Europe, capable of avoiding certain centrifugal tendencies while increasing the size of its constellation, will be able to establish itself in the field of space-based internet. This situation will contrast sharply with the terrestrial internet, which is today monopolized by U.S. and Chinese giants.

Action in Space

As a comprehensive space power, possessing a wide variety of launchers and satellites, China is aware that its only systemic global rival, the United States of America, derives a large portion of its military superiority from its space segment. However, this segment, which acts as a force multiplier, could also prove to be its Achilles' heel by revealing significant vulnerabilities. China may attempt to contest U.S. superiority from space through actions involving destruction, physical neutralization, and cyber-attacks.

The trajectory of the *Fengyun-1C* (风云, “winds and clouds”) meteorological satellite provides an example of China's offensive capabilities. Launched in May 1999, the satellite had reached the end of its operational life and was orbiting in a low polar orbit at an altitude of 850 km. It was subsequently destroyed on 11 January 2007 at 22:28 UTC by a missile launched from Xichang Base No. 27 (西昌卫星发射中心). This constituted the first Chinese anti-satellite (ASAT) missile launch. It set a world record for a direct hit, given the distance traveled, compared to similar tests conducted by the U.S. and Soviets during the Cold War. Indeed, Washington and Moscow had previously agreed to cease such experiments because they multiplied debris and posed the risk of rendering space dangerous or even unusable.

34. J.-P. Diris, “[IRIS² : tout savoir sur cette nouvelle constellation européenne](#),” *Polytechnique insights*, 11 March 2025.

35. There is no official BRICS map that would be validated by all countries or by a permanent secretariat, because the group does not function like a conventional organization with a charter and a secretariat.

China reportedly fired an SC-19 missile, derived from the DF-21 ballistic missile, equipped with a kill vehicle that may be a modified version of the HQ-19 surface-to-air missile with an infrared homing device.³⁶ While some viewed this destruction as evidence of China's growing competencies, the destruction of a satellite in low Earth orbit – particularly a cooperative one – is within the reach of all space powers capable of organizing a “rendezvous” in space.³⁷ Nevertheless, the choice of a direct ballistic strike represented a technological leap for China. It reportedly achieved this after several tests conducted under the 863 Program.

However, this launch must primarily be viewed as a strong military and political signal intended for the United States. Firstly, in military terms, China has now become an offensive space military power. It demonstrated that it possessed the capability to destroy any satellite in low Earth orbit. Military reconnaissance satellites, including optical, radar, and signals intelligence systems, are now vulnerable. Beijing thus possesses the means to blind and deafen its adversaries. It is even conceivable to threaten satellites positioned in medium Earth orbit, which comprise the GPS constellation. Should such a situation arise, satellite-guided precision weapons would lose all utility. Finally, a similar attack is ultimately conceivable against telecommunications or early-warning satellites located in geostationary orbit.

Secondly, it served as a political signal. The United States had concurrently deployed its most sophisticated anti-missile weapons, such as Aegis frigates and Patriot batteries, in the Indo-Pacific. It had also proposed that Japan, South Korea, and Taiwan join the anti-missile defense program. This program was directed against the North Korean ballistic threat, but it could also apply to China. For Beijing, the U.S. project was unacceptable because it amounted to challenging the operational credibility of its deterrent. Thus, by demonstrating through a most spectacular military action that the U.S. space segment was vulnerable, Beijing sent a clear message to Washington and other capitals.

Finally, Beijing intended to demonstrate that the interdependence in space – which some countries argue that this course of action is unreliable and risks rendering the environment unusable – is a purely relative concept. It is evident to China that certain Western countries are significantly more space-dependent than itself. Consequently, they would have much more to lose in such a situation.

China reportedly continued ASAT tests on at least three occasions, though these did not lead to further destruction with debris.³⁸ Concurrently, it quietly pursues other experiments. Under the guise of “experimental satellites” *SJ Shijian* (实践) and *SY Shiyan* (实验), Beijing is conducting numerous maneuverability demonstrations around geostationary orbit. For example, the *SJ-17* has practiced conducting prox-

36. S. Delory, C. Maire, T. Fournol, “[Armes antisatellites – La relance des programmes d’interception ascensionnelle directe \(DA-ASAT\)](#),” *Étude de fond*, no. 6, Missile Defense Observatory – Phase 3, Fondation pour la Recherche Stratégique, 11 April 2023.

37. In space jargon, we talk about RPO, for “Rendez-vous and Proximity Operations.”

38. T. Farnsworth, “[China conducts ASAT Test, U.S. Says](#),” Arms Control Association.

imity operations with other satellites, including inspection and Space Situational Awareness (SSA).³⁹ The *SJ-21* and *SJ-23* have performed debris removal and capture maneuvers using robotic arms.⁴⁰ Meanwhile, the *SJ-25* has demonstrated in-orbit refueling or capture capabilities.⁴¹ Moreover, some of their missions remain unknown and intrigue observers due to their abnormal yet controlled trajectories.

The overview of China's capabilities for action from space would be incomplete without mentioning the national equivalent of the U.S. *X-37B* mini-shuttle, the *Shenlong* (神龙, or "divine dragon"). This spacecraft opens the fields of versatility, maneuverability in space, and reusability.

Human Spaceflights

In the field of human spaceflight missions, the Central Committee of the CCP envisaged their development at a very early stage. Certainly, like the United States and the USSR, the PRC considered sending humans into space for military intelligence purposes through observation.⁴² This was before artificial reconnaissance satellites rendered such an idea obsolete. However, like Washington and Moscow, the dimension of ideological supremacy and propaganda intended for the Chinese population and socialist countries was present in the minds of the Chinese leaders. Just as the bust of Mao had to preside at the summit of Everest at all costs,⁴³ the Chinese felt it imperative to catch up in the conquest of the ultimate peak and display the five-starred red flag there. As soon as their first satellite was in orbit, Beijing launched Project 714 (*Shuguang*, 七一四工程 曙光, or "Dawn") in the 1970s. This was a smaller equivalent – restricted by the performance of contemporary launchers – to the U.S. Gemini program.

Although this initial project was abandoned, it was followed by Project 921, initiated in the 1990s. The *Shenzhou* (神舟, or "Divine Vessel") spacecraft, directly inspired by the Russian Soyuz, was to be developed. This project materialized with the first orbital flight of the *yǔhángyuán* (宇航员)⁴⁴ Yang Liwei (杨利伟) on 16 October 2003. It was followed by the first spacewalk by Zhai Zhigang (翟志刚) on 27 September 2008.

Project 921 also included the *Tiangong* (天宫, literally "Celestial Palace") space station program, which has been operational since 2021. It further included *Tianzhou* (天舟, or "Celestial Vessel") cargo ships intended to resupply it. These were designed with the aim of preparing for future lunar and Martian missions.

39. J. Cerullo, "[NOTSO_a605_11Sep-2136Z](#)," Mission Management Board.

40. A. Jones, "[China's Shijian-21 towed dead satellite to a high graveyard orbit](#)," *Space News*, 27 January 2022; M. Ryan, "[NOTSO_66f9_24Dec-1923Z](#)," Mission Management Board.

41. A. Jones, "[China launches Shijian-25 satellite to test on-orbit refueling and mission extension technologies](#)," *Space News*, 6 January 2025.

42. ALP Museum in Beijing, 1993, author's archives.

43. See the work by C. Gras, *Alpinistes de Mao*, Paris, Éditions Stock, 2023, 304 p.

44. The Chinese term for astronaut, literally "navigator of the universe." Westerners prefer the term "taikonaut," from the Chinese *tàikōng rén* (太空人), which translates as "man of the great void."

The Lunar Program

While the Moon holds limited scientific interest, it could nevertheless present long-term economic and financial benefits. This is only now being revealed by the lunar samples returned by the Apollo missions in the 1970s. The presence on the Moon of minerals employed by new technologies is frequently cited. Furthermore, the presence of the isotope Helium-3 is highlighted. This isotope is rare on Earth but could serve as a low-radiation energy source,⁴⁵ vital for the stability of future quantum computers. Above all, the exploitation of the Moon would be highly advantageous for a voyage to Mars. Water present in frozen form at its poles could be used to resupply a space vehicle once converted into fuel.

Also forming part of President Xi's "Chinese Dream," China's lunar exploration program began with a robotic phase named *Chang'e* (嫦娥, the goddess of the Moon in Chinese mythology). This will be followed by a human phase by 2030, a feat that neither the USSR nor Russia ever achieved. Beijing would then symbolically surpass Moscow in this prestigious undertaking, which carries nationalist overtones.

It is within the framework of its lunar program that the PRC achieved its first major exploits in space conquest. *Chang'e-4*, launched on 7 December 2018, was the first spacecraft to land on the far side of the Moon on 3 January 2019. In 2024, *Chang'e-6* became the first spacecraft to return a soil sample from that same side. Taking advantage of the setbacks in the U.S. Artemis and Russian Luna programs, China has thus gained a definite edge in lunar exploration. This represents a decisive step toward Mars. The *Tianwen* (天问, or "Celestial Question") probe is now the symbol of this rise in power. In 2022, China became the third space power to land a rover on Mars, following the Soviet Union (1971) and the United States (1997).

Conclusion

China now fulfills all the criteria of a fully-fledged space power. Having overtaken Russia and Europe, it is progressively narrowing the gap with the United States. Mindful of its independence, the nation has seized every opportunity available to develop its own launchers and satellites. It has furthermore embarked upon ambitious robotic and human space exploration programs. Military-civil fusion, once considered a hindrance, has become an asset. Its industrial prowess is undeniable. Its cost control provides a significant advantage over its Western competitors.

Nevertheless, obstacles remain regarding access to certain cutting-edge technologies currently under sanction. Challenges also persist in initiating or resuming international cooperation with Western nations. These countries have now recognized the systemic competitor that China represents.

45. "[Lunar Helium-3 and Fusion Power](#)," NTRS – NASA Technical Reports Server, 1 September 1988.

Finally, the Chinese political system is not conducive to the organizational agility required by New Space, while opening this strategic sector to private actors currently appears to be a facade. The successive purges within the high military hierarchy, motivated by corruption and internal political struggles, can only hinder this (long) march forward.⁴⁶

46. J. Zeng, "[Xi Jinping, Ancient Chinese Prophecies, Superstitions, and the Real Reason for the Rocket Force Purges](#)," *Japan Forward*, 20 September 2023; M. Chansoria, "[\[All Politics is Global\] The Great Xi Jinping Military Purge and CCP-PLA Loyalty](#)," *Japan Forward*, 29 January 2024.

Challenges and Innovations of the U.S. Space Force in the Era of Space Competition

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*Happy birthday Guardians!*² The U.S. Space Force (USSF) celebrated its fifth anniversary on 20 December 2024 following a phase of increasing growth that was as impressive as it was brief. It has, for example, tripled its personnel volume every year since 2019. It now has nearly 15,000 “Guardians” within its ranks, of whom more than a quarter are civilian personnel.³ This growth and the numerous changes accompanying it are part of a dynamic of adaptation specific to the space sector within a context of intense strategic competition. It is fueled by the sense of urgency felt by the high command, for whom there is no question of slowing down.⁴

1. The author dedicates this article to Diana McKissock, a key figure in *Delta 2* who made a decisive contribution to cooperation with international partners. She passed away on March 8, 2025. “Diana was one of the brightest stars in the Space Community.”

2. “The Guardians” is the nickname for members of the U.S. Space Force.

3. “[Celebrating the U.S. Space Force and Charting Its Future](#),” *Aerospace Security Project*, International Security Program, Center for Strategic & International Studies (CSIS), 17 December 2024. However, the bulk of this increase is due to the transfer of members from the U.S. Air Force to the USSF. These are therefore not new recruits but personnel who were already working for the American space component.

4. “Other senior leaders will say, ‘The Space Force has so many things going on. We need to catch our breath. Why can’t we just slow down for a while and consolidate some of our gains?’ I hear you; I really do. I wish it was that easy. I get it; I do ... but the answer is right there. The Space Force we have is still not the Space Force we need. We have come a long way, but I think we can all acknowledge there is still work to be done;” in “[Remarks by CSO Gen. Chance Saltzman at the 2025 Air and Space Force Association’s Warfare Symposium](#),” *official website* of the USSF, 3 March 2025.

Indeed, the USSF is concerned by the narrowing of the gap between its capabilities and those of China, but also by threats originating from Russia. Moscow's destruction in orbit of one of its own satellites in November 2021 brutally confirmed these fears. Furthermore, as the current USSF commander, General Bradley Chance Saltzman, declared during the Space Symposium in April 2025: "Simply put, space superiority is now a prerequisite for battlefield success. So, regardless of whether or not you believe space superiority will win the next war, it must be recognized that we will most certainly lose without it." Without it, superiority in other domains cannot be guaranteed.⁵ Beyond military stakes, it is likely the security of the United States, the growth of its economy, the guarantee of its way of life, and perhaps global stability that are at risk. The Guardians therefore have no alternative but to fulfill the promise of their motto: "Semper Supra."⁶

In this framework, this article proposes to present the recent evolution of the USSF and to highlight the challenges it must now meet. These elements could, moreover, inform reflections regarding the development of French military space capabilities.

The USSF has exerted colossal efforts to dominate its competitors on a capability level and to attempt to deter them. Nonetheless, threats continue to multiply, such that the force is concentrating its efforts on the acquisition of space superiority and is preparing for potential combat.

Born of strategic competition with Russia and, above all, with China, the USSF is thoroughly imbued with the search for efficiency and innovation. It has proved highly effective in revolutionizing procurement processes and in aligning itself closely with commercial companies. However, the challenges to be met remain significant if it is to continue to dominate the military space domain in the coming years.

Establishing the USSF upon its Foundational Principles

Returning to the origins of the USSF allows for an understanding of the founding principles that still guide its members and organization. The USSF was created to structure and strengthen U.S. space capabilities while responding to increasing international competition. The spirit of efficiency and competition, a strong environmental culture, and an awareness of space-related issues serve as guides for the members of the USSF in meeting this challenge.

An Emancipation Accelerated by Strategic Competition

From the first years of the militarization of space, the necessity of federating the entities responsible for the acquisition of space assets became a priority. The idea of creating an independent body emerged in the 1980s but remained a subject of debate

5. General Saltzman puts it in a more figurative way: "We are no longer icing on the cake;" in "[Remarks by CSO Gen. Bradley Chance Saltzman at the 2024 Space Force Association's Spacepower Conference](#)," official website of the USSF, 10 December 2024.

6. "Always Above" which reflects both the pursuit of excellence and the spirit of competition.

throughout the following decades. It was the growing concerns sparked by Russian and Chinese space threats⁷ that accelerated the emancipation of the U.S. Space Forces. They separated from those of the U.S. Air Force (USAF), which had assumed the bulk of responsibilities in this field since the beginning of the 1960s.

A strong initial impetus was given during the work of the 2001 Space Commission – also known as the “Rumsfeld Commission”⁸ –, which emphasized the importance of reinforcing space expertise within an independent entity and safeguarding budgets dedicated to space activities. However, it was not until Donald J. Trump’s first presidency that the U.S. military space landscape underwent a profound restructuring.⁹ In June 2017, he reactivated the National Space Council – active from 1958 to 1993 –, which published *Space Policy Directive-4* (SPD-4) in February 2019.¹⁰ The directive proposed the creation of a sixth branch of the armed forces under the authority of the Department of the Air Force. The USSF was to stand alongside the USAF, in the same manner as the U.S. Marine Corps coexists with the U.S. Navy under the authority of the Department of the Navy.

Forming part of a comprehensive space strategy oriented toward national security and exploration, SPD-4 announced the creation of the U.S. Space Command (SPACECOM) on 29 August 2019 and that of the USSF on 20 December 2019, upon the signing of the National Defense Authorization Act for fiscal year 2020. This event possessed a genuine historical significance given that the last creation of a branch of the armed forces dated back to that of the USAF on 18 September 1947, seventy-two years ago.

The initial years of the USSF were marked by significant governmental pressure to deliver results while limiting spending. The Biden administration supported the momentum initiated by the previous administration despite different priorities. The ever-increasing rivalry with strategic competitors¹¹ was a prevalent concern for all parties.

The Need to Aggregate Numerous Missions

At the risk of offending the informed reader, it is necessary to reiterate the difference between the SPACECOM and the USSF. The former plans and conducts military space operations, whereas the latter holds an organic role. It manages the “Organize, Train and Equip” (OT&E) functions and covers the structuring and management of resources, operational readiness, and capability issues.

7. Especially exacerbated by the Chinese anti-satellite missile launch in 2007, which generated thousands of pieces of debris, some of which will remain in orbit for hundreds of years.

8. “[Report to the Commission to Assess United States National Security Space Management and Organization](#),” Pursuant to Public Law 106-65, 11 January 2001, 165 p.

9. The operations that followed the attacks of September 11, 2001, inevitably contributed to slowing the evolution of space forces.

10. “[Text of Space Policy Directive – 4: Establishment of the United States Space Force](#),” Presidential Memoranda, 19 February 2019.

11. General Saltzman credits China and Russia with being “our best PR” (Public Relations) partners, given how strongly their actions support the USSF’s cause and budgets. See G. Hadley, “[Saltzman Defines ‘Core Truths’ About Space Force and Warfighting](#),” *Air & Space Force Magazine*, 10 December 2024.

The resources implemented by the USSF delineate a very broad set of capabilities contributing to the following mission areas: early warning, satellite communications including support for the nuclear command chain, provision of meteorological and environmental data, space surveillance, space control, launches, as well as positioning, navigation, and timing (including GPS).

To fulfill these numerous missions, the USSF had to unify processes and teams that were already well established but scattered across different services from its inception. The process resembled the reorganization of intelligence services after 9/11.¹² The transfer of various capabilities toward the USSF was gradual and sometimes contested. Even today, the other branches of the armed forces manage to retain their own specialized assets. Nonetheless, the integration of space specialists, who were generally supportive of the transfer toward the new service, proved straightforward.¹³

An Organization Designed for Strategic Competition

The adopted organizational structure rests upon the principles of efficiency, agility, and a strong work culture, which were embraced from its inception. Operational and budgetary effectiveness¹⁴ is pursued through a “lean” or “slender” organizational chart that reduces the number of command levels from five in the other branches of the armed forces to only three:

- The “Field Commands” are the three pillars of the USSF and correspond to the major functional commands.¹⁵ These are, respectively, the “Space Operations Command” (SpOC) for operations,¹⁶ the “Space Systems Command” (SSC) for acquisitions, and the “Space Training and Readiness Command” (STARCOM) for operational preparation;
- The “Deltas,” equivalent to air brigades,¹⁷ pursue a mission-based logic (for example, space surveillance for *Delta 2*);
- The “Squadrons,” or elementary units, contribute to a particular function (for example, the 18th Space Defense Squadron for space surveillance).

This structure should be supplemented by the Component Field Commands, six of which are already operational and four others remain to be created. Placed in direct

12. The reorganization of the space forces was, however, limited to the U.S. Department of Defense alone, while that of the intelligence services involved agencies from several departments.

13. While approximately 90% of personnel originated from the USAF, their transfer was based on individual choices and was not automatic.

14. To limit costs, the USSF also continues to rely on many USAF support functions (part of HR management, infrastructure, some training, chaplaincies, etc.).

15. Studies for a fourth Field Command have recently been put on hold. Called “Futures Command,” its purpose would be to prepare the USSF for future challenges by examining, particularly with allies, new technologies and associated simulations to determine the capabilities to be developed. It would build upon and expand the work of SWAC.

16. Since it is the USSF, the SpOC generates and supports space forces (which the U.S. Space Command will use for its operations).

17. More specifically, a Delta provides command levels for a French brigade and its squadrons.

support of regional or functional operational commands (Combatant Commands, COCOMs¹⁸), they contribute to a better integration of space into joint combat.

The USSF is structured to be capable of adapting very quickly to the strategic but also the commercial environment. The sector evolves very rapidly, and knowing how to capture its innovations is one of the recipes for staying ahead of the race. The Space Systems Command contributes specifically to this function, as its scope extends beyond acquisitions alone. It also encompasses research, support, and even orbital launches. It relies in particular on three dedicated structures to pace the development of space capabilities: the Commercial Space Office (COMSO), oriented toward the integration of civil and commercial capabilities and especially services; the Space Enterprise Consortium (SpEC), responsible for the rapid acquisition of space technologies, notably from startups and small enterprises; and SpaceWERX, located within the Air Force Research Laboratory's AFWERX, whose goal is to integrate innovation and emerging technologies.

This structure is furthermore complemented by two entities reporting directly to the USSF commander: the Space Rapid Capabilities Office and the Space Development Agency. The former is intended to meet critical short-term needs. It can acquire capabilities without prior authorization by committing up to 1 billion dollars. The latter, attached to the USSF since 2022, concentrates its efforts on the development of the Proliferated Warfighter Space Architecture (PWSA), a mega-constellation in low Earth orbit that will offer resilience and responsiveness to the USSF for its missions.¹⁹

The USSF also equips itself with the means to explore certain avenues and to anticipate evolutions through the Space Warfighting Analysis Center (SWAC), which also reports directly to the USSF commander. It produces conceptual, doctrinal, and capability recommendations on the basis of simulations and wargames.

Finally, the USSF sought to establish its own identity through the various names of its organization. To achieve this, it turned to its members by asking them to submit their ideas during a competition. Notable among these is the choice of a "Delta" for the insignia, which adopts a symbol dating back to the beginnings of space exploration in 1961.²⁰ Moreover, the head of the USSF has taken the evocative title of "Chief of Space Operations" (CSO).²¹ Bases with an essentially space-oriented mission have furthermore become "Space Force Bases," following the example of Vandenberg in California.

Following extensive consultation, USSF personnel decided to name themselves the "Guardians" in 2020. This name refers to the motto of the former Air Force

18. The following are currently active: SPACEFOR-INDOPAC, SPACEFOR-CENT, SPACEFOR-SPACE, SPACEFOR-EURAF, and SPACEFOR-KOR.

19. Secure communications and missile detection services should be operational by early 2027.

20. Editor's note: and not to the Star Trek saga, which came after it, even though there are striking similarities between the USSF insignia and that of Starfleet Command in the fiction.

21. Even though its responsibilities are organic.

Space Command – “Guardians of the High Frontier”²² – in reference to their mission of protecting U.S. national interests in space. Conversely, even if their modification was considered at one point, the ranks remained the same as those of the USAF, with the exception of that of “Specialist,” which corresponds to the lowest rank of the enlisted personnel. It is above all the service uniform that marks a radical change. Its style is modern, indeed futuristic, with a diagonal row of buttons, a raised collar, and a characteristic midnight blue color.

Progress and Achievements

In only five years, the USSF has skillfully managed to assert itself at the federal level to obtain legitimacy and support, and internationally through its reporting activities. While the effectiveness of its communication is noteworthy, it is primarily its resolute efforts regarding procurement, innovation, and the integration of commercial solutions that have solidified its position. The USSF is thus well on its way to acquiring capabilities that are even more robust, responsive, and resilient.

The Importance of Communication Regarding Threats

Since its inception, the USSF has consistently advocated for a budget increase by relying on sustained and documented communication, highlighting the rapidly evolving nature of space threats. Previously, these exchanges of views remained confined to a restricted circle of experts due to the classified nature of national space capabilities. It was difficult to foster a genuine public debate to support funding requests. Furthermore, prior to 2019, the Space Force requirements under the Air Force Space Command found themselves in competition with those of the USAF, with which they shared budgets. While these specific domain-related issues were taken into consideration, topics linked to a specific environment presented a difficult case for the USAF.

Today, as a force dedicated to strategic competition in space, the USSF possesses greater legitimacy to expose publicly the increasingly threatening actions of its competitors. It does so, for example, through the publication of a “Space Threat Fact Sheet” on 21 February 2025 – regularly updated thereafter – outlining the risks posed by Moscow and Beijing to the “US national security interests in, from, and to space.”²³ It furthermore enjoys the support of numerous voices. The Secure World Foundation – an independent actor – publishes an annual detailed report on counter-space threats.²⁴ In February 2024, Republican Mike Turner, then chairman of the House Permanent Select Committee on Intelligence, also accused Russia of conducting a clandestine program intended to place a nuclear anti-satellite weapon in

22. Today, the USSF has adopted the expression, transforming it into “Guardians of the Ultimate High Ground.” These terms evoke both the conquest (of the West) and the high point overlooking the battlefield.

23. “[Space Threat Fact Sheet](#),” *official website* of the USSF, September 2025.

24. V. Samson, L. Cesari (eds.), “[Global Counterspace Capabilities. An Open Source Assessment](#),” *Secure World Foundation*, April 2025.

orbit.²⁵ All this information contributes to maintaining fears regarding the ability of the United States to maintain its competitive advantage over its adversaries and facilitates the procurement of budgets.

Concurrently, publicly disclosed information contributes to strategic communication: it is used to denounce the projects of competitors, to isolate them, or even to constrain them. This maneuver is even more effective when supported by allies. For example, messages disseminated during the Combined Space Operations (CSpO) initiative stigmatize the unprofessional behavior of competitors or the arms race they are engaging in.²⁶

The USSF also speaks publicly about the initiatives and the means it deploys. More broadly, CSpO illustrates the strength possessed by the entirety of its members when they work together. The intended effect here is to discourage competitors. In parallel, the USSF communicates very little regarding its offensive capabilities: even if certain assets have attracted attention – such as the X-37B shuttle or the GSSAP satellites²⁷ – the only offensive counter-space capability recognized to date is the Counter Communications System (CCS) jamming system, with its successor, the Meadowslands.

This communication has prepared the ground for a delicate but radical change in doctrine.

The Recent Doctrinal Evolution towards the “Combat USSF”

Under the command of General Saltzman, the USSF’s doctrinal posture was defined as early as March 2023 by the concept of “Competitive Endurance,” which prioritizes resilience and deterrence against competitors.²⁸ This approach aims to maintain the advantage in space without provoking direct conflict²⁹ and to guarantee free access to, as well as the full use of, space for the benefit of the United States. To this end, the USSF seeks to guard against any operational surprise by relying on space surveillance and intelligence means. It also strives to deter its adversaries by limiting the potential effects an attack would cause on its space assets. Their architecture is thus deliberately dispersed for better resilience. Finally, it develops counter-space capabilities governed by the principle of “Responsible Counterspace,” formulated in March 2023,³⁰ accord-

25. J. Borger, “[Senior U.S. official warns of security threat amid reports of Russian nuclear capability in space](#),” *The Guardian*, 14 February 2024.

26. The following countries participate in CSpO: Germany, Australia, Canada, the United States, France, New Zealand and the United Kingdom, Japan, Italy and Norway. See “[10 ans après sa création : l’initiative CSpO toujours engagée au bénéfice de la sûreté spatiale](#),” *official website of the French Ministry of Armed Forces*, 27 September 2024.

27. The Geosynchronous Space Situational Awareness Program refers to a series of American surveillance satellites – also called “Hornet” – whose capabilities and missions are classified.

28. G. Hadley, “[Saltzman Unveils ‘Competitive Endurance’ Theory to Guide Space Force](#),” *Air & Space Forces Magazine*, 7 March 2023.

29. A conflict that would lead to the creation of orbital debris and the neutralization of orbit would be catastrophic. Any escalation must therefore be controlled and, if possible, stopped quickly.

30. G. Hadley, “[Saltzman Unveils ‘Competitive Endurance’ Theory to Guide Space Force](#),” *op. cit.*

ing to which potential offensive actions must avoid irreversible effects on the orbital environment and reduce the risk of escalation. This posture supports the normative vision of a responsible use of space promoted by U.S. diplomacy.

This doctrine, supplanting the more traditional logic of technological superiority, was criticized in early 2025 by the Mitchell Institute for Aerospace Studies, which faulted it for its lack of aggressiveness.³¹ This quarrel revealed the strategic debate regarding the posture that Space Forces should adopt. Nevertheless, the Chief of Space Operations had initiated a significant cultural transformation to develop a warfighting ethos among the Guardians and to raise the standards of operational readiness.

The publication of the new USSF doctrine on 4 April 2025 – the Space Force Doctrine Document 1 (SFDD-1) – came at an opportune time to clarify the ongoing strategic debate.³² While acknowledging the crucial support provided by the USSF to joint operations, the document now establishes space superiority as a priority. It returns to the fundamentals of the previous “Spacepower” doctrine of 2020³³ but insists more this time on the fact that space is a domain of conflict in which the Guardians are called upon to be combatants in their own right. The path to acquiring offensive capabilities is now open.³⁴

Space Architecture and Innovation: Levers for Superiority in Space

From its inception, the USSF has been the subject of very high expectations and has faced pressure, notably from the U.S. Congress, to progress rapidly toward its objectives. The scale of the task – to innovate while simultaneously replacing existing capabilities – makes the mission of this young and modestly sized service more challenging.³⁵

Long debates have been held regarding the choice of future space architecture: should one rely on a few heavy and ultra-high-performance satellites, or rather on smaller but numerous satellites, strengthening resilience against threats? The current trend is toward acquiring the latter and shortening development times. This involves building on existing commercial technologies while limiting “non-recurring” engineering.³⁶

31. C. S. Galbreath, J. K. Reeves, “[Ensuring a Spacepower Advantage in Prolonged Competition: Findings and Recommendations from the Space Endurance Workshop](#),” *Report*, Mitchell Institute for Aerospace Studies, 21 February 2025.

32. “[Space Force Doctrine Document – 1, The Space Force](#),” Space Training and Readiness Command, 3 April 2025.

33. “[Space Capstone Publication, Spacepower](#),” Headquarters USSF, June 2020, 41 p.

34. “Space is a combat domain, not a benign support function. In conflict, it will be contested. We are the military service charged with fighting in it. We do not simply provide enabling functions – we employ military force to achieve space superiority and ensure freedom of maneuver;” in *ibidem*, p. 3.

35. As General Saltzman likes to say: the smallest service with the smallest budget, yet responsible for the largest area of operations, space from 100 km altitude...

36. Non-recurring engineering (NRE) refers to the initial costs and efforts involved in the design, development, and implementation of a new product or system, prior to its mass production.

Still with this aim of acceleration, the USSF is adapting its procurement strategies to deploy new capabilities rapidly. While initiatives to stimulate innovation are manifold, two entities stand out: SpaceWERX and the Space Safari Program Office.

SpaceWERX³⁷ is the innovation arm of the USSF. Its mission is to identify and integrate innovative technological solutions originating from the private sector, academia, or other non-traditional partners. Following the example of the Pentagon's Defense Innovation Unit (DIU), it monitors commercial innovation rather than forcing manufacturers to comply with rigid Defense processes. It favors approaches that reduce costs, accelerate deliveries, and allow for scalability, in contrast to traditional procurement processes that produce capabilities which are certainly exceptional but remain too costly to be replicated in series.

An example of this promising approach is the procurement of “good enough” technology – meaning, technology sufficient to meet essential operational needs. SpaceWERX possesses an annual budget exceeding 400 million dollars. It acts as an incubator through the contracts it awards to companies within the framework of competitions. For instance, the company, Gravitics, recently received a 60-million-dollar contract under the STRATFI (STRATegic Funding Increase) program to pursue the development of its StarMax commercial orbital module. This is currently being adapted to serve as a tactical platform capable of rapidly deploying maneuvering objects within the framework of the Tactically Responsive Space (TacRS) program.

The Space Safari Program Office, for its part, was created in early 2021, drawing inspiration from the spirit of the USAF's Big Safari program during the Cold War.³⁸ Its mission is to respond to urgent and priority needs by rapidly assembling already available sub-systems. From its creation, it distinguished itself by successfully placing the TacRL-2 space surveillance satellite into orbit in June 2021, which was developed in less than a year. In doing so, the USSF demonstrates its capacity to deploy operational tactical solutions rapidly.

Integrating Commercial Capabilities: A Decisive Hybrid Approach

The USSF has clearly opted for a hybrid approach combining the ownership of assets and the purchase of services. Through this governance model, it seeks to find the best balance between operational effectiveness, strategic resilience, and budgetary control, while maintaining options for action in the “grey zone.”

The term “integration” – often translated literally from English when referring to the role of commercial capabilities – may appear disappointing in French as it sug-

37. Derived from “works” (as in Skunk Works), used in American military jargon to refer to a workshop for experimentation or agile innovation, and often spelled with an “X” to emphasize the unconventional, disruptive, or technological aspect.

38. The Big Safari program was a secret Cold War initiative aimed at rapidly adapting existing air systems to meet urgent operational needs, often related to national security. See J. Pike, “[Big Safari](#),” *Intelligence Resource Program*, Federation of American Scientists, 30 July 1997.

gests a loss of control. On the contrary, it should be understood here as a regulated and seamless recourse to external means. Such a process is necessary from a technological standpoint to keep pace with global innovation, but also for operational reasons – to maintain superiority over China – and for security reasons, in view of protecting the commercial systems that constitute a significant part of the national space architecture (economy, security, etc.). In the event of a conflict, coordination with commercial actors, who will undoubtedly be targeted, is indispensable, as is their participation in military operations. The employment of Starlink in Ukraine provides a salient example in this regard.

Space Surveillance: A Partial Shift Toward the Civil Domain

Commercial services are highly useful, particularly in the field of space surveillance, which has long been the monopoly of the USSF. This function is currently being transferred to the Department of Commerce (DoC) so that the USSF may concentrate solely on military threats. From the end of 2025, the DoC is expected to assume responsibility for civilian missions linked to space safety (safety of human spaceflight, collision avoidance). It will rely on a new infrastructure: the Traffic Coordination System for Space (TraCSS), which is slated to succeed the Space-Track.org database, previously maintained and managed by the USSF.

COMSO: Connecting the USSF to the Private Sector

Another major lever of the USSF is the Commercial Space Office (COMSO), attached to Space Systems Command. It acts as an interface with private industry and centralizes service proposals from commercial entities via a dedicated platform named “Front Door.” After verifying that there are no relations between these companies and competing states, COMSO directs them toward the appropriate government intermediaries and facilitates their access to funding programs, such as SpaceWERX or the DIU. The promotion of hybrid communication networks, blending civilian and military systems, figures among its recent successes, thereby strengthening the redundancy and resilience of transmission means.

A Strategy Governed by the Commercial Space Strategy

Published in April 2024, the USSF’s *Commercial Space Strategy* is derived from the *National Defense Strategy* of April 2022.³⁹ It aims to govern the integration of commercial capabilities into military operations by specifying the criteria used by the USSF: operational utility, cost-effectiveness, resilience to disruptions, and rapid deployment. In other words, the use of commercial capabilities is confirmed but will not be systematic. The USSF warns that it will not invest in ineffective or non-competitive solutions. The ambition is clear: to integrate these capabilities in a coherent manner and not simply to add them to existing ones.

39. “[US Space Force Commercial Space Strategy. Accelerating the Purposeful Pursuit of Hybrid Space Architecture](#),” official website of the USSF, April 2024; “[2022 National Defense Strategy of the United States of America. Including the 2022 Nuclear Posture Review and the 2022 Missile Defense Review](#),” official website of the Department of Defense, 27 October 2022.

The USSF recognizes the risks faced by commercial actors during a potential conflict. It is on this basis that it plans to share information,⁴⁰ relating notably to space and cyber threats so that they may react if necessary. It furthermore requests them to ensure the cyber resilience of their systems. Finally, interoperability is not established as a dogma. While it remains desirable, it must not act as a brake on industrial innovation.

A Commercial Space Reserve in the Event of Conflict

Beyond the routine use of commercial services, the USSF plans to leverage a commercial reserve force in wartime through the Commercial Augmentation Space Reserve (CASR) program. This program offers pre-negotiated contracts with commercial suppliers. These must be capable of rapid deployment to support military operations, particularly in the event of government systems becoming unavailable or overwhelmed by cyberattacks or electronic warfare acts. The project has been well received by the industry. Wargames and joint exercises are planned to refine coordination.

Two sensitive points nonetheless remain to be clarified: the compensation mechanisms in the event of the destruction of or damage to commercial satellites, and the management of service interruptions for non-military clients, notably foreign ones, if the service is requisitioned or simply prohibited.⁴¹

Adapting Launch Strategy to Competition: A Sine Qua Non

The Space Systems Command pilots the launch activities of the USSF through its Assured Access to Space office. In line with its *Space Access, Mobility and Logistics* plan,⁴² the USSF profoundly revised its procurement strategy in 2024 to capitalize on the dynamism of the commercial market. The objective is to transition from a model based solely on asset capabilities to one oriented toward the purchase of services.

This opening to private actors, which was long hindered by a culture of end-to-end control, is now essential, notably due to the need to better respond to strategic competition with China. It is necessary to possess the means to place large numbers of satellites into orbit rapidly, whether as part of a power build-up or to respond to the phenomenon of attrition. The USSF is also concerned with diversifying providers to limit dependence on SpaceX and to prevent its launch infrastructure from becoming overloaded.

40. The USSF announced that it would share unclassified threat information with more than 900 registered commercial actors on the Front Door through an information feed called “Orbital Watch.” See “[USSF launches Orbital Watch, strengthens U.S. commercial space industry](#),” official website of the USSF, 10 April 2025.

41. Example of Starlink in the context of the war in Ukraine.

42. The SAML plan aims to develop the USSF’s ability to rapidly access space, move flexibly within it (orbital mobility), and sustainably support its operations (orbital logistics) in order to enhance freedom of action in a contested space environment. See “[U.S. Space Force Commercial Space Strategy. Accelerating the Purposeful Pursuit of Hybrid Space Architecture](#),” *op. cit.*

Phase III of the National Security Space Launch (NSSL) program embodies this evolution. It consists of a framework agreement for ordering launches on demand over a renewable five-year period (2025-2029). This phase is structured into two tracks. Lane 1 concerns the least critical missions, with a high requirement for responsiveness, and tolerates a certain level of risk. It is well suited for mass launches, notably within the framework of military constellations such as the PWSA. Launchers whose reliability is improving are mobilized here. Lane 2, by contrast, is intended for the most sensitive missions, with launches toward complex orbits, and requires maximum reliability.

On this basis, Phase III provides for approximately 30 Lane 1 launches for an estimated amount of 5.6 billion dollars, and 54 Lane 2 launches awarded to SpaceX, ULA, and Blue Origin for a total of 13.7 billion dollars. In this regard, the presence of Jeff Bezos's company in Lane 2 marks a first. Although its New Glenn rocket has flown only once, the USSF is granting it its confidence. Blue Origin is thus betting on a good quality-to-price ratio and the attainment of its certification by 2026. This decision illustrates a strategic desire for supplier diversification, which is essential to guarantee the resilience of the U.S. military space launch system.

To conclude on the evolution of launch capabilities, the Tactically Responsive Space program, currently directed by the Space Safari Office, must also be cited.⁴³ This program offers the possibility of mobilizing commercial launch capabilities to deploy satellites at very short notice in order to monitor and react to threats in orbit. One of these applications was the Victus Nox mission, which, in 2023, placed a satellite into orbit only 27 hours after the order had been given.

Challenges and Priorities

The primary challenge which the USSF must confront is the one posed by U.S. competitors. Consequently, the previous Secretary of the Department of the Air Force, Frank Kendall III, launched the "Reoptimizing for Great Power Competition" plan in early 2024.⁴⁴ This plan was, however, placed on hiatus in February 2025 with the arrival of the new Republican administration. General Saltzman nonetheless recognizes that much remains to be done to dominate space in the event of a crisis. His principal challenges encompass the question of human resources, the integration of allies, and the budgetary conquest.

Preparing the Guardians for Combat

The USSF seeks, first of all, to consolidate its structure by attracting and retaining talent through an innovative management of its human capital. The new personnel management policy, entitled the "Personnel Management Act," introduces, for example, greater flexibility into the professional paths of USSF military personnel,

43. "[U.S. Space Force successfully concludes VICTUS NOX Tactically Responsive Space mission](#)," official website of the USSF, 19 February 2024.

44. "[Reoptimizing for Great Power Competition](#)," official website of the U.S. Air Force.

with the possibility of transitioning to part-time service. If this ambitious measure were to succeed in retaining Guardians who are on the verge of departure, it would reduce the number of vacant posts. Considered a strategic investment, the quality of life of the Guardians is, moreover, the subject of great attention, with substantial support for families designed to enhance retention.

The USSF then seeks to develop an esprit de corps oriented toward combat. Such an identity is essential for General Saltzman to achieve space superiority. It is to this end that the initiative baptized “Guardian Experience” was established to strengthen the Guardians’ sense of belonging, combativeness, and a unique culture. Collaborative work and audacity are particularly valued therein. The possibility for Guardians to spend the entirety of their careers in space-related positions in order to fully hone their skills in this domain is also strongly supported. The idea is to break with the career paths of space operators from other services, who may change expertise and lose part of their experience.⁴⁵ The USSF is now accelerating in this direction by bringing together different professions within the same teams to foster mutual understanding and personnel efficiency.⁴⁶

General Saltzman furthermore expects the Guardians to approach problems with initiative, to dare to question their daily processes, and to participate actively in doctrinal innovation. He invokes, in this regard, the heritage of General Bernard Adolph Schriever, a pioneer of the U.S. ballistic and space program of the 1950s, who asserted at the time: “Today, the risk of moving too slow is far greater than any risk associated with rapid change. We must evolve. We must take risks. We must solve problems.”⁴⁷

The USSF also strives to disseminate space culture within the other armed forces so that they may better integrate space capabilities into their own operations. The establishment of Component Field Commands, attached to joint commands, encourages the introduction of space into the multi-domain approach to operations.

Finally, the USSF seeks to emphasize operational readiness to improve its responsiveness. General Saltzman knows, indeed, that the most advanced systems remain ineffective if their operators are not trained in the face of real threats. Investment in simulation technologies must therefore be sustained to provide realistic environments where robust tactics and procedures can be developed.

The Integration of Allies

As a force multiplier, cooperation with allied countries constitutes a major lever for the USSF to reinforce its resilience and its competitive advantage.

45. The idea is not new: as early as 2003, the need to train a corps of space specialists was advocated and then formalized by a strategy – the *Space Professional Strategy*. The novelty lies in making them combatants.

46. Five job families have been defined: intelligence, cyber, operations, engineering and programs.

47. “Today, the risk of moving too slow is far greater than any risk associated with rapid change. We must evolve. We must take risks. We must solve problems;” in “[Saltzman outlines plan to reoptimize Space Force for Great Power Competition](#),” official website of the USSF, 13 February 2024.

In continuity with his predecessor,⁴⁸ who already affirmed in 2020 that “we can’t do this alone,” General Saltzman is deeply convinced of the inescapable character of cooperation and asserts that space power can only develop collectively – “Spacepower is a collaborative endeavor,” he affirmed in June 2025.⁴⁹ It is why, from his assumption of office on 2 November 2022, he insisted that cooperation should be a line of effort (LOE) in its own right among the three he retained for his duration of command. It is baptized “LOE 3 – Partner to Win.”⁵⁰

Concrete Actions Confirming the Credibility of this Intention

The first validation of this new direction is the adoption of the “Allied by Design” report, submitted by the RAND Corporation on 1 December 2023.⁵¹ This study had been commissioned by the USSF to respond to the recurring criticisms from Allies denouncing the gap between encouraging U.S. political declarations and an operational reality that was far more demotivating and closed.

The report first identifies the processes that hinder or block cooperation: regulatory barriers linked to the sharing of classified information,⁵² a lack of interoperability between communication systems, limited access to infrastructure for exchange officers, and even cultural barriers. The authors propose several concrete recommendations to better integrate allied capabilities with U.S. space strategy in order to generate space power that is more robust and genuinely shared. The first would be to remedy, through a common high-level strategy, the lack of coordination between the numerous actors in the Department of War.⁵³ Their responsibilities overlap and lead to the multiplication of dispersed cooperation initiatives. Mutual defense agreements could, moreover, be sought with certain Allies, following the example of those established with the United Kingdom. Common communication standards could be promoted. Everything that has been accomplished in the domain of special operations could inform the Guardians on the best ways forward.

However, it is indeed the title of the report – “Allied by Design” – which synthesizes its thesis. Cooperation must be planned upstream, from the conception of

48. General John William Raymond; “[Watch, Read: CSO Gen. Raymond’s Keynote from AFA’s vASC 2020](#),” *Air & Space Forces Magazine*, 5 October 2020.

49. “Spacepower is a collaborative endeavor,” in “[U.S. Space Force International Partnership Strategy. Strength Through Partnership](#),” June 2025, p. 15.

50. The two are “LOE 1 – Field Combat-Ready Forces” and “LOE 2 – Amplify the Guardian Spirit;” in “[CSO releases Lines of Effort](#),” official website of the USSF, 18 January 2023.

51. B. McClintock, A. Radin, C. Weinbaum, *et al.*, “[Allied by Design. Defining a Path to Thoughtful Allied Space Power](#),” *Research Report*, RAND Corporation, 1 December 2023, 130 p.

52. Often, the complex and differing policies between the War Department and the intelligence community make sharing classified information impossible, or at least far too time-consuming given the pace of operations. Similarly, the use of the NOFORN (“Non-Releasable to Foreign Nationals,” equivalent to “Special France”) classification is far too systematic. The increasing number of events in orbit makes information and intelligence sharing urgent. However, the vulnerabilities that such sharing entails continue to generate considerable internal debate.

53. Such as the Office of the Secretary of Defense for Policy, the Office of the Secretary of the Air Force/International Affairs, the USSF, or the U.S. Space Command.

programs, and not added a posteriori, at a time when technical choices decided according to a sovereign logic become almost insurmountable obstacles to the integration of allies (for example, the impossibility of exporting a system not originally designed to be so).

The second symbolic action was the appointment, on 17 June 2024, of Air Marshal Paul Godfrey to Assistant Chief of Space Operations for Future Concepts and Partnerships. He thus became the first foreign officer to hold a strategic position within the USSF, which sends a very strong signal of openness and trust. Air Marshal Godfrey is perfectly positioned to advance cooperation efforts at the highest level. He is, moreover, tasked with developing an international partnership strategy, expected for 2025. This strategy should contribute to the building of an integrated space architecture “by design” by offering to coordinate Allied efforts in operations, capabilities, and training. It would help, for example, to fill the existing capability gaps of Allies, provided that discussions are not hindered by classification issues.

Concrete projects already illustrate this collaborative approach: in South America, the USSF collaborates with Chile in space surveillance through the installation of a telescope at the Cerro Moreno air base in the north of the country. It is also developing, with the United Kingdom and Australia, the Deep Space Advanced Radar Capability (DARC), which is intended to lead to the construction of three shared sites for detection in geostationary orbit. This strategy should also ease the rules that prevent the necessary sharing of information between Allies.

In parallel, operational cooperation initiatives continue to progress according to varying degrees of coordination. The space security exercise, Global Sentinel, now brings together nearly 30 countries around scenarios developing interoperability and crisis management capabilities. The ten nations of the Combined Space Operations (CSpO) forum are pursuing the implementation of their “Vision 2031” by strengthening interoperability, the resilience of their capabilities, and by promoting the responsible use of space. Finally, the permanent Operation Olympic Defender (OOD), launched in 2013, closely unites seven nations to help deter hostile behavior in space. As a sign of recognized operational credibility and a proven strategic solidarity with its Allies, France joined this operation in October 2024.⁵⁴

Budgetary Ambitions

Shortly before leaving office, Frank Kendall III, the previous Secretary of the Air Force (SECAF, 2021-2025), expressed in a report his concerns regarding the budgetary obstacles hindering the modernization of the USSF.⁵⁵ He lamented funding delays due to “continuing resolutions.” He highlighted the insufficient budgets to

54. “[La France rejoint la force multinationale ‘Opération Olympic Defender’](#),” official website of French Ministry of Armed Forces, 15 October 2024.

55. “[The Department of the Air Force In 2050](#),” Report to Congressional Committees, Department of the Air Force, December 2024, 22 p. See also J. A. Tirpak, “[Strategy & Policy: Kendall: His Legacies and Look Ahead](#),” *Air & Space Forces Magazine*, 7 February 2025.

provide the armed forces with both the necessary space services and to modernize the entire space architecture.

The USSF budget has nonetheless nearly doubled since its creation in 2019, rising from 15.4 billion dollars in 2021 to nearly 30 billion for the 2025 fiscal year. However, this progression does not keep pace with growing needs. It even appears to be slowing down.⁵⁶ Yet investment needs are numerous in areas such as GPS, satellite communications, meteorology, early warning, and space surveillance. Similarly, new offensive capabilities are required to counter Russian and Chinese threats.

Faced with these challenges, the SECAF declared that the USSF budget should probably double or triple in the future, breaking with the rhetoric of relative financial restraint adopted at the USSF's inception.⁵⁷ He furthermore highlighted that, with more than 65% of the budget already dedicated to research and development, an additional effort will be difficult to further prioritize innovation without gravely compromising other requirements.

Conclusion

Despite the indisputable progress made by the USSF in a few short years, the rise of space-based threats continues and compels the force not to lower its guard. Its progress has enabled the emergence of a remarkably robust and resilient architecture that will be difficult to undermine and which should effectively support joint operations.

To maintain strategic balance vis-à-vis its competitors, who are rapidly developing their own weapons, the USSF has changed its posture and decided to prioritize acquiring space superiority through combat forces that will deploy weapons in an assertive manner. The year 2025 thus marks a strategic shift prepared by five years of strategic communication intended to shape public opinion, policy-makers, and allies. General Stephen N. Whiting, Commander of U.S. Space Command (SPACECOM), declared on 8 April 2025 during the Space Symposium that it was now time to be clear regarding the need for weapons and offensive capabilities.

Doctrine and rhetoric are changing, as are the terms. Space is a crucial arena of conflict which the USSF intends to use freely while preventing its adversaries from doing the same if necessary. In particular, it knows that it will have to protect the joint forces from any form of strike originating from space. To achieve this objective, it will have to secure new funding, toughen its Guardians, and effectively integrate its allies. In fact, only ten days after SPACECOM's intervention, the USSF publicly unveiled its space combat guide for its Guardians.⁵⁸ This handbook con-

56. The USSF had requested \$30 billion for the year 2025 but only \$29.4 billion was included in the bill, a decrease of 2% compared to 2024.

57. Its operating expenses, however, were kept relatively low (\$5.2 billion), as were those for human resources (\$1.2 billion). R&D accounted for \$18.7 billion, while acquisitions and services totaled \$4.3 billion.

58. "[Space Warfighting: a framework for planners](#)," USSF Space Warfighting, March 2025, 22 p.

firmed the importance of space superiority and the “normalization” of the USSF. It now assumes the same combat role as the other branches of the U.S. armed forces.

Contrary to popular belief, space is not reduced solely to the deployment of cutting-edge technological means. Tomorrow’s battles will be won, certainly, through judiciously chosen capabilities, but also through the quality of the combat operations implementing them. Threat anticipation, tactical acumen, initiative, combativeness, and innovation are assets that must be developed for space warfare. At a time when the French Air and Space Force is equipping itself with satellites to act in space, a widespread space culture⁵⁹ will be able to help aviators develop such qualities. They must rely on the principles of action that characterize them: agility, a pioneering spirit, and openness. Teamwork will obviously be fundamental to contribute effectively to multi-domain combat, to benefit from all forms of expertise, and to support the armed forces.

59. Within a single team, a balance between space specialists and experts from other fields fosters mutual enrichment. It also allows for the useful acculturation of personnel transitioning to senior command positions.

Arms Control in Space: When Confidence Influences Control

Hugo Peter

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“Trust, but verify.”

Lenin

This quote, which is commonly attributed to Lenin on the topic of his relationship with Leon Trotsky, is now commonplace and widely used in variety of fields. It is particularly relevant in the context of public international law (PIL) and international relations, i.e. fields in which sovereign states often exercise control so as not to indulge in blind – and ultimately rather uncertain – trust. This partly stems from these states’ different forms of sovereign power, which can sometimes be quite extensive. Two of these forms of power relate to security: internal security, i.e. regarding threats within the state; and external security, i.e. defending the state, its territory, its integrity and, ultimately, its property and population from outside threats.

The state is viewed as the primary subject of PIL: it is both the creator and debtor of international obligations. While the will of the state’s exact role in PIL doctrine is still up for debate, it remains central nonetheless. Thus, the Permanent Court of International Justice has pointed out that limitations on sovereignty cannot be merely presumed.¹ This illustrates the importance of the will of the state, which remains central both politically and legally. The return of force in international relations accentuates the fragility of international law in this regard. The collective will of states

1. PCIJ, *Lotus*, Series A, No. 10, 7 September 1927, p. 18; PCIJ, *Free Zones of Upper Savoy and the District of Gex*, Series A/B, No. 46, 7 June 1932, p. 167.

creates balance – or imbalance – between nations. Yet, given that seeking to expand its power is part of a state's very nature, its will may sometimes take on the form of ambition or conquest. Every environment occupied by humans has been subject to conquest: land, sea, air and now space.

A Historical Understanding of Outer Space as a Military Domain

As national space policies become increasingly important, outer space is no exception to the dynamics of conquest. The United States appears to be at the forefront of this movement for two reasons: firstly, because it is leading the space race; and secondly, because it is the most dependent on this environment. However, the U.S. is not alone, as Russia and China are also putting state interests ahead of the creation of an effective legal framework. In fact, this issue constitutes an enduring challenge in PIL. Nevertheless, the creation of the U.S. Space Force in 2019 has highlighted two facts: the essential role of space activities in military operations on the one hand; and a heightened fear of failure in America's space ecosystem on the other.

The first fact is nothing new. In 1991, during the Gulf War, the use of American space assets unquestionably ushered space into an era of militarization. While space had been a competitive environment since the onset of space exploration, Operation Desert Storm constituted the first example of space assets being used to support military operations on Earth. Since then, space has become an increasingly essential arena for both civilian and military activities on Earth.

This shift toward the militarization of space heightened the fear that space could become the vector of an unstoppable enemy threat. This fear originated in 2001 in particular: the Report to the Commission to Assess United States National Security Space Management and Organization highlighted the potential threat of a “Space Pearl Harbor.”² This fear is at the root of U.S. space strategy and partly justifies its policy oscillating between three concepts: control, superiority and domination. This triptych forms the pillars of U.S. doctrine, which essentially pursues space control, space superiority and, ideally, space dominance.

As such, U.S. space strategy appears to be one of the most conducive to the militarization of space, as it greatly encourages this phenomenon and undoubtedly compromises space security. The fear of a threat to American space assets – one that could lead to unpredictable consequences – is heightened by the U.S.' increase in space activities and its dependence upon them. Faced with a classic “security dilemma” in space, the United States is contributing toward increasing the risk of confrontation, rather than toward appeasement.³ Thus, the U.S. has embarked on a strategic path from which it will be difficult to turn back.

2. [“Report to the Commission to Assess United States National Security Space Management and Organization,”](#) Pursuant to Public Law 106-65, 11 January 2001, p. 19.

3. D. Grondin, “La généalogie de l'Espace comme ‘champ de bataille’ dans le discours astropolitique américain : La stratégie de construction identitaire des États-Unis comme puissance stratégique globale,” Political Science Thesis, supervised by A. MacLeod, University of Quebec at Montreal, March 2008, p. 316.

For example, the U.S. Space Force's strategy – titled "Space Warfighting: A Framework for Planners" (March 2025) – outlines the means that the United States is prepared to use in the event of a space threat.⁴ The section on "Offensive Actions" includes the possibility of carrying out an orbital strike, particularly through the use of a kinetic weapon, i.e. one that creates debris.⁵ It is not our place to judge the relevance of this choice. Nevertheless, the disastrous consequences it may yield lead us to express serious reservations regarding the use of such devices. Whether it is a deterrent maneuver or a real strategic calculation, America's space posture does not contribute to the appeasement of international relations – particularly regarding space. The existence of such national strategies only perpetuates and exacerbates the space security dilemma.

Elements such as these go on to structure international relations and also influence the law. Although these two disciplines may seem distinct, their interconnection is well established. The omnipresence of law in space activities is counterbalanced by the existence of numerous gaps, ones that raise questions about the law's permissive nature as they contribute to undermining its implementation, legitimacy and effectiveness.

The mere existence of the five space treaties⁶ leads toward two observations. The first is positive, as it illustrates the law's ability to provide a framework for space activities. The second is much less agreeable, as it relates to the difficulties in creating a truly binding legal instrument, following the highly unsatisfactory adoption of the Moon Agreement (1979) which was not signed by the major space powers. These difficulties stem from the type of competition that is inherent to the space sector. The five treaties mentioned above were signed in a period of the Cold War that was favorable to negotiations. Space activities had to be regulated so that neither bloc could gain an advantage over the other. With this goal having already been achieved, negotiating a new instrument or revising existing ones now seems impossible. The Moon Agreement's current status and the ongoing questions regarding its legal effectiveness further confirm this observation.⁷ Moreover, the normative vacuum in

4. U.S. Space Force, *Space Warfighting: A Framework for Planners*, April 2025.

5. *Ibidem*, p. 9.

6. *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Outer Space Treaty)*, London, Moscow, Washington, 27 January 1967, entered into force 10 October 1967, United Nations Treaty Series, Vol. 610, p. 205; *Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (Rescue Agreement)*, London, Moscow, Washington, 22 April 1968, entered into force on 3 December 1968, United Nations Treaty Series, Vol. 672, p. 119; *Convention on International Liability for Damage Caused by Space Objects (Liability Convention)*, London, Moscow, Washington, 29 March 1972, entered into force 1 September 1972, United Nations Treaty Series, Vol. 961, p. 187; *Convention on Registration of Objects Launched into Outer Space (Registration Convention)*, New York, 12 November 1974, entered into force on 15 September 1976, United Nations Treaty Series, Vol. 1023, p. 15; *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (Moon Agreement)*, New York, 18 December 1979, entered into force 11 July 1984, United Nations Treaty Series, Vol. 1363, p. 3.

7. On this topic, confert: S. Hobe, *Space Law, 2nd edition*, Baden-Baden, Nomos, 2023, p. 221; F. Lyall, P. B. Larsen, *Space Law: A Treatise, 3rd edition*, London, Routledge, 2024, p. 175.

which we stand is a common phenomenon in space law: no binding multilateral instrument has been adopted since 1979, regardless of the subject matter.

Legal Challenges for Space and Hesitations Regarding Legal Constraints

The challenges faced in adopting legal instruments in space law – particularly binding ones – highlights the existence of certain obstacles. These obstacles became evident from the very onset of negotiations on potential binding instruments. The PAROS initiative – Prevention of an Arms Race in Outer Space – promoted by the Conference on Disarmament has been on the agenda since 1982, yet has seen no progress since 1993. The same can be said of the Sino-Russian proposal for a Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects.⁸ Neither the initial draft version submitted in 2008 nor the amended version proposed in 2014 was received favorably, particularly by the United States.⁹ Although the U.S.’ opposition is officially based on the imprecise nature of certain elements,¹⁰ the possibility that the White House rejected the treaty by mere principle cannot be entirely ruled out.

While legal instruments have indeed benefited certain fields, two observations must nevertheless be made. First of all, there is a general distinction between binding instruments (“hard law”) and non-binding instruments (“soft law”). The former allow for legal sanctions in the event of a violation, while the latter do not; indeed, an instrument’s legally binding nature is the prerequisite for sanctions to be applied. However, the legal instruments governing space activities fall under soft law, which make them easier for states to accept, given that parties who do not apply the commitments they include cannot be sanctioned.

The second observation, however, concerns the topics addressed in law. The non-binding nature of space-related guidelines is not the only factor underlying their adoption: the topics being regulated also explain – at least in part – why negotiations have proved successful. So far, guidelines have been adopted on the mitigation of space debris and the long-term sustainability of space operations.¹¹ The same cannot be said for the issues of military space activities or space-based military activities.¹² Any regulation on these subjects is rejected, particularly by the United States. This stance obviously stems from essential security concerns. The fact that activities on Earth depend heavily on space capabilities is well established. Military activities are no exception; the latter’s depend-

8. Also known as the “PPWT”.

9. *Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects*, 2008; *Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects*, 2014.

10. M. Listner, R. Rajagopalan, “[The 2014 PPWT: A new draft but with the same and different problems](#)”, *The Space Review*, 11 August 2014.

11. UN, COPUOS, *Guidelines of the Committee on the Peaceful Uses of Outer Space for the Long-Term Sustainability of Space Activities*, ST/SPACE/79, 2021; UN, COPUOS, *Guidelines on Space Debris Mitigation of the Committee on the Peaceful Uses of Outer Space*, ST/SPACE/49, 2010; *Inter-Agency Space Debris Coordination Committee, IADC Space Debris Mitigation Guidelines*, Revision 3, June 2021.

12. While the two expressions may seem relatively similar, the first emphasizes the space-related nature of activities that may subsequently be used for military purposes, whereas the second emphasizes the military nature of activities that may subsequently be used in space or for space-related purposes.

ence is perhaps even greater than that of purely civilian activities. The dual nature of space assets, which are both civilian and military, only adds to this dependence. Moreover, the difficulties in negotiating military issues can also be explained by the national space strategies mentioned above.

At this stage, it is important for us to make a distinction between passive and active ways of using outer space for military purposes. The latter is generally referred to as weaponization. Passive militarization, on the other hand, refers to the use of space assets to support military activities on Earth. A typical example is the use of satellite positioning data to determine the precise location of a unit, or to significantly improve the way a missile is guided toward a specific target. These uses of space assets are tolerated and not questioned, be it from a strategic, political or legal standpoint.¹³

On the other hand, the idea of weaponizing outer space remains more controversial across all fields of thought. Although the concept of outer space as a military battlefield in its own right is gradually gaining ground – particularly in the upper echelons of the U.S. administration¹⁴ – the consequences of this approach would prove extremely harmful, given the potential impact on the way space systems function. Thus, developing arms control measures appears to be a relevant and beneficial solution for all, even if its practical implementation may seem challenging.

Toward Taking Political Opposition Into Account to Create a Relevant Legal Framework

As things stand, it seems impossible to create an arms control treaty covering weapons intended for use in space, or capable of causing damage to assets in orbit. Such a treaty would, by its very nature, be binding. What's more, the lack of space-related regulations since the early 1980s leaves little room for optimism in this regard. Furthermore, previous experiences, particularly with bilateral agreements between the two blocs during the Cold War, have led to mixed results. The U.S.' withdrawal from the Anti-Ballistic Missile (ABM) Treaty in 2002 and Russia's suspension of the New START Treaty – the very existence of which now seems to be in serious jeopardy – give little cause for optimism once again.¹⁵

13. On this topic, confer the author's thesis: H. Peter, "L'encadrement juridique de l'arsenalisation de l'espace extra-atmosphérique : enjeux juridiques et institutionnels," Public Law Thesis, supervised by P.-F. Laval, Jean Moulin – Lyon III University, 2024.

14. P. L. Hays, "Military Space Cooperation: Opportunities and Challenges," pp. 32-43; in J. C. Moltz (dir.), *Future Security in Space: Commercial, Military, and Arms Control Trade-Offs*, Monterey, Center for Nonproliferation Studies, 2002, pp. 32-43.

15. Regarding the ABM treaty, confer: G. W. Bush, "[Remarks Announcing the United States Withdrawal From the Anti-Ballistic Missile Treaty](#)," *The American Presidency Project*, 13 December 2001; "[ABM Treaty Fact Sheet: Statement by the Press Secretary, Announcement of Withdrawal from the ABM Treaty](#)," official website of the White House, 13 December 2001; "[Text of Diplomatic Notes Sent to Russia, Belarus, Kazakhstan and Ukraine](#)," official website of the U.S. State Department, 14 December 2001; W. von Kries, "[The demise of the ABM Treaty and the militarization of outer space](#)," *Space Policy*, Vol. 18, No. 3, August 2002, pp. 175-178. Regarding the New START Treaty, confer: "[Presidential Address to Federal Assembly](#)," official website of the Kremlin, 21 February 2023; E.

The current situation is also very different from the one that fostered the adoption of space treaties and bilateral Russian-American agreements on strategic arms control. Multilateralism is no longer in vogue and the law itself may even be facing often-feared state opposition. In space, states no longer seem willing to be constrained by legal rules. Space competition and mistrust between the main stakeholders (i.e. the United States, China and Russia) mean that we need to rethink ways of reducing tensions and, thereby, of increasing space security.

However, while the wall of state opposition against a legal instrument to regulate the weaponization of space currently stands too tall, there is no guarantee that it will remain so. States essentially fear that their ability to act will be overly restricted, yet the law offers other possibilities that could better satisfy them. While results and guarantees in this regard may initially prove fragile, the effects could nevertheless turn out to be satisfactory in the long run.

The competition that currently governs the space sector results from a twofold fear: each power fears being overtaken and, ultimately, losing. The more there is to lose, the greater the fear. The more a state depends on space activities, the more it fears that its security could easily be compromised. Current state strategies – particularly those of the United States – aim to increase military capabilities, be they offensive or defensive. However, the resulting security dilemma inevitably highlights the weakness and limitations of this strategy. Of course, the deterrent aspects of such a strategy cannot be overlooked, but the risks involved seem very high, while the guarantees of its success remain very low. At a time of heightened space competition, states would be well advised to rethink their national strategies by placing greater emphasis on confidence-building and reciprocity measures.

Such choices would not be synonymous with failure; on the contrary, they would demonstrate an ability to adapt while working to increase space security. While trust does not exclude control, it could nevertheless become an essential part of the space security framework through weapons control.

Maitre, B. Tertrais, "[Le Traité New Start : bilan et perspectives](#)," *Note*, No. 59/20, Foundation for Strategic Research, 28 August 2020, pp. 1-11; A. Woolf, "[The New START Treaty: Central Limits and Key Provisions](#)," *Congressional Research Service*, February 2022; E. Maitre, "[Suspension du Traité New Start](#)," *Observatoire de la Dissuasion*, No. 107, Foundation for Strategic Research, March 2023, pp. 8-11; L. Flatoff, D. G. Kimball, "[Russia Rejects New Nuclear Arms Talks](#)," *Arms Control Today*, Vol. 54, March 2024, pp. 37-38.

Transparency and Confidence: Essential Elements of a Legal Framework for Space-Based Military Activities

Transparency and confidence-building measures count among the useful instruments available to lawmakers.¹⁶ Although their nature is difficult to define from a legal standpoint, they are generally considered to be the non-binding (soft law) equivalent of verification measures.¹⁷

The failure of arms control instruments stems from the fact that verification measures can sometimes be viewed as overly intrusive. Furthermore, the binding nature of legal instruments also constitutes a hindrance. This is where transparency and confidence-building measures – much like other soft law instruments – offer an advantage: they do not bind signatory states. Furthermore, transparency and confidence-building measures can promote gradual change in state behavior. When properly used and respected, transparency and confidence-building measures can also produce two short-term effects that complement and reinforce each other: increased transparency and increased confidence. This virtuous circle could potentially yield positive effects on existing law. In the right conditions, this type of measure could even promote the emergence of a binding legal framework, either through a binding agreement or through a custom being formed. The latter would result from legal practice, *opinio juris* and the successful use of transparency and confidence-building measures, thereby ensuring the peaceful use and long-term sustainability of outer space.

Transparency, Confidence and Control: A Three-Part Approach to Space Security?

Ultimately, while the pursuit of an arms control instrument appears to be largely compromised at present, certain initiatives could well lead to a satisfactory level of space security. Transparency and confidence-building measures could help to ease current tensions between states. It is clear that competition in space is currently exacerbated by mistrust between major players. Thus, the pursuit of a binding legal instrument to curb the risks of an arms race in space is likely to be a long-term endeavor – one that will require certain preliminary steps. Lawmakers have a range of

16. On this topic and for an overview of these measures regarding space, one can refer to the table compiled by Jana Robinson, which summarizes the various transparency and confidence-building measures that exist in space law: J. Robinson, “[The Role of Transparency and Confidence-Building Measures in Advancing Space Security](#),” *Report*, No. 28, European Space Policy Institute (ESPI), September 2010, pp. 41-49. For example, in space law, transparency measures include the transfer or sharing of information, particularly in the context of space surveillance. Additionally, one can refer to the measures aimed at preventing the re-entry of space objects into the atmosphere. Also confer: P. Martinez, R. Crowther, S. Marchisio and G. Brachet, “[Criteria for developing and testing Transparency and Confidence-Building Measures \(TCBMs\) for outer space activities](#),” *Space Policy*, Vol. 30, No. 2, May 2014, pp. 91-97.

17. These are generally considered to be binding. On this topic, confer: C. M. Chinkin, “[The Challenge of Soft Law: Development and Change in International Law](#),” *International and Comparative Law Quarterly*, Vol. 39, October 1989, pp. 850-866; J. D’Aspremont, “[Softness in International Law: A Self-Serving Quest for New Legal Materials](#),” *The European Journal of International Law*, Vol. 19, No. 5, 2008, pp. 1081-1087; J. Cazala, “[Le Soft Law international entre inspiration et aspiration](#),” *Revue interdisciplinaire d’études juridiques*, Vol. 66, No. 1, 2011, pp. 41-85.

measures at their disposal in order to achieve the singular goal of restoring peaceful relations between these players. In this regard, demonstrations of force – or any moves to this effect – seem particularly counterproductive and contribute toward increasing the threat, rather than toward dispelling it.

The work carried out by the United Nations Open-ended Working Group¹⁸ to develop standards for responsible behavior counts among the legal levers that are currently available. This type of non-binding instrument can highlight good practices that could be adopted within national space policies and military space strategies.

Let us remember that state sovereignty plays a fundamental role in international public law – and perhaps even more so in space law. The legal measures being explored must be designed to allay perceived external threats. Standards of responsible behavior, as well as transparency and confidence-building measures, must assure the different states that they are operating in an environment that is conducive to peace and security. Lawmakers must therefore proceed with caution in order to strike a balance between two major imperatives. The first is to ensure strategic and space security for these states. The second is to ensure that the legal instruments being developed – which are generally non-binding – remain attractive, even if it means that the guarantees they offer in the event of a violation remain weak.

While trust does not exclude control, it seems that neither is being ensured as things stand. Moreover, control must be viewed as a global and, ultimately, multilateral guarantee. It must not be understood as an advantage for one party over others, at the risk of turning control into domination – the effects of which are invariably harmful.

18. On this topic, confer: The United Nations General Assembly, [*Reducing space threats through norms, rules and principles of responsible behaviors*](#), Resolution 78/20, U.N. Doc. A/RES/78/20, 4 December 2023; United Nations General Assembly, [*Reducing space threats through norms, rules and principles of responsible behaviors*](#), Resolution 76/231, U.N. Doc. A/RES/76/231, 24 December 2021; United Nations General Assembly, [*Reducing space threats through norms rules and principles of responsible behaviors*](#), Resolution 75/36, U.N. Doc. A/RES/75/36, 16 December 2020. For an overview of all contributions to this topic, confer: The United Nations General Assembly, [*Report of the Secretary-General on reducing space threats through norms, rules and principles of responsible behaviors*](#).

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Star Wars: The Warfare Depictions of a Popular Saga

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The Star Wars film saga, released in three parts between 1977 and 2019,¹ remains one of the most popular in the world in cinematic history. In the wake of the initial films, an entire segment of popular culture has developed. This movement is sustained by significant sales of merchandise revolving around the universe conceived by director George Lucas. A figure of the New Hollywood wave and a protégé of Francis Ford Coppola, Lucas set Star Wars in the highly famous “a long time ago in a galaxy far, far away.”² This was intended to signal the total otherness of his universe in relation to our reality.

Star Wars³ is therefore a work of science fiction,⁴ insofar as futuristic technologies are staged. However, it also draws heavily upon fantasy. More generally, these films have the distinction of evoking a wide range of cinematic references. Thus, the first trilogy borrows from Westerns, Japanese sword films, and certain war classics of the 1950s. The second trilogy, for its part, draws its references from the peplum

1. The first series of films was released between 1977 and 1983 (commonly referred to as the “Original Trilogy”), the second between 1999 and 2005 (referred to as the “Prequel Trilogy”) and the third between 2015 and 2019 (designated by another neologism: the “Sequel Trilogy”).

2. Each of the nine films in the three main trilogies opens with this famous title card in blue writing on a black starry background.

3. In this article, we will use the original title rather than the French translation: “Star Wars.”

4. There is a debate as to whether Star Wars is a work of science fiction or “fantasy.”

genre⁵ and Hong Kong martial arts films, among others. All these diverse references primarily aim to provide the audience with points of reference to make the otherness of the universe more easily comprehensible.

This imaginative piece rapidly spread beyond its original audience to gain a broader following. One particular event illustrates this crossing of boundaries. On 23 March 1983, U.S. President Ronald Reagan announced the Strategic Defense Initiative (SDI). This project aimed to establish an anti-missile shield intended to protect U.S. territory from a potential ballistic attack. The project was nicknamed “Star Wars” by the U.S. press.⁶ The term was adopted by political opponents and swiftly entered common parlance. This case is undoubtedly one of the most famous examples of repertoires drawn from popular culture entering strategic language. They do so not because of their technical characteristics, but because they evoke references to which the majority can relate and because they represent an idea. In this instance, the “futuristic” aspect of the project reflects the science-fictional nature of the films.⁷

There exists, therefore, a permanent dialogue between popular culture and strategic culture. Although difficult to measure, its effects likely remain minimal on the conduct of strategic debate, at least among specialists. Conversely, analyzing these films sheds light on the underlying collective depictions. Generally, a warfare film provides less information on the practice of warfare than a certain vision representing the public’s perception at a given moment. Similarly, a historical film sheds much more light on the era in which it was produced than on the one it narrates in its diegesis – that is, the universe intrinsic to the film.⁸ Since the Star Wars films all depict – at least as a backdrop – an armed conflict between two factions, they are therefore replete with references to contemporary armed conflicts, both in the script and narration and in the various directorial choices.

The universe of the Star Wars franchise is vast and encompasses films, television shows, video games, novels, comic books, etc.⁹ To limit the scope of analysis while remaining as accessible as possible, this article focuses solely on the films released at the time of writing. These include the nine films of the three trilogies as well as the two so-called ‘spin-off’ films. While incursions into television shows will be restricted, no consideration will be given to the various novels, video games, or comic

5. The peplum genre refers to a cinematic or literary genre that features historical or mythological stories, often set in Antiquity, with epic plots and heroic characters.

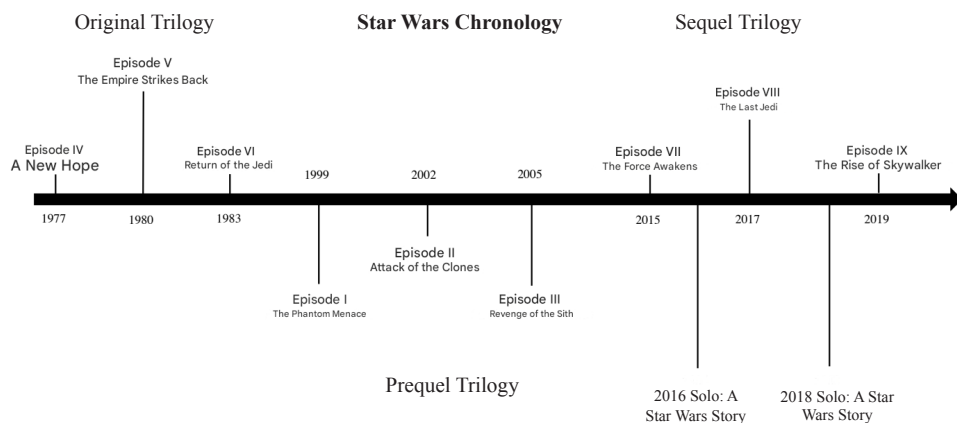
6. The term was reportedly used by a Washington Post article dated 23 March 1983, quoting Senator Edward Moore Kennedy describing the project as “misleading Red-scare tactics and reckless Star Wars schemes;” in L. Cannon, “[President Seeks Futuristic Defense Against Missiles](#),” *The Washington Post*, 23 March 1983.

7. Similarly, the expression “Terminator syndrome” has also been used many times to describe the rise of robotic combat and the various fears associated with artificial intelligence. Even today, it is not uncommon to find articles on this topic illustrated with images from James Cameron’s Terminator films.

8. For example, the film Kelly’s Heroes takes place during World War II but features a decidedly “hippie” tank crew. This is a completely anachronistic depiction in 1944, but perfectly in keeping with the year of the film’s production (1970).

9. All these elements together form what is commonly called a “canon,” or “lore” (a contraction of the term “folklore”).

books. To facilitate readability and comprehension, the structure follows the release dates of the films. The first part is thus dedicated to the original trilogy (1977-1983). The second concerns the films of the “Prequel Trilogy” (1999-2005). Finally, the third part addresses those of the “Disney era” (since 2015).¹⁰



The first film trilogy was produced between 1977 and 1983, in a United States still profoundly marked by the Vietnam War. During this period, references to that conflict were almost omnipresent in the country’s popular culture. Cinema, in particular, seized upon it extensively. This was further reinforced by the fact that, since the late 1960s, Hollywood had been undergoing profound changes. The expectations of the U.S. public, weary of classical Westerns and grand biblical epics, turned towards more experimental projects featuring more intimate stories and characters. The major studios, facing financial difficulties, diversified their economic activities. Simultaneously, new actors took their places on boards of directors. Finally, the great directors and iconic actors of the Golden Age of the 1930s and 1940s began to retire, making way for a new generation. In the wake of the French and Italian New Waves, the term “New Hollywood” was coined.

George Lucas is arguably among the most emblematic directors of this generation, alongside other figures such as Martin Scorsese, Brian De Palma, and, naturally, Francis Ford Coppola. Following an initial foray into science fiction with the experimental film THX 1138, and after having been designated for a time by Francis Ford Coppola to direct *Apocalypse Now*, George Lucas embarked on the project of a mainstream science fiction film. The project was risky, as the genre was no longer very popular in cinema. Nevertheless, after a long and chaotic production,¹¹ the film was finally released in the United States on 25 May 1977.¹² It was met with immense

10. In October 2012, the Walt Disney Company acquired Lucasfilm, the production company behind the Star Wars films, which owns the rights to the entire franchise and its related merchandise. The acquisition price was estimated at four billion dollars.

11. Numerous books and articles recount the difficult journey of making the first Star Wars film. However, we recommend Jonathan Rinzler’s comprehensive and informative book, *Star Wars, le making of* (Bordeaux, Akileos Éditions, 2014).

12. The film was released in September of the same year in France, under the name “La guerre des étoiles”

success, becoming the most profitable film in history. This success motivated George Lucas to launch two sequel projects: *The Empire Strikes Back* (1980) and *Return of the Jedi* (1983).

The films recount the story of Luke Skywalker, a young farmer living on a remote and desert planet in the Galaxy (which is never named), who aspires to become a pilot. He rapidly experiences a series of encounters that lead him, on the one hand, to join the Rebellion – an abstract political force fighting an uneven battle against the Empire, an authoritarian political organization that has controlled the Galaxy since “the Clone Wars”¹³ – and, on the other, to become a “Jedi Knight” – a type of warrior monk fighting with a “lightsaber” and utilizing “the Force,” an invisible and mystical energy whose characteristics shift according to the requirements of the script.

The narrative is therefore both a personal and collective coming-of-age tale drawing upon multiple references. However, the focus here is on the backdrop: the war between the Rebellion and the Empire. Although George Lucas stated that, in his opinion, the Empire is an allegory for the United States under Richard Nixon and that the Rebellion is inspired by the Vietnamese guerrilla movement, this plot actually rests upon a nebula of references. For instance, it is difficult not to perceive a parallel with the Second World War. Above all, it offers a series of depictions of armed conflicts.

The power dynamic between the Rebellion and the Empire is immediately presented as asymmetric, or at least highly dissymmetric (see the opening scene, where a small Rebel ship is pursued by a massive Imperial cruiser). The ultimate embodiment of this imbalance rapidly takes the form of the “Death Star,” a battle station the size of a moon capable of annihilating entire planets, to which shall be discussed later. Nevertheless, the Rebellion is not, strictly speaking, a clandestine organization. It also possesses substantial capabilities, including relatively large and well-equipped operational bases and, most notably, a complete combat fleet with logistics and command vessels. It also possesses fighter-bombers¹⁴ whose performance is presumably superior to those of the Empire, even if their numbers are fewer. Furthermore, its operational modes are closer to those of special forces than to the typical actions of an armed insurgency, which include acts of sabotage or targeted assassinations of high-ranking military officials. Its methods involve very targeted raids, sometimes combined and aimed at achieving maximum strategic effects.

Thus, the assault against the Death Star at the end of the first film resembles a strategic raid. Following an analysis of the intelligence obtained, the rebels deduce that the station is designed to repel a large-scale attack but is poorly equipped to handle the lower layers of its anti-aircraft – or rather anti-space – defenses, though no distinction is made in the staging. Consequently, they decide upon a corre-

(War of the Stars). The plurals were reversed in the translation, probably for reasons of sound in the title.

13. The 1977 French translation refers to it as the “black war” (*La guerre noire*).

14. Among the most famous are the X-Wing, whose design is inspired by a dragster, and the Y-Wing, which is inspired by the *Grumman TBF Avenger* torpedo bomber.

sponding mode of action. The battle is, moreover, highly inspired by Second World War films, particularly *The Dam Busters*, which recounts the 1943 raid against German dams.¹⁵

The operation conducted at the end of Episode VI, *Return of the Jedi* (the third film released chronologically), is also a special forces raid. It mobilizes a small group¹⁶ tasked with sabotaging an installation on a planet to deactivate the defenses of a second Death Star. This segment depicts a combined operation, as the spectator's perspective alternates between a terrestrial battle and a space battle, the outcome of which depends on the former. The terrestrial battle, in which the Rebellion enlists the reinforcements of an auxiliary indigenous force, reconnects with the Vietnam reference invoked by George Lucas in the first film (it takes place within a forest).

The space battle is, for its part, very similar to a naval-air battle of the Second World War. Two fleets face each other and clash primarily with their respective fighters in a near-symmetrical power balance. This symmetry was already present at the beginning of the second film, when the hidden rebel base on an ice planet is attacked by Imperial troops in a futuristic iteration of Fort Alamo. The rebel troops are barricaded there and must slow the adversary's advance while they evacuate their forces. The Empire attacks with machines that have become iconic to the franchise: gigantic armored units moving in a straight line on four large legs, with a design that seems to be at the confluence of German Panzers from the Second World War and Hannibal's elephants. It is surprising, moreover, that the Empire possesses no anti-aircraft defense during its assault, whereas the third dimension is the rebels' strong point...

Above all, Episode V, *The Empire Strikes Back*, provides an opportunity to examine the organization of the antagonists more closely. Originally conceived as an allegory for Richard Nixon's United States, its general imagery will surely evoke Nazi Germany for most viewers. This imagery is clearly transcribed through the field-grey uniforms associated with black leather boots, as well as in the design of certain machines, particularly the armored units mentioned above. This is especially apparent in the highly hierarchical organization, coupled with the fact that the Empire appears primarily as a strongly militarized and ideologically driven regime.

However, on this last point, the films ultimately say very little. They do not inform the audience of the political goals of this system, but focus much more on the means employed to achieve them. Thus, in the first film, one learns that the Empire has just completed the Death Star, a "supreme weapon" capable of annihilating entire planets with a single blast. The objective is clearly stated by the station's commander: "To instill fear in the rebels." The deterrent nature of the "space station" is evident, as is the desire to govern through fear which, in Imperial political doctrine, seems to be both a means and an end in itself.

15. The staging in both films is very similar: the raid follows a "corridor" (a river in *Dam Busters*, a trench in *A New Hope*) and consists of several passes over the target. Likewise, the targeting systems on the British bombers and the rebel ships are similar.

16. Strangely composed of some of the highest-ranking members of the Rebellion...

This brutal method is also found in the exercise of command. Darth Vader, the primary antagonist of this first trilogy, regularly executes his subordinates at their slightest error. This management, based on remote strangulation, appears to inhibit the initiative of his subordinates very strongly. They show very little creativity, if not outright clumsiness and incompetence. To such an extent that, later in the second film and after the battle on the ice planet,¹⁷ Darth Vader is obliged to resort to mercenaries who prove to be far more effective.

Finally, the third film, *The Return of the Jedi*, depicts two special operations. The first is intended to liberate Han Solo on Tatooine – the same desert planet where the first film began – where he is being held by a warlord.¹⁸ The second operation seeks to destroy the shield generator protecting the second Death Star. This latter operation, somewhat curiously led by the primary leadership of the Rebellion, necessitates establishing contact with an underdeveloped indigenous population.¹⁹ The sabotage mission is thwarted, as the Empire has detected and anticipated the rebel manoeuvre. A pitched battle ensues within the forest between Imperial troops and the small rebel contingent, which is supported by the Ewoks. Although the latter are under-equipped, their familiarity with the terrain serves a probable intent to reconnect with the Vietnamese reference.²⁰

Concurrently, a space battle takes place around the Death Star, pitting the rebel fleet against that of the Empire. The latter resembles, almost feature for feature, a naval-air battle from the Pacific War. This is characterized by the main ships being positioned at relative distances from one another, while fighters engage in aerial combat. Once again, the film concludes with the destruction of the ultimate Imperial weapon and the end of the conflict between the Empire and the Rebellion. This reflects a resurgence of the belief in the “decisive battle,” wherein military victory inherently brings about a political resolution to the conflict.

Although this initial trilogy references the Vietnam War in its premise, the depictions it invokes relate more closely to the Second World War and its aerial, naval, and terrestrial battles. The depictions remain relatively conventional, featuring more or less symmetrical armies. Furthermore, the function of the equipment they employ remains easily identifiable by the audience. Space is not truly treated as a distinct strategic domain in its own right. There are no truly specific stakes attached to it. Despite these films being somewhat associated with Reagan’s famous “Star Wars” project, nothing in this trilogy closely or remotely resembles the principles of the SDI.

17. Named Hoth. In contrast to the planet from the first film, Tatooine, which was entirely desert. This is a regular trope in space opera science fiction universes, where planets often feature a single biome.

18. Which is based on a somewhat strange plan consisting of infiltrating the palace in successive stages...

19. We will learn their name later, the Ewoks, when they are at the center of the plot of two TV movies: *Caravan of Courage: An Ewok Adventure* (1984) and *Ewoks: The Battle for Endor* (1985).

20. The battle also sparked numerous humorous and sarcastic comments, as we see “teddy bear” Ewoks triumphing over the “best troops” of the Empire (according to the Emperor)...

The Second Trilogy: A Civil War

The second trilogy of Star Wars films was released between 1999 and 2005. Unlike the first, it was entirely directed and written by George Lucas. Commonly referred to as the “Prequel Trilogy,” it serves as a prequel to the first three films, with the plot beginning approximately thirty years before *A New Hope*.²¹ It recounts the unfolding of a civil war that erupts within the Galaxy, which is then governed by the Republic, pitting the latter against “Separatists.” The Empire is born at the conclusion of this conflict. In parallel, the films follow the youth, Anakin Skywalker, a child slave who joins the Jedi Order and is the future father of Luke Skywalker. One notes that the first film, *The Phantom Menace*, induces a time skip of about ten years before the two subsequent films: *Attack of the Clones* and *Revenge of the Sith*.

In the script of the first film, the civil war is still in its infancy. The focus is primarily on a conflict involving the planet Naboo, which is subjected to a blockade and subsequently a military occupation by the “Trade Federation.” The trigger for this appears to be tariffs. From this starting point, it may be considered that George Lucas draws partial inspiration from U.S. history. The U.S. Civil War also took root, in part, in disputes over tariffs between the North and the South. Following sequences on Naboo and Tatooine (once again), the action shifts briefly to Coruscant, the capital of the Republic, thus allowing for a deeper understanding of its workings. A regime in decline is glimpsed, hampered by a cumbersome bureaucracy, where the primary military institution – the Jedi Order, discussed below – is losing its prestige and influence.

In several respects, this Republic can be paralleled with the nineteenth-century United States. This is clear, on the one hand, in its highly parliamentary system marked by the predominance of the Senate over the executive, and on the other, in the fact that it does not possess a standing army, mirroring the provisions of Article 1 of the U.S. Constitution. However, this source of inspiration is not unique. References to the Weimar Republic, the First French Republic, the Roman Republic, and even the United Nations can also be identified.

Furthermore, this first film possesses many attributes of the peplum genre. The “pod race” is a revisited chariot race, and plot elements revolve around slavery. Above all, the theme of the “Chosen One” and the story of Anakin relate quite explicitly to Jesus Christ and, consequently, to biblical films. These references are also found in certain battle scenes, particularly those occurring at the end of the film. It pits the forces of the Trade Federation, which are exclusively robotic, against a troop from a local population on Naboo. The staging of this pitched battle and its scenic arrangement on a vast, gently rolling plain recall the final battle of Stanley Kubrick’s film *Spartacus* (1960). Similarly, the Federation robots move in close formation, in “squares” and at a slow march, in the image of a Roman legion.

21. *A New Hope* is the subtitle of the first film released in 1977. Initially, it was simply titled “Star Wars,” but during a re-release in 1981, the famous opening credits included the mention “Episode IV” as well as the subtitle “A New Hope” in anticipation of the release of the future trilogy, which was still largely hypothetical at the time.

The remainder of the battle, however, presents less interest, as the action is centered on a single character and his blunders.²² Simultaneously, a battle in space takes place, very similar to that of the first film, yet also centered on the character of Anakin, then still a child. The atmosphere and staging are therefore very “light” and playful. This peplum inspiration nevertheless ceased with this film, apart from a “circus games” sequence at the end of Episode II.

The two following films depict the famous “Clone Wars,” a founding event in the Star Wars universe that was already briefly mentioned as early as the first film in 1977.²³ This war thus pits the Republic against so-called “Separatist” forces, among which the Trade Federation from the first film of the Prequel Trilogy is found. While the Separatists can rely on the robotic army provided by the Federation, the Republic, as has been observed, lacks a standing army.

Questions of “national security” appear to be managed there by a semi-religious, semi-combatant organization: the Jedi Order. Composed of mystical warrior monks formed and trained from a very young age (they are separated from their families for this purpose), this community is also responsible for the command of troops in the event of war. In Episode I, it can be seen that the Jedi also perform diplomatic functions. Although controlled by the Senate, the power of this organization is therefore significant, as it constitutes, in a sense, the *ultima ratio* of the Republic.

In Episode II, a well-known Jedi, Obi-Wan Kenobi, is observed investigating a bounty hunter. His investigation leads him to a planet where an army of clones (created from the bounty hunter’s DNA) is being “constructed,” complete with all their equipment, including warships, armored vehicles, artillery, and more. In summary, this represents a complete army, ready for use and immediately available. This army was allegedly “commissioned” a decade earlier by a Jedi, without the latter informing his superiors.²⁴ At the end of the film, this army proves instrumental for the Republic and the Jedi in launching an assault on one of the primary Separatist bases.

The highly spectacular scene draws inspiration from films such as *Apocalypse Now* (1979) and its famous helicopter sequence. It also references shows like *Band of Brothers* (2001), specifically the depiction of the airborne operation in Normandy. Reference can also be made to the film *Braveheart* (1995) and its final battle, which depicts two armies charging directly at one another. This model is extensively replicated in Episode III, *Revenge of the Sith*, where most of the battle sequences unfold in this manner.

22. The character, Jar Jar Binks, was the first fully digital character in film history to be inserted into a movie. He was generally poorly received by the public, mainly due to his very childish character portrayal...

23. During a dialogue between Luke Skywalker and Obi-Wan Kenobi at the beginning of the film. The French translation, however, refers to it as a “dark war.”

24. In the film, this plot point remains particularly obscure. In later works, the audience learns that this Jedi was in fact one of the major antagonists of the saga, using a false identity.

The third film describes the end of the Clone Wars, the fall of the Republic, and the advent of the Empire.²⁵ It opens with a space battle in orbit above the capital planet between the Republican army and Separatist forces that have succeeded in kidnapping the Chancellor. This battle also largely resembles a naval-air clash, featuring references to the modern era. Consequently, the primary combat vessels of the belligerent fleets feature armament on their gun ports and engage in close combat.

The remainder of the film focuses on the conspiracy orchestrated by Chancellor Palpatine, who arranged his own kidnapping and is revealed to be in control of the Separatists. His objective was to organize this war in order to seize absolute power and claim the title of Emperor, thus establishing the antagonistic regime of the Rebellion in the first trilogy.

This entire sequence references several historical events, such as the end of the Roman Republic or that of Weimar, as well as Napoleon's rise to power in France. Released in 2005, the film also contains a fairly explicit reference to the Iraq War, which the director initially denied. This occurs when the character of Anakin, having become an antagonist, declares, "if you're not with me, then you're my enemy," in reference to the quote by George W. Bush: "Either you are with us, or you are with the terrorists."²⁶ The pivotal moment of the film is manifested in a coup d'état orchestrated by Palpatine. By fabricating a Jedi assassination attempt against himself, he organises the retaliatory murder of the majority of the order (in a sequence reminiscent of the Night of the Long Knives)²⁷. He is subsequently granted absolute powers indefinitely and founds the Empire, thereby concluding the "Prequel Trilogy."

Due to its "saga" quality, this second trilogy mobilizes cinematic references imbued with classicism. Logically, its warfare depictions align with those of peplums and other historical films. Following the image of battles in Homeric epics, heroes are seen clashing above a troop reduced to a relatively formless mass whose actions exert almost no influence. The spatial dimension is even less represented here than in the first trilogy. It serves as little more than a transitional area between different worlds and narrative stages.

The Final Trilogy: Self-Citations and Repetitions

The final film trilogy, occasionally referred to as the "Sequel Trilogy," was released in theaters between 2015 and 2019. Its production framework differed sig-

25. The gap between the second and third parts, which recounts the entire course of the war, was filled in by two animated series: the first, produced in 2003, consists of three seasons totaling 25 episodes of approximately five minutes each. The second, in 3D animation, was produced starting in 2008 and comprises seven seasons. These will not be discussed in this article.

26. "[Address to a Joint Session of Congress and the American People](#)," The White House, President George W. Bush, 20 September 2001.

27. The Night of the Long Knives (June 29-30, 1934) refers to the political assassinations ordered by Adolf Hitler against members of the SA (Storm Troopers), the paramilitary organization of the Nazi party. This operation allowed him to eliminate his main opponents and consolidate his control over the party and Germany.

nificantly from that of previous trilogies. Indeed, while the first two were almost exclusive productions of Lucasfilm – effectively making them independent films – the final trilogy was produced following the acquisition of George Lucas’s company by The Walt Disney Company in 2012. Furthermore, the period between 2015 and 2019 witnessed the release of not merely three films, but five. In addition to the Trilogy, two further “spin-off” films (which do not follow the primary chronological storyline) were also released.

The story of this new trilogy unfolds approximately thirty years after the conclusion of Episode VI, *Return of the Jedi*, which was the third film in the order of release. Following the fall of the Empire, a new republican regime was established. However, this regime remained fragile. This was notably due to the fact that the Empire had not entirely vanished but had reformed under the name of the First Order, which became a particularly menacing organization. The heroes of the first trilogy had dispersed, and only Princess Leia, having attained the rank of General, remained within the new regime.

The story focuses on Rey, an orphan abandoned on a remote planet, who survives as a scavenger. She swiftly encounters Finn, a First Order “stormtrooper” who has deserted. The two protagonists find themselves pursued when Rey acquires a robot in possession of a valuable map. Episode VII, titled *The Force Awakens*, adopts many aspects of the script from the first film, a choice for which it was heavily criticized by both critics and the public. Consequently, this episode offers relatively little material for analysis. The exception is a commentary on the peculiar military organization adopted by the new Republic. Lacking an official army, it relies on a parallel organization named the “Resistance,” which combats the First Order more or less on its behalf. Its operational modes, however, remain essentially similar to those of the Rebellion. These consist of a combination of “special operations” and aerial raids – here, once again, directed against a super-powered space station. Similarly, the First Order borrows heavily from the Empire of the initial films, and even somewhat reinforces its fascistic aesthetic. Furthermore, both sides utilize a significant portion of the equipment and hardware employed by their predecessors.

The second film, titled *The Last Jedi*, contains slightly more elements for analysis, although it too follows much of the structure of the film *The Empire Strikes Back*. Much like the acclaimed Episode V, this Episode VIII opens with the Resistance base under attack by the First Order. Rapidly overwhelmed, the Resistance fighters are compelled to flee. During their retreat, they attempt a daring move. They seek to exploit a gap in the Order’s defenses to destroy one of their most valuable units, a “Dreadnought” class cruiser.²⁸ To this end, Poe – a veteran pilot and one of the primary leaders of the Resistance – chooses to engage the bombers after successfully neutralizing the cruiser’s defense system. However, despite possessing a substantial strike force, the bombers are vulnerable. The Order’s fighters eventually

28. A name that refers to the British destroyer class, the Dreadnoughts, produced from the early 20th century and which served as a model for the design of modern battleships.

decimate them. Although one of them succeeds in destroying the cruiser, this sacrifice is heavily criticized by Leia, who demotes Poe.

This entire sequence, featuring a raid that produces meager military results at the cost of numerous crew lives, appears as a fairly evident reference to the bombings of Nazi Germany conducted by the Eighth Air Force, particularly those targeting the factories at Schweinfurt.²⁹ Certain shots refer quite clearly to archival footage showing Allied bombers riddled by flak, or German fighters crashing in a burst of fire. The remainder of the film, however, offers little interest for analysis from the perspective of warfare depictions. Nevertheless, it can be noted that the narrative arc of the character Poe revolves around the notion of command and leadership, somewhat in the image of Maverick in *Top Gun* (1986), whose challenge is to gain maturity and a sense of responsibility.³⁰ Similarly, one of the film's sequences allows a glimpse of what occurs on the margins of the war. It evokes, in particular, a class of armament tycoons who enrich themselves by supplying both sides.

Finally, the ninth and currently last film, *The Rise of Skywalker*, also presents little interest for this article. Structured as a treasure hunt film, it invokes very few depictions of warfare. It can be noted, however, that the First Order – now termed the “Final Order” following the somewhat curious return of Palpatine – possesses a considerable fleet of cruisers. These are produced under conditions and with resources that are presumably magical. Each is equipped with armament capable of destroying a planet. They thus become the ultimate instrument of the doctrine articulated in the first film.

The period of the “Sequel Trilogy” also saw the release of two films that do not fall within the main chronology but are situated between the first trilogy and the prequels, during the era of the Empire. The second film, *Solo* (2018), which traces a period of the character Han Solo's youth, presents relatively little interest, with the exception of a short scene heavily inspired by the First World War. This depicts a battle from the perspective of the Empire, occurring on a planet against an unidentified enemy, which takes the form of trench warfare. However, the sequence is neither long enough nor sufficiently developed to derive anything more than a simple aesthetic commentary.

In contrast, the preceding film, titled *Rogue One* (2016), is of greater interest. Indeed, it adopts the perspective of a war and espionage film, as it follows the story of the small team that succeeds in stealing the Death Star plans. It is therefore set immediately before the first film of 1977. Its story allows for a better understanding of the Rebellion's inner workings, notably the existence within it of a “radical” faction advocating a more direct struggle against the Empire. Their meeting with the team of heroes occurs during an ambush in the streets of a city with urban planning

29. The bomber model used by the Resistance is also called “Star Fortress,” a direct reference to the B-17 bomber also known as the “Flying Fortress.”

30. Beyond *Top Gun*, the director of this eighth installment, Rian Johnson, extensively cited Henry King's film *Twelve O'Clock High* (1949) as his main source of inspiration (particularly regarding the theme of leadership). Similarly, there is at least one shot directly taken from the silent film *Wings* by William A. Wellman and Harry d'Abbadie d'Arrast (1927).

strongly inspired by the Middle East. This scene refers quite explicitly to the irregular conflicts of the 2000s and 2010s conducted by the United States and their allies, primarily in Afghanistan and Iraq. This is further reinforced later in the plot, where the hideout of the “radicalized” group is shown to be situated in a cave.

The final part of the film is dedicated to the attack on the Imperial base where the aforementioned plans (and with them, the Imperial archives in general) are located. Originally, the mission was initiated by the small team assembled throughout the plot, reinforced by a few hastily recruited members from the Rebellion’s base. This lack of resources is explained by the fact that the Rebellion’s war council failed to reach an agreement to conduct the attack. It is noted here that the Rebellion has not delegated this function to a single military authority. Instead, it maintains a fairly firm political control over its operations, and decisions are reached through deliberation.

The assault therefore takes the form of a special action, aiming to maximize the element of surprise. However, the group is quickly overwhelmed by the Imperial troops guarding the base, who are too numerous and far better equipped. Fortunately, a portion of the rebel fleet, disregarding the orders given by the council, joins them to provide support in a sequence reminiscent of the final confrontation in *Return of the Jedi*. The battle takes place simultaneously in space and on land. This terrestrial segment appears to reference the Second World War through clashes on beaches, and also through the rebels’ attire, which is very similar to that of American GIs. The film could therefore be criticized for becoming somewhat lost in the references it displays. It relates the Rebellion at times to the Allies of the Second World War and at others to the insurgents of the Middle East during the “Global War on Terror.” Alternatively, this latter reference may serve to recall that, originally, the Empire is a caricature of the United States, which has ostensibly become a mafia and fascist state.

Space is slightly more prominent in this final trilogy, particularly in *The Last Jedi*, where an entire portion of the film features a pursuit of spacecraft reminiscent of Peter Weir’s film *Master and Commander* (2003). In practice, however, the spatial environment here is much closer to a maritime setting. This is evident both through the pursuit in Episode VIII and the presence of a “Dreadnought” bombarding a terrestrial base in the same film.

Conclusion

As a work of popular culture with significant echoes, the Star Wars films draw from an extensive range of armed conflicts across all historical periods to provide meaning to their storylines. Nevertheless, it is worth noting that the saga derives its warfare depictions from an essentially Western repertoire.³¹ Indeed, although it has reached a nearly global audience,³² it remains a product primarily intended for European and North American audiences.

31. In purely cinematic terms, the saga drew heavily on Japanese cinema and, to a lesser extent, on Hong Kong martial arts films. The lightsaber combat style, for example, is directly derived from *chanbara*, the Japanese equivalent of the swashbuckler film genre in Europe.

32. It is worth noting, however, that the saga has had a limited impact in India, despite it being a major film-producing country on a global scale. The same is true in mainland China (which also boasts a rich film industry), where it has only been officially released since 2015.

Furthermore, it is necessary to accept the work for what it is: mainstream entertainment that does not aim to shed light on specific military practices. Like any work, it is situated within its era of production – or rather, its “eras” of production. Each expresses characteristic traits of its respective cinematic and political time: reminiscences of the Vietnam War for the first trilogy, echoes of the Global War on Terror for the second, or a global reference to the Second World War. In the U.S. collective imagination and its popular culture, the latter serves as the ultimate embodiment of the conflict between Good and Evil.³³

The treatment of the spatial environment remains distinctive. In practical terms, it is most often merely a transitional space, akin to the sea between two islands. Spatial confrontations, moreover, resemble naval battles more than conflicts occurring in a vacuum without gravity. As in many works of science fiction intended to be accessible to the general public, Space presents the peculiarity of being an environment unified with the classic third dimension. The technologies for access and movement are virtually identical; one transitions from one environment to the other in a completely fluid manner, as though no frontier existed. Depending on the requirements of the storyline, the characteristics of either the aerial or maritime domains are adopted.

Thus, while war is indeed a central entity in the saga and is present in nearly every film, it is not necessarily a central theme insofar as it serves as little more than a backdrop. It is not inevitably a defining element for the evolution of the story or the characters. An exception is noted for Luke Skywalker in the first film, whose participation in a battle is essential to his character development. More broadly, the saga of the three Star Wars trilogies can only be relevant to understanding the depictions of war in Hollywood cinema when considered within a wider corpus of films. This includes not only the science fiction or war genres but also the general history of the industry. Consequently, the first trilogy is understood when placed in perspective with the New Hollywood movement, the second within the context of post-9/11 cinema, and the third within an era of highly calibrated franchised blockbusters.

33. This article does not address the *Andor* series, whose numerous and highly explicit references to war almost warranted a dedicated article.

Human Presence During Spaceflight: Strategic Advantage Versus Biological Vulnerability

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With the new focus on Mars, satellite constellations and the resurgence of empire-building mentalities, space missions are set to become more frequent and longer-duration. Although the presence of astronauts¹ on board spacecraft has often contributed decisively to mission success, space remains a hostile environment, threatening their health and, de facto, their performance. The purpose of this article is to weigh the risks and benefits of crewed spaceflight.

Historical Overview of Crewed Spaceflight

After the fall of the Third Reich, mastery of aerospace technologies became an element of national power at the heart of the growing ideological rivalry between the United States and the USSR.

Consequently, the Soviets and Americans rushed to recruit German scientists who already had extensive experience in this field. For example, engineer Helmut Gröttrup (a contributor to the Soviet space program) was transferred to the East as part of Operation Osoaviakhim. At the same time, Operation Overcast-Paperclip enabled engineer Wernher von Braun (father of the V2 ballistic missiles and the future

1. The term *astronaut* is the most generic term for a space traveler, while *cosmonaut* (Russian), *spationaut* (French), and *taikonaut* (Chinese) reflect the national origin of space programs.

Saturn V rocket) and physician Hubertus Strughold (pioneer of space medicine) to join the ranks of the future NASA. Also at this time, though at a lower level, France welcomed Austrian engineer Eugene Sänger, who founded the International Astronautical Federation in Paris in 1951.

From the earliest days of the Cold War, space thus became a key component of the military and political doctrines of the major powers.²

Following the launch of the first artificial satellite, *Sputnik 1*, in 1957, cosmonaut Yuri Gagarin inaugurated the first manned spaceflight aboard Vostok 1 in 1961. On the American side, the Gemini (1965-1966) and Apollo (1968-1972) programs saw flight durations increase to 14 days in some cases, even as biomedical data at the time began to warn of the harmful effects of prolonged periods in space.³ After NASA's successful Moon landings, the period of détente (1960s-1970s) brought the White House and the Kremlin closer together with the docking of the Apollo and Soyuz spacecraft in orbit in 1975.

Multilateral scientific cooperation intensified, with the result that since 1998, the International Space Station (ISS) has been home to a permanent human presence in low Earth orbit (LEO), with missions following on from or overlapping each other approximately every six months.⁴

Space exploration projects are now focusing on Mars, with the Moon and the Gateway cislunar station as potential intermediate stages (Artemis program).⁵

Paradoxically, these initiatives are taking place against an international backdrop marked as much by scientific cooperation as by rising geostrategic rivalries: commercial exploitation of space resources, mastery of advanced propulsion technologies, development of autonomous systems, and military domination of higher airspace (HA). These economic and strategic issues are now being reconsidered in light of Sino-American competition and new private-sector players such as SpaceX and Blue Origin.

All these indeterminates are transforming space into a polynomial equation, in which the future role of human crews remains to be defined.

Strategic value of human presence in space

Limitations of automated and robotic systems

Autonomous systems are an integral part of the space age. While astronauts were historically selected among fighter pilots, rockets were developed from ballistic mis-

2. X. Pasco, "[La mise en œuvre de la Stratégie spatiale de défense française : vers la maîtrise de l'Espace ?](#)," Note No. 12, Fondation pour la Recherche Stratégique (FRS), 2023.

3. R. W. Bullard, "Physiological problems of space travel," *Annual Review Physiology*, Vol. 34, 1972, pp. 205-234.

4. "[International Space Station: Significant Challenges May Limit Onboard Research](#)," U.S. Government Accountability Office, 2009, p. 39.

5. B. Cohen, "Artemis Program Overview," NASA, 2023.

siles rather than aircraft. In fact, during his maiden flight, Yuri Gagarin did not need to take control of Vostok 1 during any of the phases of takeoff, orbiting, revolution, and atmospheric reentry (he did land using his parachute, but only after ejecting from the capsule).

Similarly, the *Lunik 9* probe was the first spacecraft to land on the Moon in 1966, three years before the astronauts of the Apollo-11 mission. As for the Red Planet, the Soviet *Mars 3* probe landed there in 1971, while the American *Sojourner* rover was already exploring the Martian surface in 1996.

Furthermore, the presence of humans aboard spacecraft requires considerable logistical resources: oxygen, water, food, waste treatment, additional weight and therefore fuel, all of which increase the cost of such missions. These are all arguments in favor of uncrewed missions.

In reality, despite remarkable progress in automation, robotics, and artificial intelligence (AI) applied to the space sector, these systems often require human supervision and still lack the cognitive flexibility needed to handle unforeseen situations in dynamic environments.⁶ Some estimates show that even the best GPUs⁷ have 1,000 times less raw computing power than the human brain, while consuming 10 times more power⁸ – raising questions about the sustainability of such technologies.

Thus, certain tasks that are difficult to perform remotely can be carried out more quickly and efficiently by astronauts operating on the spot.^{9,10} The most emblematic example remains that of the STS-61 mission, during which seven astronauts from the space shuttle *Endeavour* performed five extravehicular activities (EVA) to repair the Hubble telescope.¹¹

Symbolic dimension

In addition to their operational role, astronauts send a powerful message to individuals and other nations.

Crewed space missions fuel the collective imagination, serve as a source of inspiration for younger generations and stimulate scientific advances, thereby contributing to a nation's (or community of nations') excellence in cutting-edge technologies.¹² As true ambassadors of science, astronauts also contribute to their country's

6. P. Thangavelu, "The limits of autonomy: AI in space missions," *IEEE Aerospace Conference Proceedings*, 2021.

7. A Graphics Processing Unit, or GPU, is an electronic circuit that performs image processing functions.

8. "[Intelligence artificielle – L'IA est très loin de l'optimisation énergétique réalisée par le cerveau humain](#)," Délégation régionale académique au numérique éducatif, 2024.

9. G. A. Boy, "[La machine comme partenaire. La question du Human Autonomy Teaming](#)," pp. 73-86; in CESA (dir.), *Vortex. Puissance aérienne et spatiale*, CESA, No. 3, June 2022.

10. C. Verseux, "[Peut-on, et doit-on, aller sur Mars ? Note à l'intention des décideurs](#)," *European Astrobiology Institute*, 2025.

11. Z. Shao, "Human spaceflight maintenance: A critical capability for space infrastructure sustainability," *Acta Astronautica*, Vol. 172, 2020, pp. 114-121.

12. F. Gaillard-Sborowsky, *Géopolitique de l'Espace. À la recherche d'une sécurité spatiale*, Paris, Le Cavalier Bleu, 2023.

diplomatic influence on the international stage, promoting cooperation between states and industry, and consolidating lasting strategic alliances.

Ultimately, the role of astronauts remains essential from both an operational and symbolic point of view, especially if their missions involve human values and/or sovereignty issues.

Main Threats to The Human Body in Space

While human presence in space is desirable for the reasons mentioned above, it is also threatened by the extreme conditions of the space environment. It is essential to remember the basic fact that humans are terrestrial beings, in the literal sense of the term, in other words, adapted over thousands of years to 1g gravity,¹³ annual radiation of around 3mSv,¹⁴ and generally circadian biological rhythms (24-hour cycles). They are also driven by a gregarious instinct and motivated by emotional bonds.

In space, these parameters differ (microgravity, space radiation, confinement), exposing astronauts to major physiological and psychological consequences¹⁵ that compromise human performance and even the success of missions. Understanding these effects makes it possible to design preventive measures, known as “counter-measures,” aimed at ensuring the health, safety, and optimal performance of astronauts in flight.

Microgravity

Inside a spacecraft in free fall, astronauts no longer have to fight against the effects of gravitational attraction: this is known as microgravity.

Instantly, microgravity causes a feeling of floating, similar to that experienced during an aerodynamic stall, displacement of body fluids (fluid shift) characterized by swelling of the face (known as “moon face”)¹⁶ and spatial disorientation causing dizziness, nausea, vomiting, and drowsiness (space sickness).¹⁷ In the longer term, microgravity can also lead to:

- *musculoskeletal maladaptation*, mainly in the spine and lower limbs, with loss of strength and risk of fracture;^{18,19}

13. G: unit of acceleration due to gravity, equivalent to 9.80665m/s² or 9.80665 N/kg.

14. Sievert (Sv): unit used to quantify the biological effects on humans of exposure to ionizing radiation.

15. A. Nicogossian, *Space Physiology and Medicine from Evidence to Practice*, 4th edition, New York, Springer, 2016.

16. “[What Is Microgravity?](#),” NASA Facts, 2019.

17. M. Reschke, “Space motion sickness: Incidence, etiology, and countermeasures,” *Journal of Clinical Pharmacology*, Vol. 38, No. 8, 1998, pp. 625-630.

18. A. P.-L. Traon, “From space to Earth: advances in human physiology from 20 years of bed rest studies (1986-2006),” *European Journal of Applied Physiology*, Vol. 101, 2007, pp. 143-194.

19. L. Vico, P. Collet, A. Guignandon, M. H. Lafage-Proust, T. Thomas, M. Rehaillia, *et al.*, “Effects of long-term microgravity exposure on cancellous and cortical weight-bearing bones of cosmonauts,” *Lancet*, Issue 355, Vol. 9215, 2000, pp. 1607-1611.

- increased *cardiovascular risk* and orthostatic dysregulation;²⁰
- *altered metabolism*: lipids, insulin,²¹ or bone;²²
- in 70% of ISS astronauts, *visual impairment* as part of Spaceflight Associated Neuro-ocular Syndrome (SANS).^{23,24}

The physiological consequences of microgravity are more dramatic when astronauts return to Earth and experience gravity again. Orthostatic hypotension can then cause discomfort, while muscle weakness makes it difficult to stand, walk, and perform certain physical tasks²⁵ (Figure 1). It should be noted that lunar gravity is about 1/6 that of Earth, and that this ratio is about 1/3 on Mars.



Figure 1. Astronaut Thomas Pesquet (center) being carried on his return to Earth in 2017, after spending six months in microgravity aboard the ISS.
(credit: Shamil Zhumatov/Pool/AFP).

20. P. Arbeille, "Cardiovascular adaptations to microgravity," *European Journal of Applied Physiology*, Issue 117, Vol. 2, 2017, pp. 251-265.

21. A. Nicogossian, *Space Physiology and Medicine from Evidence to Practice*, op. cit.; A. P.-L. Traon, "From space to Earth: advances in human physiology from 20 years of bed rest studies (1986-2006)," op. cit.

22. S. Smith, "Bone metabolism and nutrition in spaceflight," *Nutrients*, Issue 4, Vol. 7, 2012, pp. 979-995.

23. A. G. Lee, et al., "[Spaceflight associated neuro-ocular syndrome \(SANS\) and the neuro-ophthalmologic effects of microgravity: a review and an update](#)," *NPJ Microgravity*, Vol. 6, 2020, p. 7.

24. SANS (Spaceflight Associated Neuro-ocular Syndrome) combines papilledema, flattening of the posterior pole of the eyeball, and thickening of the retina.

25. M. Guilbaud, "[Muscles, os, vue... Pourquoi le retour des astronautes bloqués neuf mois dans l'Espace sera douloureux](#)," *Ouest-France*, 18 March 2025.

The main countermeasure for cardiac, vascular, muscular and bone deconditioning is physical exercise performed on a treadmill, stationary bike, or ARED (Advanced Resistive Exercise Device) for two hours a day while in space.^{26,27}

More specifically, pharmacological agents such as bisphosphonates (alendronate tablets) have been shown to almost completely halt bone loss induced by microgravity,²⁸ although they cause significant gastric burns. Nutritional programs are rigorously planned to ensure adequate intake of vitamin D, calcium, protein, micronutrients, and antioxidants.²⁹

SANS-induced visual impairment could be reduced by various physiological actions (negative leg pressure, modulation of the translaminal pressure gradient).^{30,31}

The presence of artificial gravity within the spacecraft, for example through centrifugal force, would logically mitigate or even eliminate the aforementioned effects.

Space radiation

On the *Earth's surface*, the human body is naturally exposed to background radiation from several sources: telluric radioactivity (uranium and thorium, 0.6mSv/year), radioactive radon gas produced (1.5mSv/year), internal radioactivity (water and food, 0.5mSv/year), and cosmic radiation (0.3mSv/year). This amounts to a total dose of approximately 3mSv/year (and up to 70mSv/year in the Ramsar region, Iran, where natural radioactivity is the highest on Earth). To this must be added artificial sources of radiation, such as the nuclear industry (+/- accidents) and the medical field, including radiology (a full-body scan delivers between 5 and 20 mSv), nuclear medicine, radiotherapy. The professional limit is internationally set at < 20mSv/year (average over 5 years, with no single year exceeding 50 mSv).³²

Higher airspace extends approximately from 20 to 100km above the Earth. By convention, the World Air Sports Federation (French: Fédération aéronautique internationale) sets the boundary between the atmosphere and space at 100km above sea level (also known as the "Kármán line").

26. R. Ploutz-Snyder, "Exercise as a countermeasure to cardiovascular deconditioning in microgravity," *Medicine & Science in Sports & Exercise*, Vol. 50, No. 5, 2018, pp. 928-937.

27. J. W. Wolfe, J. D. Rummel, "Long-term effects of microgravity and possible countermeasures," *Advances in Space Research*, Issue 12, Vol. 1, 1992, pp. 281-284.

28. A. Leblanc, "Bisphosphonates as a supplement to exercise to protect bone during long-duration spaceflight," *Osteoporosis International*, Issue 24, Vol. 7, 2013, pp. 2105-2114.

29. S. Zwart, "Nutritional considerations for long-duration spaceflight," *Advances in Nutrition*, Issue 4, Vol. 6, 2013, pp. 792-805.

30. J. Ong, *et al.*, "[Spaceflight associated neuro-ocular syndrome: proposed pathogenesis, terrestrial analogues, and emerging countermeasures](#)," *British Journal of Ophthalmology*, Issue 107, Vol. 7, 2023, pp. 895-900.

31. T. Nguyen, *et al.*, "[Spaceflight Associated Neuro-ocular Syndrome \(SANS\) and its countermeasures](#)," *Progress in Retinal and Eye Research*, Issue 106, 2025, 101340.

32. "ICRP Recommendations of the International Commission on Radiological Protection," *ICRP Publication*, Vol. 37, 2007, pp. 1-332.

At this altitude of 100 km begins space, filled with radiation – consisting of hydrogen nuclei (protons), helium nuclei (alpha particles), gamma photons, neutrons, and other electrons (Figure 2):

- of cosmic origin, from: solar wind,³³ solar particle events (SPEs)³⁴ and the explosion of other stars at the end of their lives called supernovae (GCR – galactic cosmic rays);³⁵
- secondary to the collision of cosmic radiation with the spacecraft's shielding;³⁶
- and possibly the radiation encountered when crossing the magnetosphere (Van Allen belts), between 700km and 65,000km above the Earth's surface.

For astronauts, the occupational exposure limit set by the European (ESA), Russian (Roscosmos) and Canadian (CSA/ASC) space agencies is 1,000mSv/career^{37,38} and 600mSv/career for NASA astronauts;³⁹ an increase in the American acceptability threshold is currently under discussion.⁴⁰ In practice:

- On board the ISS (cruising altitude of 400 km), astronauts receive an average of 150 mSv/year (0.4 mSv per day, or approximately 73 mSv for a typical 6-month mission);³³
- Among the various strategies for Mars missions, the 'conjunction' scenario involves a journey of approximately 6 months to Mars, 500 days on site, and 6 months for the return journey.⁴¹ Radiation measurements taken during previous reconnaissance missions have shown that the equivalent doses received would be around 330 mSv for a 6-month Earth-Mars transit, and 200-400 mSv for 500 days⁴² (absorbed dose: 45-75 mGy/year)⁴³ spent on site (Figure 8), for a total of approximately 1,000 mSv spread over a two-and-a-half-year mission. This value therefore corresponds to the occupational exposure limit in force in Europe, Russia, and Canada.

33. J. Restier-Verlet, "Radiation on Earth or in Space: What Does It Change?," *International Journal of Molecular Sciences*, Issue 3, Vol. 7, 2021, p. 3739.

34. "[Our Sun: Facts](#)," NASA.

35. V. Tatischeff, "The Origin of Galactic Cosmic Rays as Revealed by their Composition," *37th International Cosmic Ray Conference*, Berlin (Germany), 2021.

36. G. Nelson, "The Space Radiation Environment," *TRISH Red Risk School Seminar Series*, 2020.

37. E. Detsis, "Ethics in Space: The Case for Future Space Exploration," pp. 111-121; in D. O'Mathúna, *Ethics, Integrity and Policymaking: The Value of the Case Study*, Cham (Switzerland), Springer, 2022.

38. F. Cucinotta, "[Radiation Risk Acceptability and Limitations](#)," NASA, 2010.

39. "[Space Flight Human-System Standard Volume 1: Crew Health](#)," NASA, 2025.

40. F. Cucinotta, "A proposed change to astronaut exposures limits is a giant leap backwards for radiation protection," *Life Sciences in Space Research*, Issue 31, 2021, pp. 59-70.

41. "[Human Exploration of Mars – Design Reference Architecture 5.0, Addendum #2](#)," NASA, 2014.

42. B. Ehresmann, "The charged particle radiation environment on Mars measured by MSL/RAD from November 15, 2015 to January 15, 2016," *Life Sciences in Space Research*, Issue 14, August 2017, pp. 3-11.

43. J. L. Chen, S. J. Yun, T. K. Dong, *et al.*, "Studies of the radiation environment on the Mars surface using the Geant4 toolkit," *Nuclear Science and Techniques*, Issue 33, Vol. 11, 2022.

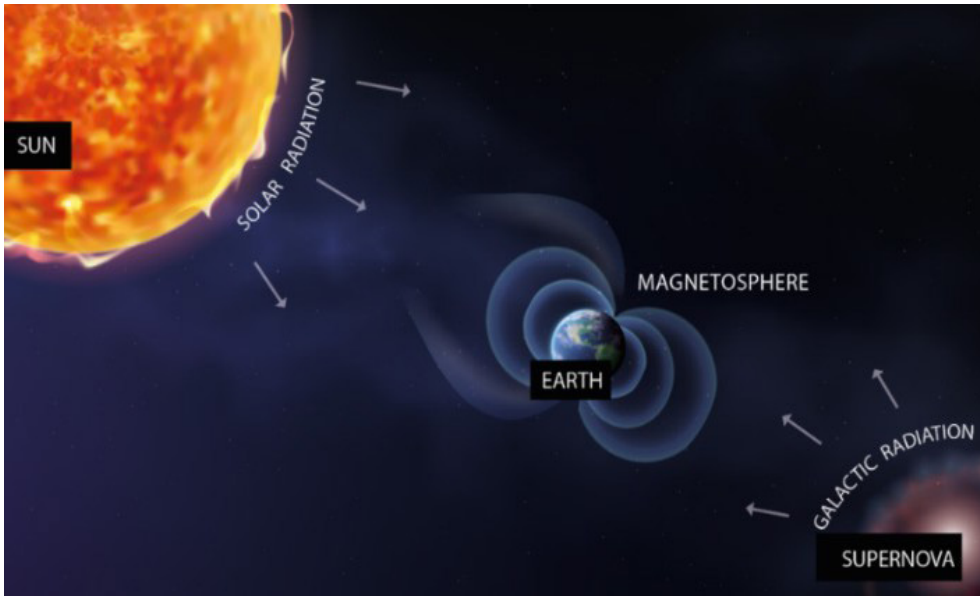


Figure 2. Cosmic radiation can be solar or galactic. The Earth's magnetosphere traps cosmic radiation in structures called Van Allen belts.

(credit: L. Han/IAEA).

From a biological viewpoint, space radiation has sufficient energy to damage the DNA of human cells: this is referred to as “ionizing” radiation. The main identified side effect of space radiation is the risk of cataracts (clouding of the lens), occurring in more than 80% of ISS astronauts exposed to 0.4mSv per day of mission (i.e., approximately 73mSv for six months spent aboard the ISS).^{44,45} These data have recently been corroborated by in vitro results.⁴⁶ Space radiation could also cause neuronal damage, increasing the risk of cognitive impairment and neurodegenerative diseases.⁴⁷ Several in vivo studies have also highlighted a synergistic effect of microgravity and radiation in the mechanisms of bone demineralization and muscle loss, suggesting that these deteriorations are partially radiation-induced.^{48,49}

Countermeasures to protect against space radiation are operational, structural, and medical. Firstly, particular care is taken when choosing the launch period: the

44. F. Cucinotta, “Space radiation and cataracts in astronauts,” *Radiation Research*, Vol. 156, 2001, pp. 460-466.

45. M. Maalouf, “[Biological effects of space radiation on human cells: history, advances and outcomes.](#)” *Journal of Radiation Research (Tokyo)*, Vol. 52, 2011, pp. 126-146.

46. J. Restier-Verlet, A. Granzotto, M. L. Ferlazzo, F. Kormann, A. Joubert, C. Devic, E. Le Reun, F. Trompier, S. Louvel, M. Bourguignon, N. Foray, “Exposure of human tissues to stratosphere radiation behind different shielding: data from a campaign of three balloon flights,” *Submitted*.

47. F. Cucinotta, M. Durante, “Cancer risk from exposure to galactic cosmic rays,” *Life Sciences in Space Research (Amsterdam)*, Vol. 3, 2006, pp. 54-63.

48. J. Dong, “The combined effects of simulated microgravity and X-ray radiation on MC3T3-E1 cells and rat femurs,” *NPJ Microgravity*, Issue 15, Vol. 1, 2021, p. 3.

49. A. Farley, “Unloading-Induced Cortical Bone Loss is Exacerbated by Low-Dose Irradiation during a Simulated Deep Space Exploration Mission,” *Calcified Tissue International*, Vol. 107, 2020, pp. 170-179.

mission window must be free of SPEs. In the case of flights to the Moon or Mars, orbital positions are considered to minimize travel times.⁵⁰

Spacecraft are also equipped with multi-layer shielding (synthetic materials and metallic films)⁵¹ which, in the future, could be supplemented by biological shielding using the fungus *Cladosporium sphaerospermum*, which can absorb ionizing radiation.⁵² An artificial magnetosphere surrounding the spacecraft would also protect the cabin from radiation damage.⁵³

Finally, there is ongoing research into tocopherol (vitamin E, 1,000IU/day) and pentoxifylline (anti-TNF α , 800mg/day) – two antioxidant drugs used to treat the side effects of radiation therapy^{54,55} – for applications in the space sector.^{56,57}

Confinement

Space missions take place in closed, confined, and isolated environments, where astronauts live far from their loved ones and have limited access to social interaction. This situation creates significant psycho-physiological constraints.

One of the main difficulties is the desynchronization of circadian rhythms (24-hour light cycles). In low Earth orbit (LEO), the day/night cycle repeats every 90 minutes, subjecting astronauts to a rapid succession of eclipses and solar exposure. On a trip to Mars, the view from a single window could remain unchanged for several months. This leads to sleep disorders that increase stress and impair *cognitive functions*.⁵⁸ Some studies also suggest that confinement could be responsible for the hippocampal atrophy observed in the brains of astronauts returning after six months on the ISS.⁵⁹

50. K. N. Prasad, W. C. Cole, G. M. Haase, "Radiation protection in humans: extending the concept of as low as reasonably achievable (ALARA) from dose to biological damage," *British Journal of Radiology*, Issue 77, Vol. 914, 2004, pp. 97-99.

51. M. Finckenor, "Multilayer Insulation Material Guidelines," NASA Facts, 1999.

52. E. Dadachova, "Ionizing radiation: how fungi cope, adapt, and exploit with the help of melanin," *Current Opinion in Microbiology*, Issue 11, Vol. 6, 2008, pp. 525-531.

53. P. Desiati, "CREW HaT: A Magnetic Shielding System for Space Habitats," *51st International Conference on Environmental Systems*, 2022.

54. S. Delanian, R. Porcher, S. Balla-Mekias, J. L. Lefaix, "Randomized, placebo-controlled trial of combined pentoxifylline and tocopherol for regression of superficial radiation-induced fibrosis," *Journal of Clinical Oncology*, Vol. 21, No. 13, 2003, pp. 2545-2550.

55. S. Delanian, C. Chatel, R. Porcher, J. Depondt, J. L. Lefaix, "Complete restoration of refractory mandibular osteoradionecrosis by prolonged treatment with a pentoxifylline-tocopherol-clodronate combination (PENTOCLO): a phase II trial," *International Journal of Radiation Oncology Biology Physics*, 2011, Issue. 80, Vol. 3, 2011, pp. 832-839.

56. M. F. McLaughlin, D. B. Donoviel, J. A. Jones, "Novel Indications for Commonly Used Medications as Radiation Protectants in Spaceflight," *Aerospace Medical and Human Performance*, Issue 88, Vol. 7, 2017, pp. 665-676.

57. X. Gomez, S. Sanon, K. Zambrano, S. Asquel, M. Bassantes, J. E. Morales, *et al.*, "Key points for the development of antioxidant cocktails to prevent cellular stress and damage caused by reactive oxygen species (ROS) during manned space missions," *NPJ Microgravity*, Issue 7, Vol. 1, 2021, p. 35.

58. C. W. Jones, *et al.*, "[Sleep deficiency in spaceflight is associated with degraded neurobehavioral functions and elevated stress in astronauts on six-month missions aboard the International Space Station](#)," *Sleep*, Issue 45, Vol. 3, 2022.

59. S. Batool, *et al.*, "[Hippocampal Volumetric Changes in Astronauts Following a Mission in the International Space Station](#)," *NeuroSci*, Issue 6, Vol. 3, 2025.

For this reason, artificial lighting is adjusted to simulate a 24-hour cycle, sometimes supplemented by hypnotic drugs.⁶⁰ Vitamin D supplements are also necessary due to the lack of exposure to sunlight.⁶¹

Confinement in a cramped cabin, promiscuity, routine, the impossibility of physical or sensory isolation, and the distance from Earth also increase the mental burden,⁶² promoting the onset of psychological disorders such as stress, depression, and interpersonal conflicts.⁶³ These effects increase with mission duration. In the case of a trip to Mars, there will also be communication delays with Earth of up to several tens of minutes.

To limit psychological risks with potentially disastrous consequences for the crew and their mission, astronaut recruitment campaigns pay particular attention to the mental stability and resilience of candidates. Once selected, astronauts undergo in-depth psychological preparation. During the mission, remote psychological support, structured daily activities, and digital tools that facilitate communication with Earth are essential.⁶⁴ They help maintain motivation, emotional balance, and crew cohesion – key conditions for the success of long-duration missions.



Figure 3. Concordia, Franco-Italian base in Antarctica.
(credit: Sylvain Guesnier/IPEV).

60. L. Barger, “Prevalence of sleep deficiency and use of hypnotic drugs in astronauts aboard the ISS,” *Journal of Clinical Sleep Medicine*, Issue 10, Vol. 6, 2014, pp. 603-608.

61. S. Zwart, “Nutritional considerations for long-duration spaceflight,” *op. cit.*

62. A. Arone, *et al.*, “[The Burden of Space Exploration on the Mental Health of Astronauts: A Narrative Review](#),” *Clinical Neuropsychiatry*, Issue 18, Vol. 5, 2021, pp. 237-246.

63. N. Kanas, D. Manzey, *Space Psychology and Psychiatry*, Dordrecht (Netherlands), Springer, 2008.

64. G. Sandal, “Psychological issues in long-term space missions,” *Acta Astronautica*, Issue 69, Vol. 7-8, 2011, pp. 613-620.

The effects of confinement in space are widely studied on Earth thanks to structures that enable similar missions to be carried out on the ground. Examples include the Concordia Antarctic station⁶⁵ (Figure 3), managed by the French Polar Institute (IPEV) and the French space agency (CNES), and simulations of Mars missions (Mars500).⁶⁶

It should be noted that other physiological effects, such as decreased immunity, are also observed during long-duration flights.⁶⁷

Risk Assessment Based on Spaceflight Duration

The duration of a space mission determines the risks to which the crew is exposed. Short flights, such as orbital missions lasting a few days or weeks, present different constraints compared to future expeditions to the Moon and Mars, which will last several months or even years.

Short flights (< 30 days): acute effects and initial adaptation

Short-duration missions are dominated by the effects of adapting to microgravity. It is essential to anticipate phenomena such as space sickness, fluid shift, and sleep disorders. These effects are often transient and reversible in the short term, but require close medical monitoring.

Exposure to radiation is generally limited, as the protection provided by the Earth's magnetosphere is effective in LEO, reducing the risk of chronic radiation-related pathologies.

Astronauts are selected, trained, and monitored on a psychological basis.

Medium-duration missions (1 to 6 months): cumulative risks and extended effects

For medium-duration missions, such as those carried out aboard the ISS, muscle and bone atrophy becomes significant, cardiovascular changes stabilize in a new equilibrium, and the psychological effects of isolation and confinement increase.

Solar radiation management remains effective, but the probability of a major solar storm requires strict shelter procedures and monitoring of cumulative doses.

In addition, circadian rhythm disturbances can become chronic, affecting alertness and decision-making abilities.

65. A. Van Ombergen, *et al.*, "[White Mars – nearly two decades of biomedical research at the Antarctic Concordia station](#)," *Experimental Physiology*, Issue 106, Vol. 1, 2021, pp. 6-17.

66. C. Tafforin, "[Confinement vs. isolation as analogue environments for Mars missions from a human ethology viewpoint](#)," *Aerospace Medicine Human Performance*, Issue 86, Vol. 2, 2015, pp. 131-135.

67. B. E. Crucian, "[Immune System Dysregulation During Spaceflight: Potential Countermeasures for Deep Space Exploration Missions](#)," *Frontiers in Immunology*, Vol. 9, 2018.

Long-term missions (> 6 months): major and unknown risks

Extended stays on the Moon or future missions to Mars would expose crews to radiation doses of around 1,000mSv, equivalent to the occupational limit already in force in Europe, Russia, and Canada.⁶⁸ In the United States, however, raising the acceptable limit, currently set at 600mSv/career,⁶⁹ is under debate.⁷⁰ Exceeding current safety thresholds would effectively increase the risk of cancer, cardiovascular disorders, and neurodegenerative diseases.⁷¹

Prolonged confinement, isolation, and physical inactivity would also increase somatic and psychosocial risks.⁷² The absence of a welcome upon the astronauts' arrival on another planet would further complicate their rehabilitation.

Risk management perspectives based on duration

Understanding and modeling risk based on duration is crucial for designing countermeasures and planning missions. An integrated approach, combining biomedical, psychological, and technical measures, is essential to ensure astronaut safety.

Emerging technologies, such as personalized medicine, telemedicine, and targeted pharmacological interventions, offer promising avenues for mitigating these risks. In addition, new means of propulsion (particularly thermonuclear) could reduce transit times for interplanetary missions,^{73,74} thereby reducing exposure times to microgravity, radiation, and isolation.

Conclusion

The presence of humans in space missions confers an operational and therefore strategic advantage. However, the characteristics of the space environment (microgravity, radiation, confinement) expose astronauts to complex and multifaceted biomedical risks, which increase with the duration and altitude of flights and compromise their chances of success. The benefit of having a crew therefore depends on the objective of the planned space mission. Three types of missions can be distinguished.

The *colonization* of another planet by humans can only be considered sustainable on a celestial body with living conditions similar to those on Earth (gravity, low

68. “[Valeurs limites d'exposition \(Articles R4451-6 à R4451-9\)](#),” Légifrance; E. Detsis, “Ethics in Space: The Case for Future Space Exploration,” pp. 111-121; in D. O'Mathúna, *op. cit.*

69. “[Space Flight Human-System Standard Volume 1: Crew Health](#),” *op. cit.*

70. F. A. Cucinotta, W. Schimmerling, E. A. Blakely, T. K. Hei, “A proposed change to astronaut exposure limits is a giant leap backwards for radiation protection,” *Life Sciences in Space Research (Amsterdam)*, Vol. 31, 2021, pp. 59-70.

71. F. Cucinotta, “Space radiation cancer risk projections and uncertainties,” *Radiation Research*, Issue 179, Vol. 1, 2013, pp. 50-60.

72. D. Williams, “Long-duration spaceflight and effects on human physiology,” *Journal of Applied Physiology*, Issue 127, Vol. 2, 2019, pp. 548-561.

73. “[Nuclear Propulsion Could Help Get Humans to Mars Faster](#),” NASA, 2021.

74. R. Bardan, “[NASA, DARPA Will Test Nuclear Engine for Future Mars Missions](#),” NASA, 2023.

radioactivity). Even if such an exoplanet (a planet outside the solar system) exists, we do not currently have the means of propulsion that would allow us to travel there within a human lifetime.

Crewed exploration of our solar system must be motivated by a major scientific interest. As with current missions, it is reserved for experienced astronauts who are aware of the risks involved depending on the duration of the flight.

Higher airspace (HA) and low Earth orbit (LEO) are now increasingly accessible, both for good (biomedical research, Earth observation) and for bad (ballistic missiles). Their relative proximity (tens or hundreds of kilometers above launch sites) allows for frequent rotation of human crews. Safety in these zones must be ensured by aviators or astronauts who are fully familiar with the constraints involved. As such, the French Air and Space Force must maintain and increase its capability to project power, knowledge, and human expertise into near space.

Attracting All Talents to the U.S. Space Force and the French Space Command: A Convergence of Intentions with Different Trajectories

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Introduction

In 2019, under the impetus of President Donald Trump, the United States established the United States Space Force (USSF) as the sixth branch of the U.S. armed forces, intended to address emerging threats related to the space domain. From its inception, the USSF did not limit itself to strictly operational considerations. Instead, it integrated societal issues into its thinking by examining the question of inclusion.

In June 2020, General John W. Raymond, the first Chief of Space Operations, stated in a letter addressed to the men and women of the U.S. space forces: “We have an opportunity to get this right from the beginning, and we are committed to doing so. We must build diversity and inclusion into our ‘cultural DNA’ – make it one of the bedrock strengths of our Service.”

This objective aligns with a broader strategy pursued by President Joe Biden, who in 2021¹ published an executive order emphasizing the necessity of promoting diversity, equity, and inclusion within the federal public service.

1. “[Executive Order on Diversity, Equity, Inclusion, and Accessibility in the Federal Workforce](#),” official website of the White House, 25 June 2021.

Simultaneously, inclusion became a governmental priority in France. President Emmanuel Macron designated the role of women within state institutions as a key focus of his term. This policy marks a deliberate shift within the armed forces toward greater female representation within their ranks, with the objective of combining operational performance with societal engagement.

To understand how the French Air and Space Force (FASF) and the USSF approach the issue of inclusion, this article compares the U.S. and French approaches to the recruitment and integration of women. It also identifies the primary obstacles. The analysis is based on the accounts of senior officers from both countries responsible for recruitment policy, highlighting potential pitfalls related to the implementation of inclusive policies. Furthermore, this article relies on official statistics to observe the evolution of female representation within military institutions, while referencing literature on organizational culture to identify the dynamics at play.

The research findings demonstrate that the USSF and the FASF adopt significantly different approaches to inclusion, primarily due to their sociological trajectories inherited from their respective pasts. France favors a logic of strict gender equality and equal opportunity, attempting to eliminate any perception of differentiated treatment between male and female military personnel. Conversely, the United States directs its efforts toward the notion of “wellness” for women within the armed forces, with the stated ambition of creating a professional environment better adapted to female-specific needs, which they do not hesitate to highlight.

Far from being incompatible, these two approaches could prove complementary. Consequently, the sharing of best practices between France and the United States could foster the implementation of more robust, resilient, and inclusive policies, serving the operational performance of their respective militaries.

1. Including Women: What are the Underlying Justifications?

1.1 What is it Exactly?

The United States has always accorded great importance to questions of diversity and inclusion, owing to its cultural and historical construction (see 3.1). However, this article focuses specifically on the inclusion of women, a matter for which France and the United States demonstrate the same concerns today. Although frequently overused, the term “inclusion” warrants a precise definition and must be distinguished from that of “diversity.”

Diversity refers to the recognition and appreciation of differences between individuals within the same group. It encompasses various individual characteristics such as ethnic origin, language, disability, gender, age, or religion within a professional context.²

2. “[Diversity](#),” Cambridge Dictionary.

Inclusion, for its part, denotes a set of behaviors and practices that allow individuals to feel valued for their unique qualities and to experience a sense of belonging to the group.³

An institution or a company may be diverse without, however, being inclusive.

1.2 When the Inclusion of Women Benefits the Institution

The inclusion of women continues to provoke debate, despite having been studied for many years and regardless of their level of representation within organizations. Research demonstrates that groups composed of individuals with similar backgrounds, which are homogeneous in terms of gender exhibit greater cohesion, reach decisions more rapidly, and operate in a less conflictual environment. Homogeneous groups, therefore, appear more effective at first glance.⁴

Based on this observation, why should an organization make the inclusion of women a major strategic stake? Bishop Garrison, Senior Advisor to the U.S. Secretary of Defense for Diversity, Equity, and Inclusion, argues that a plurality of backgrounds and profiles fosters the emergence of innovative thinking, which is particularly welcome in a constantly evolving world. He thus invites the consideration of diversity, equity, and inclusion not as secondary tools, but as major strategic instruments.

From an organizational perspective, gender diversity constitutes a valuable lever for collective performance. Studies show that groups with a high degree of gender mix are more effective in the complex processing of information.⁵ Indeed, the confrontation of divergent yet complementary opinions proves particularly necessary in contexts characterized by uncertainty. In such environments, a plurality of opinions enriches the analysis and avoids the pitfalls associated with cognitive biases and groupthink. The benefit of diversity is therefore notable in unstable environments, encouraging complementary approaches and a more comprehensive understanding of challenges.

As highlighted by Francesca Gino, Professor at Harvard Business School, “while it is difficult to change the way our brains are wired, it is possible to change the context in which decisions are made by building teams that allow for different points of view.” Gender diversity is therefore not merely an ethical issue but pertains to a broader organizational strategy aimed at fostering group effectiveness. Consequently, it appears crucial to promote this diversity, particularly within leadership positions.

1.3 The Necessary Social Representativeness of the Armed Forces

The implementation of diversity and inclusion programs in the United States relies on the legal obligation to meet the requirements of the Equal Employment

3. “[U.S. Department of Housing and Urban Development](#),” official website of the U.S. Department of Housing and Urban Development.

4. A. Nahavandi, *The Cultural Mindset: Managing People Across Cultures*, Thousand Oaks (California), SAGE Publishing, 2021, p. 196.

5. G. D. Fenwick, D. Neal, “Effect of Gender Composition on Group Performance,” *Gender Work & Organization*, No. 8, April 2001, pp. 205-225.

Opportunity Commission.⁶ Nevertheless, beyond this legal foundation, military institutions appear to be an ideal ground for the elaboration of ambitious, or even pioneering, inclusion policies, given their structuring role within society.

In a society driven by social justice, a moral responsibility exists to treat every individual with equal respect and to guarantee the same opportunities to all. In the work *The Cultural Mindset*, Afsaneh Nahavandi argues that the implementation of diversity and inclusion constitutes an effective path toward achieving this fundamental ideal of social justice.⁷ This assertion is particularly true for the armed forces, which are often considered models to be followed. The political scientist Everett C. Dolman, a fervent defender of this principle, points out “the tendency of military organizations to influence political organizations and development, rather than the reverse.”⁸

By way of illustration, Dolman explains that from 1939 to 1953, the United States had adopted a policy offering African Americans equal opportunity through integration into the armed forces. Having experienced a certain equality of treatment in the military – notably during the Korean War, where soldiers of all origins fought side by side – African Americans returning to civilian life of the 1950s struggled to find their place in a social context that continued to discriminate against them. Similarly, Executive Order 9981, signed in 1948 by President Truman, which abolished all discrimination based on race, color, or religion in the U.S. Armed Forces, preceded the founding 1954 Supreme Court decision, *Brown v. Board of Education*, which declared racial segregation in public schools unconstitutional.

Furthermore, the social responsibility of organizations implies an obligation to act in favor of improving society in which they conduct their activities. Consequently, institutions that adopt an inclusive policy reinforce their positive image in a ever-evolving world.

It is also observed that a group wishing to strengthen its civic and patriotic sense tends naturally to take the armed forces as an example. According to the sociologist Christopher Dandeker, social progress within the military environment subsequently reverberates in the civilian world. Thus, the persistent exclusion of women from certain positions, notably combat roles, may be perceived as a symbol of structural inequality. This encourages certain groups to initiate legal action to denounce their marginalization within state agencies.⁹

Therefore, the armed forces may be considered a true “laboratory” for social experimentation and must be mobilized as such. The increasing acceptance and

6. “[Sex Discrimination](#),” official website of the U.S. Equal Employment Opportunity Commission; “[Code pénal – Section 1 : Des discriminations \(Article 225-1 à 225-4\)](#),” *Légifrance*.

7. A. Nahavandi, *The Cultural Mindset...*, op. cit., p. 195.

8. E. C. Dolman, *The Warrior State: How Military Organization Structures Politics*, New York, Palgrave Macmillan, 2004, p. 3.

9. C. Dandeker, “[Femmes combattantes : problèmes et perspectives de l’intégration des femmes dans l’armée britannique](#),” *Revue française de sociologie*, Vol. 44, 2003, p. 738.

recognition of women within military ranks illustrate this societal function of the armed forces, which remain a source of ethical and cultural inspiration for the society they serve.

To explain this phenomenon, Christopher Dandeker advances the hypothesis that military institutions respond to two fundamental imperatives: a functional imperative and a societal imperative. On the one hand, political and military leaders must take the strategic environment into account and create armed forces capable of effectively accomplishing their missions (functional imperative). On the other hand, they must ensure that these institutions remain aligned with the society they protect and upon which they depend for their legitimacy and resources (societal imperative). Although these two imperatives may appear contradictory, their reconciliation is essential to the proper functioning of the armed forces.¹⁰

Given the nature of their missions, the USSF and the FASF could find an interesting balance between these two imperatives. Both organizations demonstrate a desire to recruit more women, thereby responding to societal and professional expectations. Can it be said that, however, they play a leading role in matters of gender equality?

2. Identifying Structural Obstacles to the Recruitment and Retention of Women in the Armed Forces

2.1 Is the Issue Exclusively Related to the Professional Environment?

2.1.1 The Lack of Mentors and Role Models

Mentorship plays an essential role for junior military personnel, who thus benefit from the experience and expertise of their seniors. Mentors offer strategic career advice and facilitate access to networks and opportunities, particularly within the officer corps. However, Heather N. McAteer asserts that “the gender disparities observed in mentorship roles, combined with a minority proportion of women in the ranks, constitute a major challenge for initiating and maintaining effective mentoring relationships throughout a career.”¹¹ Consequently, female officers reportedly do not always fully benefit from this mentorship system due to their under-representation in the senior ranks.¹²

Furthermore, it is observed that mentorship relationships often form spontaneously between members of the same sex. This occasionally marginalizes female officers and effectively limits their access to the same opportunities offered by this informal network. This dynamic is exacerbated in the United States, where sexual harassment

10. *Ibidem*, p. 747.

11. L. L. Levesque, R. O’Neil, T. Nelson, C. Dumas, “[Sex Differences in the Perceived Importance of Mentoring Functions](#),” *Career Development International*, Vol. 10(6/4), 2005, pp. 429-443; cited in H. N. McAteer, “Mentorship of women in the U.S. army: A qualitative case study,” *Dissertation*, University of the Rockies, 2016.

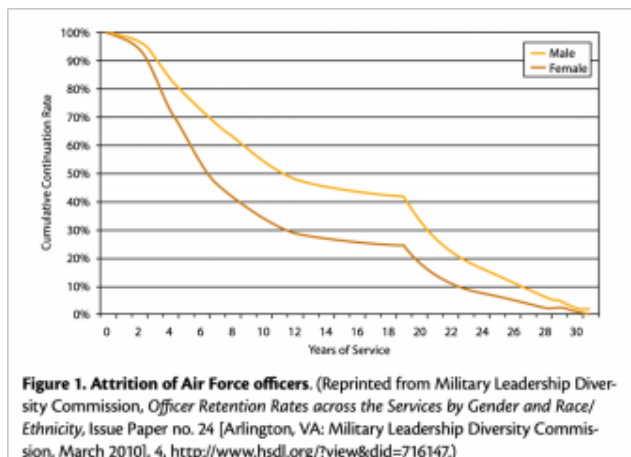
12. *Ibidem*, pp. 2-3.

has considerably affected male-female relations in the military. This has been particularly evident since the #MeToo movement, the emergence of which created a sense of unease between men and women. As a result, senior male U.S. officers were prohibited from any one-on-one meetings with lower-ranking female officers. While this policy aims to prevent inappropriate behavior, it deprives female U.S. officers of mentorship, which relies spontaneously on informal interactions with a hierarchical superior outside the strictly professional setting.¹³

2.2 Is the Social Role of Women Incompatible with the Military World?

2.2.1 Gender-Related Social Disparities as a Source of Female Absence in the Military World

Beyond issues such as sexual harassment and the lack of mentors or role models, social biases can discourage women from committing to the armed forces over the long term. Statistically, French female military personnel leave the forces after an average of 14 years of service, compared to 26 years for their male counterparts.¹⁴ While a large number of them make this decision voluntarily, others depart for family reasons deemed incompatible with the military profession. The same phenomenon was highlighted within the U.S. Air Force in a study conducted in 2014.



Similarly, at high-level positions, prolonged working hours, late meetings, and informal social interactions (often occurring in the evening) contribute to the marginalization of women. Furthermore, the disconnection between the public and private spheres exacerbates this dynamic, as many women are responsible for childcare after school.¹⁵

13. “Informal mentoring relationships are often less visible or unknown to the larger organization and include more significant psychosocial support. Formal mentoring relationships tend to be shorter due to predetermined objectives, while informal relationships are not limited by external policies;” in *ibidem*.

14. C. Abad, “*Femmes militaires, et maintenant ? Le cas de l’Armée de terre*,” *Les Cahiers de la Revue de la Défense Nationale*, 2017, p. 11.

15. S. J. Rutherford, “Organisational cultures, patriarchal closure and women managers: in what ways do organisational cultures act as a means of patriarchal closure to exclude and/or marginalize wom-

Finally, young girls too rarely choose science-focused tracks in secondary school. This puts them at a disadvantage when selecting higher education pathways that value these disciplines. Consequently, they do not naturally turn toward a career in the FASF or within the USSF, where scientific backgrounds are prioritized and engineering positions constitute the vast majority.

2.2.2 Sociological and Anthropological Biases

The concept of military identity is frequently associated in the collective imagination with combat, the use of force, weaponry, violence, and the capacity to kill. These attributes are culturally perceived as masculine and constitute a significant barrier to the large-scale inclusion of women in the armed forces. The French anthropologist Alain Testart sought proof of this in primitive societies, noting that women hunted alongside men but utilized different weapons, such as the club or the staff, to avoid the shedding of blood.¹⁶

Since women are tacitly forbidden from shedding blood, they have traditionally been deprived of the use of bladed weapons. To do otherwise would be to transgress an anthropological taboo that contemporary societies unconsciously maintain.

Nevertheless, during the Second World War and the colonial wars in Indochina and Algeria, women participated in combat, occasionally even on the front lines. They were, however, not authorized to carry weapons under the military laws in force at the time. The argument that women – symbolically associated with maternity and life – would be unable to deal death has often been put forward, particularly during postwar periods and demographic reconstruction in Western societies. The Israeli historian Martin van Creveld even suggested that the integration of women into the armed forces accelerated in the 1970s, driven by political and ideological considerations rather than military effectiveness. According to the author, this integration resulted in the decline of war – the primary social function of which was to valorize men – and consequently led to the decline of the armed forces themselves.¹⁷

Despite these sociological considerations related to gendered representations of women's roles in war, the Soviet Union deployed women en masse to fight at the front lines during the Second World War. This female militarization was rooted in the interwar period. During this time, the USSR, threatened by powers hostile to socialism, implemented a vast propaganda campaign aimed at generating a patriotic fervor within the population, regardless of gender, to defend the country in the event of aggression. Paramilitary organizations were subsequently established, attracting numerous Soviet women who volunteered to fight on the front lines.¹⁸

en managers?," *Thesis*, University of Bristol, 1999; C. Maligorne, "[Au travail, les mères restent plus pénalisées que les pères](#)," *Le Figaro*, 22 February 2019.

16. A. Testart, *L'Amazone et la cuisinière : anthropologie de la division sexuelle du travail*, Paris, Gallimard, 2014, p. 28.

17. M. van Creveld, "[Armed but Not Dangerous: Women in the Israeli military](#)," *War in History*, Vol. 7, No. 1, January 2000, pp. 82-98.

18. A. Krylova, "[Stalinist Identity from the Viewpoint of Gender: Rearing a Generation of Professionally Violent Women-Fighters in 1930s Stalinist Russia](#)," *Gender & History*, Vol. 16, No. 3, November

According to Roger R. Reese, the voluntary militarization of women during the war was actually linked to an ideological promise of the October Revolution of 1917, which established gender equality as a founding principle of socialist Soviet society. Reese emphasizes that “the ideology of the Russian Revolution regarding the promised equality of the sexes played a significant role in the psyche of the volunteers.” He adds that “the acceptance of women in combat and wearing the uniform was the logical consequence of decades of work by a pro-gender equality left, as part of a movement for the liberation of Russian women.”¹⁹ Thus, the militarization of Soviet women was tolerated, or even encouraged, as long as operational and strategic necessities dictated it, particularly during the Great Patriotic War. However, it was abruptly discontinued at the end of the conflict. This reflected a desire by the Soviet regime to avoid the disapproval of its population regarding this transgression of traditional gender roles.

This ambivalence is eloquently illustrated in Svetlana Alexievich’s work, *The Unwomanly Face of War: An Oral History of Women in World War II*. Through the testimonies of Soviet female soldiers, the author highlights how the war structurally transformed the Soviet armed forces by accepting women in massive numbers. Nevertheless, the regime’s silence on the subject reveals the concealment, or even the disavowal, of the role of women during the Second World War, which was thus erased from institutional memory.²⁰

2.2.3 When Military Cohesion is Threatened

Beyond the common association between masculinity and warfare, the historical exclusion of women from the battlefield may reveal, on the one hand, the persistence of a gender stereotype and the fear induced by their integration into the ranks. On the other hand, it may reflect a questioning of the very legitimacy of the use of violence, which is characteristic of the military world.²¹ Indeed, the status of a soldier implies a tacit legitimization of the “license to kill,” conferred by the endangering of one’s own life in the service of the common good. An essential question then arises: how can women be integrated into this founding myth of the soldier, constructed around a masculine identity?

At the end of the eighteenth century, the French Revolution established combat aptitude as a fundamental value of modern masculinity. However, according to U.S. historian George L. Mosse,²² the exclusion of women from the army was more of a political construction than mere determinism. This is evidenced by the actions of female

2004, p. 630.

19. R. Reese, *Why Stalin’s soldiers fought: The red army’s military effectiveness in World War II*, Lawrence (Kansas), University Press of Kansas, 2011, p. 261 et p. 266.

20. B. Fieseler, M. Hampf, J. Schwarzkopf, “[Gendering combat: Military women’s status in Britain, the United States, and the Soviet Union during the Second World War](#),” *Women’s Studies International Forum*, Vol. 47, 2014, p. 119.

21. C. Boutron, C. Weber, “[La féminisation des armées françaises : entre volontarisme institutionnel et résistances internes](#),” *Travail, genre et sociétés*, No. 47, April 2022, p. 44.

22. G. Mosse, *L’image de l’homme. L’invention de la virilité moderne*, Paris, Abbeville, 1997, p. 56.

figures such as Pauline Léon or Théroigne de Méricourt, who asserted the right to form an army corps as early as that period. This went beyond their simple presence in military spaces, where they were often confined to roles as laundresses or even prostitutes. Following the defeat of France by Prussia in 1871, the Third Republic revived this link between masculinity and citizenship through the establishment of conscription. This was designed as an instrument of “virilization” and a rite of passage to the status of citizen.²³ The male monopoly on the exercise of legitimate violence was thus reinforced, further marginalizing any female participation in combat.

Surprisingly, the perception of committed violence varies considerably according to the gender of the individual.²⁴ Indeed, violence perpetrated by men is often considered rational and inherent to their role as defenders. Conversely, violence exercised by women is perceived as deviant or even pathological. This double standard is echoed in the media treatment of women involved in acts of violence, as illustrated by the case of Lynndie England. As a soldier of the 372nd Military Police Company, she was convicted in 2005 for the torture and abuse of prisoners at Abu Ghraib in 2003. Her behavior provoked shock within U.S. public opinion.²⁵ This reaction reflects the popular perception of a transgression of the social contract, according to which women, even when joining the armed forces, must not exceed the limits of a codified and masculine violence.

Therefore, the militarization of women may appear as a threat to cohesion within the armed forces by openly challenging the male monopoly on violence.

2.3 The Need for Recognition and Integration of Women in Their Social and Professional Environment

2.3.1 The Uniform as a Stake in Belonging and Visibility

The military uniform plays an essential and equalizing role as an element of cohesion and recognition. It embodies membership in a single institution by erasing individualities, at least in appearance, and contributes to the construction of a collective identity. Although the wearing of the uniform in public was temporarily discouraged in France due to the terrorist attacks targeting military personnel in the 2010s, it remains a source of pride. This sentiment is heightened in the United States, where the military uniform is simultaneously a tool of cohesion, a marker of merit, a symbol of authority, and a patriotic emblem. This social valuation was strengthened after the Vietnam War, a period during which veterans were often received with hostility or indifference. From the 1990s onward, a collective desire to rehabilitate the image of the soldier resulted in public recognition of their commitment. This is evidenced by the frequent expressions of gratitude addressed by citizens to military personnel, who are perceived as the guarantors of the common good and national sacrifice.

23. G. Mihaely, “[L’effacement de la cantinière ou la virilisation de l’armée française au XIXe siècle](#),” *Revue d’histoire du XIXe siècle*, No. 30, 2005.

24. C. Cardi, G. Pruvost, “[La violence des femmes : occultations et mises en récit](#),” *Champ pénal*, Vol. VIII, 2011.

25. L. Sjöberg, G. Caron, “Reduced to bad sex: Narratives of violent women from the bible to the war on terror,” *International Relations*, Vol. 22, No. 1, 2008, pp. 5-23.

However, despite this symbolic weight, the military uniform in France reveals the limitations of the institution regarding inclusion. The unsuitability of military attire – poorly adapted to female morphology and even less to maternity – reflects a certain lack of interest, or even a notable delay, concerning questions of inclusion. This stands in contrast to the United States, which has provided military uniforms that account for specific female requirements, particularly those related to pregnancy.²⁶ In France, women in the FASF may obtain authorization to wear civilian clothing during this period. However, this transitional solution, while pragmatic, implies a symbolic renunciation of their military status in the public space. It visually excludes them from the institutional recognition mechanism provided by the uniform.



Department of Air Force Women's Initiatives Team LinkedIn Page
(March 2023)

Often relegated to the rank of a secondary concern, the uniform possesses a strong symbolic dimension within the armed forces. As such, it could constitute a relevant lever among others to strengthen the attractiveness of the military for women by helping to consolidate their sense of legitimacy and belonging to the institution.

2.4 When Recruitment Policies Fail to Meet Expectations

2.4.1 Affirmative Action: A French Experience Struggling to Convince

While the introduction of explicit quotas is illegal within the civil service, France and the United States employ mechanisms aimed at multiplying the professional opportunities offered to women, particularly within historically masculine institutions such as the armed forces.²⁷ Under the leadership of Florence Parly, Minister of the Armed Forces from 2017 to 2022, a proactive policy to increase the representation of women was implemented. The aim was to accelerate female access to the highest ranks. The initially set objective of reaching 10% of women among general officers by 2025 was doubled in the latest Military Programming Law (*Loi de programmation militaire*, LPM). This law aims to increase this rate to 20% within a few years.^{28,29}

26. “[Getting a Seat at the Table: How a WIT LOE changed pregnant airmen’s access to maternity uniforms](#),” *The Military Working Mom*, 7 January 2023.

27. “[Affirmative Action: Myth versus Reality](#),” Upstate Medical University.

28. M.-H. Herouart, “[La longue et délicate féminisation des armées](#),” *France Inter*, 14 March 2021.

29. “[Loi de programmation militaire 2019-2025](#),” official website of the French Ministry of Armed Forces.

Although constituting major progress in terms of the inclusion of women, this objective has nonetheless drawn criticism from observers. Both within the institution and in the media, voices have denounced a rushed feminization policy. Furthermore, female military personnel have expressed concerns regarding a strategy deemed at times counter-productive, notably following the Promotion Council of December 2020. Indeed, the publication of the list of promoted officers was delayed by several days due to a disagreement between the highest state authorities. They judged the representation of women on this list to be too low in relation to inclusion objectives. This episode fed suspicions of interventionism in the promotion process. Consequently, it altered the perception of neutrality and merit which traditionally underpins hierarchical legitimacy in the military.

This example supports the narrative that criteria of excellence could potentially be sacrificed on the altar of inclusion. Such a perception has a deleterious effect on the ideal of equal opportunity upheld by the military.

In an institution deeply attached to the principles of merit, seniority, and neutrality, a policy perceived as imposed or artificial can encounter strong resistance, including from those it is intended to benefit. As highlighted by U.S. General Lori Robinson: “The military is a true meritocracy. We all start on the same playing field with the same oath.” This rule must prevail to guarantee the effectiveness of inclusion policies without compromising internal cohesion or the meritocratic justice prevailing within the armed forces.

2.4.2 Evaluating Efforts in the Absence of Effective Tools: A Difficult Quantification of Inclusion

Initiatives aimed at strengthening the inclusion of women in the military encounter a structural paradox. According to Lieutenant-Colonel Alexei Kambalov, former commander of the 348th Recruitment Squadron, the U.S. armed forces possess sophisticated systems for collecting detailed demographic data on their new recruits. However, they lack quantified targets regarding parity, for fear of violating federal legislation prohibiting any discrimination based on sex.

The USAF’s Air Force Recruiting Information Support System (AFRISS) constitutes a telling example in this regard. It systematically records data relating to gender, ethnic origin, and other demographic variables of candidates.³⁰ These statistics, which include the percentage of female candidates, are closely monitored by human resources departments. However, despite being available, these indicators are not intended to be used to help recruiters guide selection, thus limiting their operational utility.

Each selection board of the USAF, and now of the USSF, publishes its detailed demographic data on personnel composition. These elements, categorized by specialty and command, are regularly transmitted to the Department of Defense and to Congress. They allow for a retrospective evaluation of the efforts and progress made

30. Interview with Lieutenant-colonel Alexei Kambalov, Commander of the 348th Recruiting Squadron, January 2023.

in terms of inclusion. Nevertheless, in the absence of explicit quantified objectives, it remains difficult to translate them into effective recruitment policies on the ground or into coherent institutional directives.

Under these conditions, several questions arise. How can the process of recruitment and retention of women be improved in the absence of formalized tools to define clear objectives? And, more specifically, how can the USSF and the French Space Command (Commandement de l'Espace, CDE) distinguish themselves positively in terms of inclusion by learning from the limitations observed in other branches of the armed forces?

3. Understanding the Importance of Organizational Culture: An Essential Condition for Success

3.1 France and the United States: Perspectives Shaped by Distinct Historical Heritages

Both the USSF and the FASF have room for improvement in terms of inclusion. However, any attempt to transpose best practices from one country to the other requires, as a prerequisite, a nuanced understanding of their respective national cultures. Indeed, divergent conceptions of diversity, equality, and identity – deeply rooted in the political and social histories of France and the United States – shape inclusion strategies and the public reception they receive.

In her work, *The Cultural Mindset*, Afsaneh Nahavandi sheds light on the contrasted philosophical approaches to diversity in France and the United States. The French republican tradition is based on a principle of universalism, inherited from the Enlightenment and the Revolution. According to this conception, individuals must be treated in a strictly equal manner, independent of their origins, gender, or religion, to avoid a fragmentation of the social body.³¹ However, the drawback of such a policy, which deliberately ignores differences, is that it renders structural inequalities invisible, effectively preventing their treatment and resolution within organizations.

Conversely, the social and political history of the United States has favored a multicultural approach. In this model, the recognition of ethnic, cultural, or religious identities is not only permitted but also often encouraged within many institutional contexts.

Despite persistent social inequalities between different communities, the U.S. system relies on highlighting differences and implementing policies aimed at integrating them into a common framework. Thus, diversity is frequently valued through concrete measures. These include the recognition of cultural heritage – such as the authorization of traditional hairstyles like braids – or the adaptation of uniforms to physical realities, particularly during pregnancy.

31. A. Nahavandi, *The Cultural Mindset...*, *op. cit.*, p. 206.

These fundamental divergences between the French and American approaches explain the contrast in their inclusive policies within the armed forces. While the United States explicitly acknowledges particularities, France maintains a posture of symbolic erasure of these differences, particularly in the military world, due to its attachment to the principle of republican equality.³²

This tension raises the question of how inclusion policies should be adapted. It underlines the necessity of avoiding the mechanical duplication of foreign models, suggesting instead the design of strategies consistent with national cultural foundations.

3.2 The Creation of the USSF and the CDE: Accompanying Organizational Change

3.2.1 When everything remains to be constructed

The establishment of the French Space Command (CDE) and the USSF offers a rare opportunity to foster an entirely new organizational culture. In the absence of a heavy institutional heritage, these entities possess a unique potential to initiate a dynamic of cultural transformation based on innovation, strategic vision, and risk-taking.³³ This situation grants their leaders exceptional latitude to define a new cultural DNA by establishing new norms, values, and practices to be adopted.³⁴

In his work, *Organizational Culture and Leadership*, Schein posits that the creation of an organizational culture relies on specific tools of influence available to founding leaders. These tools allow them to imprint their beliefs and values.

Schein thus identifies several major levers:

- the manner in which leaders react to crises and critical situations;
- the allocation of human and material resources;
- the capacity to teach, train, and support expected behaviors;
- the attribution of rewards and sanctions;
- the processes of recruitment, selection, promotion, and exclusion.

According to Schein, by acting concretely upon these elements, top leaders can profoundly orient collective representations and professional practices. Within the context of creating new military structures, this capacity for influence is a powerful lever for establishing a new organizational culture and communicating a message in line with contemporary expectations.³⁵ Consequently, leaders play a crucial role in the establishment of a new, more inclusive culture at every stage of the organization's growth. According to U.S. political scientist Peter Garretson, military culture

32. *Ibidem*, p. 207.

33. K. Cameron, "A Process for Changing Organizational Culture," p. 433; in T. G. Cummings, *Handbook of Organizational Development*, Thousand Oaks (CA), SAGE Publishing, 2008.

34. E. H. Schein, *Organizational Culture and Leadership*, New Jersey, Wiley, 2017, p. 18.

35. *Ibidem*, p. 184.

varies widely from one service to another. However, it depends above all on what he designates as the “founding effect,” namely the lasting imprint left by the structural choices made by the initial leaders of a new organization.³⁶

The command of the USSF appears to be perfectly conscious of this reality. Thus, the Chief of Space Operations (CSO) and the Chief Master Sergeant of the Space Force (USSF) have placed inclusion at the heart of their strategy. As explained by Lieutenant-Colonel Alexei Kambalov, former commander of the 348th Recruitment Squadron, “This guides our recruitment efforts, and we prioritize our time and the messages we disseminate.”³⁷ The USSF thus relies on a diversity of profiles – not necessarily female, but those who demonstrate a genuine commitment to an inclusive culture – thereby shaping the DNA of this military branch in the making.

3.2.2 The USSF: A Unique Opportunity to Establish New Standards

Unlike other branches of the armed forces, whose traditions are inherited from an era marked by strong male homogeneity and conservatism, the USSF and the French Space Command possess the unprecedented opportunity to create an institutional culture that meets contemporary expectations.³⁸ They can become a laboratory for innovation in matters of diversity and human resources management by integrating the notion of inclusion from their very inception.

In a context where the expectations of new generations – particularly Generation Z (the population born between the late 1990s and the late 2000s) – are evolving rapidly, organizational reputation constitutes a determining factor in the recruitment process. Potential candidates inform themselves in advance about an organization’s culture via digital communication channels, such as websites or social networks. They determine whether they share their values before applying. Therefore, the representation of diversity in these spaces becomes a key strategic tool. It creates an inclusive identity and plays a vital role in attracting talent and building human capital.³⁹

As written by Rachel Cohen, a U.S. journalist specializing in defense issues, “The U.S. Space Force has the opportunity to make history as the first military branch created with women in mind from the start.”⁴⁰ This statement underscores the strategic importance of the initial choices made by the USSF and the CDE, as well as their transformative potential across the entire national military landscape.

3.3 Can War Be Waged in Space? When the Spatial Domain Reduces Biases

3.3.1 Specificities of the Space Domain: A Questioning of Gender Biases

The space domain differs fundamentally from other military components by its unique relationship to the use of violence. Unlike other traditional armed forces,

36. P. Garretson, “[Space Force’s Jupiter-Sized Culture Problem](#),” *War on the Rocks*, 11 July 2019.

37. Interview with Lieutenant-colonel Alexei Kambalov, *op. cit.*

38. E. H. Schein, *Organizational Culture and Leadership*, *op. cit.*, p. 332.

39. N. Diaz, “[The Z Factor: What Companies Need To Know About Hiring Gen Z](#),” *Forbes*, 5 September 2022.

40. R. S. Cohen, “[Can the Space Force Be the First Military Branch Built for Women?](#),” *Air and Space Forces Magazine*, 30 October 2020.

the USSF and the CDE do not mobilize their personnel in offensive spatial operations involving direct physical deployment.⁴¹ This characteristic profoundly modifies the representations associated with the military role. In particular, it affects the functional imperative (see 1.3), which is based on the use of force and a gendered division of labor.

The USSF thus offers an operational environment far removed from the traditional image of the battlefield. Although its members participate in training or exercises, deployments remain limited. This ensures a better reconciliation between professional life and family obligations for its members, which remains a decisive factor in women's career paths.

From a sociological perspective, space constitutes a field for the redefinition of military norms. Combat in space is characterized by remote actions, the effectiveness of which relies more on advanced weaponry than on the physical skills of the "Space Guardians." Consequently, highlighting these specificities unique to the spatial domain could contribute to broadening the recruitment pool. It may attract female candidates who do not recognize themselves in the traditional warrior narrative, which remains widely prevalent in the other services. As a new space for military action, the spatial domain therefore offers the opportunity to rethink gendered roles within defense.

3.3.2 Constructing a Spatial Culture Founded upon Prestige and Representation

The construction of an organizational culture specific to the spatial domain constitutes a strategic lever for attracting ambitious and enthusiastic profiles to accomplish this new mission. Within any organization, symbolic references play an essential role in generating meaning and creating a collective identity.⁴² Thus, specific medals rewarding Space Guardians for their particular activities constitute a compelling artefact, contributing to the construction of a distinct DNA and military identity for the USSF.

Role models play an equally central part. Since November 2022, the selection of Sophie Adenot – the first female officer of the FASF to be chosen as an astronaut for the European Space Agency – has illustrated the mobilizing power of female role models in structuring this new culture. Beyond the general public interest in space, this appointment contributes to legitimizing the growing presence of women in historically male-dominated fields. It simultaneously positions France as a credible actor within the international spatial ecosystem. In this regard, a RAND Corporation survey conducted in 2017 demonstrated the powerful incentive effect of increased visibility for women in high-responsibility positions, both for candidates and potential recruits. Certain female officers even maintain that representation played a fundamental role in their personal trajectories.⁴³

41. P. Thornhill, "[Space Force Isn't a Military Service](#)," *Defense One*, 18 February 2022.

42. E. H. Schein, "[Culture as an Environmental Context for Careers](#)," *Journal of Occupational Behavior*, Vol. 5, No. 1, 1984, p. 71.

43. Y. Douglas, C. E. Steiner, C. M. Hardison, L. M. Hanser, K. N. Kamarck, "[Recruiting Policies and](#)

The spatial domain benefits from a positive image in the collective imagination, associated with conquest and technological innovation, which the armed forces must capitalize on. By constructing their DNA on prestige, modernity, and inclusion, the USSF and the CDE possess a unique opportunity to position themselves as institutions resolutely oriented toward the future, in tune with societal and generational expectations.

4. CDE and USSF: Two Distinct Approaches for Convergent Results

4.1 Common Objectives...

“It does not matter whether a cat is black or white, as long as it catches mice.”

– Deng Xiaoping, Chairman of the Chinese Central Military Commission (1983-1990)

France and the United States share a common conviction: the necessity of attracting all talents, both female and male, to build high-performing workforces. Both the USSF and the FASF encourage a diversity of backgrounds and perspectives, which only a plurality of profiles can provide. However, the primary challenge remains recruitment based upon competence, independent of gender.

The question of the feminization of ranks is the subject of sustained debate in France. Those in favor of complete feminization – of both the rank and the preceding article – view it as a necessary linguistic evolution, illustrated by the use of forms such as *colonelle* or *sergente*. Their opponents favor partial feminization, or its complete absence (for example, *la sergent* or *le colonel*), asserting that the military must stand above gender considerations, including grammatical ones.

Parallel to this, the USSF has opted for an inclusive lexical strategy with the adoption of the term “Guardians,” deliberately erasing any reference to gender in the designation of its members. As highlighted by Major General Clinton E. Crosier, Director of Space Force Planning, “We are currently working on what we call Space professionals. The new term will not include ‘men’. It will not be ‘spacemen’. It will not be a gendered term.”

Thus, the modernization of the armed forces also involves language. This is certainly a symbolic lever, yet one that French and U.S. forces can deliberately integrate into their transformation process.

4.2 ...and Divergent Approaches

Despite a similar objective regarding inclusion, French and U.S. approaches in this matter diverge significantly. While the USSF appears to focus on a recruitment policy specifically centered on women, the FASF adopts a more comprehensive strategy, endeavoring to promote gender equality in a transversal manner.

Thus, several specific mechanisms have been put in place in recent years, reflecting a desire to establish equality of treatment between women and men within the armed forces:

- The 2019 Diversity Plan (*Plan mixité*), which asserts the role of diversity as a lever for operational effectiveness. It notably provides for the presence of at least one woman on every military examination board and develops mentorship, independent of gender considerations;
- The 2018 and 2023 Family Plans (*Plans famille*), aimed at facilitating the reconciliation of professional and personal lives by introducing greater flexibility into military careers, particularly for parents.

These French initiatives align with a logic of equal access to rights without gender distinction. They offer universal measures to military personnel rather than a differentiated approach based on sex.

Conversely, the U.S. armed forces, and particularly the USSF since its inception, have adopted a strategy of highlighting female military personnel, amplified by the media.⁴⁴ This communication relies on showcasing all-female crews or remarkable individual career paths.⁴⁵ Although this media exposure may have an incentive effect on young women, it is not without criticism. Certain female officers maintain that the excessive media coverage of female recruits can engender a differentiated, or even stigmatizing, treatment.

This tension was notably illustrated when Caroline Aigle, then a young lieutenant in training, found herself simultaneously in the media spotlight while engaged in a discreet effort of integration within her squadron. The use of this type of communication to promote diversity may therefore come into conflict with the objectives of combating discrimination and ensuring equality of treatment, which are vital to the French mentality.⁴⁶

In 2004, Michèle Alliot-Marie, then Minister of Defense, asserted that “the integration of women into the armies is thus achieved not through affirmative action measures, but through a policy of strict equality.” This position illustrates the attachment of French institutions to a principle of formal equality, favoring the uniformity of rules rather than differentiation according to social groups. For this reason, the media coverage of French female military personnel generally remains limited and confined to institutional communication. This stance is part of a French republican tradition of uniformity, guaranteeing each individual access to the same opportunities, regardless of their membership in a particular group.

44. H. H. Seck, “US Space Force may become the most female-friendly military service,” *Military.com*, 3 March 2020.

45. J. Whitley, “[Space Force makes history with all-female 2 SOPS crew](#),” official website of the 10th Air Force, 28 July 2020 ; “[Women’s equality day all female crew](#),” official website of the U.S. Army; L. Harsen, “[Super Bowl features all-female flight crew for 50 years of women in naval aviation](#),” *WBCR News*, 13 February 2023.

46. A.-L. Michel, “[Médiatisation des femmes dans les Armées : atout ou faiblesse ?](#),” *Le Figaro*, 26 March 2014.

The policies pursued by the USSF and the USAF are thus part of a dynamic explicitly oriented toward the promotion of women.⁴⁷ The leeway granted since 2008 to the activities of the Women's Initiative Team (WIT) within the Department of the Air Force constitutes a strong signal in this regard.⁴⁸ This team, composed of volunteers, has worked to identify and eliminate the obstacles specifically faced by women within the USSF and the USAF through structural reforms.⁴⁹

Among the primary advancements attributed to the WIT are the improvement of breastfeeding support mechanisms for military mothers, the revision of hair standard policies following alerts concerning the health consequences of prolonged bun wearing, and the abolition of the "pink tax" on female military uniforms, which were previously more expensive than those of men.

These concrete measures, focused on the well-being and quality of life of female military personnel, contribute to establishing an attractive and safe working environment. In return, such measures foster commitment, loyalty, and professional satisfaction among those concerned, who subsequently appear less inclined to leave the institution.⁵⁰

Conclusion

The concomitant creation of the U.S. Space Force and the French Space Command in 2019 occurred within a context where the challenges related to the inclusion of women within the armed forces were more relevant than ever. Since their creation, both entities demonstrated a desire to "get things right," namely to integrate the principles of equity, diversity, and openness into the structuring foundation of their organizational culture.

However, even though the USSF and the FASF are confronted with comparable challenges regarding the recruitment, retention, and career progression of women, their strategic responses differ significantly. These discrepancies are explained notably by historical, cultural, and sociological heritages unique to each country. These include the universalist tradition derived from the French Revolution on the one hand, and the history of immigration and the recognition of collective identities on the other hand.

Thus, France prioritizes an approach based on gender equality, understood as the erasure of perceived differences between male and female military personnel, to guarantee equal opportunities for everyone. This results notably in incentive measures such as the encouragement of paternity leave for male personnel, the deconstruction of gender stereotypes, and the development of relationships of trust between male and female staff. These are established particularly through mentorship based on competence and specialty rather than identity.

47. See Chapter 4, Section 1.

48. As one of seven teams within the Air Force's Barrier Analysis Working Group, the WIT reported to the Secretary of the Air Force's Office of Diversity & Inclusion and was composed of volunteers from the USAF and the USSF. The WIT was dissolved in January 2025 by the Trump administration.

49. Interview with Senior Master Sergeant Brianna Fields (USSF), member of WIT.

50. K. Walsh, S. S. Fleming, C. A. Enz, "[Give and you shall receive: Investing in the careers of women professionals](#)," *Career Development International*, Vol. 21, No. 2, 2016, p. 196.

In contrast, the United States adopts an approach more focused on the well-being of women, by adapting the military environment to the specific needs of women. This includes clothing adjustments for maternity, the revision of hair standards, and the abolition of cost discrepancies between male and female items.

These two approaches, far from being contradictory, could prove to be complementary. Closer collaboration between the USSF and the FASF would allow not only for the sharing of best practices but also for the construction of effective inclusive policies, thereby strengthening the resilience of the space forces in both countries. This cooperation could focus on reducing inequalities in access to scientific training, strengthening prevention against sexual harassment, and increasing the involvement of male personnel in this domain.

As relatively new organizations, the USSF and the CDE have a unique opportunity to establish new organizational standards. Advocating for the inclusion of women is not merely an ethical imperative dictated by current trends. It is, above all, a powerful strategic lever for attracting new talent by reinforcing the appeal of space-related professions. This paradigm shift could undoubtedly constitute a strong new identity marker for these developing institutions.

Author's Note

Despite notable progress in diversity, equity, and inclusion within the U.S. armed forces, the return of Donald J. Trump to power has terminated ongoing initiatives. According to a report by the Government Accountability Office (GAO), these efforts were swiftly suspended. This is evidenced by the elimination of 188 positions related to such initiatives by the Department of Defense (DoD) as early as January 2025, as part of the dismantling of certain inclusion programs.⁵¹ Similarly, the Women's Initiative Team (WIT, see 4.2), which had worked to improve conditions for women in the armed forces since 2008, was dissolved by decree in February 2025.⁵² This resulted in the removal of resources devoted to what the Department describes as "gender ideology."⁵³

This new orientation has also resulted in the dismissal of several female generals whose activities included initiatives promoting inclusion. Among them, Admiral Linda Fagan, the first woman to lead the Coast Guard, was dismissed on the first day of President Trump's return to power. The stated reasons included an "inability to manage border threats and an excessive focus on diversity programs."⁵⁴ A few weeks later, Admiral Lisa Franchetti was likewise removed from her post by the Secretary of Defense, Pete Hegseth, followed by Lieutenant General Telita Crosland, Director of the Defense Health Agency. Finally, Vice Admiral Shoshana Chatfield, known

51. S. Losey, "[Since early 2024, DOD has cut nearly 200 DEI-related jobs: Report](#)," *Military Times*, 17 April 2025.

52. Savannah Bray's post, *LinkedIn*, February 2025.

53. "[Memorandum for All MAJCOM-FOA-DRU-FLDCOM-COCOM/CC](#)," official website of the Department of the Air Force, 4 February 2025.

54. J. Wu, "[DOD leadership firings spark concerns over support for female officers](#)," *Marine Times*, 17 March 2025.

for her stance on gender equality within the armed forces, was dismissed in April 2025 due to a “loss of confidence in her ability to lead.”⁵⁵ Extensively covered by the media, these successive dismissals provoked a wave of protest for rendering women invisible at the highest levels of responsibility.

Other positions taken are indicative of a marked change in orientation within the armed forces. For instance, a memorandum from the Department of the Air Force dated 4 April 2025, entitled “Implementation of Executive Order 14168, Defending Women from Gender Ideology Extremism and Restoring Biological Truth,” now mandates the use of the term “sex” instead of “gender,” which had been previously used in administrative forms.⁵⁶

These decisions are echoed in the speech delivered last September 30 by Pete Hegseth to U.S. generals.⁵⁷ During this address, he notably described inclusion policies as “ideological distractions” that diverted the military from its primary mission: the preparation for and conduct of war. The change in terminology by the Department of Defense – now referred to as the “Department of War” in certain communications – confirms this martial shift.

Return to a Martial Discourse

Although meritocracy remains a central principle for progression through the military ranks, Pete Hegseth now establishes “combat capabilities” as the sole criterion for professional recognition. He has even suggested a re-examination of current standards. This conservative approach marks the return of a masculinist and restrictive vision of the armed forces. Within this framework, non-physical qualities would be ignored, mechanically ousting numerous women from the ranks.

The question then arises as to whether this constitutes a confirmed trend or a temporary setback. The extension of this vision to the space sector, where physical confrontation is not on the agenda, could prove problematic. A marginalization of women risks depriving the military of fundamental expertise. Furthermore, however paradoxical it may seem, the art of war relies upon empathy or, according to Sun Tzu, the art of disregarding one’s own perception – a faculty essentially nurtured by a diversity of perspectives.

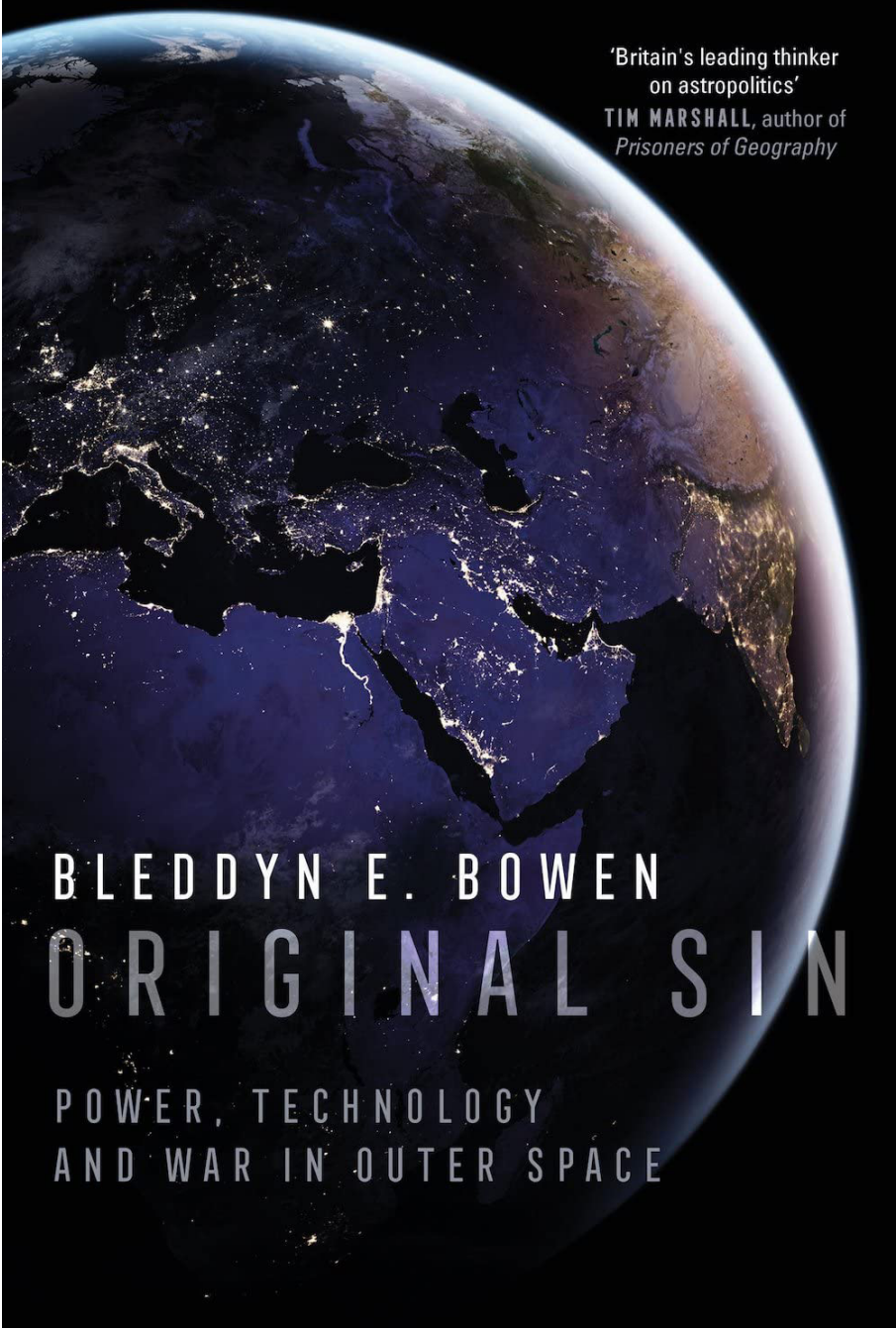
As such, the United States is on the verge of becoming a laboratory for ideological, and thus organizational, experiments. The implications of these choices, whether adopted or contested, will undoubtedly guide future practices. They will provide major lessons for the design of human resources policies within the armed forces.

55. E. Watson, “[With ousting of admiral to NATO, Trump administration has fired at least 9 senior officers](#),” *CBS News*, 8 April 2025.

56. “[Defending Women From Gender Ideology Extremism and Restoring Biological Truth to the Federal Government](#),” Executive Order 14168, 20 January 2025.

57. “[Secretary of War Pete Hegseth Addresses General and Flag Officers at Quantico, Virginia](#),” *official website of the Department of War*, 30 September 2025.

INTERVIEW



'Britain's leading thinker
on astropolitics'

TIM MARSHALL, author of
Prisoners of Geography

BLEDDYN E. BOWEN
ORIGINAL SIN

POWER, TECHNOLOGY
AND WAR IN OUTER SPACE

Interview With Bleddyn E. Bowen

by Béatrice Hainaut



Could you briefly introduce yourself?

I am Dr Bleddyn Bowen, Associate Professor of Astropolitics, and Co-Director of the Space Research Centre (SPARC) at Durham University, UK. I specialise in the military uses of outer space, and international politics in space.

Why have you chosen to study space affairs?

I have always enjoyed scifi and popular science, and when I studied International Politics as an undergraduate at Aberystwyth University's International Politics Department, I got into Strategic Studies and learning about modern warfare. Learning about the U.S. military's modern weapons systems opened my eyes to the practical uses of space technologies and I realised I could study the very real aspects of politics and military affairs in and to do with outer space, rather than speculating about distant visions of human exploration on the Moon or Mars.

This book was written in an interdisciplinary way (history, political science, anthropology...). Is adopting a multi- or transdisciplinary approach when conducting academic research on space policy mandatory?

No, it is not mandatory but it is encouraged in the UK. However, many academic disciplines remain tribal or factional. There is often more scope to write interdisciplinary work for book publishers than academic journals. However, my own discipline of International Relations (IR) can be argued to be inherently interdisciplinary – it draws on political theory and international history to name only two major disciplines that IR draws from. Fortunately British IR tends to be more pluralist than U.S. or European counterparts, therefore in *Original Sin* I was able to draw useful insights across political theory, military history and strategy, postcolonial history and theory, critical theory, and international/Cold War history.

What issues did your latest book address and what were you aiming to demonstrate?

Original Sin is an international political history of the Space Age. It tries to weave together a broad overview of what major powers have built and deployed in Earth orbit, and why, alongside what modern space infrastructure means for global military strategies. Unlike many other works which tend to focus on the United States or the Soviet Union/Russia, I deliberately integrated the space histories and activities of the Asian space powers, as well as Britain and France to paint a Global Space Age. Additionally, I focused on satellites and infrastructure which are the space technologies that really matter for politics and power on Earth – and not astronauts and interplanetary exploration which are scientific and symbolic sideshows.

To phrase it another way, I tried to show how outer space is as political and problematic as any other aspect of human activity – despite the subject matter still mostly focusing on machines in space! Space has always been militarised, and has been weaponised in the past – yet many professionals and experts in space and in diplomacy still think these are new or dangerous areas of activity. In fact, as I tried to show with *Original Sin*, those things have been with us for a long time. Space is more than just rocket science, and I hope *Original Sin* has shown what ‘astropolitics’ is and how outer space is not only for the scientists. Humanities researchers and social scientists also belong in space.

Could you briefly tell us what is this so-called “original sin of space technology” you refer to?

This refers to the military and genocidal origins of much space technology, as a result of Nazi rocket engineering progress with Wernher von Braun in WWII, but also as many of the fundamental space technologies are tied to nuclear weapons industries and infrastructures which would be genocidal in their effects. Whilst the Space Age means more than that of course, we would not have had the Space Age as we know it without WWII and the prospect of nuclear apocalypse.

Some observers in the space sector today seem to regret the Cold War era, when space was seen as a “sanctuary.” Do you agree with them?

If by regret you mean miss its end, then I would argue that they have a very selective reading of Cold War history. Space was not a sanctuary during the Cold War. The U.S.S.R. and U.S. pursued and deployed multiple kinds of antisatellite weapons through the Cold War, and should a nuclear war have happened then, satellites would have been targeted in some way.

One might feel pessimistic when reading your book. You seem to think that space warfare is inevitable. One reason is that you put emphasis on the anarchy of the international relations in the global space age. Still, is there any reason to be optimistic?

No – I do not say space warfare is inevitable. No war is inevitable, nor are the tactics and methods in which such wars may be pursued. However, should a war happen between or involving significant space powers, we should expect space systems to be targeted. Indeed, they already are in the Russian-Ukrainian War through methods such as electronic warfare and cyberattacks.

You note that the ever-growing number of satellites in orbit will not necessarily make space powers omniscient or fully in control of those capabilities. You underline that “No matter the information gathered, the final intention of the other side will never be certain.” The fog of war remains. Don’t you think that this fog is still starting to lift?

No. Clausewitzian theory is particularly useful in explaining this point. Uncertainty and unknowns will always be present, no matter what technical sensors can be built and interpreted. Part of this is the ambiguity of technical data and the duplicitous and deceptive capabilities of people to fool sensors and lie. No sensors can objectively divine human intent or reactions to events.

What do you think of some state actor’s dependence on space-based commercial services? Could it be otherwise? Does this give rise to new risks?

In capitalist states private actors have always been present in the space industry and infrastructure. Their roles as contractors are hardly new to military logistics. There are always risks and all economic actors and interests are given more or less power based on the will and design of the political authority of the day, as it is the political authority that ultimately can seize or nationalise assets, and arrest private actors for breaking laws in their jurisdictions. However the military-industrial complex in space is well established across NATO states and the relationship is symbiotic now between public and private, notwithstanding recent events in U.S. leadership and industry relations.

In your view, what will be the consequences of a growing number of states seeking autonomy in certain space technologies? Should we be concerned about a potential proliferation of space systems that could threaten regional or even international stability?

Space systems are proliferating regardless, and international stability beyond the notion of guaranteed second strike nuclear capabilities is a chimera. More space systems mean more environmental pollution on Earth and in space, therefore space technologies are not a silver bullet to environmental problems on Earth. The notion of strategic stability is often parochial and selective, such as the Cold War which was seen by many as stable yet millions of people died in various wars through the Cold War around the world. Today, even though China, Russia, and NATO may not be at war with each other and observe a nuclear peace, wars continue to rage. Therefore the idea of strategic stability is not a useful one.

Can you elaborate a little bit on your concept of “technopolitics of the Global Space Age”?

Technopolitics refers to the political values and interests that are imbued in technological designs, systems, and artifacts. People create machines to meet the interests of people – the meeting of technics with the whims of a polis, or, technopolitics. Often technologies of all kinds, not just those in space, meet the needs and interests of certain groups at the expense of others.

You show how the “stabilising role” once attributed to space technology is now being challenged, as space powers deliberately use it across “the full spectrum of military combat and support missions during wartime and crisis situations.” According to you, the development of space weaponization is not the true cause of instability – rather, it is a consequence of the increasing dependence of military power on satellites, which can be targeted in times of war. So, in your view, would the solution be to demilitarise space? Or, because it is hardly feasible, how could we slow the so-called arms race in space?

Yes, perceptions held by Cold War historians such as John Lewis Gaddis that reconnaissance satellites were “stabilising” is only a partial view, and one that often reflects U.S. preoccupations. Yes, it helped curb some of the worst paranoia in Washington, D.C., but little else. It did not eliminate the risks of nuclear annihilation, and indeed was a product of the same technologies that brought about that risk in the first place. Satellite reconnaissance and early warning has always been far less relevant for the nuclear threat perceptions and postures of the other nuclear powers: China, Russia, Britain, France, India, Pakistan, and North Korea.

Indeed, if you want to eliminate the risk of space warfare to zero, you would have to never use space, or more specifically Earth orbit, for military or economic purposes. After that, space warfare would serve no practical purpose. That is not feasible for the same reason we will not demilitarise the oceans or the skies.

I wouldn't say there is an arms race in space at the moment. The concept of an arms race is ill-defined, even within IR which spills much ink on it. The situation we are in with space weapons is not comparable in scale or importance to the arms developments of Britain and Germany at sea in 1900-1912, or the U.S.S.R. and U.S. in nuclear missiles between 1950-1970.

At what point does a systematised, methodical armaments and research and development programme become a race? I'm not sure – but I am not seeing crash programs and mass deployments of space weapons at the scale necessary to destroy all the satellites of a potential adversary, and nothing in terms of the resources spent in the supposed arms races of the past. But it is true that the major powers and many other modest space powers – not least France – are interested in developing more methods of disrupting and neutralising space systems in the event of war. I don't like to use the phrase “arms racing” as I feel it traps people into thinking simplistically in terms of action-reaction whilst arms developments and research happen all the time, and can also see peaks and troughs in activity, as they did throughout the Cold War.

How can we assess Russian space power today? Do you think it is on the verge of collapse? Or do you believe that Russia still is capable of keeping its capabilities afloat?

It's very much in decline compared to India, China, and the U.S. It can only keep trading on its Soviet legacy for so much longer. It will probably be able to maintain essential military and civil satellites (e.g. satellite TV, reconnaissance) but it will struggle to innovate as it grapples with severe financial and demographic problems which have only been exacerbated with its war of aggression on Ukraine. Its human spaceflight future seems to be tied to Chinese interests and how much trust China places in future Russia robotic and human space exploration capabilities, which haven't had a good record in the last 10 years.

According to you, space warfare “needs to help achieve the goals of the war on Earth by creating strategic effects in space or with space systems.” Do you believe space warfare exists only in times of war, or does it also occur in peacetime – if we consider the increasing number of hostile or at least unfriendly acts taking place in orbit?

By definition space warfare only exists in a condition of war. But it is a subjective definition. Acts that would constitute space warfare actions in a campaign, e.g. electronic warfare, cyberattacks, can also be part of low-intensity sabotage campaigns in peacetime.

But other forms of space warfare would not – i.e. nuclear detonations or a missile strike on a satellite. Whether or not you think one is at war with another is a political judgment, not a technical one. Watertight definitions are impossible, as Clausewitz would argue. What matters is if the concepts you are using help you make sense or clear points about the argument you are trying to make. Either way, you cannot view acts in space in isolation – you have to attach political context to them to make sense and respond accordingly. Individual acts always happen in a wider political context.

What form could space warfare between great powers take in the future according to you?

I would recommend that readers read *War in Space* for that as the theory explores it across 100,000 words. The forms can take many shapes and in different levels of intensity. It is difficult to summarise shortly because the number of space systems and their varieties, as well as services and users, are so diverse. There are many different ways of disrupting or destroying the complex space infrastructures that military force and economic systems rely upon. My point in my work is that we are dealing with possibilities and diverse scenarios where actions are difficult to predict, whilst many commentators think that their particular vision of space warfare is a certainty or inevitability.

Can strategic objectives be achieved using what you refer to as “soft-kill methods” such as cyber-attacks and electronic warfare?

Yes, if those strategic objectives are defined in such a way that cyberattacks and electronic warfare help meet the wider objectives and no recourse to other methods are required. Those would be quite unique and rare strategic objectives though. But not impossible. Most major powers do not place their faith in a small number of weapons systems and instead want a range of options to choose from.

You have introduced the concept of the “cosmic coastline of Earth orbit” which has far greater explanatory power than the notion of the “ultimate high ground.” Could you briefly explain why?

Again I would recommend readers to read my prior work for the full description and explanation. In short, the ultimate high ground induces a strategy of positions rather than a strategy of action and reaction, of directing blows against the enemy. Clausewitz warned against position-based strategies where victory is assumed because of a perception of superior position and omniscience via better reconnaissance. In contrast the cosmic coastline encourages thinking of Earth orbit as still a terrestrial environment that cannot be understood in isolation from events on Earth. It is a secondary environment like continental naval powers view the sea in land wars. It is not the primary theatre and often serves logistical and support effects towards other theatres. It needs active protection and exploitation to make it useful to an overall war plan, and even with that, it is not decisive in winning wars by itself. Continental naval powers such as France and India know this all too well, but it is a concept that is alien to maritime powers such as the United States and Britain.

What long-term consequences might arise from the fact that most of the GAFAM companies have aligned themselves with the MAGA movement?

We shall have to wait and see. The relationship between Donald Trump and MAGA itself seems febrile at the moment, let alone with the elites of U.S. industry. Either way, we are in uncharted waters and the unpredictability and volatility of policy and behaviour at the White House and across the Republican Party is fast eroding U.S. power and the foundations of trust U.S. allies have had in U.S. institutions and

the stability of its foreign and security policy. Either way, the United States is an increasing source of uncertainty for the security and economic policies of Europe, South Korea, Taiwan, and Japan.

Do you plan to write a new book?

Yes I am currently working on a more historically oriented book on British space history supported by SPARC at Durham University – there'll be more to come on that in due course as it is early days at the moment!



Interview With Arnaud Saint-Martin and Irénée Régnauld

Béatrice Hainaut



Copyright: Anthony Francin/La Fabrique
Irénée Régnauld (left) et Arnaud Saint-Martin (right)

Irénée Régnauld is a doctoral candidate in sociology at EHESS/INSA, specializing in digital issues and space policies. Since 2014, he has maintained the blog “Mais où va le web?” He is the author of Technologies partout, démocratie nulle part : Plaidoyer pour que les choix technologiques deviennent l’affaire de tous (Paris, FYP, 2020) with Yaël Benayoun.

Arnaud Saint-Martin is a sociologist at the CNRS, affiliated with the European Centre for Sociology and Political Science (CESSP). He specializes in political space activities through the lens of social sciences and is completing an investigation into the rise of New Space in the U.S. Since 2024, he has been a Member of Parliament for Seine-et-Marne, a member of the National Defence and Armed Forces Committee, and Vice-President of the Aeronautics and Space study group.

The book *Une histoire de la conquête spatiale. Des fusées nazies aux astrocapitalistes du New Space* by Arnaud Saint-Martin and Irénée Régnauld¹ proposes, contrary to existing literature, a return to the origins and evolutions of using space to satisfy human needs. Far from the romanticized narratives of space conquest, the authors revisit the original military objectives of this enterprise, which originated in Nazi Germany and was very strongly associated with the development of ballistic missiles. This legacy persists when these same Nazi engineers were recruited after the war by the victorious states of the Second World War to support their exploitation of space.

They also contributed to promoting an “astroculture,” which asserts that the conquest of space is inherent to humanity. This offers a positive interpretation, marked by “dreamlike, peaceful, and futuristic thoughts.” This astroculture continues to stimulate individual and collective imagination. It is still used to “sell” space today. Nevertheless, far from these rosy narratives, the authors show that the militarization of space continues unabated and that its weaponization is inevitable. The authors also announce the expansion of “astrocapitalism,” a form of capitalism applied to space, which began as early as the 1980s. This notion is currently embodied by the New Space concept, which promotes SpaceX as the model for all states to follow. Not entirely convinced by these dynamics, the authors explore other potential uses of space that would be neither warlike nor mercantile, but rather sustainable.

We wished to discuss this original book with the authors and the intriguing theses they develop.

Which of you two came up with the idea of such a work? What were the reasons for writing it, and why was it written by the two of you?

We met in 2021. Irénée was preparing to organize a roundtable discussion on the astronautical industry within the framework of his association for reflection and debate on technologies, “Le Mouton Numérique.” Arnaud was necessarily among the invited guests, being one of the few French specialists on the subject in the humanities at the time, then working at the CNRS. Geographer Isabelle Sourbès-Verger and astrophysicist Éric Lagadec were also invited. Through emails and lunches, we continued the discussion. Arnaud had already extensively covered the field of “New Space” with several research articles and an ongoing study. Irénée linked space issues to his preferred topics, namely socio-technical controversies in the digital domain.

We shared a common observation: the absence of a detached work on the history of astronautics. We also had two parallel book projects with slightly different but compatible approaches. In practical terms, we made the decision to write it together quite simply, during a lunch at the Tourne Bouchon, just steps from the EHESS in Paris. Several choices of publishers were presented to us. Arnaud had been discussing the project with La Fabrique for some time. This was the editor we finally settled upon, as it perfectly matched the general idea of the future book: to provide a critical

1. I. Régnauld, A. Saint-Martin, *Une histoire de la conquête spatiale. Des fusées nazies aux astrocapitalistes du New Space*, Paris, La Fabrique Éditions, 2024.

perspective on the subject while maintaining academic rigor. From chapter to section, we refined the coherence and the style, and created a writing dynamic that felt natural.

The book analyzes how the space conquest of yesterday fueled that of today. It discusses, in particular, the media's portrayal of a specific image of space conquest: that of dreams and scientific discoveries. However, you assert that this conquest of space and minds actually conceals warlike and speculative dimensions. This paradigm is still present today to the extent that it gave rise to astrocapitalism, characterized by a destructive headlong rush. Were you surprised by these findings during your research? If so, in what way?

Our research strategy can be summarized quite simply: we take issue with a certain number of commonplaces in space history to enhance their comprehension. We do not do this to feed a kind of social critique of techniques, which would be futile, or to reinforce a negative prejudice towards space. Rather, the objective, shared by specialists in human and social sciences interested in space issues, is to analyze these realities objectively. This is not easy because the fantasies and the enchantment, maintained since the space age, shape a perception that is often uncritical, or even hostile to questioning.

A methodological reflex, for those of us working within this scientific perspective, is to analyze and thus distance ourselves from the cultural definitions of “the conquest of space.” This involves identifying the justifications for this endeavor. This serves to illustrate its historical and, at times, controversial nature. The space race has not always won the support of the masses, far from it. The dream, the science, the naturalization of the need to explore space, and also the chauvinistic temptation, are all expedients used to sell space. And, it must be said, to divert attention. While the general public was invited to admire the feats of astronauts on the Moon, the military was deploying their capabilities in Low Earth Orbit with the utmost discretion. Astrocapitalism is not new either, and this destructive headlong rush that defines it comes from afar.

For us, the entire challenge is to explain why and how these path dependencies are organized – the fact that these social, economic, military, and political structures of astronautics are long-lasting – and to what extent this obstructs alternative conceptions. We were neither disconcerted nor surprised in our work on the archaeology of Space. What is most striking is that it is always the same themes that recur. Notably, the repressed Apollo-11 moment, which relentlessly keeps resurfacing.

Some rather hostile (but also enthusiastic) reactions were made upon the publication of your book. Did you expect this?

Initially, we did not specifically anticipate such strong reactions. After all, a good part of this work consisted of cataloging events that were more or less known but were, in any case, established by historical records. We referred to classic authors in the field, such as John Logsdon and Michael J. Neufeld, while attempting to diver-

sify our approach with more critical narratives that were nonetheless rooted in the humanities. The result is an original history of the conquest of space, certainly less unanimous than what is usually read. This exercise earned us some criticism from several quarters. First, promoters within the French astrocapitalist ecosystem engaged in crude slanders against us, even in a recent essay. Then, a YouTuber, who is quite popular in France, promised a year ago to “debunk” us, while calling us various colorful names in passing. Many space enthusiasts were disturbed by our questioning of the sector’s promises or the value of manned spaceflight.

Concretely, of course, absolutely nothing happened. These various attacks resembled strategies of symbolic defense, activated from a small professional field where space is a matter of passion, careers, and heroic narratives that must be preserved. The mere presence of critical discourse, even modest, is sometimes enough to trigger disproportionate reactions, often more emotional than rational. Ultimately, it is somewhat ridiculous. However, it is also revealing: dogmas die hard in the space industry. Let us be clear: nobody has ever challenged us on the content of the book, which is, moreover, very well received in the academic sphere and even within parts of the industry where reflexivity can be high.

Can you define astrocapitalism? Where does this concept come from?

This concept did not exist in nature. We forged it to construct the subject and avoid integrating endogenous preconceptions prevalent in the environment we were observing. The idea was already circulating. We could cite the pioneering work of the Marxist sociologists Peter Dickens and James Ormrod. Another source of theoretical inspiration was provided by the equally Marxist approach of geographer David Harvey. He offered the theoretical means to analyze the dynamic expansion of capitalism into geographical space, initially terrestrial in his essays. This expansion aims to resolve the internal contradictions related to crises of over accumulation. His key concept is the “spatial fix,” which we translated as the “spatial solution” (which allows us, incidentally, to connect with the literature on technological solutionism). This spatial solution allows us to describe the insatiable search for new niches and markets by astrocapitalists. This expansion is akin to an inherent constraint for an accumulation system that seeks to be limitless and is driven by hypotheses of exponential growth. This is the oblique meaning of the “fix,” which denotes an irresistible need, like that of a drug addict in withdrawal.

Much remained to be characterized and explored, especially given the rapid pace of evolutions. It is a critical concept in the sense that it aims to break with the common-sense constructions of the “space economy.”

Astrocapitalism allows us to expose how capitalism has been, in a sense, projected into exo-atmospheric space. This process is intrinsically linked to the space age. It is just as constitutive of the dynamic of its formation as militarization is. This astrocapitalism has been deployed primarily in Low Earth Orbit, via space telecommunications, and various markets that merchants have attempted to capture: space transport, Earth imaging, scientific research and technological development, tour-

ism, celestial resource mining (which is still very theoretical), and etc. This astrocapitalism is not an abstraction in orbit: it constructs social relations of production on Earth, dividing space capitalists and workers. It is an entire field of commercial activities and organizations that we are reconstituting through the use of this descriptive and explanatory concept. Breaking also with the sympathetic yet unrealistic vision of the “space community” motivated solely by exploration and the desire for the cosmos, we reintroduce social and political conflictuality *through* and *in* space: the economic power dynamic, domination, the predatory appropriation of resources, the lure of gain, and the race for profit.

The other point we intentionally insist upon is the intimate relationship between astrocapitalism and the state. It is a delusion to imagine that the “private” entrepreneurs of New Space are free from public power. SpaceX would be nothing without the infrastructure, the mass of accumulated expertise, the past investments, and the contracts and orders from the U.S. federal State. It is an armed wing, a giant that has become “too big to fail,” and in a certain way, a kind of Frankenstein’s creature: a public-private hybrid. This organizational complicity leads us to speak of state astrocapitalism. This is now entering a phase of militarization, coinciding with the era of the “war economy” and the increase in spending in the military space sector. Here again, the example of SpaceX, an increasingly unavoidable supplier to the Pentagon, is highly telling.

Is the astrocapitalism you describe ultimately only a purely U.S. phenomenon, given the specific characteristics of the U.S. space sector? Can this “model” be exported without “local” adaptation?

Capitalism, and even more so astrocapitalism, which is an extension of it, is not a U.S. invention. The ground was certainly fertile in the United States for it to take root. It is in this spirit, moreover, that we interpret the rhetoric of “New Space” as an ideology of the total commodification of space uses. It is a byproduct of U.S. political culture. It emerged during the ultra-liberal and pro-business Reagan era and was then consolidated during the 1990s under the influence of intense normative work, carried out by entrepreneurs, investors, and evangelists of the New Space gospel. This concept has since been adopted in other countries. The collapse of the USSR favored an internationalization of space commerce. The entrepreneurs, mercenaries, and other brokers of astrocapitalism are busy capitalizing on the promises of the various niches in the space economy, beginning with telecommunications, which is pulling everything in.

France is an excellent case study of this local adaptation. Astrocapitalism has long been a French passion. The “useful space” strategy, championed at CNES by Hubert Curien in the 1970s and 80s, accompanied by a policy of creating subsidiaries (Arianespace, SPOT Image, CLS), aimed to promote the use of space for economic ends. This proved profitable. The state assumed the role of a strategist on the commercial and industrial front. We will not recount the entire chronology, but at one point in the history we sketch, this vision of an administered space economy

(which prevailed in the United States and the USSR) collided with the methods of entrepreneurs who embraced the start-up spirit and Silicon Valley.

The rise of SpaceX sharply awakened awareness. Initially scorned during the 2000s, and not taken seriously by the suit-and-tie executives of French and European agencies and industry, the Californian company began to raise concerns with its technical achievements and commercial successes, before being associated with commercial aggression. At one point, it became the model to follow. SpaceX, along with all the trendy imagery of “disruptive” technosciences that promise so much in the United States and attract global finance, became dominant. “New Space” is the keyword summarizing this shift in model and regime: through commerce, the cult of the new enterprise, privatization, and profit. In France, the planning and strategic state has been replaced by the “start-up mode” state. The Ministry of Economy and Finance took things in hand at the beginning of the 2020s to devise an astrocapitalism “2.0” and made-in-France, through the space component of the France 2030 program and other initiatives moving in the same direction. It may still be too early to fully evaluate the results of this commercial escalation, which has not been unanimously embraced by the space community.

Do you think that the existence of an imaginary world is essential to “legitimize” the use of space?

Historically, this has certainly been the case. The history of space is entangled with foundational myths: those of the frontier, the Wild West, and Manifest Destiny in the United States, and partially Cosmism in the USSR. The very idea of materially and humanly occupying space was not a given before the end of the 19th century. One could also perceive a colonial or neocolonial imaginary at play, depending on the period (the idea of the wilderness or savage expanse to be conquered clearly relates to this). Graphically, these myths were illustrated very early on by “space artists,” such as Lucien Rudaux in France and Chesley Bonestell in the United States in the mid-20th century. However, space travel cannot be dissociated from the science fiction narratives that emerged a few decades earlier, including the genre of *merveilleux scientifique* (scientific wonder) in France, and adventure stories of the Edisonade type, followed by space opera, on the other side of the Atlantic.

Some of these “imaginaries” are indeed recycled to justify and legitimize certain uses of space, foremost among them its occupation by humans. As we show in our book, they nevertheless struggle to be convincing over the long term. They are regularly supplemented by rhetorical additions that draw from other registers of justification. This includes science, health, and even economic growth, which fall under different horizons of belief or socio-technical imaginaries. Thus, the original myths are never far away. For example, when there is talk of creating medicines to cure rare diseases in orbit, the same promise of abundance is found. This is similar to the idea of going to mine the Moon (which already abounds with gold in Fritz Lang’s 1929 *Woman on the Moon*). Nearly a century later, this remains a focal point of global geopolitical competition due to the resources supposedly located there.

Behind the scenes, many actors in the space community know that these objectives remain highly speculative or, at the very least, symbolic. Military prerogatives remain paramount. They, too, rest on representations that are always debatable: the idea of the “highest point” and that whoever “dominates space will dominate the world.” This rhetoric is also heard in the field of artificial intelligence to justify enormous public spending while everything around seems to be collapsing, starting with the climate, social justice, and so forth.

To answer the question more precisely: any massive investment in advanced technologies – in the case of astronautics a heavy and expert industry – also relies on a compelling narrative. The fact that the narratives which have prevailed until now have dominated does not mean that no alternative is possible. European space endeavors, for example, draw their sources from the same place as U.S. astronautics: war and nuclear technology. Nevertheless, the social artefacts and arrangements that followed adopted other forms, linked to efforts of scientific cooperation between European countries and a somewhat less belligerent perception of space. The future of this industry is therefore anything but predetermined.

Does forcefully recalling the Nazi past of rockets teach us anything about space today?

Yes, clearly. Recalling the Nazi origin of a (consequential) part of the astronautical sector is more than just a duty of remembrance: it is a critical key to understanding the contemporary spatial imaginary. We wanted to present this in the form of a concise first chapter, which broadly recounts what everyone seemed to know without ever having articulated it so distinctly. Beyond the already known elements (the construction of the first V-2s at Dora-Mittelbau and the “migration” of Nazi engineers to the United States and elsewhere, including France), we sought to enter into the details of this graft that “took hold” from one continent to another, against a backdrop of clearly compatible ideologies.

Alabama in the 1940s was a rather welcoming state for former dignitaries of the Third Reich. In its own way, so was France. If we consider only the figure of Wernher von Braun – though we actually follow a number of the engineers from that clique – the book is also an opportunity to recall, with the support of academic and historical sources, the responsibility of these men in the deaths of tens of thousands of concentration camp prisoners, and their active participation in the Nazi regime. Insofar as several of these figures are still widely mobilized as “pioneers” of astro-culture, this is a way of putting history back in its proper place. This work has also earned us thanks from specialists of that period, including a grandson of a deportee to Dora.

Describing this sequence is also a way of assuming this past rather than constantly glossing over it. It does not condemn the entire industry to opprobrium; that would be falling into a highly reductive form of technical determinism. However, for anyone analyzing the recent movements of the world’s “space armies” that are being formed almost everywhere, starting with the industrial shift of the Second World

War, where Germany attempted to develop a “miracle weapon,” is undoubtedly more useful than asking why, after sending men to the Moon, the world suddenly decided to convert this magic into weapons of war. The space industry is originally and primarily a military industry, certain components of which became “civilianized” here and there, in the midst of the Cold War. This is a tentative and uncertain diplomatic construction, but certainly not an impossible one. Knowing what the industry went through before, for example, prohibiting the placement of nuclear weapons in orbit (which, according to certain rumors relayed in high places, appears to be being called into question), shows that provided the adequate international efforts are made, nothing is completely lost.

How should we interpret the relative “divorce” between Donald Trump and Elon Musk? Is it in one way or another a questioning of astrocapitalism?

It is always tricky to give an immediate response to subjects on current affairs. This is especially true when commenting on the latest declarations from Trump or Musk. We attempted this in an op-ed published on 13 December 2024,² in which we explained why the convergence of interests and political views between Trump and Musk was no accident and that they had every reason to agree. This association, combining both the MAGA ideology championed by Trump and Musk’s post-Fordist authoritarian entrepreneurial hubris (which is highly questionable, as attested by that double Nazi salute on Inauguration Day in Washington), might not last. It may be a radical burst of temper born in the triumphalist and insurrectional atmosphere of President Trump’s new victory. However, we must depersonalize the situation. Trump and Musk are the proper names of collective enterprises: of underlying movements that transcend them.

In the meantime, the damage is significant. NASA, the world’s premier civil space agency, is the target of a massacre, inspired by the DOGE (Department of Government Efficiency), which Musk led until his withdrawal in May 2025. The White House anticipates a 25% budget cut, 2,000 employees are being dismissed (and eventually 6,000), 41 missions are cancelled (including many in cooperation with other nations, including France), and science is under attack. The program is clear and explicit: business and inflation in military capabilities are the priorities for restoring the United States’ greatness. The feeling of industrial decline, combined with the dread of space dominance before China, gives strength to this aggressive strategy.

Evidently, the military-industrial space complex is won over and didn’t ask for anything less. The “Golden Dome,” among other pharaonic projects announced as a vague replica of Reagan’s Strategic Defense Initiative, is the promise of enormous contracts for the next few years. Trump’s relaunch of the conquest of Mars is another reassuring vanishing point for those nostalgically interested in U.S. space power. Musk shows the way, and Trump takes it in his own thunderous and uncompromising fashion.

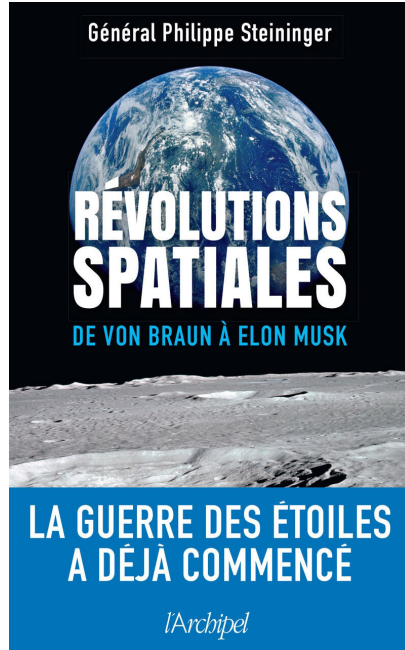
2. A. Saint-Martin, “[Le duo Trump-Musk : la menace fantôme d’une Amérique ‘astrofascisée’](#),” *Le Nouvel Obs*, 13 December 2024.

At the time of writing, at the end of July 2025, it is uncertain how things will evolve in the coming months, and we shall refrain from making any predictions. Nevertheless, we can observe that the context is, in fact, entirely favorable to the intensification of astrocapitalism, undoubtedly in the United States, and everywhere else. A disastrous alignment, in short.

REVIEWS

Space Revolutions: From von Braun to Elon Musk

Philippe Steininger



Reviewed by Jean-Paul Maréchal

At a time when space activities occupy an increasing place both in our daily lives and in our defense systems, General Steininger's latest book is particularly timely.¹ In six chapters, the author paints a detailed picture of the transformations that have occurred within the space sector over recent years. Furthermore, he discusses the political, legal, economic, and, naturally, military challenges that these transformations entail.

1. P. Steininger, *Révolutions spatiales. De von Braun à Elon Musk*, Paris, L'Archipel, 2024, 318 p.

Within this environment, which is ultimately lightly regulated – since exo-atmospheric space evades the principle of sovereignty – two perspectives appear to be emerging. On the one hand, the multiplication of incidents, or even confrontations, of a military nature, and on the other, the exacerbation of competition in a rapidly expanding civil and military market.

Regarding the first point, a “self-regulating restraint through a deterrent effect”² could logically impose itself due to the creation of dangerous debris for numerous satellites in orbit – including those of the aggressor – following the destruction of an orbital platform. Nevertheless, military action in space can take forms other than the destruction of satellites. Over the last fifteen years, there has been an observed increase in space conflictuality in the form of cyberattacks, jamming, and laser blinding. As General Steininger summarizes, “as of today, the focus is on digital data – the product and fuel of all space activity – rather than seeking the degradation of the orbital platforms themselves.”³

As for the second point, it is easy to note the shift from a near-artisanal production of a small number of very costly satellites to the mass production of small telecommunication satellites. Around 2015, between 20 and 30 large commercial satellites were manufactured for placement in geostationary orbit. The majority of these were produced by a small group of industrial firms, including Thales Alenia Space (TAS) and Airbus Defence and Space (ADS). Today, these two companies only account for half of this type of production, while new actors manufacture thousands of small satellites intended to form mega-constellations in Low Earth Orbit. The same applies to the launch services market, where Arianespace has lost its position as the global market leader, notably due to competition from SpaceX, which has established itself in the domain of “reusable” launchers. As a consequence of these upheavals, the average price per kilogram launched has fallen by more than 30% over ten years, dropping from \$25,000 to \$17,000.⁴

These developments in the military domain and the civil sector are, in fact, closely linked. Starting as a sector of activity that was exclusively state-owned and essentially military in scope (strategic deterrence and intelligence), space activity gradually integrated a scientific dimension and, more recently, developed an economic and commercial component designated by the term “New Space.”

The figures speak for themselves. Between 2017 and 2022, the space activities market grew from \$350 billion to \$464 billion (80% of which was generated by services relying on space-sourced data). The figure of \$1,000 billion could be reached within a decade and, according to certain estimates, \$2,700 billion before the middle of the century.⁵

Within this evolution, New Space obviously plays an essential role, yet, as the author emphasizes, this role must be “objectified” at the same time as the expression itself is clarified. The notion of New Space, General Steininger writes, “is in reality

2. *Ibidem*, p. 45.

3. *Ibidem*, p. 47.

4. *Ibidem*, pp. 76-77.

5. *Ibidem*, p. 35.

presented as the product of technological progress, specifically, the alliance of miniaturization and digitalization in the space domain, and a political decision made by the United States in 2010. This decision permitted the incursion of private actors and thus a commercial logic into a domain that had until then been strictly sovereign and structured by strategic and scientific challenges. The dynamic of New Space might suggest that the role of states has now become secondary compared to that of private actors. The reality, conversely, is certainly that the space domain has always been and remains an essentially sovereign domain.”⁶

Far from the conventional discourse on the genius of certain entrepreneurs and the beneficial dynamic of markets, the author highlights the role of states – and particularly that of the United States – both in the creation of the space market and in the support provided to the operators present there (or those wishing to enter it).

Regarding market creation, General Steininger dates the birth of New Space to 11 October 2010 with the adoption of the NASA Authorization Act. Among the twelve titles contained within this law, the fourth, entitled “Development and Use of Commercial Crew and Cargo Transportation Capabilities,” is indicative of the orientation of the Obama administration, an orientation that has been confirmed, even amplified, by its successors.

Once the markets were created, the actors operating within them were strongly aided by public contracts. Indeed, the NASA Authorization Act 2010 – which followed Barack Obama’s abandonment of the Constellation program, launched by George W. Bush in 2004 with the main objective of sending astronauts to the Moon around 2020 – allowed the funds thus released to be funneled toward the extension of the International Space Station (ISS), R&D activities, the project of landing a human on Mars around 2035, and, relevant here, aid to private industry. The decisions made quickly played “a major role in the rise to power of the young startup SpaceX.” “State support for the private sector was also reflected at that time by concrete actions in the technical domain, with the granting of licenses and the gratuitous provision of testing facilities and engineers.”⁷

Thus, the Merlin engine used by SpaceX for its Falcon 9 launchers reuses, with NASA’s agreement, a large number of design and technology elements from an engine demonstrator named “Fastrac,” which NASA had developed at the end of the 1990s for a reusable vehicle.

As for launchers, under the National Security Space Launch (NSSL) program, contracts were awarded to United Launch Alliance (ULA) and SpaceX for 34 military launches to be carried out between 2022 and 2026. The estimated amounts of these contracts are \$3.5 billion for ULA and \$2.5 billion for SpaceX. The two companies are required to carry out 60% and 40% of the launches respectively. It is noteworthy that, by the end of 2023, 48 launches had already been conducted, demonstrating a more intense military activity than originally anticipated.⁸

6. *Ibidem*, pp. 35-36.

7. *Ibidem*, p. 188.

8. *Ibidem*, p. 84 and p. 121.

As for SpaceX, the company is not only supported by the Department of Defense. It is also supported by NASA, which has awarded it a \$2.2 billion contract for eight Commercial Crew missions to the ISS and another \$1.15 billion contract to develop a version of its Starship vehicle capable of delivering four astronauts to the Moon. In total, in 2022, SpaceX garnered nearly \$3.5 billion in public contracts. This governmental aid allows it to engage in dumping⁹ in the private launch market. A Falcon 9 launch, for instance, is billed at \$129 million to the U.S. government but between \$70 and \$90 million on the commercial market. It should be noted that, since 2019, SpaceX has launched 6,400 satellites (approximately three-quarters of currently active satellites) and plans to deploy 12,000 in total. The company has furthermore applied to launch 42,000.¹⁰

Small and medium-sized enterprises are not overlooked in U.S. measures. A program known as SBIR (Small Business Innovation Research) is designed to support R&D in firms with fewer than five hundred people.¹¹

Facing this “civil-military” model, where the viability of the civil sector is assured by the military “crutch”¹² – the latter having the advantage of offering multi-year contracts – Europe is undeniably struggling. Contrary to certain preconceived notions, the European space industry is, in fact, far more dependent on the commercial market – that is, on sales to private actors and exports outside Europe – than its competitors. It is estimated that this open market represents 40% of its revenue, compared to an average of 15% for its competitors.

European – and notoriously French – advances have often resulted from the recognition of French dependence on the United States and the will – particularly France’s will – to break free from it. This led, for example, to the development of *Helios*, *Ariane*,¹³ and more recently *IRIS²* (Infrastructure for Resilience, Interconnectivity and Security by Satellite). The latter is set to provide sovereign connectivity services using approximately 300 satellites starting in 2027.¹⁴

The link between the civil and state sectors is also observed in military operations. The author stresses that Western armed forces rely heavily on private companies¹⁵ to pilot their drones, exchange non-sensitive information between their various components, and offer internet access to their personnel.¹⁶ This demonstrates a col-

9. Dumping is a practice prohibited by the World Trade Organization, which consists, for an exporter, of selling a product on a foreign market at a price lower than its cost price or its price on its domestic market.

10. “[The rockets are nifty, but it is satellites that make SpaceX valuable](#),” *The Economist*, 17 October 2024.

11. P. Steininger, *Révolutions spatiales...*, *op. cit.*, p. 82.

12. General Steininger points out in this regard that no U.S. state satellite can be launched by a rocket manufactured with less than 51% of its components in the United States; in *ibidem*, p. 38.

13. *Ibidem*, p. 80.

14. *Ibidem*, p. 101.

15. “[L’usage du renseignement géospatial dans le conflit russo-ukrainien](#),” *La Note du CESA*, no. 574, October 2024.

16. P. Steininger, *Révolutions spatiales...*, *op. cit.*, pp. 151-152.

laboration between military satellites, which retain the best performance capabilities and civilian systems, which offer a higher revisit rate.¹⁷

Numerous themes other than those mentioned in this review are also addressed. These include hypersonic devices and the issue of resource exploitation on celestial bodies, which pits proponents of a universalist conception against those who consider, as in Washington, Luxembourg, and Abu Dhabi, that these are not global common goods.¹⁸ The author also analyses in detail the different types of military space operations.¹⁹ The penultimate chapter offers a meticulous overview of the space powers (United States, China, Russia, Japan, India, Europe, but also the two Koreas, Iran, and the United Arab Emirates). In the final chapter, dedicated to France, General Steininger notes that the national budget dedicated to space (approximately three billion euros per year) is the largest in Europe, while the French space budget per capita (47 euros per year) is the second largest in the world. The author concludes by analyzing French space policy as structured around the idea of sovereignty and European cooperation before outlining the panorama of excellent actors, both public (CNES, ONERA) and private, that France possesses.

At the conclusion of a text extremely rich in analysis and factual data, General Steininger insists on the necessity of placing the notion of sovereignty at the heart of French space policy and taking into account the new threats emerging more than one hundred kilometers above our heads. In order to avoid any risk of falling behind, it is necessary to reinforce French strategic autonomy across the three pillars of the space ecosystem: industry, infrastructure, and sovereign military and dual-use space intelligence capabilities. Europeans would be well advised to favor trusted partners²⁰ and rely on their own strengths. However, this is far from being the case when one learns that the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) decided on 27 June 2024, under German pressure,²¹ that its *Meteosat MTG-SI* satellite would no longer be launched by an Ariane 6, as initially planned, but by a Falcon 9 from SpaceX!

17. *Ibidem*, p. 141 and p. 153.

18. *Ibidem*, pp. 42-43.

19. *Ibidem*, chapter 5.

20. As is the case, for example, with the *Pleiades* satellites, which belong to CNES and for which Airbus Defence and Space obtained a public service delegation to market the images with a priority acquisition right for the French Defense; in *ibidem*, p. 138.

21. A country that, in the early 2000s, entrusted Russia with the task of launching its constellation of military observation satellites before contracting with SpaceX. In *ibidem*, p. 118.

La ruée vers l'Espace. Nouveaux enjeux géopolitiques

Xavier Pasco



Reviewed by Jean-Paul Maréchal

While the media regularly discuss “trips to Mars,” “terraforming,” the “return to the Moon,” the “privatization of space,” and the “exploitation of resources from celestial bodies” (preferably at the Moon’s South Pole), it was time that a globally recognized specialist in space activities... brought us back down to Earth!

Thus, Xavier Pasco’s latest work¹ delivers a complete status report and a detailed analysis of the challenges inherent in the “new” space activities across seven chapters.

Far from interplanetary utopias, the book by the Director of the Fondation pour la Recherche Stratégique (Foundation for Strategic Research) opens with an unequivocal observation: while space stations – such as Mir or the International Space Station

1. X. Pasco, *La ruée vers l'Espace. Nouveaux enjeux géopolitiques*, Paris, Tallandier, 2024, 358 p.

– are certainly formidable “balconies overlooking space,” they have not enabled the emergence of a new mode of human habitation of space.² Furthermore, the lunar endeavor, in hindsight, proved to be more of an “incursion” than a “new beginning.” It remains true that moving past the protective limits of the atmosphere and going beyond the Van Allen belts, which shield us from cosmic radiation, remains a highly risky undertaking.³ As for Low Earth Orbit (between 500 and 1,200 kilometers), the laws of celestial mechanics are implacable. Human activity can only be deployed there in a concerted manner because any debris can instantly turn into a projectile. It is perhaps this specific characteristic that has prevented an arms race in space so far.⁴

Nevertheless, in just a few years, space activity has intensified dramatically. The figures are indisputable. In 2023, there were 223 rocket launches (211 of which were successful), with 1,519 tones placed in orbit, representing 45% more than in 2022. As the author summarizes, “the space timeline appears to have accelerated. [...] For several years, space activities have experienced a new, highly sustained rhythm that is incomparable to past decades. Their nature has been transformed with the appearance of genuine infrastructures in orbit, composed of thousands – soon tens of thousands – of satellites, which are themselves destined to eventually become the pawns of gigantic networks stemming from the era of globalized digital communication.”⁵

The figure of 100,000 satellites could be reached by 2030.⁶ Currently, 90 countries possess at least one satellite. The projects of some appear to defy common sense. Rwanda, for instance, has filed a frequency request for 337,320 satellites! However, it would be wrong to conclude that there has been a genuine democratization of access to space. For example, three countries accounted for the majority of launches in 2023: the United States (over 45%), China (nearly 30%), and Russia (less than 9%). The remaining 15% was accounted for by eight other countries. Regarding the satellites placed into orbit (also in 2023), 87% were U.S. in origin, and 83% of the mass placed into orbit globally was launched by SpaceX.⁷ This massification of space activity is due to the large-scale deployment of telecommunications satellites by private companies such as Starlink and OneWeb.

However, interpreting the key role played by these private actors as a sign of simple “privatization” of space would be an error, against which Xavier Pasco cautions. Major satellite projects rely on a triptych that combines the space sector, the information sector, and public investment.

The relationship between the first two sectors, the “marriage of the satellite and the Cloud”⁸ – the hybridization between space and connectivity – can be illustrated by the decision made by Elon Musk in 2020 to establish a partnership with Microsoft

2. *Ibidem*, p. 12.

3. *Ibidem*, p. 42.

4. *Ibidem*, p. 15

5. *Ibidem*, p. 16.

6. *Ibidem*, pp. 21-41.

7. *Ibidem*, pp. 21-22.

8. *Ibidem*, p. 92.

Azure. Through this agreement, Elon Musk hoped to acquire Microsoft's clientele. Microsoft, for its part, anticipated gaining access to a global communication network (Starlink). However, as the market did not yet fully exist, public funding was necessary to launch the project. This aid often takes the form of multi-year contracts for capacity purchasing. In this particular example, the Pentagon awarded a ten billion dollar contract to ensure the global connection of the military cloud over a decade with Microsoft Azure and Starlink. Amazon, disappointed at having been excluded, managed to have the contract cancelled. The contract was then distributed among the various actors to prevent the creation of a monopoly situation.⁹ Two years later, in 2022, Starlink was still not profitable despite its 5,000 satellites in orbit. Elon Musk's company currently has only one million customers, a figure twenty times lower than that announced in 2015 to attract investors.¹⁰

As the author highlights, "for Starlink, as for its other activities, SpaceX relies essentially on public contracts, the majority of which originate from the U.S. authorities. The company is inclined to continue signing lucrative contracts with the military, just as it is with the U.S. space agency, NASA, for its exploration program."¹¹ This explains, for example, the purchase of 300 *Starshield* satellites from SpaceX by the American armed forces for \$1.8 billion, as revealed in 2024.¹²

In fact, as Xavier Pasco explains, New Space is not quite as new as one might think. Achievements such as satellite constellations and reusable launchers had been in development for nearly three decades. Their emergence results from a long-term accumulation of considerable resources, whether through defense budgets or the increasing power of information industry actors. The author's analysis is that these actors are not so much taking over as they are undergoing a strategic reconversion, intertwining "private interests and political objectives."¹³

Within this dynamic of intensifying space activities, new countries, China and India foremost among them,¹⁴ are emerging as major players and challenging the status quo inherited from the Cold War.

As for Europe, despite possessing a very high level of expertise, it initially appears to be a space power in search of its identity. European space activities were first nurtured by national projects – particularly French ones (Ariane benefited from French research in the field of strategic missiles) – before moving away from them. Subsequently, genuine European programs emerged, such as *Galileo* (1999), whose origin dates back to 1994 with the Egnos (European Geostationary Overlay System) program. The United States opposed the development of a system that would compete with GPS. Next came *Copernicus* (2013), which resulted from the transformation of the GMES (Global Monitoring for Environmental Security, later re-

9. *Ibidem*, pp. 93-94.

10. *Ibidem*, p. 141.

11. *Ibidem*, p. 143.

12. *Ibidem*, p. 277.

13. *Ibidem*, p. 36.

14. *Ibidem*, pp. 31-34.

named Global Monitoring for Environment and Security) program. The objective was to provide reliable environmental information in response to the debates held during the negotiation of the Kyoto Protocol (1997), an international commitment that Washington attempted to sabotage by withdrawing from negotiations. Finally, in 2022, the IRIS² program was launched. Europe is thereby seeking to ensure its independence in the domain of new satellite communication systems. In the meantime, the Lisbon Treaty, through its Article 189 in 2007, will have reinforced the European Union's status as a full-fledged space actor.¹⁵

The rise of private actors in the space domain poses the formidable problem of the degree of a state's dependence on a commercial company to which it subcontracts the execution of sovereign missions. This problem becomes even more complex when the private actor is foreign. This was evident in 2022 when Elon Musk decided to disconnect the Ukrainian military from the Starlink network. Symmetrically, the non-state character of such capabilities can, as Xavier Pasco underscores, "be likened to a means of intervening in a conflict without truly entering into war."¹⁶ Hence the necessity of relying on trusted actors, as is the case in France with companies such as Airbus or Thales Alenia Space. The Centre national d'études spatiales (National Centre for Space Studies, or CNES) thus participated in the development of the *Pléiades* satellites, the imagery from which Airbus commercializes. Fifty of these images are reserved for the government.¹⁷

Among the numerous other themes addressed in this book, the question of a potential territorial escalation in space, notably between Washington and Beijing, is raised. A report from a 2021 USAF research laboratory explained that the Space Force, created in December 2019, must defend U.S. interests not only up to Geostationary Orbit (approximately 36,000 km), but also extending to Cislunar Space (435,000 km). Another text, dated January 2024 and titled "Securing Cislunar Space and the First Island Off the Coast of Earth", explicitly referenced a Chinese thesis developed in 2017 by Ye Peijian, the director of the Chinese lunar exploration program. He indeed declared: "The universe is an ocean; the Moon, the Diaoyu Islands; Mars, the Huangyan Islands" – islands, of course, respectively claimed by Japan and the Philippines (as well as by Taiwan for the latter). To prevent Beijing from succeeding in establishing a space anti-access/area denial (A2/AD) strategy, some in the United States are considering permanently stationing space assets at the five Lagrange points...¹⁸

As Xavier Pasco analyses, such reasoning is reminiscent of the *Sputnik* years. However, applying the theories of Alfred Mahan to space is a step that the laws of physics (fortunately) prevent from being taken. The author reminds us that "[t]he notion of spatial 'straits' from which the first arrival could dominate spatial 'traffic' remains today a vision that is far removed from the realities of physics."¹⁹

15. *Ibidem*, pp. 115-137.

16. *Ibidem*, p. 147.

17. *Ibidem*, p. 278.

18. *Ibidem*, pp. 234-235.

19. *Ibidem*, p. 236.

La ruée vers l'Espace addresses many other themes which, due to space limitations, cannot be covered in this review. One can only mention the fascinating pages dedicated to Russian “cosmism,” a philosophical-metaphysical movement that appeared in the 19th century and permeates Putin’s ideology. In the West, this is primarily known through the metaphor of Earth as the “cradle of humanity,” which implies that humanity must one day leave it.

Far from easy certainties and definitive conclusions, one of the great interests of this book is finally to demonstrate that many uncertainties remain today regarding the future of space activities. Questions persist regarding the profitability of satellite constellations (compared to that of behemoths like terrestrial network operators), the public or private nature of the actor(s) who will define anti-collision standards, and the precise forms that the militarization of space will take (with the U.S. claiming that the Russians are preparing a nuclear weapon in orbit). All of these domains are extensively analyzed throughout the book.

From his vast expertise in the field, Xavier Pasco draws a conclusion – simple in its formulation yet weighty in its implications – that the new space geopolitics will be constrained by the “simple” obligation for actors to coexist in a hostile environment. This coexistence will necessitate “certain doses of cooperation” and, consequently, a balance between sovereignty, competition, and cooperation.²⁰

20. *Ibidem*, p. 330.

Ten Books to Address Strategic Space Issues

Captain (PhD) Béatrice Hainaut – Anne Maurin

Captain Béatrice Hainaut, who holds a Phd in Political Science and International Relations from Paris II Panthéon-Assas University, joined the Institute for Strategic Research of the Military School (Institut de recherche stratégique de l'École militaire, or IRSEM) in September 2022 as a researcher focusing on space issues. Her doctoral research focused on the emergence and promotion of behavioral norms related to the security of space activities.

Anne Maurin holds a Phd in Geography and has been working in Center for Aerospace Strategic Studies since 2019. Her research, conducted under the supervision of Professor Philippe Boulanger at Sorbonne University, focuses on the strategic use of outer space by Russia.



*Géopolitique du monde spatial*¹

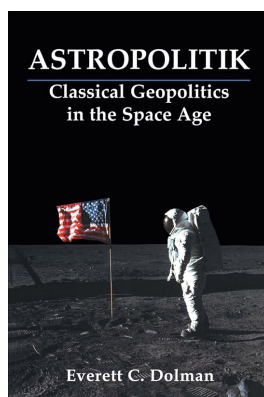
In 40 fact sheets illustrated with maps, diagrams, tables, and schematics, Isabelle Sourbès-Verger offers readers an overview of the challenges associated with the extra-atmospheric environment. She presents the main elements of human activity in this environment, covering the political, military, economic, historical, and also symbolic domains. She lists them in fact sheets according to four chronological parts.²

The author begins with a historical reminder of the conquest of this exceptional environment during the Cold War, under the subtitle of the work, “To understand the occupation of outer space.” After emphasizing the military and ballistic foundations of the first spacecraft that allowed the exploration of the low layers of circumterrestrial space up to the lunar orbit, I. Sourbès-Verger demonstrates the place that the space conquest occupied in international relations between 1945 and 1989 on the political, legal, and symbolic levels. A second part allows for an understanding of the transition between the era when space represented a theater accessible to only a few powers (before 1991) and the era of progressive democratization, or even normalization, of the environment, up until the 2010s, with the emergence of new actors like India or China. The reader thus obtains the necessary elements to grasp the current period, which is detailed in the last two sections. The space environment is becoming cluttered and “occupied,” and it is at the heart of the power struggles among the states and actors projecting and investing themselves there.

This work offers a novice reader the opportunity to become familiar with geopolitical issues surrounding space and to obtain a clear and precise vision of them. It places human investment in outer space at the core of the political, military, economic, and symbolic power of States.

1. I. Sourbès-Verger, *Géopolitique du monde spatial*, Paris, Éditions Eyrolles, 2023.

2. “La conquête de l’espace au temps de la Guerre froide” (I), “De l’exploration à la banalisation des activités spatiales – 1991-2010” (II), “Un monde spatial en devenir – 2012-2022” (III). She concludes the book with a more contemporary section on “Les défis du monde spatial” (IV).



*Astropolitik: Classical Geopolitics in the Space Age*³

In this work, Everett C. Dolman proposes to transpose theories of environments and geopolitics (Alfred T. Mahan, Halford J. Mackinder, Nicholas J. Spykman, and others) to outer space. The author asserts that space must be conceived of as a new strategic theater, endowed with its own geography and its essential control points (orbits, Lagrange points, transit corridors, and so forth), just like the oceans or the continents.

The central concept he develops is that of “Astropolitik,” a blend of astropolitics (political aspects of any activity in or related to space) and Realpolitik. The use of space by states today must be interpreted according to a realist lens.

According to his thesis, which remains controversial, E. C. Dolman claims that the United States should proactively weaponize and control space as the dominant and hegemonic power. He argues that a U.S. monopoly over space – by establishing military and technological supremacy – would guarantee not only the national security of the United States but also a form of global stability. No other power could challenge this order. This realistic and offensive vision undermines approaches attached to respecting the *corpus spatialis* – that is, the body of law applicable to space. The author judges these approaches to be unrealistic in the face of strategic competition.

This book, published in 2002, has strongly influenced thinkers on space strategy, particularly in the United States. It contributed to structuring the intellectual and strategic debate in that country. Some of its ideas, in fact, continue to inform U.S. space policy, without political decision-makers expressly referring to them.

His thinking has since been supplemented by other approaches favoring cooperation between the United States and its allies. However, the objective remains the same: to ensure Washington’s dominance in space in the face of potential competitors, the most threatening of which today is China.

3. E. C. Dolman, *Astropolitik: Classical Geopolitics in the Space Age*, Londres, Routledge, 2002.



*Original Sin: Power, Technology and War in Outer Space*⁴

With *Original Sin*, Bleddyn E. Bowen presents a genealogy of space utilization by calling its beginnings the “original sin.” For the author, this term designates the initial ambitions, which were primarily economic and military, of the states that wished to invest in and project themselves into space. His thesis, which is extensively documented and supported by evidence, makes this work a valuable tool for better understanding the evolution of space. The author explores the space conquest by the United States and the USSR during the Cold War, but also of those lesser known by France, the United Kingdom, China, Japan, and India during that period, in a chapter titled “Beyond Bipolarity.”

The author then shows how this “original sin” is perpetuated today, even though the space landscape has evolved considerably. In his view, the uses of space are essentially intended to increase the power of States. Other projects, such as lunar missions, would only be intended to capture public attention and mask the central objective of States, which is to establish their military and economic control over space as a new source of terrestrial power.

As the author insistently reminds us, thousands of satellites work silently today, providing military and intelligence capabilities and contributing to the economic growth of States. These assets have become indispensable, and no country wishing to claim the status of a great or even medium power can now do without them. From a military perspective, a link exists between the development of ballistic missiles and the operative and tactical use of satellite services. Future uses of space on the battlefield can be foreseen, such as the consideration of space itself as a theater of war. Ultimately, space powers fully measure the strategic advantages offered by mastering the “Cosmic coastline of Earth Orbit,” which is simultaneously a stage for confrontation, a lever for development, and a matter of prestige.

In his conclusions, the author suggests that the perpetuation of the original sin is not inevitable. A better understanding of the stakes by political decision-makers could allow space to be used in a sustainable manner for the benefit of all.

4. B. E. Bowen, *Original Sin: Power, Technology and War in Outer Space*, Oxford, Oxford University Press, 2023.



*La Ruée vers l'Espace. Nouveaux enjeux géopolitiques*⁵

This new work by Xavier Pasco can be read as a continuation of his previous book, published in 2017.⁶ While the latter described the evolution of the space landscape over the long term and dwelt on the new vision of the environment summarized by the U.S. expression “New Space,” *La ruée vers l'Espace* studies its ramifications and global implications. The content is structured around seven chapters which help the reader to comprehend the current space landscape and to question Europe’s role and position within it.

The author’s analogy with the “gold rush” accounts for the “democratization” of access to space that is underway (no fewer than 90 countries now have at least one satellite in orbit). However, the shared attraction for this new environment must not allow one to forget that it remains dominated by only a few actors, with the United States and China being significantly ahead. Furthermore, these two nations, in addition to engaging in fierce competition for the occupation of Earth orbits for strategic and economic purposes, are launching themselves into a “new race to the Moon.”

Europe may have been caught off guard by this new space landscape. Unlike other states, it struggles to develop a unifying narrative around its space achievements. By emphasizing “useful space,” its initiatives appear less legible and less engaging than those of the United States, which uses space as a “new political and economic weapon.” In this context, the leading space power tends to dictate the norms or “rules of the game.”

Chapter 7 recalls that space is now a domain of conflictuality in its own right. The “rumbling of arms” can be heard there. The great powers are preparing to wage war there, alone or in coalition. Yet the dependence of states, including France, on space systems has never been greater.

The author concludes with the role that Europe can play in this new “space geopolitics.” It currently appears to be “withdrawing from the defining of the new (space) rules of the game,” but there is still time for it to assume certain “strategic choices” to remain as a significant power.

5. X. Pasco, *La Ruée vers l'Espace. Nouveaux enjeux géopolitiques*, Paris, Éditions Tallandier, 2024.

6. X. Pasco, *Le Nouvel âge spatial. De la Guerre froide au New Space*, Paris, CNRS Éditions, 2017.



*Révolutions spatiales. De von Braun à Elon Musk*⁷

In this work, General Philippe Steininger estimates that the first “space revolution” took place on 3 October 1942 when the third prototype of the *Aggregat 4* rocket was launched by the Third Reich and reached an altitude of 90 km before falling back to Earth. Since this event, revolutions have succeeded one another in this field, according to the author. Mobilizing the history of the “conquest” of space, he recalls how much the development of its uses is closely linked to the military domain. He then demonstrates the strong dependence that our societies have developed on space infrastructure. From this dependence then arises the vulnerability and the necessary need to protect and defend these assets. “There is no longer any Defence without Space, nor Space without Defence.”

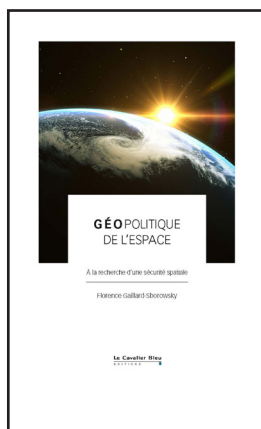
Consequently, a conflict in space is no longer impossible. The author envisages the different forms it could take. He also insists on the notion of “strategic sovereignty in the space domain,” describing its components, such as a high-performing national space industry with a secure supply chain, sovereign infrastructure on the ground and in orbit, the development of military and dual-use capabilities contributing to autonomy of decision and action, and the mastery of human spaceflight.

A welcome chapter is also dedicated to a typology of “military space operations.” This allows for a better analysis of this term, which is often used but whose content is rarely developed. Numerous examples support the author’s arguments.

Finally, after an overview of the space powers, General Steininger dedicates an entire chapter to the leading space nation in Europe, namely France. This chapter offers a description of the capabilities that France possesses.

The author concludes by outlining two ideas. The first concerns the strong link uniting national defense policy and space policy. The second insists on the paradigm shift in space affairs. Consequently, a state that wishes to be or remain a space power must place the notion of sovereignty at the heart of its space policy and take into account the risks and the “new threats.” To this end, the author identifies areas for progress for France and Europe. It is necessary to improve space surveillance capabilities, establish sovereign early warning systems, and finally, provide the armed forces with permanent connectivity through the use of sovereign low Earth orbit constellations.

7. P. Steininger, *Révolutions spatiales. De von Braun à Elon Musk*, Paris, Éditions l’Archipel, 2024.



*Géopolitique de l'Espace. À la recherche d'une sécurité spatiale*⁸

In this collective work, edited by political scientist Florence Gaillard-Sborowsky, a senior research fellow at the Fondation pour la Recherche Stratégique (Foundation for Strategic Research), authors specializing in the geopolitical and multidisciplinary study of the space environment present the main current challenges dominating the use of outer space.

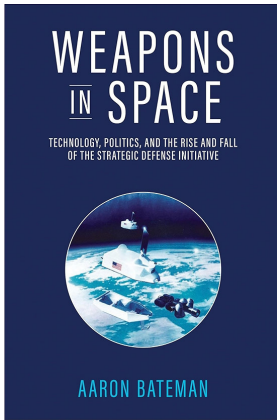
The common thread running through this essay is security in outer space. The editor provides the following definition: “The capacity to place and operate assets outside the Earth’s atmosphere without external interference, damage, or destruction.”⁹ Stemming from this definition is the question of space-related risks and threats, which can take multiple forms. She highlights the importance of theoretical prediction models for anticipating any event that might occur. She also initiates a reflection on the factors of insecurity and proposes solutions for improving security in this environment.¹⁰

Notably, F. Gaillard-Sborowsky insists that the dangers of this environment are not solely caused by human factors. Certainly, the increasing militarization of space is a major risk that must be taken into account in the current period of growing geopolitical tensions. However, the rise in space traffic also represents an endogenous risk due to the cluttering of orbits. The author continues by offering an overview of the conceivable diplomatic and legal solutions, as well as technical tools that are implemented or under development, to secure outer space.

8. F. Gaillard-Sborowsky, *Géopolitique de l'Espace. À la recherche d'une sécurité spatiale*, Paris, Le Cavalier Bleu, 2023.

9. *Ibidem*, chapter “Sécurité nationale, sécurité internationale et sécurité spatiale,” pp. 19-21.

10. *Ibidem*, chapter “Risques et menaces en matière spatiale,” pp. 23-30.



*Weapons in Space.
Technology, Politics, and
the Rise and Fall of the
Strategic Defense Initiative*¹¹

Aaron Bateman's work takes the Strategic Defense Initiative (SDI), launched by U.S. President Ronald Reagan in March 1983, as its case study. Popularized by the expression "Star Wars," this anti-missile defense program, elements of which were to be installed in space, aimed to prevent the penetration of intercontinental ballistic missiles and ultimately to prove the obsolescence of nuclear weapons.

In support of his analyses, the author uses a large number of documents declassified in the United States, the USSR (and later Russia), and also in Western Europe, to trace the genesis, development, and the technical, political, and diplomatic debates surrounding this project. He also studies the effects of the program beyond the Cold War.

The author demonstrates that the origin of the SDI project significantly preceded the 1980s and was inherent in the nature of the US-Soviet relationship. The will to place defensive and offensive weapons in space was linked to the need to "control" this environment.

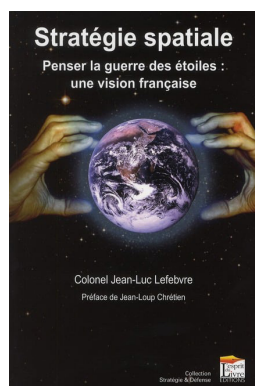
A. Bateman also shows that while this project provoked controversy in the 1980s, particularly from the perspective of its technical feasibility, other controversies focused on the destabilizing effects of such an undertaking on international balances and global strategic stability.

The author also notes, quite relevantly, that several European states were solicited to contribute to the SDI. European leaders responded in various ways. France, for example, chose not to participate, in order not to fuel what it considered to be the beginnings of an arms race in space.

The implementation of this program resulted in making the conclusion of treaties or agreements to limit armaments in space more difficult. Although the SDI, as envisioned in 1983, never fully materialized, it left a definite and still visible mark on how the United States considers space security today.

This work illuminates a central episode in space history that structured the end of the Cold War – and which some believe even hastened it. It also contextualizes the current decisions of the U.S. administration regarding a similar project: the Golden Dome.

11. A. Bateman, *Weapons in Space: Technology, Politics, and the Rise and Fall of the Strategic Defense Initiative*, Cambridge, MIT Press, 2024.



*Stratégie spatiale. Penser la guerre des étoiles : une vision française*¹³

Inspired by the thinking of Hervé Coutau-Bégarie, developed in the space section of his *Traité de stratégie* (1st ed. 1999), and by Serge Grouard's work, *La guerre en orbite* (1994), Jean-Luc Lefebvre discusses the constituent elements of conflictuality in orbit according to a contemporary French perspective. The objective of the work is to propose, across nine chapters, elements of an answer to the following question: "Can strategic thinking be applied to outer space?"¹² To answer this, the author first offers a definition and a conceptual framework for these challenges by differentiating between the geostrategy of space and space strategy. He then focuses on precisely describing the framework of the environment under study, devoting a chapter to the physical limits of outer space, the question of access, and the opportunities it offers.

These three elements explain the fundamental and original dimension of the space environment for the support and backing of operations. It is, in fact, a geopolitical and geostrategic zone that must be protected and monitored. The development of combat in space is thus detailed, from the low layers of the atmosphere (very high altitude and the aerospace concept) up to circumterrestrial and even deep space.¹⁴

In terms of strategy, J.-L. Lefebvre distinguishes three sets of four principles.¹⁵ The four principles prior to any action in space are knowledge of the spatial situation, the need to cultivate a spatial imagination, the act of informing and educating on spatial capabilities, and finally the necessity of investing over the long term.

The author also proposes four cardinal principles for acting in space. These are: accessing space by one's own means, protecting or attacking the lower levels to defend or defeat the upper levels, neutralizing without destroying, and finally, recreating the fog of war to one's advantage.

Four complementary principles are ultimately suggested, namely: making the best use of space specificity, prioritizing and protecting intangible Lines of Communication (LOCs), developing space resilience, and finally, contributing to the global strategy.

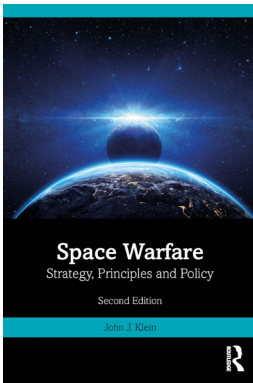
For any reader wishing to reflect on space strategy outside of doctrinal documents, such as the French *Defence Space Strategy* published in 2019 or the new *National Space Strategy* of 2025, J.-C. Lefebvre's work remains essential.

12. *Ibidem*, "Avertissement," p. 15.

13. J.-L. Lefebvre, *Stratégie spatiale. Penser la guerre des étoiles : une vision française*, Paris, L'Esprit du livre Éditions, 2011.

14. *Ibidem*, chapter 7 "Combattre dans l'espace," pp. 189-213.

15. All of these principles are detailed in chapter 8 of the book: "Principes de la stratégie spatiale," pp. 229-269.



*Space Warfare. Strategy, Principles and Policy*¹⁶

In this re-edition of a work initially published in 2006, John J. Klein, PhD and former U.S. Navy officer, proposes an essay on space strategy by drawing certain parallels with the various strategies of other geographical environments. While he briefly addresses an analogy with the aerial and terrestrial environments, the author mainly develops a space vision inspired by the reflections of the British scholar Julian S. Corbett on maritime strategy.

In fact, the maritime environment is central to international trade and the global economy. Its use is structured notably around maritime communication lines to support fleets, overseas militaries, and trade routes.¹⁷ J. S. Corbett continues the work of the U.S. Admiral Alfred T. Mahan, specifying that controlling these lines contributes to achieving power in that environment. The use of force is paramount to supporting one's economic or commercial projects and undermining those of an adversary. By controlling these major communication axes, a fleet, even a modest one, can exert a form of "deterrence" by its mere presence.¹⁸ This is the notion of the "fleet in being."¹⁹

John J. Klein dedicates a large part of his work to this analogy between the strategy of controlling maritime lines and that of celestial lines of communication. In the second part of the work, titled "Corbett in Orbit," he proposes a definition of the concept of "Command of Space" as: "ensur[ing] access and use of celestial lines of communications when needed to support the instruments of national power – diplomatic, economic, information, and military. It also includes the ability to prevent or deny the enemy's access to and use of his celestial lines of communications, or at least minimize the most severe consequences an adversary can deliver along them."²⁰ This notion, according to him, can be applied through a simple presence in the environment, but also through coercion. This coercion can be diplomatic, economic (directed against the economic interests of a state or actor in the space domain), or informational.

More precisely, at the military level, outer space contains a number of strategic locations and points that can be considered CLOCs. Even if the number of human casualties during a space conflict might be limited, the essential exploitation of this environment leads states to consider their space capabilities as part of their vital interests.²¹

16. J. J. Klein, *Space Warfare. Strategy, Principles and Policy*, 2nd ed., London, Routledge, 2025.

17. *Ibidem*, p. 49.

18. In English, "deterrence" does not refer solely to nuclear matters, as is the case in French. The term "découragement" (discouragement) may be preferable.

19. See J. J. Klein, "[Corbett in Orbit. A Maritime Model for Strategic Space Theory](#)," *Naval War College Review*, Vol. LVII, no. 1, Winter 2004.

20. J.J. Klein, *Space Warfare*..., Part II, chapter 7 "Command of Space," p. 60.

21. *Ibidem*, chapter 12 "Dispersal and concentration," p. 107.



Espace. Le nouveau front.

*Penser les contraintes opérationnelles de la bataille spatiale*²²

In this concise work, Amaury Dufay, a doctoral candidate in political science and a research fellow at the Institut d'études de stratégie et de défense (Institute for Strategic and Defence Studies, Lyon III), presents a brief analysis of strategies related to the military use of outer space. Following three chapters introducing the environment, its main actors, and the legal challenges that characterize it, the author focuses on defining space tactics by questioning the concept of maneuver. Drawing on events of the past ten years, he presents the general principles of space maneuvers employed by the major competitors. He also details the technical constraints that any action in this exceptional physical environment represents. Furthermore, he questions the notion of “space warfare”, detailing the various capabilities of states or the actions they have undertaken, particularly against satellites.

In this regard, he develops the concept of the weaponization of space (the placement of weapons), which he distinguishes from militarization, a term more broadly designating the military use of this environment. He details, in a nearly exhaustive manner, the full range of current possibilities in this domain, from cyberattack to the potential placement of nuclear weapons in orbit. These elements allow him to conclude his work with a prospective reflection linked to the potential evolution of conflict in this environment.

22. A. Dufay, *Espace. Le nouveau front. Penser les contraintes opérationnelles de la bataille spatiale*, Monaco, Éditions du Rocher, coll. “Défis stratégiques,” 2024.

