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Crowded and Dangerous Orbits

European Space Governance at a Time of Potentially Saturating Programs

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An Initiative on "European Space Governance"

This initiative is intended to provide analysis pertaining to the international competition in space and its impact on the European space industry as well as its governance. Through a series of publications and public events, the goal of the initiative is to raise awareness among stakeholders in the European Union about the challenges presented by the transformation of the global space industry. It is coordinated by Éric-André Martin, General Secretary of the Study Committee on Franco-German relations (Cerfa) at Ifri.

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Executive Summary

The unprecedented growth of space activities, the multiplication as well as diversification of players involved in the exploitation of outer space, and even, more generally, the dependence of all sectors of activity on space infrastructures are some of the main phenomena that have led to a progressive overuse of orbits and to saturation in the frequency spectrum. Considered by international law, and in particular by the International Telecommunication Union (ITU), as limited natural resources, Earth orbits – and more specifically the geostationary orbit (GEO) – are currently at the heart of fierce competition between states and private companies that have developed their own space policies (SpaceX, Blue Origin).

The principles of freedom and non-appropriation that govern the use of Earth orbits are gradually being erased due to the unprecedented increase in requests for frequency allocations and the proliferation of satellite systems by nations and companies that free themselves from ITU rules. The struggle between space actors, on the one hand, and between space actors and those who wish to achieve this status, on the other, therefore calls for in-depth reform of international standards that were essentially enacted at a time when space was the business of a club composed of only a few technological and industrial powers. The present situation and the evolution that is taking shape also require setting up codes of conduct and establishing good practices among the contenders that will compete in tomorrow's space race.

Beyond these legal and regulatory issues, it is important to emphasize that such developments regarding space take place in a context marked by a worrying resurgence of international geopolitical tensions. These "terrestrial contingencies" also enter the space domain. Whether through co-orbital operations of intimidation, demonstrations of force intended to attest to the crossing of technological milestones or, more radically, anti-satellite (ASAT) tests, all of those maneuvers contribute to the establishment of a climate of mistrust between states.

As far as European space is concerned, the stakes mentioned above highlight the shortcomings of its governance model. The challenges posed by the saturation of orbits and the congestion of the frequency spectrum, as well as the threat posed by the proliferation of space debris and their impact on freedom of access to space, have prompted the Member States of the European Union (EU) and the European Space Agency (ESA), through their organizations and agencies involved in the various dimensions of the space sector, to invest in a more coordinated approach to existing space surveillance tools and technologies. Europe is also attempting a difficult

relaunch of international dialogue in order to institute a code of conduct and establish confidence-building measures intended to guarantee sustainable use of outer space. The aim of this study is to understand the new opportunities that meeting these challenges could offer for Europe in space, but also to clearly identify the limits of its action.

Résumé

L'accroissement à un rythme inédit des activités spatiales, la multiplication et la diversification des acteurs impliqués dans l'exploitation de l'espace extra-atmosphérique, ou encore, et plus généralement, la dépendance de l'ensemble des secteurs d'activité aux technologies satellitaires et aux services qui y sont associés sont quelques-uns des phénomènes qui ont conduit à une surexploitation progressive des orbites et à une saturation du spectre des fréquences. Considérées par le droit international, et notamment par l'Union internationale des télécommunications (UIT), comme des ressources naturelles limitées, les orbites terrestres – et plus spécifiquement l'orbite géostationnaire – sont actuellement au cœur d'une compétition acharnée entre les États et les entreprises privées, qui ont développé leurs propres politiques spatiales (SpaceX, Blue Origin).

Les principes de liberté et de non-appropriation qui régissent l'emploi des orbites terrestres s'effacent progressivement du fait de la hausse sans précédent des demandes d'attributions de fréquences et la prolifération des systèmes satellitaires par des nations et des entreprises toujours plus nombreuses à s'affranchir des réglementations de l'UIT. La lutte entre acteurs spatiaux, d'une part, et entre acteurs spatiaux et ceux qui souhaitent atteindre ce statut, d'autre part, appelle donc une réforme en profondeur des normes internationales qui furent édictées pour l'essentiel à une époque où l'espace était seulement l'affaire d'un club restreint de puissances technologiques et industrielles. La situation présente et l'évolution qui se dessine exigent, en outre, l'instauration de codes de conduite et l'établissement de bonnes pratiques entre les prétendants à la course spatiale de demain.

Au-delà des questions juridiques et réglementaires qui viennent d'être évoquées, il importe de souligner que ces évolutions du spatial s'inscrivent dans un contexte marqué par une résurgence préoccupante des tensions géopolitiques internationales. Or, celles-ci se traduisent également dans le champ spatial. Qu'il s'agisse d'opérations co-orbitales d'intimidation, de démonstrations de force ayant pour but d'attester du franchissement de paliers technologiques ou, de façon plus radicale, d'essais d'armes antisatellites, chacune de ses manœuvres participe à l'instauration d'un climat de défiance entre les États.

Pour l'Europe spatiale, les enjeux qui viennent d'être mentionnés mettent en lumière les carences de son modèle de gouvernance en la matière. Les défis posés par la saturation des orbites et la congestion du spectre des fréquences, ainsi que la menace que fait peser la prolifération des débris spatiaux sur l'accès à l'espace, ont incité les États membres de

l'Union européenne et de l'Agence spatiale européenne (ESA), au travers des organismes et agences impliqués dans les divers volets du secteur spatial à investir dans une meilleure et indispensable coordination des outils et technologies de surveillance. L'Europe tente également une difficile relance du dialogue international pour l'établissement d'un code de conduite et de mesures de confiance destinées à garantir la pérennité de l'usage de l'espace extra-atmosphérique. L'ambition de cette étude est de comprendre l'importance que représente pour l'Europe spatiale le fait de relever ces défis mais aussi d'évoquer les limites de son action.

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Introduction: European Space Governance in a Changing Space Environment

It is well known that our societies have become heavily dependent on Earth-orbiting satellites and space infrastructures for a wide range of services that are often taken for granted. Space provides invaluable services and capabilities that are particularly relevant for everyday life, defense and security. It also offers technical means to help mitigate the potential risk of strategic surprises. From the earliest days of their development and deployments, space assets played a key role in the military, especially regarding nuclear deterrence. During the Cold War, both the United States and the Soviet Union fielded satellites aimed at mitigating any risk of escalation that could result from maneuvers or other military activities. Regarding nuclear deterrence, space assets were of first importance in maintaining strategic balance between the two protagonists. The ability to detect the launch of an ICBM as part of a first-strike operation and respond to it with a counterstrike was essential to preserving the strategic balance of the Cold War.[1] Successful nuclear deterrence still assumes that nuclear powers are able to rely on several space assets, including situational awareness, early-warning sensors and attribution capabilities.

Until recently, the source of space power has relied considerably on state funding and innovation. The space sector has been primarily powered by governmental demands. It was the defense sector, especially in the United States, that propelled the space industry for more than thirty years.[2] By the 1990s, in the post-Cold War world, the United States had no other choice than to adopt a 180-degree turnaround in order to guarantee the continued profitability of a space industry that had been entirely conceived and tailored for the eventuality of a large-scale war with the Soviet Union. To this purpose, the Clinton administration changed US policy to stop intentionally degrading GPS signals for civil users. The US had initiated a similar reform with commercial satellite imagery. Satellite imagery was a government domain until 1992 when the US Land Remote Sensing Policy Act enabled American firms to operate imaging satellites. This first step towards the gradual opening-up of space products and solutions also led to

1. T. Schütz, "Technology and Strategy: The Changing Security Environment in Space Demands New Diplomatic and Military Answers", *DGAPkompakt*, DGAP, No. 14, July 2019.
2. Z. Shabbir, A. Sarosh, S. I. Nasir, "Policy Considerations for Nascent Space Powers", *Space Policy*, No. 56, 2021, pp. 1-10.

progressive privatization of space services and laid the foundations for the New Space revolution.

Alongside these institutional reforms, many changes have affected the space industry. Advanced computing systems and new-generation algorithms have considerably lowered the development costs associated with space systems. Many improvements, including customizable, small, powerful, and energy-efficient software, have contributed to making satellites more profitable and more efficient.

Innovative manufacturing processes also helped start-ups invested in space to make space missions cheaper. In the past, building one or several satellites would have required facilities and manufacturing processes that only heavy industry could provide. Disruptive innovation based on new manufacturing techniques such as 3D printing and laser sintering reduced production costs by a factor of ten. Disruptive innovation has created a new market and value network that have displaced, and sometimes replaced, established market leaders.[3]

Cost reductions not only affects the construction of satellites; sending them into space has also become much cheaper. Since their official entry into the launch market, companies such as SpaceX have worked to lower the cost of space launches. To this purpose, they have opted for unorthodox choices: vehicles modularizing, new design methods, manufacturing processes based on vertical integration, etc.

Likewise, new start-ups have been working on the development of smaller satellites. Previously, such systems carrying reduced payloads were produced as part of scientific experiments or academic demonstrations. Their launch required space for carrying heavy launchers. Developments in technology have made it possible to produce satellites that, although smaller, have proven to be reliable and robust. These advances have contributed to the development of a niche industry in the field of light launchers. Within two decades, the cost of launching such lightweight satellites could sometimes be divided by 25.

New entrants to the space market are not just companies or start-ups; some states are taking their first steps in a sector hitherto exclusively controlled by the great technological powers. These new spacefaring nations form a cluster of countries with limited technological resources in the space field. However, associated with New Space companies, these new spacefaring nations are on the way to becoming major space players. Their arrival in a domain that, up to now, has been the "reserved domain" of a few dominant powers, has profoundly modified the current definition of "space power". Previously defined as "the ability to use space while denying

3. G. Denis, D. Alary, X. Pasco, N. Pisot, D. Texier, S. Toulza, "From New Space to Big Space: How Commercial Space Dream is Becoming a Reality", *Acta Astronautica*, No. 166, 2020, pp. 431-443.

reliable use to any foe",[4] space power should now rather be understood as "the ability of a nation to exploit the space environment in pursuit of national goals and purposes"[5] while including "the entire astronautical capabilities of the nation".

All of these transformations have profoundly modified the spatial ecosystem. The democratization of space – confirmed by the increase in the number of new entrants, both public and private – is not without risk for the future of the sector. In addition, this increased use of space is not without cost to the delicate space environment.

The "space activism" of the last twenty years has generated new difficulties that were not taken into account by the Outer Space Treaty. The diplomats and lawyers of the time were not able to predict phenomena such as the increase in space debris due to ASAT tests or space tourism. Likewise, the space sector was still considered to be the prerogative of a few powers.

Moreover, matters related to orbit congestion, frequency allocation and space debris have prompted Europe to proceed to a radical shift on space issues. For decades, space has been conceived as a supportive tool for the environmental, economic, and scientific policies and interests of European countries. In accordance with this view, the European Space Agency, civilian by essence, has been the main responsible actor. Over the last decade, however, the EU has come to realize that space is also a crucial constituent of European security and defense, particularly concerning the prevalent notions of strategic autonomy and techno-political independence. Such a shift has recently propelled issues as Space Traffic Management to the forefront of the European security agenda. It has also led to reflection about the adaptability of European institutions and agencies dedicated to space. The new EU Space Programme adopted on April 27, 2021, was the first attempt to take account of these new developments.

Purpose and Organization of the Study

The objective of the present note is twofold. In the first chapter, we look at the main transformations that have affected the space milieu since the eve of the 21st century. We also observe how such challenges affect the status of orbit and frequencies in relation to international law. We briefly recall the international law provisions dedicated to the methods of allocating space orbits and frequencies associated with the placement of satellites. This reminder allows us to take stock of the main threats that currently weigh on the future of space sustainability in a period characterized by the

4. C. S. Gray, "The Influence of Space Power Upon History", *Comparative Strategy*, Vol. 15, 1996, pp. 293-308.
5. D. E. Lupton, *On Space Warfare: A Space Power Doctrine*, Montgomery, Alabama: Air University Press, Maxwell Air Force Base, 1988.

democratization of the space sector and the emergence of private companies alongside the established state actors. The last part of this first chapter is more specifically devoted to the space debris issue and to the initiatives engaged in order to mitigate it.

As a corollary, Space Traffic Management (STM), and the way Europe is approaching it, is at the core of our argument in the second chapter. As we will discuss, in less than a decade, the STM issue has become a growing concern for the European Union and the ESA as the number of ASAT tests and other hostile maneuvers in space has multiplied. In the same period, new actors from the private sector have given rise to a new space activism that has resulted in the multiplication of launchings and of human objects placed in orbit. To cope with the resulting risks, European institutions are trying to develop programs and diplomatic initiatives aimed at managing the impact of orbit saturation and space debris. Although some Member States already have their own STM capabilities, Europe suffers from a lack of coordination and has failed to establish a coherent normative approach to STM issues. This second chapter takes stock of the actions undertaken by the EU, the European Space Agency, and their respective member states to break free from US dependency.

Orbits, Frequencies and Space Debris

While space has never been so critical to our lives and organizations, it is today at the heart of major concerns as to the sustainability of its exploitation. It is now that space has become an increasingly *contested*, *congested* and *competitive* environment.[6]

The Space "3C" Environment

First, space has become a *contested* environment.[7] The ASAT test conducted on November 15, 2021, by Russia in low-earth orbit (LEO), when an interceptor of the Nudol ground-based ASAT system was used to destroy the derelict Cosmos-1408 satellite, clearly confirms not only the existence but also the persistence of a nascent and potentially destabilizing weaponization process. This is not the first time a country has tested an ASAT weapon and produced debris on orbit. The event shows that the space powers are far from adopting any form of unilateral moratorium on destructive ASAT testing and that a global, United Nations-led initiative on space threats and responsible behavior has never been so urgent. Besides ASAT tests, it should be recalled that other kinds of malevolent or threatening maneuvers in space have been detected. Although such maneuvers do not offer a clear indication of the operating state's resolve, they could engender strategic miscalculations. These maneuvers are very diverse and may include software or hardware alterations, intentional and/or unintentional interference through jamming, the blocking of transmissions between satellites and ground stations, spoofing, etc. Such activities not only threaten space infrastructures indispensable for daily civil functions, they also jeopardize space assets that are of first importance for strategic stability, especially regarding nuclear deterrence.[8] These considerations impelled NATO to adopt its first space strategy in June 2019 wherein it designates space as an "operational domain" of its own.[9] NATO's changing posture on space is to some extent the direct result of the wave of doctrinal moves initiated by many countries, especially space powers,

6. Z. Shabbir, A. Sarosh, S. I. Nasir, "Policy Considerations for Nascent Space Powers", *op. cit.*, pp. 1-10.
7. T. Shütz, "Technology and Strategy: The Changing Security Environment in Space Demands New Diplomatic and Military Answers", *DGAPKOmpakt*, DGAP, No. 14, July 2019.
8. X. Pasco, « L'espace, domaine de confrontation stratégique », *Revue Défense Nationale*, No. 835, 2020, pp. 59-63.
9. T. Schütz, "Technology and Strategy: The Changing Security Environment in Space Demands New Diplomatic and Military Answers", *op. cit.*, p. 6.

relating to the status of space in their respective defense organizations. The Trump administration's resolve to establish a Space Force in 2019 was the concretization of an old – and often contested – aim to detach the space domain from the other services. Despite inevitable compromises concerning the hierarchical relationship between the new Space Force and the Air Force, the result does not suffer any ambiguity: space can be definitely considered as a domain of action that requires a dedicated structure and chain of command. Following this trend, other countries also initiated reforms to elevate space to a new strategic level. France adopted in July 2019 a *Stratégie de défense spatiale* and set up a dedicated *Commandement de l'espace*. Similarly, other countries in Europe and the world have followed this trend by designating a dedicated institutional structure in charge of military space issues.

Secondly, space has also become an increasingly *congested* environment because of the rapid intensification of space activities worldwide. This is also the direct consequence of the emergence of "new actors", a catchall expression that includes new spacefaring nations (China, India, but also Paraguay, New Zealand, Luxembourg, and the United Arab Emirates) and private companies generally grouped under the New Space label (SpaceX, Blue Origin, Planet).

Luxembourg, in this regard, is a very illustrative case of the challenges new spacefaring nations could pose for European space governance. Luxembourg is currently transforming its economy in order to attract emerging space companies, by creating a positive regulatory, legal, research and business environment. It is the first country in the European Union to adopt dedicated national legislation with the intention of regulating property rights over resources returned from space. The Luxembourg legislation could serve as a precursor for similar legislation in other countries and encourage more private business initiatives aimed at exploiting space resources without any consideration of international rules and codes of conduct.[10]

This phenomenon has thus led to an unprecedented upsurge in global space activity and generated a doubling of the number of operating satellites in less than a decade. As we will detail further, this increase in the number of satellites is mainly located in Low Earth Orbit and in the Geostationary belt (GEO). This is not surprising, since most of these satellites provide operational capabilities and services for telecommunication, Earth observation and navigation of particular interest, especially for the military. If multilateral corrective policies are not commonly adopted by space actors and the international community,

10. C. G. Starling, M. J. Massa, Lt Col C. P. Mulder, J. T. Siegel (eds.), *The Future of Security in Space: A Thirty-Year Strategy*, Washington: The Atlantic Council, Sowcroft Center for Security and Strategy, April 2021, p. 29.

orbital congestion will dramatically increase the risk of collisions between satellites or between satellites and space debris. It is worth noting that the European Commission, in a communication in 2021, declared space infrastructure as a "critical infrastructure".[11] Such risks are no longer just theoretical probabilities. The number of Collision Avoidance Maneuvers (CAMs) has considerably increased with the global rise of space activity. CAMs imply several costs; they cost time due to the hours spent in sky-monitoring, collision-risk calculations, and maneuver planning; CAMs also incur fuel consumption and, last but not least, a temporary shutdown of science instruments, optical sensors or telecommunication relays before the services are restarted. Space debris poses direct risks in terms of human life, especially for those astronauts residing in the International Space Station (ISS). The Russian ASAT test on November 15, 2021, clearly endangered the ISS crew, forcing them to take temporary refuge in the Soyuz and Crew Dragon transport modules.

Third, space has evolved as an increasingly *competitive* milieu in the sense that many new concepts and approaches have recently appeared, including large constellations (Starlink, Kuiper), miniaturized systems (CubeStats), In-Orbit Services (IOS), etc. These new approaches, while revolutionizing some of the mainstream uses of space for diverse purposes, also contribute to the orbital congestion and elevate the risk of interferences in frequencies. Intuitively, it can be asserted that the inflation of orbital objects endangers the space environment.

The unprecedented increase in space activities now raises the question of its sustainability. Space is today at the heart of a global competition of unprecedented complexity. This competition opposes public actors to the new private entrepreneurship, driven by libertarian ideals and by the conviction that reviving the exploitation of space will offer a new El Dorado to the most ambitious entrepreneurs. This ambition has a name: Big Space. It lies outside the scope of the present note. Nevertheless, although these actors are private and try to free themselves from the legal and regulatory frameworks that apply to their activities, they are the responsibility of the states that host them. Behind the activism of this new entrepreneurship lies a logic of interstate competition, the grammar of which has not fundamentally changed. To put it more simply, space is and will remain a field of competition between great powers.[12]

11. European Commission, Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions towards a Space Strategy for the European Union that Benefits its Citizens; 2011. COM, European Commission, Brussels, 20211, p. 6, 152 FINAL.
12. C. G. Starling, M. J. Massa, Lt Col C. P. Mulder, J. T. Siegel (eds.), *The Future of Security in Space: A Thirty-Year Strategy, op. cit.*, p. 27.

Legal and Political Aspects

Before discussing in detail, the threats that weigh today on the future of the allocation of orbits and frequencies, it seems essential to recall some fundamental principles of space law.

The "law of outer space" is usually distinguished from "space law". The first refers to the legal corpus formed by the great space treaties established between 1967 and 1979. The latter can be defined as the law governing space, celestial bodies, and space activities, strictly speaking. The space law is not statutory; above all, it fulfils one function: regulating human activities in space.[13] The creation of such a regime for space has its origins in the Cold War. The fear at that time was of a possible appropriation of resources and access to space by the only two superpowers: the United States and the Soviet Union.

The launch of Sputnik I was followed by several resolutions adopted by the United Nations General Assembly to guarantee the free development of space activities. Resolution 1148 thus recommends peaceful use of space, while resolution 1721 affirms the principle of the free exploitation of outer space as well as celestial bodies in accordance with international law (i.e., without national ownership). Resolution 1961, for its part, lays the foundations for what will become the future Outer Space Treaty of 1967.

Later, after several rounds of negotiations, various more specific resolutions adopted by the United Nations General Assembly were added: Resolution 37/92 of December 10, 1982 (Principles Governing the Use by States of Artificial Earth Satellites for International Direct Television Broadcasting), Resolution 41/65 of December 3, 1986 (Principles Relating to Remote Sensing of the Earth from Outer Space) and, finally, Resolution 47/68 of December 14, 1992 (Principles Relevant to the Use of Nuclear Power Sources in Outer Space).

Apart from these elements of soft law, space law also includes a hard law, sometimes referred to as *corpus juris spatialis*. This legal corpus is made up of spatial treaties. There is therefore a framework treaty, which is supplemented by other treaties.

It is important to stress that this body of provisions relating to the status of space also includes agreements negotiated and concluded within the framework of specialized agencies, in particular within the International Telecommunication Union.[14]

13. I. Chalaye, Le statut des orbites terrestres et leur utilisation à la lumière des principes du droit spatial, Paris, Institut d'Etudes de Géopolitique Appliquée, octobre 2021.
14. The main provisions relating to the ITU include the Convention, signed on October 25, 1973 (and entered into force on January 1, 1975). This convention lists the various rules governing telecommunications and radiotelecommunications. To this convention was added a constitution (established in 1992) that contains the fundamental provisions of the ITU.

The 1963 World Radiocommunication Conference provided an opportunity for states to enact the principles governing satellite communication systems. Among the measures taken are the rules relating to the sharing of frequency bands as well as the use of orbital positions.[15]

The study of orbits and frequency must be carried out in the light of the two main principles that govern the law of space today: the principle of freedom and the principle of non-appropriation. The former is the first principle of space law since it is mentioned in Article 1 of the Outer Space Treaty. The principle of non-appropriation, for its part, is stated in Article 2 of the Treaty and is therefore subordinate to the principle of freedom. Both principles are weakened by the practices of certain public and private actors. In fact, faced with the effective and growing privatization of space activities, the Outer Space Treaty is today the subject of interpretative controversies. Legal doctrine considers that the state is the exclusive owner and therefore the first guarantor of spatial freedom. Non-governmental entities are subject to state authorizations and permanent state control. In other words, the freedom of companies remains ancillary to that of states. We will also add that extra-atmospheric space has never been the object of human colonization; the latter has the status of global common under the law. Nevertheless, with the development of space technologies and the sending of human-made objects into outer space, it was necessary to imagine a system of legal responsibility that allows states to exercise their sovereignty over these same objects. This is the whole scope of Article VIII of the Outer Space Treaty, which stipulates: "A State Party to the Treaty on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, and over any personnel thereof, while in outer space or on a celestial body."

Despite its apparent common sense, the logic of attributing state responsibility to objects placed in outer space has been the subject of numerous disputes on the part of non-space states (including states just free from colonization or lacking the industrial and technological base required to become a space player).[16] This challenge gave rise, in 1976, to the Declaration of Bogota through which all the equatorial states claimed their sovereignty over the geostationary orbit. In response to the claims of these states, the United Nations General Assembly adopted in 1996 a "Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries".[17]

15. Frequencies are distributed by service and by region. The planet is divided into three regions: Europe, Russia, and Africa (Region 1), the Americas (Region 2) and Asia and the Pacific (Region 3).
16. A. D. Roth, *La prohibition de l'appropriation et les régimes d'accès aux espaces extra-terrestres*, Geneva : Institut des hautes études internationales, 1992.
17. Resolution 51/122, December 13, 1996.

The objective of this declaration was to reassure the non-space states and to include them as much as possible in the dynamics of the development of space technologies, in particular by granting an equitable access regime to the geostationary orbit. These measures to ease the tensions arising from the implementation of the Outer Space Treaty have remained very limited in their application. Moreover, taking into account the grievances of non-space states posed a major problem: it called into question, to a certain extent, the principles of freedom and non-appropriation.

The fact remains that Earth's orbits are considered by the ITU and the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) as a limited natural resource. This is more particularly the case of the geostationary orbit (located at an altitude of almost 36,000 km). The geostationary orbit allows for a satellite to have the same period of revolution as the Earth. This particularity makes it a hot spot for telecommunications applications.[18]

It will be observed that, at the time when the main space treaties were drawn up, issues such as space debris and the saturation of orbits and frequencies were not on the agenda of space powers. Today, the dependence of our societies on satellite resources, which has resulted in an unprecedented increase in the launching of objects into space, has raised the question of orbits and frequency allocations as a real strategic issue.

We have therefore witnessed, after sixty years of space exploitation, an unprecedented increase in the security issues linked to orbits. Since the Chinese ASAT test in January 2007, demonstrations of force in space have multiplied, in various forms. The question that is clearly posed today relates to the risk of weaponization of space. In terms of international law, this question lies at the heart of a gray area. To date, there is no definition of what constitutes a space-level means of attack, nor of what constitutes aggression in outer space. However, attack methods in space are diverse and varied; they include missile strike, laser beam blindness, cyberattacks on communication relays, co-orbital maneuvers, etc.

The problem of space debris has arisen with a whole new acuteness since the increase in the number of ASAT tests. It primarily concerns low orbit, which contains the largest amount of debris of all sizes. The geostationary orbit, for its part, is faced with a difficulty of a different nature: frequency congestion and the risk of interference. However, the geostationary orbit represents a critical zone for the continuity of telecommunications services for all the states of the planet.

18. N. Nayebi, "The Geosynchronous Orbit and the Outer Limits of Westphalian Sovereignty", *Hastings Science & Technology Law Journal*, 2011, Vol. 3, No. 2, pp. 492-497.

The number of geostationary satellites has nearly tripled in barely thirty-five years. From 210 in 1985, their number was an estimated 562 in 2021. This is mainly explained by the increase in the number of states that now depend on space for their social, political, and economic infrastructures, but also by the increase in the offer of services since the opening of space technologies to the private sector. This development is not without posing a number of legal difficulties. The development of the geostationary orbit has led to the creation of an economic market, and even to the birth of speculation. In other words, despite being seen as a finite natural resource, geostationary orbit has become an increasingly coveted commodity. This is explained by the fact that each state has an equal right to participate in the competition in matters of access, exploration, and use of space. However, this equality in principle does not allow all the actors to access space. There is therefore a gradual shift towards the exercise of an exclusive property right through the activities of a few states or private companies. This put into question the founding principles of public international law laid down by the space treaties. Moreover, one must underline the existence of unfair practices whereby some states can contrive to reserve a geostationary position without any real future project. Such a method, also known as "over-filing", allows a state that has acquired a slot to retain it for seven years (according to ITU rules) without bringing it into use. This is why there is so much uncertainty about the exact number of operating satellites placed in GEO orbit.[19]

The main interest in the geostationary orbit in terms of telecommunications, as mentioned, is that the satellites placed in this orbit require less burdensome flight-tracking techniques (the ground segment antenna aims at a unique point since the satellite is stationary relative to the Earth). The gradual saturation of the GEO orbit has recently forced states and manufacturers to place telecommunications satellites in low and medium orbits. The use of these orbits makes it possible, on the one hand, to circumvent the problem of saturation of the GEO orbit and, on the other, to shorten the propagation times of information and communications.[20]

Circumterrestrial space does not benefit, today, from any dedicated legal regime. No internationally recognized legal definition characterizes the altimetric limits of outer space. This absence of a legal framework opens the door to behavioral drifts on the part of states and private actors, to the point of calling into question the principles established by the space treaties.

19. The most famous example of over-filing was the case of Tonga, which filed for 16 GEO positions, ultimately acquiring only six of them the following year, without any specific or real plan to launch its own satellites. Actually, the Tongan government had no intention of putting any satellite into orbit. Instead, Tongasat, a satellite company set up by an American businessman, proceeded to rent an allotment of slots to Unicorn, a Colorado-based company.
20. *Les constellations de satellites,* available at *:* www.anfr.fr.

Orbit Saturation and Frequencies Congestion: from "Global Common" to Privatization?

The scarcity of the orbital resource results from the fact that it is coveted by states for the deployment of satellite systems. This saturation results from interference and jamming between the space telecommunications systems and not from physical saturation of the orbits. In 1971, the World Radiocommunication Conference (WRC) – formerly the World Administrative Radiocommunication Conference (WARC) – for the first time highlighted the limits on frequencies in geostationary orbit. In its Resolution SPa2-1, the WARC stipulated that "all countries have equal rights in the use of both the radio frequencies allocated to various space radiocommunication services and the geostationary satellite orbit for these services". It added: "the radio frequency spectrum and the geostationary satellite orbit are limited natural resources and **should** [my emphasis] be most effectively and economically used".[21]

Faced with the danger of saturation of orbits and frequencies, the 2020 World Radiocommunication Conference incorporated a modification in the terms used. Thus, WRC-19 resolution 599 now specifies: "In using frequency bands for radio services, Member States shall bear in mind that radio frequencies and any associated orbits, including the geostationary-satellite orbit, are limited natural resources and that they **must** [my emphasis] be used rationally, efficiently and economically, in conformity with the provisions of the Radio Regulations, so that countries or groups of countries may have equitable access to those orbits and frequencies taking account the special needs of the developing countries and the geographical situation of particular countries".[22]

The last Report of the Scientific and Technical Subcommittee on its fifty-eighth session, held in Vienna from April 19 to 30, 2021, stated that some delegations had underlined the fact that "the geostationary orbit was a limited natural resource that was at risk of becoming saturated, thereby

21. Resolution No. Spa2-1 Relating to the Use by all Countries, with equal Rights, of Frequency Bands for Space Radiocommunication Services, The World Administrative Radio Conference for Space Telecommunications (Geneva, 1971).

22. Resolution 599, Additional temporary regulatory measures following the deletion of part of Annex 7 to Appendix 30 (Rev.WRC-15) by WRC-19, available at: www.itu.int.

threatening the sustainability of space activities in that environment, that its exploitation should be rationalized and that it should be made available to all States, under equitable conditions, irrespective of their current technical capabilities, taking into particular account the needs of developing countries and the geographical position of certain countries"[23].

An additional point raised by some delegations concerned the status of mega-constellations. They expressed "the view that, while future mega-constellations of satellites would bring about new approaches to the establishment of nationwide telecommunication networks, for some States, geostationary satellites would continue to be irreplaceable, owing to the special geographical conditions in which they operated, and hence there was a need to preserve the geostationary orbit region. The active development of such mega-constellations would also create a number of significant problems, such as radio frequency interference and overpopulation of orbits, and thus the matter should be expediently addressed by States, within both ITU and the Subcommittee".

The Dynamics of "Orbits Grabbing"

Earth orbits, as it has been said, constitute a global common. In this sense, they can be used by everyone; they can be used by everyone. The notion of global common designates goods so mutual to all human societies that no-one can appropriate them or deprive others of them. This approach to terrestrial orbits is found in the text of the Outer Space Treaty, Article 1 of which stipulates: "The exploration and use of outer space, including the moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind".[24] Moreover, the fact that the orbits are allocated to states free of charge by the ITU does indeed confirm that they constitute a global common. However, today, the unprecedented increase in space activity is calling this principle into question. The scarcity of outer space orbits leads to unprecedented development.

If under international law all states have an equal right to use orbits and frequencies, in practice the disparity in technological development between states prevents the implementation of this principle of freedom of access and use. Even though most ITU members are made up of states that lack technological and industrial resources in the space domain, the main technological powers of the planet have succeeded in establishing a system of allocation of orbits and frequencies that favors them. To put it more

23. Committee on the Peaceful Uses of Outer Space, Scientific and Technical Subcommittee, Fifty-eight session, Vienna, 19 – 30 April 2021, A/AC.105/C.1/L.386/Add.8, available at: www.unoosa.org.
24. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, Art. 1., 1967.

simply, the ITU has implemented the "first occupant" rule for states filing requests to occupy certain orbits. This rule clearly conflicts with the principle of freedom of access to orbits and frequencies. On May 26, 2021, at the end of a meeting on the challenges of civil space, organized by the Permanent Representation of France to the United Nations, Stéphane Israël, CEO of Arianespace, warned against the risk of "de facto monopolization" that could result from the "first occupant" rule.[25] In the sights of the CEO of Arianespace is Elon Musk's Starlink project, for which SpaceX has requested authorization from the US Federal Communications Commission to launch more than 40,000 satellites. This strategy, according to Stéphane Israël's analysis, consists of accelerating the deployment of Starlink satellites in order to occupy the orbits and thus be in an advantageous balance of power with the regulatory authorities.

This "grabbing" dynamic that results from the practice of certain players in the space sector is accompanied by progressive privatization of rights to terrestrial orbits. Orbital positions are considered as "hot slots", which are particularly prized by states. However, for several years an unprecedented increase in requests for frequencies and orbital locations has been observed. This multiplication of requests in turn generates delays in their processing by the ITU. There is therefore a great temptation for space players to circumvent ITU rules and to make arrangements between themselves for the exploitation of orbital resources.

This trend of developing private law practices for orbits and frequencies is accompanied by an increase in the intervention of private companies active in the space sector. Previously, private companies forwarded their authorization requests through the government of the state in which they operated. Today, more and more private operators are contracting with foreign administrations in the hope of finding a complacent state that will file the requests with the ITU. This development is leading to a loss of control by the states of orbital positions and the frequencies allocated to them. This enhancement of terrestrial orbits and frequencies is contrary to the spirit and letter of the Outer Space Treaty. Yet, to some extent, it is the very procedures of the ITU that allow this type of drift to develop. Strictly speaking, states do not have the right to property in the orbits. However, when a satellite comes at the end of its life, there is no ITU regulation that provides for withdrawing the use of the orbital position from the operator.

It is therefore sufficient for the state to renew the occupation of the orbit allocated to it by placing one or more new satellites. If the state cannot itself ensure the placement of a satellite, it will open this right to private operators. While the allocation of orbits and frequencies offers a simple

25. Comments reported in « Centième succès d'affilée pour le Falcon 9 », *Air & Cosmos*, No. 2738, June 4, 2021, p. 33.

right to use them, the practice gives rise to perpetual endless occupation of an orbital position.

In the United States, a real market for orbit-spectrum resources has been created. In 2002, the US Federal Communication Commission authorized the transfer of spectrum operating licenses and the transfer of user rights between operators. The commission will even go so far as to promote the efficient use of frequencies through the contracting of secondary contracts by authorizing the leasing of frequency bands in the short and long term. The United States is not the only one to deregulate in this way.[26] The European Union has also recognized the existence of this secondary market, through Article 19 of the preamble to its framework directive of March 7, 2002 (also known as the "Telecom Package"). The text provides that the "transfer of radio frequencies can be an effective means of increasing efficient use of spectrum, as long as there are sufficient safeguards in place to protect the public interest, in particular the need to ensure transparency and regulatory supervision of such transfers".[27]

The endorsement of such practices in various national regulations now gives rise to the possibility of patenting orbits and frequencies for the needs of private operators.[28] Many observers of space affairs are currently talking about the development of a Space Rush to describe this phenomenon.

The Space Debris Issue

Nowadays, orbital debris is a significant part of the near-Earth environment. Fifty years ago, the idea that space debris could endanger humanity would not have figured on any political agenda. As Torben Schütz underlines, "arms control regimes are [...] unprepared to assure stability in space. Existing arms control treaties barely prohibit or even regulate the military capabilities and the equipment that are required for ASAT capabilities".[29] Today, orbital debris and their threat not only to space sustainability but also to humanity as a whole is a fact we have to cope with.[30] If left unchecked, the growing amount of orbital debris could have grave economic, social, political and military consequences since all our

26. R. M. Nunno, "Review of Spectrum Management Practices Regional and Industry", *Federal Communications Commission International Bureau, Strategic Analysis and Negotiation Division*, Analysis Branch, August 30, 2002.
27. §19, Preamble of the Directive 2002/21/EC of the European Parliament and of the Council of March 7, 2002, on a common regulatory framework for electronic communications networks and services (Framework Directive).
28. B. L. Smith, « Brevetabilité des Orbites et Fréquences », in: *Orbites et fréquences : statut, répartition et régime juridique*, T. 1, Lyon: A. Pedhone, 2005.
29. Quoted in T. Schütz, "Technology and Strategy: The Changing Security Environment in Space Demands New Diplomatic and Military Answers", *op. cit.*, p. 5.
30. V. V. Adushkin, O. Yu, S. S. Veniaminov, S. I. Koslov, V. V. Tyurenkova, "The Small Orbital Debris Population and Its Impact on Space Activities and Ecological Safety", *Acta Astronautica*, No. 176, 2020, pp. 591-597.

modern organizations and infrastructures depend on reliable space systems.

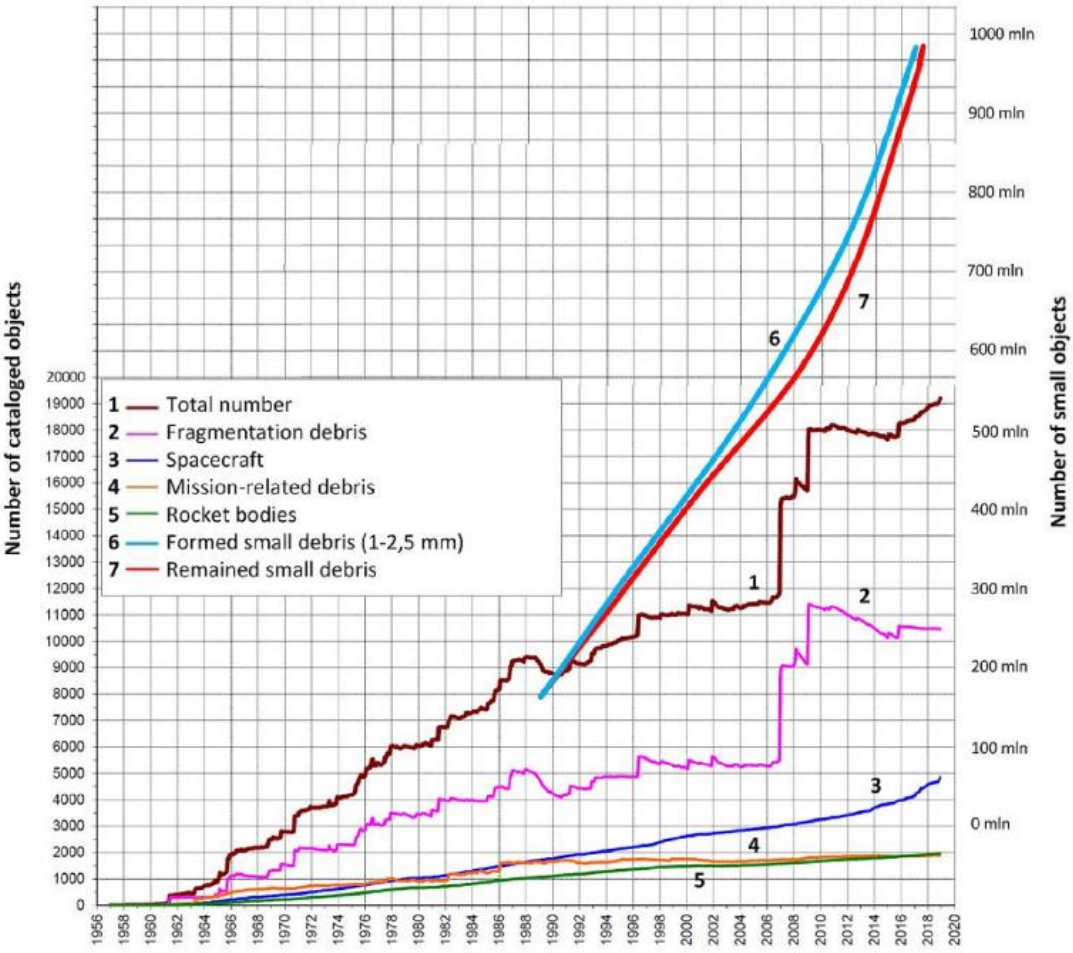
The origin of space debris is very diverse. The debris results from two types of phenomena. Natural phenomena are at the origin of certain debris. About 40,000 tons of meteoroids enter Earth atmosphere's annually. However, these meteoroids, asteroids or other cosmic bodies penetrate near-Earth space very quickly, and just once. Moreover, they finish their course either by leaving the near-Earth zone or by burning when entering the dense layer of the atmosphere.[31] Thus, for the most part, space debris is the product of human activity in space. Each rocket launch leaves in its wake a large amount of various debris, including in the rocket stages when a satellite is placed in its orbit. The debris can also result from congestion in certain orbits, in particular in low Earth orbit. The multiplication of satellites mechanically increases the risk of collision. The collisions in turn generate debris that can either collide with each other or affect other satellites, whether they are operational or not. New Space activism could greatly worsen the space debris environment, particularly in LEO, even if there are also signs of progress as some New Space operators are actively working to mitigate their impact. Nevertheless, New Space marks a significant break with past experience. Without entering into the technical details, it is worth explaining how mega-constellations could endanger LEO sustainability. Deployments of large constellations of satellites next to existing residents will automatically raise the probability of conjunction occurrences and mechanically increase the number of alerts due to the close proximity of the constellations. This phenomenon will inevitably lead to a "conjunction warning overload". Worst of all, a large constellation must consider close approaches with itself. Even in the absence of neighboring systems, self-conjunction can occur between two or more elements of the same constellation.[32] In addition to conjunction predictive models, failure rates also enter into consideration. The historical failure rate of all vehicles launched by humans to date is about 15%. For a 2,000-satellite constellation with a five-year lifetime, a 10% failure rate results in approximatively 40 failed satellites per year, or 200 derelict satellites for this one constellation. This highlights the need for operators to share accurate information with other operators and regulating authorities. Bodies such as the Space Data Association (SDA) provide services aimed at reducing the number of conjunctions and incidents. However, the SDA only uses owner-operator data from its members. Although more and more owners and operators have stated their intention to follow best practices in order to become "good citizens" of outer space, many indicators suggest a decrease in the number of satellite recordings within the ITU.

31. *Ibid.*, p. 591.
32. Some aerospace models show that 2 to 3 collisions per year could occur per constellation if no action is taken.

Orbital debris is also the result of deliberately hostile activities in outer space: ASAT-type tests. These are demonstrations of force intended to illustrate, within the framework of deterrence, a state's degree of technological development. These tests generate a considerable amount of debris that affects not only the opposing satellites but also the systems belonging to the state making the test.

States seem to have become aware of the risks of saturation and congestion of orbits and frequencies, but this awareness is not being followed up with immediate action. The ESA has warned that current space behavior is unsustainable in the long term. If the pace of orbit placements does not decrease, the deployment of human devices in outer space would become impractical. The ESA more particularly has drawn the attention of states to the dangers hanging over low orbit.

The history of contamination of near-Earth space (including with small orbital debris of 1 to 2.5 mm in size) from 1957 to 2019



Source: V. V. Adushkin, O. Yu, S. S. Veniaminov, S. I. Koslov, V. V. Tyurenkova, "The Small Orbital Debris Population and Its Impact on Space Activities and Ecological Safety", Acta Astronautica, *No. 176, 2020, p. 593.*

In 2021, no fewer than 2,600 satellites were identified in Low Earth Orbit. With such a large number, the risk of collision increases. Thus, low orbit is often referred to as "trash orbit".[33] One example of an incident was, in February 2009, the collision between the Russian military satellite *Kosmos 2251* (out of service since 1995) and the *Iridium 33* satellite (which was still in operation) – the impact of which considerably increased the amount of space debris, adding to the already numerous pieces of debris resulting from the Chinese ASAT test of January 2007.

The US National Aeronautics and Space Administration (NASA) defines orbital debris as "human-made objects in space that are no longer operational". Debris results from rocket launches, satellite break-ups and the impacts of debris hitting satellites. The United Nations Committee on the Peaceful Uses of Outer Space (COPUOS), adopting a more elaborate approach, considers "space debris" as "all manmade objects, including their fragments and parts, whether their owners can be identified or not, in Earth orbit or re-entering the dense layers of the atmosphere that are non-functional with no reasonable expectation of their being able to assume or resume their intended functions or any other functions for which they are or can be authorized". The European Space Agency's definition for space debris is similar to that of COPUOS; it defines space debris as "all the inactive, manmade objects, including fragments, that are orbiting Earth or re-entering the atmosphere". The main difference between NASA's definition and the COPUOS and ESA approaches concerns the artificial/natural origin of space debris. While NASA tends to include in the category of space debris objects of natural origin (i.e. naturally occurring particles associated with solar system formation or evolution), COPUOS and ESA insist on the human source of space debris.

According to ESA data (last updated on November 9, 2021), the number of debris objects regularly tracked by Space Surveillance Networks and maintained in their catalogue is around 30,000. Since humankind started to exploit space orbits, more than 630 incidents, including break-ups, explosions, collisions, and anomalous events, have created fragmented debris. However, these data provide only a partial view of the danger to come. Some statistical models results offer a far more alarming picture:

33. Union of Concerned Scientists, UCS satellite database: In-depth details on the 3,372 satellites currently orbiting Earth, including their country of origin purpose and other operational details, January 1, 2021.

Estimated statistical number of space objects on Earth orbit classified by size category

Diameter	Total estimated number of objects
Greater than 10 cm	36.500
Greater than 1 cm to 10 cm	1 million
Greater than 1 mm to 1 cm	330 million

Source: European Space Agency.

The amount of space debris is on the rise, and it can be explained by two phenomena. First, the number of satellite launches has dramatically increased.[34] In 2020, the total number of rocket launches (excluding failures) since 1957 was estimated at 5,990. One year later, the estimate was 6,120. It seems obvious that this trend will continue due to the emergence of new actors in the space sector (such as SpaceX and Blue Origin) and the rise in the number of states developing their own space agencies. More worrying is the fact that new space firms have not internalized the costs of the debris generated from their launch activities.[35] Moreover, debris mitigation technology, whatever the solution envisaged, is costly, and individual companies underinvest in these technologies. Second, the constant miniaturization of satellites has resulted in a greater number of pieces of space debris that are far less detectable and trackable.

Several experts have warned about collisional cascading, also known as the "Kessler Syndrome". In a 1978 paper, two NASA scientists, Donald J. Kessler, and Burton G. Cour-Palais, described the process of ring formation around planets, and then explained how satellite collisions could produce orbiting fragments, each of which would increase the probability of further collisions, leading to the growth of a belt of debris around the Earth. In 2010, Donald J. Kessler defined the concept of orbital collisional cascading and demonstrated its possible implications for future space operations. The Kessler Syndrome is based on the fact that the more debris there is in orbit, the more collisions will occur, and the more debris will be created. Kessler predicted that, in the specific regions of LEO, there would be a slow but continuous increase in collision fragments.[36] The increasing commercialization of space activities will contribute to making the problem of orbital debris more and more acute. The most worrying dimension of this development stems from the fact that the private companies active in the space sector no longer act only as subcontractors of states but also develop their own programs.

34. P. Bernat, "Orbital Satellite Constellations and the Growing Threat of Kessler Syndrome in the Lower Earth Orbit", *Safety Engineering of Anthropogenic Objects*, Vol. 4, 2020.
35. N. Adilov, P. J. Alexander, B. M. Cunningham, "The Economics of Orbital Debris Generation, Accumulation, Mitigation and Remediation", *Journal of Space Safety Engineering*, No. 7, 2020, p. 447.
36. D. J. Kessler *et al.*, "The Kessler Syndrome: Implications to Future Space Operations", *Advances in the Astronautical Sciences*, No. 137, 2010, pp. 47-62.

As we can see, the intensification of space activities worldwide, the emergence of new actors – not only new spacefaring nations but also commercial companies – and the development of new concepts (CubeSat, mega-constellations, etc.) are raising new challenges for space sustainability and the security of future space activities. They also jeopardize the freedom of access to space of all nations and private companies that are active in space.[37] These threats to space infrastructures make all states vulnerable, but not all space players face these threats equally.

Both the nature and the unique dimension of the risks associated with today's space activities lead us to examine European space governance under a new light. Among the policy responses to the challenges related to orbit congestion, frequency interference and space debris resulting from the intensification of space activities, the development of Space Traffic Management frameworks was recently brought to the forefront of the global political agenda. In the United States, US Space Policy Directive-3 (National Space Traffic Management Policy), issued on June 21, 2018, defines the principles, purposes, roles, and responsibilities that should be followed in establishing a new approach to STM.[38] A comparable STM policy in Europe has not yet emerged. The next chapter will explore, first, the consequences of the absence of such a European regulatory framework, and second, how this gap should be filled.

37. *Towards a European Approach to Space Traffic Management – Full Report*, *ESPI Report*, No. 71, Vienna: European Space Policy Institute, January 2020.
38. M. Polkowka, "Space Situational Awareness (SSA) for Providing Safety and Security in Outer Space: Implementation Challenges for Europe", *Space Policy*, No. 51, 2020, p. 3.

Space Traffic Management as a European Governance Issue

Definition Essay and Diverging Approaches

Before entering into the details of the STM issue as European actors approach it, it is important to define Space Traffic Management. What is particularly revealing when examining the concept of STM is that, although it has become a critical topic for the space community, it has not yet received a clear and unambiguous definition. In such a context, it is no surprise that the United States is the first space actor to have produceed a regulation framework that determines the definitions in use and the standards to be adopted. Yet, it is critical to agree on the terminology that could provide a clear framework to enable cooperation and collaboration among European states. Beforehand, it is essential to insist on two aspects of the STM debate. First, when discussing STM, one has to keep in mind that the focus should be on "activities", not "entities". In other words, what should be the core of any STM analysis is not so much the question of the total exact number of objects existing in near-Earth space as that of the attitude adopted by space actors? This precision will be important later when we discuss the governance issue. Second, STM is not a solution in itself; rather it is a constitutive part of a global solution scheme. In other words, STM is both an organizational framework and an operational concept involving a set of complementary means and measures intended to enhance the safety of on-orbit operations and to guarantee the long-term sustainability of the space environment.

When discussing the STM issue, several divergences usually appear among space players. These disagreements help explain why STM can be a difficult matter for Europe in terms of governance. A first divergence relates to the nature, scope and strictness of the regulatory provisions that can be included. Many stakeholders belonging to the space domain, though recognizing the limits of a self-regulatory approach, are not keen to accept common constraints. As a result, the prospect of developing enforcement and verification mechanisms is highly controversial. The question that remains to be solved is: how can we best integrate the STM dimension in existing regimes dedicated to space? How can we develop a regulatory framework that could include the STM dimension? This last observation leads us to the "cooperative dimension" issue, which is a subject of debate. Most stakeholders agree that cooperation at the international level is by far

the best solution to cope with STM issues. They also share the vision of a coherent and coordinated framework among space actors in order to manage questions related to the space environment. However, when discussing the exact nature or dimension of the setup required to translate cooperative efforts into a viable regime, divergences resurface, especially about roles and sharing of responsibilities. In the same way that many actors are at the source of the problem, various players must contribute to the solution. It is thus essential to establish constructive dialogue between private and public entities, as it would be opportune to link civil and military actors in a STM scheme. Yet, such a perspective does not generate great enthusiasm among the concerned entities. Issues such as those related to the degree of sensitivity of certain information and functions, and the processing and distribution of Space Situational Awareness data, do not generate consensus.

Space Traffic Management: Not New But Still Unregulated

Space Traffic Management is far from being a new concept. However, due to the nature and importance of the challenges to the security, safety and sustainability of space activities, STM has acquired an unprecedented degree of priority among space actors and states aware of their dependency on space assets. Yet, it is true, only states with the required technological capabilities are already equipped with Space Surveillance and Tracking (SST) and Space Situational Awareness (SSA) Programmes. The US Department of Defense is currently operating the most advanced system by far. Its Space Surveillance Network (SSN), which relies on ground and space-based radar, provides the US with a unique detection and identification capability, which it also uses as a formidable instrument of influence with regard to its allies and partners. Other states such as Russia, China, Japan, India, and some European countries (France, Germany) have also developed space monitoring programs. Given their strategic function, the vast majority of STM programs fall under the control of the military, with the support of space agencies. Some private companies have also established their own SST/SSA systems in order to provide commercial data and services.

The main problem related to the prevailing mosaic of STM programs lies in the lack of international standardization. Yet, there is a clear need to develop international STM standards, guidelines, and best practices. As previously mentioned, such regulation measures are driven by the rapid growth of space activities since the turn of the century. The New Space age not only requires new models and new technologies; above all, the current situation calls for new rules and regulations. Despite a shared situation analysis, many tensions still arise between the governmental need for regulation to protect the safety, security and sustainability of the space

environment and industry's desire for minimal, clear and consistent regulatory constraints.[39] The rationale that figures behind these tensions can be found in the difference between, as Scott Pace has suggested, "Guardian" and "Merchant" cultures.[40] For nearly forty years, space activities have been mainly conducted by public agencies operating on behalf of governments. These governmental actors have exploited space for strategic purposes, to safeguard populations against possible global conflict. Since the end of the Cold War and the eve of the 21st century, space has increasingly become a Merchant's business. Today, these two cultures, these two visions of space find it difficult to coexist.

For Europe, the existence of global initiatives and decisions regarding STM are likely to create a challenging environment for European space actors. Many reforms undertaken by the US administration could have a significant impact on many dimensions of European space activities. When the US National Space Council released its Space Policy Directive-3 (SPD-3) on National Space Traffic Management Policy, the primary goal was the development of STM standards, guidelines, and best practices. However, this policy stated that the US should lead the world in developing improved space situational awareness data standards, develop a set of standard techniques for mitigating collision risks, and internationally promote a range of norms of behavior, best practices, and standards for safe operations in space. Unambiguously, section 1 of the SPD-3 states that, "**to maintain U.S. leadership in space** [my emphasis], we must develop a new approach to space traffic management that addresses current and future operational risks. This new approach must set priorities for space situational awareness and STM innovation in science and technology (S&T), incorporate national security considerations, encourage growth of the U.S. commercial space sector, establish an updated STM architecture, and **promote space safety standards and best practices across the international community**" [my emphasis]. Given the absence of any comparable European regulatory proposal, the US feels free to take the lead on this issue.

The US resolve to lead future talks on the use of space by state actors and private companies has given birth to a contested initiative: the Artemis Accords. Concluded under the auspices of NASA, the Artemis Accords, signed on October 13, 2020, officially claim to establish a common set of principles to govern the civil exploration and use of outer space.[41] Moreover, the objective pursued by the US is to "describe a shared vision

39. M. P. Gleason, "Establishing Space Traffic Management Standards, Guidelines and Best Practices", *Journal of Space Safety Engineering*, No. 7, 2020, pp. 426-431.
40. S. Pace, "Merchant and Guardians", in: J. M. Logsdon, R. J. Acker (eds.), *Merchants and Guardians: Balancing U.S. Interests in Global Space Commerce*, Washington D.C.: Space Policy Institute, George Washington University, 1999.
41. The first eight countries that signed the Artemis Accords were: Australia, Canada, Italy, Japan, Luxembourg, the United Arab Emirates, the United Kingdom, and the United States. Later, Ukraine, South Korea, New Zealand, Brazil, Poland, Mexico, and Israel joined the Accords.

for principles, grounded in the Outer Space Treaty of 1967, to create a safe and transparent environment which facilitates exploration, science, and commercial activities for all of humanity to enjoy".[42] The Artemis Accords, behind the official purpose of progressing towards a more coordinated approach between space actors at the international level, are designed to initiate a historical breakthrough regarding the way space issues are discussed on the international scene. While the text itself affirms multilateralism's benefits and the importance of COPUOS, the Accords have never been debated inside COPUOS.

The adoption of the Artemis Accords generated diverse reactions. They were not universally welcomed. Among the spacefaring states, Russia raised the impossibility of signing the Artemis Accords due to their being perceived as protecting the interests of the US in pursuing the exploitation of the Moon's natural resources.[43] China has mostly remained silent due to NASA's legal inability to cooperate with Chinese agencies, while disapproving of the US unilateral approach to regulating space activities. Likewise, Germany did not express any official position about the Accords; the reason may be found in Germany's involvement in the construction of the Orion capsule (the selected spacecraft for lunar missions), a core part of NASA's Artemis program.[44] Other international actors, such as the European Space Agency, have finalized agreements with NASA to collaborate on the creation of the lunar Gateway space station by providing two modules thereof.

Initiated, drafted, and promoted by the United States, the Accords are a non-legally binding agreement, at most a political document between spacefaring nations and agencies. Yet, while the US official discourse is to promote international cooperation at a time when space sustainability is at risk, the hidden purpose of the US initiative – that of dissociating spacefaring states from their cooperative frameworks – has been reached. Inside ESA, only Italy, Luxembourg and the United Kingdom joined the US initiative.

STM Stakes for Europe

The progressive deterioration of the space-operating environment should be an incentive for Europe to engage in efforts to develop its own SSA/STM standards and programs. Yet, over the years, issues such as space security and the future of space environment sustainability have reached a certain level of priority among private and public stakeholders.

42. The Artemis Accords: Principles for Cooperation in the Civil Exploration and Use of the Moon, Mars, Comets, and Asteroids for Peaceful Purposes, available at: www.nasa.gov.
43. The head of the Russian space agency quickly responded in a since-deleted tweet by likening the Accords to an invasion of the Moon, an Operation Iraqi Freedom redux, to be performed by a new "Coalition of the Willing".
44. R. Deplano, "The Artemis Accords: Evolution or Revolution in International Space Law?", *International and Comparative Law Quarterly*, Vol. 70, July 2021, pp. 799-819.

It seems that Europe has taken the measure of the strategic, commercial, and geopolitical dimensions of the STM issue, which is not limited to outer-space sustainability but also includes questions regarding the future of Europe's autonomy in accessing and using space.

European space actors have already developed some policies and initiatives aimed at managing directly or indirectly STM concerns. However, Europe's delay in addressing the STM issue through common projects has consequences.

First, it may jeopardize the sustainability of Europe's autonomous access to space and its use. By depending on the US regulatory framework, European space actors would not be able to meet some of the most stringent requirements unless they rely exclusively on US data in order to operate. Having no other choice than to rely on US guidelines, Europe sovereignty, interests and needs could be put at risk.

Second, the competitiveness of the European space manufacturing industry would not be immune to potential consequences resulting from the absence of European regulation. It is more than likely that insurance companies would push for the adoption of the highest level of services in order to better manage their financial risks. In that context, they would be prone to promote the use of existing US-defined "enhanced" services. Moreover, the future competitiveness of European satellite manufacturing could be endangered if companies were forced to resort to US STM data or to file a US STM license, with the possibility that it could be refused. Considerable risks also exist for European providers of launch services. They could suffer from the competitive disadvantage of not having their launch windows and collision launch avoidance certified by US authorities.[45] Regarding SSA, many European players rely extensively on data-sharing agreements signed with the United States. These agreements include ministries and armies (Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, UK), European intergovernmental organizations (ESA, EUMETSAT), commercial satellite operators and launch service providers.[46] From a US perspective, these SSA sharing agreements are powerful leadership instruments.

In the long term, European companies might fall behind US firms when acquiring critical market shares, as US companies would be likely to dominate the bidding SSA/STM market thanks to anchor contracts with the Department of Commerce in order to develop a fee-based "enhanced" level of service that would supplement the basic level of service offered. In such a scenario, US companies would benefit from a decisive competitive

45. The risk that European launch providers may be subject to extra fees as non-US companies should not be an excluded scenario.
46. *Towards a European Approach to Space Traffic Management*, *op. cit.*, p. 30.

advantage that could seriously erode European space industry attractiveness.

It is thus essential to guarantee the value of the European space infrastructure and the future competitiveness of European space programs. A recent European Commission study revealed that more than 10% of EU GDP depends on space infrastructure and services.[47] Any kind of incapacitation of space systems (deliberate or not) would lead to substantial economic loss. The need to protect space assets and to guarantee the benefits that they generate call for strong and decisive measures in a wide variety of domains, including technology, rule of law and standardization. Moreover, the considerable development of European space programs over the 2014–2021 period (Galileo, EGNOS, Copernicus) and the launch of new initiatives (such as GOVSATCOM) requires that EU Member States take the actions needed to enhance space security. These actions should also reinforce user confidence in European space services. To this end, Europe must adopt provisions aimed at guaranteeing not just a certified level of performance but the long-term availability of space-based services. Moreover, at a time when Europe is trying to implement a credible Common Security and Defence Policy, to which space-assets constitute an essential – if not vital – contribution, Europe should meet the most stringent security and safety requirements for governmental and defense users.[48] Current debates about the Strategic Compass and European strategic autonomy integrate reflections about future initiatives and programs that would support Europe's autonomy of action in space.

Space as a Critical Infrastructure

A great step forward was made was made when, in 2011, the European Commission recognized space assets as a "critical infrastructure". In its communication, the EC stated that "space infrastructure is critical infrastructure on which services that are essential to the smooth running of our societies and economies and to our citizens' security depend. It must be protected, and that protection is a major issue for the EU which goes far beyond the individual interests of the satellites owners".[49]

47. European Commission, Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Dependence of the European economy on space infrastructures: potential impacts of space assets loss, Publications Office, 2018, available at: https://op.europa.eu.
48. The recent temporary disruption of the Galileo system was a reminder of the importance of space infrastructure.
49. European Commission, Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions towards a Space Strategy for the European Union that Benefits its Citizens; 2011. COM, European Commission, Brussels, p. 6, 152 FINAL.

The identification of outer space infrastructure as "critical infrastructure" indicates its perceived importance to EU Member States and institutions. Beyond that recognition, the very issue relating to outer space infrastructure resides in the solutions aimed at protecting it. Experts generally recognize two approaches to defending critical infrastructure integrity. The first concentrates on protecting the infrastructure and its components. It is essentially a threat-based security strategy intended to eliminate perceived, pre-existing threats. In other words, critical infrastructure protection relies on a reactive approach to security, whereby known threats are analyzed and mitigated against.[50] Moreover, outer space infrastructure protection is not a cost-effective approach since a small amount of extra protection may introduce high additional costs. The second approach is *resilience*. This entails a *proactive* stance that concentrates on maintaining the services, rather than only the assets providing these services. It is acknowledged that infrastructure components, even critical ones, will inevitably fail at some point.

Although the EU's approach in the past has been mainly oriented towards the physical protection of space assets – which relies on a rigid and expensive strategy – recent initiatives launched by the EU suggest a transition towards a more resilience-oriented approach. The path being pursued by the EU is to advocate for an anticipatory strategy on outer space infrastructure security. To this aim, it launched two important initiatives: the proposal to establish an International Code of Conduct for Outer Space Activities, and the European Space Situational Awareness Programme.

In Search of a More Coordinated Approach

As previously mentioned, several initiatives aimed at addressing STM issues have been taken by some European states involved in space activities. However, the European approach on this subject is multilayered and encompasses various national, intergovernmental, supranational, and international engagements that are not always coordinated. More exactly, European STM-related activities and programs are generally conducted at the national level, for nation states are both the owners and operators of the dedicated systems. As a consequence, laws, rules and regulation provisions surrounding these STM activities are generally defined at a national level. Moreover, STM activities are based on different models and address different concerns according to different national governance models.[51] Given the sensitivity of space security issues, actions taken by European nation states are generally managed under a military or national security

50. P. A. Slann, "Anticipating Uncertainty: The Security of European Critical Outer Space Infrastructures", *Space Policy*, No. 35, 2016, pp. 6-14.
51. *Towards a European Approach to Space Traffic Management, op. cit.*, p. 45.

umbrella. In contrast to what is currently developing in the United States, the direct contribution of civil/private companies is generally weak, even if some recent moves tend to prove that things are progressing.

The predominance of national approaches on STM issues did not hamper the progressive development of some bilateral and multilateral agreements for data sharing, resources pooling and diplomatic coordination. In such a context, the role of the European Union and the European Space Agency have grown as more recognized competence has been conferred to these institutions in relation to STM and space security.

However, the EU's contribution in this field is greatly limited to supportive actions and diplomatic initiatives. It is worth outlining the three frameworks where STM is indirectly addressed within the EU.

STM Issues in FP7 and Horizon 2020

The Framework Programmes for Research and Technological Development, also designated FP7, included a contribution of about €68 million for the period 2007-2017. Within the new Horizon 2020 program, the EU-funded SPACEWAYS project is expected to establish a common understanding of the rules and standards required to develop a concept of STM for the EU. The described ambition of the project is very indicative of the dimensions that remain to be covered by the EU in this field. The purpose of the project is to assess the available and required European technical capacities in the fields of spatial situational awareness and space surveillance and monitoring. Recommendations and best practices in VTS relevant to the interests of the European Union are also expected to be developed. To that end, the project will assess European technology gaps and establish a networking platform for stakeholders. With a total budget of €1,498,470, the SPACEWAYS program is expected to deliver its results by June 2022.

The ESA Initiatives

Alongside with EU advances, the European Space Agency has progressed on space security issues and has now recognized competence and expertise in the science and research dimensions associated with these issues. To date, ESA initiatives include: a Space Situational Awareness Programme, a CleanSpace Initiative, the development of standards through the European Cooperation for Space Standardisation (ECSS) and participation in those international organizations whose competences overlap space security issues.

The SSA Programme

The European Space Situational Awareness (SSA) Programme, which reunites the 19 ESA members, has been funded with a total budget of approximatively €200 million for the period 2009-2020. It encompasses

three areas of expertise: a Space Surveillance and Tracking Framework, an architecture dedicated to forecasting and monitoring space weather events, and a detection capacity for Near-Earth Objects. For the purpose of the present note, we will focus on the EU SST dimension.

The EU established in 2014 a **Space Surveillance and Tracking (EU SST) Framework** whose objective is to develop a network of national SST assets in order to provide EU member states with a pre-STM service.[52] The introduction of the framework is, above all, the result of requests made by some European states, including France and Germany. Paris and Berlin pushed for the development of governance schemes specifically adapted to STM issues. A compromise was needed between the preservation of national interests associated with STM capabilities and the search for a cooperative approach aimed at reinforcing outer space sustainability. The result of the compromise efforts was to allow states to continue monitoring existing STM assets while promoting the sharing of data issued by these systems. It is partly the role of the European Commission to define the general guidelines for the governance of the EU SST Framework and to encourage as many Member States as possible to cooperate within the EU SST consortium.[53] Three categories of objectives have been assigned to the EU STM Framework:

- to assess and reduce the risks of collision in order to allow operators to initiate the required mitigation measures;
- to reduce the risks associated with launching operations;
- to monitor and track re-entry objects, as well as to prevent the proliferation of space debris.

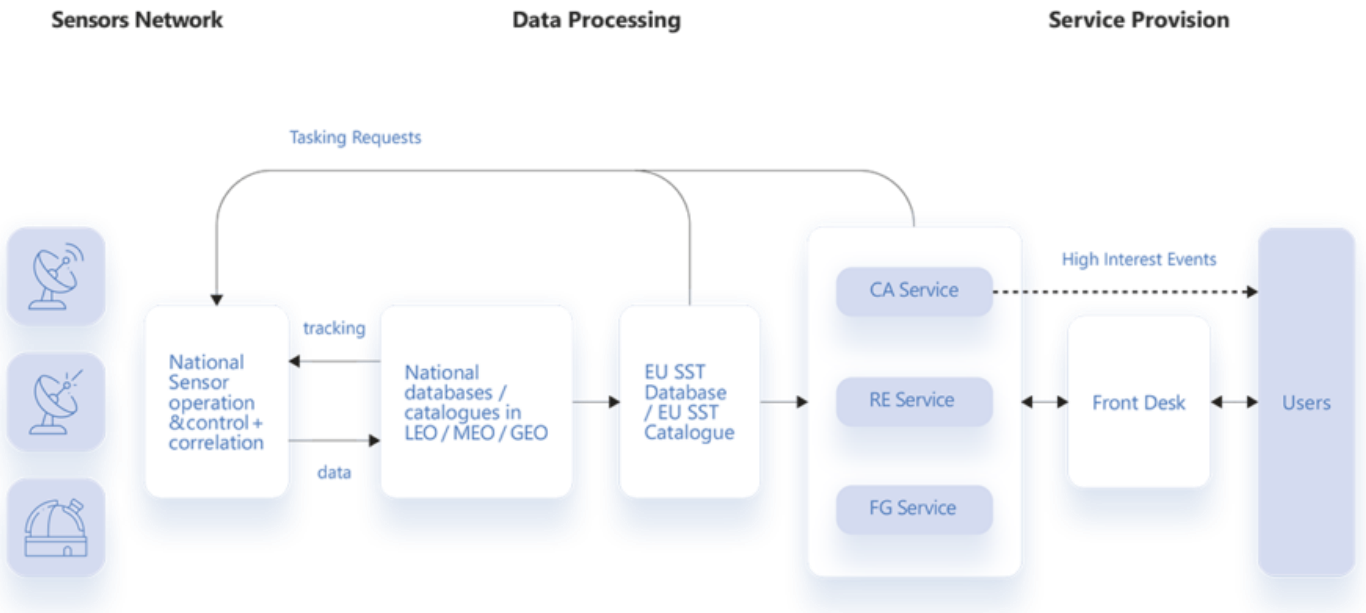
During the 2015-2020 period, around €170 million was allocated to the EU SST Framework. Since April 1, 2019, a European database that collects data from the sensors of the network has been operating.[54]

In its current configuration, most of the sensors integrated in the EU SST network are purely institutional in nature. The division of labor between the dispersed operational centers responsible for providing the data to the joint EU SST database does not allow the industry to directly contribute to the catalogue. This state-centered approach artificially constrains the ability of the EU SST to leverage detection and tracking capabilities. This set-up

52. European Commission, Commission Implementation Decision of December 19. 2016 on a Coordination Plan for the Space Surveillance and Tracking Support Framework and on the Procedure for the Participation of the Member States, C(2016)8482 FINAL, 19 December 2016; European Commission, Commission Implementing Decision, C(2014)6342 FINAL of September 12, 2014, on the Procedure for Participation of the Member States in the Space Surveillance and Tracking Support Framework, C(2016)6342 FINAL, 12 September 2014.
53. The members of the EU SST Consortium are: France, Germany, Italy, Poland, Portugal, Romania and Spain.
54. *Towards a European Approach to Space Traffic Management, op. cit.*, pp. 49-50.

prevents the emergence of a domestic European market for SSA services and data providers – which further limits the competitiveness of European players in this emerging market. The opposite approach has been adopted by the United States, where the Open Architecture Data Repository (OADR) fully involves commercial SSA data providers in order to allow US industry to compete on the international scene.

The EU SST Architecture



Source: European Union Space Surveillance and Tracking website (www.eusst.eu).

EU SST Sensors Network

Source: European Union Space Surveillance and Tracking website (www.eusst.eu).

Towards an International Code of Conduct on Outer Space Activities

The EU also encouraged the establishment among its Member States of **Space Policy Dialogues** with selected partners in order to coordinate diplomatic positions within international organizations and specialized agencies such as the UN COPUOS and the ITU. It is in such a context that, in 2008, the EU officially proposed at the UN an **International Code of Conduct on Outer Space Activities**. It seems obvious that the rationale behind such a proposal was also the direct consequence of the ASAT test conducted, one year earlier, by China. The EU proposal is the most likely foundation for an international agreement related to outer space sustainability. Concurrent proposals co-authored the same year by China and Russia, namely the Treaty on Prevention of the Placement of Weapons in Outer Space and the Threat or Use of Force against Outer Space Objects, have not gained similar support in the United Nations so far. The objective

of the EU code is to "enhance the security, safety and sustainability of all outer space activities pertaining to space objects, as well as the space environment".

Although the first draft of the code tried to draw attention to the predictability of the conditions in which future space activities should take place, the 2010 version marked a clear preference in favor of "sustainability". This was not so much the expression of an anticipatory stance of the EU about future space actors' responsibilities as the reflection of a wider shift among spacefaring entities towards the long-term security and safety of human activities in outer space.[55]

While much of the code is devoted to minimizing space debris generation through transparency and confidence-building measures,[56] an expected result of the EU proposal would be to reduce the occurrence of deliberate collisions and debris fragmentations in outer space as well as limiting the use of terrestrial or space-based ASAT systems. Rather than overtly prohibiting the use of such ASAT systems (which the code does not mention as such), the code set out specific conditions where the resort to such systems could be justified. The last version of the code, dating back to 2014, states in its article 4.2 that:

"[the] Subscribing States resolve, in conducting outer space activities, to refrain from any action which brings about, directly or indirectly, damage, or destruction, of space objects unless such action is justified:

- by imperative safety considerations, in particular if human life or health is at risk; or
- in order to reduce the creation of space debris; or
- by the Charter of the United Nations, including **the inherent right of individual or collective self-defense**. [my emphasis]

and where such exceptional action is necessary, that it be undertaken in a manner so as to minimize, to the greatest extent practicable, the creation of space debris [...]".

Along with its articles dedicated to the space debris issue, the code also calls for the subscribing states to commit "to improve adherence to, and implementation of International Telecommunications Union regulations on allocation of radio spectra and orbital assignments, and on addressing harmful radio-frequency interference".[57]

55. P. A. Slann, "Anticipating Uncertainty: The Security of European Critical Outer Space Infrastructures", *op. cit.*, p. 10.
56. J. Robinson, Transparency and Confidence-Building Measures for Space Security, *Space Policy*, No. 27, 2011, pp. 27-37.
57. European Union, Draft International Code of Conduct for Outer Space Activities, Version, March 31, 2014, available at: Code of conduct Working Document 21 (europa.eu).

At the time of the negotiations, the European Union was criticized for having placed too much emphasis on short-term threats to outer space activities. The dangers that were then associated with interference and frequency saturation problems were not considered to be of greatest concern. It now appears, in view of the concerns that have emerged over the past few years, that the text proposed by the European Union drew up a realistic inventory of the threats to come. The sudden explosion of space activities led by the private sector was not anticipated, but it is the private companies that, in the future, will be called upon to implement the best practices in order to guarantee outer space sustainability.

The fact remains that the lack of progress in the negotiations relating to the code attests to the limits of European governance in the space sector. Although the code does not formally prohibit the use of ASAT systems, the European Union seems to have encountered difficulties in convincing its international partners of the need for its adoption.

Conclusion:
The Way towards Autonomy

The Space Strategy for Europe states "that reinforcing Europe's autonomy in accessing and using space in a secure and safe environment" is a prime objective. This independence of resources must, in the long term, integrate the framework of broader cooperation with third states, in particular the United States. Autonomy should not be understood here, as a process of rivalry but as a European solution in support of STM, systems that already exist.

This study of European initiatives in the field of space security and STM has clearly shown that Europe as a whole has become aware of the problems associated with the congestion of orbits and space debris. This awareness was gradual but real. It has given rise to various diplomatic programs and commitments.

However, the picture we have just drawn up reveals many shortcomings. A first insufficiency lies in the difficulty of coordinating the capacities held by certain Member States, which have their own surveillance and monitoring means. Even today, it is difficult to reach consensus on the goals to be pursued by a European STM program. The issue of Space Traffic Management is, to a large extent, the perfect illustration of the difficulty of bringing about the emergence of genuine European governance in the space sector, even though the issues of the sustainability of space and the security of outer space is common to all European states, either because they deploy space capabilities, or because they are users of space resources.

European divergence concerning SSA/SST/STM systems also has consequences for the influence of Europeans in setting worldwide approved standards in this area. As we have observed, most of the standards and other good practices implemented by European stakeholders have been designed in the United States. This European "normative ineffectiveness" is an obstacle to European space industry competitiveness on an international scale. In the long term, the lack of standards established by Europe could even more severely hamper the European space industry and jeopardize the freedom of access to space. Having your own launch capacity is not enough. It is also necessary to be able to deploy satellites independently without depending on standards defined outside Europe. In this regard, many experts are calling for a top-down dynamic to emerge. If the existence of norms and standards at the national level among certain member states can prove useful for the development of common provisions, it will nevertheless be imperative for Europe to establish itself as the final arbitrator of

standardization measures. This requires that EU and ESA member states agree on the goals and principles of European efforts in the field of STM; that they define consultation and coordination mechanisms, and that they determine (a) a clear delimitation of roles, (b) unequivocal sharing of responsibilities and (c) transparent distribution of activities among member states and European stakeholders.

Therefore, any European governance project in the space sector, especially with regard to the STM issue, has to be **integrated**, **dual** and **coordinated**.

It must be integrated in order to allow the European institutions in charge of space to establish themselves as authorizing officers for the programs to be carried out and the normative measures to be enacted. However, the inherent complexity of European institutions is an obstacle to achieving such an objective in the medium term.

Moreover, European governance must be dual insofar as it will be called upon to associate public institutions with private actors, whose role will be increasing in the decades to come.

Finally, governance should be coordinated on a perennial basis so that a sustainable distribution of the roles of the different institutions, agencies and Member States can be established.

Although it seems to be security- and defense-oriented, the new EU Agency for the Space Programme, launched on May 12, 2021, following the adoption of the Regulation establishing the new EU Space program, does not offer a strong indication that Europe is about to clarify its institutional architecture with regard to the space domain.

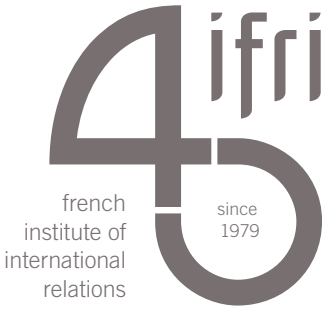
An interesting perspective was provided by European Commissioner Thierry Breton during the 14th European Space Conference held in Brussels on January 25/26, 2022. The commissioner clearly mentioned the need for progress in elaborating a European strategy for Space Traffic Management. Having stressed that more than one million pieces of debris are orbiting around the Earth and that more than 30,000 additional satellites are expected to be launched in the coming years (a number that results mainly from the proliferation of mega-constellations), Mr. Breton said the European Union would face an unprecedented challenge in tracking and monitoring its satellites. Although the EU could rely on information delivered by the US and on some capabilities provided by certain Member States, he said it was time for Europeans to strengthen their own capabilities and to reduce their dependence on US monitoring systems.[58] A very stimulating aspect of the commissioner's speech was the link he established between EU STM capabilities and the geostrategic dimension of

58. Speech by Commissioner Thierry Breton at the 14th EU Space Conference, Brussels, January 25, 2022, available at: https://ec.europa.eu.

space in order to enhance the EU's collective situational awareness of threats to European and/or national space assets. This was a belated but welcome acknowledgment of how important it is to address the multilevel challenges that will result from the increase in space activities as they threaten to jeopardize the global military balance.

List of Abbreviations and Acronyms

ASAT	Anti-Satellite (System)
CAM	Collision Avoidance Maneuver
CEO	Chief Executive Officer
CERFA	Comité d'études des relations franco-allemandes (Study Committee on Franco-German Relations)
COPUOS	United Nations Committee on the Peaceful Uses of Outer Space
DGAP	Deutsche Gesellschaft für Auswärtige Politik
ECSS	European Cooperation for Space Standardisation
ESA	European Space Agency
EU	European Union
GEO	Geostationary Orbit
IAI	Istituto Affari Internazionali
ICBM	Intercontinental Ballistic Missile
IOS	In-Orbit Services
ISS	International Space Station
ITU	International Telecommunication Union
LEO	Low-Earth Orbit
NASA	National Aeronautics and Space Administration
OADR	Open Architecture Data Repository
S&T	Science & Technology
SDA	Space Data Association
SPD	Space Policy Directive
SSA	Space Situational Awareness
SSN	Space Situational Network
SST	Space Surveillance and Tracking
STM	Space Traffic Management
US	United States



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