Food For Thought 2024

Finabel's Space Handbook

FINABEL - The European Land Force Commanders Organisation

AN EXPERTISE FORUM CONTRIBUTING TO EUROPEAN ARMIES INTEROPERABILITY SINCE 1953

Written by
Asia Corsano
Manfred Sintorn
Irene Verduci
Christos Loizou
Vittorio Ippolito
Harold Degeert
Oliver Leicester
Gloria Bertasini
Cecilia Rosa Yáñez
Elena Valente

Written by Asia Corsano, Manfred Sintorn, Irene Verduci, Christos Loizou, Vittorio Ippolito, Harold Degeert, Oliver Leicester, Gloria Bertasini, Cecilia Rosa Yáñez, Elena Valente

This Food For Thought paper is a document that gives an initial reflection on the theme. The content is not reflecting the positions of the member states but consists of elements that can initiate and feed the discussions and analyses in the domain of the theme. All our studies are available on www.finabel.org

TABLE OF CONTENTS

Director's Editorial

In the modern age, space has become integral to the defence sector, offering indispensable tools and capabilities crucial for warfare and national security. Breakthroughs in one arena frequently spill over into advancements benefiting the other, as both domains thrive on cutting-edge technology. Satellite systems stand as pivotal examples, supporting military endeavours for communication, navigation, and surveillance while also improving the quality of civilian life. Technologies birthed from space exploration, such as robotics, have also found crucial roles in defence applications.

Furthermore, national security hinges significantly on a state's capability to access and manage space. Collaboration between governments, space agencies, and private entities has also become commonplace, fostering joint ventures that leverage expertise and resources across these sectors, while, these same private space entities, such as SpaceX, have inadvertently been granted unprecedented importance in the realm of modern warfare, a dynamic made abundantly clear throughout Russia's aggressive war in Ukraine.

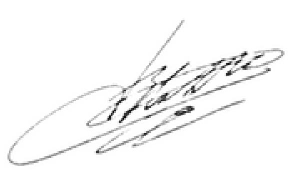
With the publication of this Food for Thought (FFT) paper, Finabel addresses the critical importance of the space sector within defence-related issues, delving into the symbiotic relationship of the two within several domains, including topics such as the legal consequences of space's militarisation, the underlying issue of European Union member state fragmentation in the space governance and, in line with the organisation's fundamental objective, a dive into European army interoperability in the realm of space.

Ultimately, the synergy between the space and defence sectors not only propels technological innovation but also solidifies strategic capabilities vital for national security and military interoperability, rendering it a sector firmly in the crosshairs of our organisation. Thus, Finabel has identified space as an indispensable area of study moving into the future and promises to continue producing a rich vein of research on the topic.

Sincerely,

Mario Blokken

Director



Acknowledgments

The first Finabel's Food For Thought (FFT) about space, coordinated this year by Irene Verduci, has benefited in particular from a truly collective effort by the Finabel's Space Committee. More specifically, Irene Verduci as Head of the Committee, Vittorio Ippolito and Julien Potin on the European and International Affairs section and Elena Valente on the European Union's and International Law section. A special thanks goes to the Manager of the Research department Emile Clarke without whom this FFT would not have come to light. Thanks also to the whole Finabel team and all the Managers, in particular Cecilia Rosa Yáñez and Veronica Quattropanetti, who have provided a stimulating environment throughout the redaction of the papers and the ideation of the FFT.

Executive Summary

Against the backdrop of the ongoing Russo-Ukrainian War and Europe's changing security environment, space has become ever more significant in the field of defence and security. Of course, outer space has long been an arena in which states have competed and vied for influence. From the Soviet launch of the 'Sputnik' satellite in 1957 to the U.S. Apollo 11 moon landing in 1969, space emerged as a point of competition throughout the Cold War, becoming indispensably linked to nuclear deterrence with the development of the first successful Soviet R-7 intercontinental ballistic missile in 1957 (Siddiqi, 2000). Today, the spatial context has moved beyond the binary Soviet-American dynamic of one-upmanship experienced during the Cold War. A multitude of countries now possess independent spatial launch capacities, while a huge number of state and private actors possess satellite infrastructure (UCS, 2023). Furthermore, modern society has grown increasingly reliant on the space domain as satellite technology widely contributes to the day-to-day necessities of civilian life including Internet access, telecommunications and GPS navigation (Steer, 2020). Greater acknowledgement of the domain's importance to modern society has led to a renewed look at space within military affairs in recent years, spurring the formal recognition of space as an operational domain by NATO allies in 2019 (Eagleson, 2023). Just as satellites offer a host of benefits to civilian society, space operations through satellite-based communication, navigation and real-time intelligence and surveillance are pivotal in the conducting of modern military operations (Basham, 2024). Hence, space assets facilitate a wide array of military functions, including effective response to crises and deterrence and defence against potential adversaries in worst-case scenario contingencies.

The Russo-Ukrainian War has demonstrated the critical role that space has to play in the waging of modern conflict, showing that societal reliance on space-based infrastructure has resulted in vulnerabilities. For instance, just hours before the start of Russia's full-scale invasion of Ukraine in February 2022, the issue of cybersecurity of space infrastructure was brought to the forefront of military affairs when Russian forces launched a cyberattack against ViaSat's satellite network, which supported the Ukrainian army (ESPI, 2022). Russian forces have frequently made use of such anti-space capabilities in an attempt to soften Ukrainian forces before engaging them. Moreover, space and cyberspace have been described as "critical enablers for Russian forces" during the conflict, facilitating theatre precision strikes, allowing for encrypted communications, and providing a means of navigation for Russian units (ESPI, 2022). In contrast, the conflict has also highlighted the inherent possibilities offered by spatial infrastructure in wartime scenarios. After all, Ukraine has been able to respond and adapt to such cyber offensives and its own formal lack of space capabilities by buying commercial data and services primarily from private U.S. companies such as SpaceX which, in turn, has provided off-grid internet access to Ukraine, crucial in battlefield communications and information sharing (Ogden et al., 2024).

In response to the changing security environment, the European Union defined space as a contested strategic domain in the 2022 Strategic Compass for Security and Defence, outlining the imminent need for the conceptualisation of a common EU Space Policy (EEAS, 2022). In March 2023, as a direct continuation of the Compass, the Commission presented a European Space Strategy for Security and Defence which underlines the pivotal role of space in the field and the action the EU is taking to "protect space assets, defend its interests, deter hostile activities in space and strengthen its strategic posture and autonomy" (European Commission, 2023). The Union's Space Strategy covers several fundamental points (Council of the European Union, 2023). Not only does it mark an attempt to harmonise a common understanding of space threats, but also pushes for further resilience and protection of space systems and services in the EU. This would involve the creation of mechanisms to ensure an EU-wide approach to space problems, allowing the EU to respond to threats and encourage responsible behaviour in the domain. From this move, it is clear that space has emerged as a fundamental concern for the European Union at present and moving into the future, demanding continued analysis in order to facilitate Europe's goal of developing into a coherent and capable defence actor in the domain.

With the publication of this Food For Thought (FFT), Finabel explores various strands of the strategic domain of space in the European context, involving analyses ranging from explorations of the sector's legal dimensions to a further dive into the lessons learned from the Russo-Ukrainian War in the realm of space. The first paper tackles the issue of fragmentation in the EU's space landscape, highlighting the limitations of governing the domain across numerous different organisations. The second evaluates the establishment of the EU's Infrastructure for Resilience, Interconnectivity and Security by Satellite (IRIS^2), while the third and fourth delve into European endeavours to bolster future capabilities in space and the upper atmosphere and the European Space Agency's Ariane 6 Rocket, respectively. Moreover, it is here, in the fifth paper, where the space lessons of the Russo-Ukrainian War are considered. Finally, as previously touched upon, this FFT's second section explores the legal dimensions of space in the realm of defence and security, including an examination of international space law, an exploration of anti-satellite weapons, and the future creation of EU space regulation.

Part One: International and European Affairs

The Issue of Fragmentation in EU Space Governance

Written by: Asia Corsano
Edited by: Alex Marchan
Supervised by: Emile Clarke

Introduction

With the advent of the so-called "space race" era during the Cold War, states started giving major consideration to developing their space capabilities, having realised the many advantages they could bring. Indeed, military operations in space primarily concern satellite-based surveillance, communications, and intelligence operations, thus allowing states to benefit from them as space-related development can, among many things, extend the range and capabilities of communications, improve missile early warning and enhance situational awareness beyond any terrestrial capability. Realising the various advantages brought by space policies led to proliferation as space capabilities are now increasing across a growing list of nations. Nevertheless, competition has also risen, as states aspire to improve their space capabilities to have a significant advantage over their counterparts. In this context, the European Union has acknowledged the risks that competition and proliferation can bring and has started working on a common Space Policy and Strategy; such action could better protect space systems and services, while maximising the potential use of these systems for security and defence purposes, thus reinforcing the role of the EU as a global space power (EEAS, 2023.) However, fragmentation challenges current European space policy governance.

The Fragmented Landscape

Space policy in Europe is implemented by the European Union through the Commission, the External Action Service (EEAS), the European Union Agency for the Space Programme (EUSPA), European intergovernmental organisations like the European Space Agency (ESA) and some key Member States with national space agencies. Such European organisations include different member states and follow different procedures for decision-making or budget implementation compared to the EU.

This diversity benefits the Member States, as it provides them with a certain degree of flexibility in choosing whether to implement their space programmes at a national level, through the ESA's or EU's space programmes, or in collaboration with other states depending on their interests and budgets. On the one hand, this dynamic has led to the involvement of more and more EU Member States in the space sector and the development of a robust European space industry. On the other hand, a complex system of governance for the space sector in Europe has emerged, resulting in great difficulties in adopting key documents proposed (EPRS, 2017).

Space competencies and capabilities at the European level are thus divided into several different layers of governance, not all of which are fully controlled by the EU, negatively impacting the EU's capacity to pursue strategic autonomy in this domain.

Fragmentation is also a key issue for European representation in space matters at the international level. Depending on the international institution, Europe is represented either by its individual states, by the EU and/or by ESA (EPRS, 2017).

The following graph outlines the roles of the different actors in European space policy:

Activities	EU	ESA	EUMETSAT	GSA	Member States	National space agencies	Industry
Define space policy	●	●			●		
Define and fund space programmes	●	●	●		●		•
Develop and implement programmes		●				●	●
Operates space programmes		●	●	●		●	•
Fund space R&D activities	●	●			●		●
Perform space R&D activities		●				●	●
Conduct space exploration programmes		●				●	
Regulate the space sector	●				●		

Source: EPRS. • The private sector is beginning to enter these activities (Newspace)

Limitations to European Space Governance: the EU/ESA Relationship

In recent decades, the European Commission (EC) and the ESA have worked together to improve European space policy cooperation. The ESA, although created with the aim of formulating a common European space policy, has developed outside the process of European integration, since not all EU Member States are ESA members and vice versa. In 2004 the two institutions signed an agreement formally separating their roles. The ESA possesses the technical competency to implement space programmes and oversees the development of European space science and space exploration programmes. The EU's competencies lie in regulation and the financial capacity to invest in large long-term space programmes, while also being able to develop Member States use of EU space infrastructure, services, and data. However, the Commission's competence is not to manage and operate these programmes (EPRS, 2017). A good illustration of the partnership between ESA and the EU and their different roles is Galileo, the European satellite navigation and positioning programme. In this partnership, the EU, needing space facilities, commits to paying for half of the project, and the ESA, possessing the expertise and technological capabilities, funds the rest (ESA, n.d. - a).

Nevertheless, the growing importance of European space programmes and the EU's dependence on the ESA's technical expertise have not translated into the evolution of space-policy-related governance at the European level. Indeed, different obstacles in EU/ESA relations exist, all contributing to limiting European governance in space cooperation.

One such obstacle is the different funding regimes and financial rules adopted by the two institutions. ESA programmes are, in most cases, financed by Member States' holdings based on their Gross National Product (GNP) and pursue the goal of geographical return, namely, a principle by which the ratio between the share of a country in the weighted value of contracts, and its share in the contribution paid to the Agency, must be x per cent (e.g. 0,98%) by the end of a given period (ESA, n.d. - b). Additionally, ESA programmes receive an annual contribution from the EU. In contrast, EU rules require compliance with the principle of the most economically advantageous tender. These regulatory differences create difficulties and constraints especially when programmes are financed through joint ESA and EU participation, thus exacerbating decision-making processes and causing programmes and their impact to be less effective (Liakopoulos, 2019).

The shared management of programmes such as Galileo between the EU and ESA leads to a multiplication of the expertise needed to define, develop, and operate the programme across the two. The principle behind their agreement is that the Commission has to focus its involvement in space on a number of key issues (such as navigation and Earth observation), whereas the founding elements and scientific responsibilities remain ESA competencies. Nevertheless, ESA's technical nature has adversely affected its policy-making abilities despite the fact it has proven its ability to implement ambitious and successful space programmes. ESA has displayed, over time, difficulties in elaborating a comprehensive and solid space policy.

This is due to the fact that, firstly, it is not politically responsive and has no formal political link with European society, and secondly, ESA Member States are generally represented by their research ministries rather than strategically minded national policymakers (Mazurelle, Wouters, Thiebaut, 2009). These elements have led to disagreements between the EC and the ESA on how to effectively manage their joint programmes. Notable events highlighting this division include: 1) former ESA Director Jan Wörner criticising the planned costs for the Galileo and Copernicus programmes in the EU 2021-2027 Plan for space research. He strongly disapproved of the proposed establishment of an "EU Agency for the Space Programme" (EUSPA) that was successfully launched in 2021 (Science Business, 2018). 2) The Commissioner for Internal Market Thierry Breton openly criticised the ESA for using American private firm SpaceX navigation satellites for the Galileo program, stating that if this competency was in the hands of the Commission, it would have not happened (Anastasio, 2023). Interestingly, this last event highlights both the ESA and EU's willingness to cast blame on each other. This is further demonstrated by current ESA director Josef Aschbacher, who declared, in contrast: "[...] Whether or not the launch will be decided to take place with SpaceX is not in our hands. It is a decision of the European Commission"." In reality, it seems that the tense situation prompted by the four-year delay of the ESA's rocket, Ariane 6, has exacerbated the division between the ESA and the EU. This analysis also unveils, in part, the reasons for this delay (Foust, 2023).

The Role of Member States

The origin of fragmentation can be found in the structure of the European Union itself and the Treaties that constitute its foundation. Indeed, given the concerns over national sovereignty and security, the Treaty of the European Union establishes that Member States are endowed with the power to create their own domestic industries in the security and defence sector (Barbieux, 2023).

Consequently, this aspect also affects the role of Member States as regulators of space-related activities. Art. 189 of the Treaty on the Functioning of the European Union (TFEU) allows "joint initiatives, support [to] research and technological development and coordination of the efforts needed for the exploration and exploitation of space". Still, the EU cannot harmonize national legislation in the space sector, in turn, leaving Member States the power to adopt national legislation inter alia in newly emerging areas of space regulation, such as exploitation of space resources or space traffic management. This undermines the efforts for the adoption of a common regulatory approach at the EU level (Barbano,2022).

National space agencies also carry out their own activities within the ESA. It is worth mentioning that in 2022, only 28.4% of the ESA budget was based on EU income, while more than 64% of the ESA budget came from individual ESA members, with the three major funders being Italy, Germany, and France, which are also the three Member States with the largest independent national space programmes. This further shows that EU cooperation with the ESA and the related development of EU space programmes do not preclude Member States from pursuing their own national space policy parallel to the EU, provided that the principle of loyal cooperation is complied with (European Papers, 2023).

Another relevant issue is the “trust gap,” as the various initiatives to address European space security have suffered from both a lack of trust between Member States and a chronic lack of investment in such security and defence issues, as well as limited and selective cooperation among European countries. This situation stems from the fact that European states have generally held different views on the required level of ambition and action regarding space in the realm of defence (Penent, 2023).

Conclusion

In March 2023, the joint adoption of the “EU Space Strategy for Security and Defence” by the Commission and the High Representative of the European Union for Foreign Affairs and Security Policy confirmed a convergence of space policy and the goals of the Common Foreign and Security Policy (CFSP). This convergence was pursued inter alia through the cooperative action of all institutions involved in the matter in their respective competence domains.

Still, in view of this analysis, the European Union is facing challenges in its space policy governance, especially with regard to the issue of fragmentation.

In an era of strategic competition and transformation, today’s unpredictable space environment requires the EU to develop a common understanding of the current problems that it is experiencing, better coordinate its space activities, protect its interests as a Union, and work to close the “trust gap” between Member States by continuing to engage with international partners in support of effective multilateralism.

Bibliography

Anastasio, P. (2023). Bruxelles critica l'ESA per dover usare i lanciatori di Space X per Galileo. Key4Biz. https://www.key4biz.it/bruxelles-critica-lesa-per-dover-usare-i-lanciatori-di-space-x-per-galileo/464989/.

Barbano, M. (2022). Space Traffic Management and Space Situational Awareness: The EU Perspective. Air and Space Law. https://kluwerlawonline.com/journalarticle/Air+and+Space+Law/47.2/AILA2022023.

Barbieux, F. (2023). Tackling the Issue of Fragmentation in the European Defence Industry. Finabel - European Army Interoperability Centre. https://finabel.org/tackling-the-issue-of-fragmentation-in-the-european-defence-industry/.

European Parliamentary Research Service Report. (2017). European Space Policy: historical perspective, specific aspects and key challenges. European Parliament Think Tank. https://www.europarl.europa.eu/thinktank/en/document/EPRS_IDA(2017)595917.

European Papers. (2023). EU Space Policy and Strategic Autonomy: Tackling Legal Complexities in the Enhancement of the 'Security and Defence Dimension of the Union in Space. European Papers. https://www.europeanpapers.eu/en/europeanforum/eu-space-policy-and-strategic-autonomy.

European Union External Action Service. (2023). EU Space Strategy for Security and Defence. European External Action Service. https://www.eeas.europa.eu/eeas/eu-space-strategy-security-and-defence0_en#:~:text=The%20strategy%20outlines%20concrete%20measures,orbit%20and%20protect%20EU%20assets.

European Space Agency (n.d. - a). ESA and the EU. European Space Agency Website. Retrieved November 27, 2023, from https://www.esa.int/About_Us/Corporate_news/ESA_and_the_EU#:~:text=ESA%20has%20been%20a%20close,whereas%20the%20EU%20is%20supranational.

European Space Agency (n.d. - b). Industrial policy and geographical distribution. European Space Agency Website. Retrieved November 27, 2023, from: https://www.esa.int/About_Us/Business_with_ESA/How_to_do/Industrial_policy_and_geographical_distribution.

Foust,J.(2023). EU Finalizing contract with SpaceX for Galileo launches. Space News. https://spacenews.com/eu-finalizing-contract-with-spacex-for-galileo-launches/.

Liakopoulos, D. (2019). The Future of the European Space Agency-EU relationship: Critical Aspects and Perspectives. European Journal of Current Legal Issues. https://webjcli.org/index.php/webjcli/article/view/649/919.

Mazurelle, F., Wouters, J., and Thiebaut, W. (2009). The evolution of European space governance: policy, legal and institutional implications. Leuven Centre for Global Governance Studies, KU Leuven. https://www.law.kuleuven.be/iir/nl/onderzoek/working-papers/wp135e.pdf.

Penent, G. (2023). A European Perspective on Space in an Era of Strategic Competition and Transformation. Stimson. https://www.stimson.org/2023/a-european-perspective-on-space-in-an-era-of-strategic-competition-and-transformation/.

Science Business. (2018). EU denies 'power grab' on European Space Agency. Science Business. https://sciencebusiness.net/news/eu-denies-power-grab-european-space-agency.

Transitional Segment

While the challenge of European fragmentation in the space domain persists, the emergence of new risks associated with space-based technologies and policy prompts a reconsideration of priorities among various stakeholders, emphasising the need for effective crisis management and enhanced security measures. The growing recognition of space assets as vitally important to civilian activities underscores the imperative to protect them and secure communications within the space domain. This consensus has led to an acknowledgement that safeguarding these assets is a shared priority among European states. However, in the current arguably disorganised environment, individual states and actors are unlikely to adopt a holistic approach to achieving these objectives on their own, potentially leaving critical vulnerabilities unaddressed.

Against this complex backdrop, the European Union (EU) has strategically positioned itself to assume a leading role in the realm of space activities with a specific focus on security matters. This commitment is vividly demonstrated through proactive initiatives such as the Infrastructure for Resilience, Interconnectivity, and Security by Satellite ($IRIS^2$). The following paper aims to undertake a comprehensive exploration of the pivotal role played by $IRIS^2$ within the broader context of the EU's space strategy. The analysis delves into various facets, including its contextual significance, operational mechanisms, strategic implications, and, notably, its indispensable role in ensuring the security of Europe's space assets. Particularly pertinent in the aftermath of events such as the war in Ukraine, $IRIS^2$'s multifaceted contributions become apparent, reflecting the EU's dedication to fostering resilience and addressing security challenges in the rapidly evolving landscape of space technologies.

IRIS^2: The Dawn of EU Leadership in Space?

Written by: Manfred Sintorn and Irene Verduci
Edited by: Clelia Vettori
Supervised by: Emile Clarke

Introduction

As great power politics returns to the world stage, so does space policy. States that can afford to are funnelling money into their space programmes in pursuit of everything from space-based weaponry to technological development, research, and communications. The European Union, in a bid to become the leading space actor, has also launched a flurry of projects and established both an operational agency and a specialised directorate-general for its space policy. One of the many lessons from the war in Ukraine is the importance of resilient and secure satellite internet during times of crisis. In setting up such a capability, the EU is establishing the Infrastructure for Resilience, Interconnectivity and Security by Satellite (IRIS^2), which will be fully operational by 2027 (Regulation 2023/588).

IRIS^2 aims to develop a reliable satellite-based internet system for European, invited, and allied use. The intent is to cover the EU, its delegations, member state embassies, and strategic areas for both civilian and military applications. In a context where the only existing alternative, Starlink, is privately owned, US-based, and has restricted the connection for a Ukrainian drone strike after its CEO was contacted by Russian officials (Brunnstrom, Landay, Stewart & Popeski, 2023), IRIS^2's necessity cannot be overstated. Recent experiences such as the suspected sabotage of undersea cables in the Gulf of Finland show that the EU's telecommunications infrastructure is vulnerable to hybrid attacks, stressing the need for alternative networks (Kauranen & Solsvik, 2023). IRIS^2's ramifications for strategic autonomy, redundancy in communications and military capacity are all significant (European Commission, 2023a). Further, in establishing the first publicly controlled satellite service of its kind, the EU is seeking a leading role in space technology and policy (European Commission, 2023a).

Therefore, it is worthwhile to review what IRIS^2 will accomplish and how it will function. With this aim, the paper analyses IRIS^2 in relation to its context, functioning, launch, control structure, necessity, applications, and implications for European security. After providing a general background on EU space strategy, attention will be devoted to the context of the war in Ukraine and the lessons learned in how space-based internet affects modern warfare.

The EU's Space Strategy

Space policy has always been an interest of the European Union, but cooperation has mainly been driven by single member states and has also been rather inconsistent, as continuous supranational elements are a recent addition. Because the space domain is an important enabler for EU strategic autonomy, the space realm has grown increasingly relevant (Cellerino, 2023).As per Article 4 of Regulation 2019/452 establishing a framework for the screening of foreign direct investments into the Union, the aerospace sector has long been considered strategic, motivating a decision to designate foreign investments into the sector as a possible risk to security and public order. In the same vein, Directive 2022/2557 on the resilience of critical entities classifies space service operators as critical entities.

Acknowledging the importance of space as a critical asset for societal needs, the EU has, and is, trying to secure its own space infrastructure. The growing space-related private sector is a considerable commercial opportunity while the Union's freedom of action in this domain is dependent on its ability to achieve safe, secure, and autonomous access to space (Celerino, 2023). It is also worth noting that the space sector is essential for a wide range of policies and aims that are not limited to security and defence, such as for GPS and satellite imagery. Further, the space sector is becoming increasingly congested, which in tandem with increased global attention to space creates a clear need to act fast (European Commission, 2022).

Aware of both needs and advantages, the EU is structuring a space policy with tools capable of addressing its security, defence, public, and commercial interests. This task becomes more complex as the Union has to address certain specific matters, such as the role of the European Space Agency [ESA] in what is seemingly becoming an EU competency. The prime example of member state cooperation in space is ESA, which is not an EU structure, has non-EU participants and is mainly concerned with ensuring steady public investments in the space sector and providing technical expertise for its members' space programmes. While security and defence are exclusive member state competencies under Article 4(2) TEU, space policy is not. Hence, EU space policy has traditionally been considered a supranational EU competency and, even as it is entangled with defence, it has usually been placed among TFEU competencies, eventually falling under civil control (Reillon, 2017).

Since the 1980s, space policy has been an EU interest. As the Union did not have the technical capacity to carry out programmes on its own, it collaborated with ESA in establishing, for instance, the Copernicus and Galileo programmes, among others. Non-EU participation in ESA poses issues in regard to sensitive information since ESA, along with all its members, has complete access to all data and is also the only actor with the technical capabilities necessary to operate the programmes (Celerino, 2023). In addressing this issue, the Council and the Commission acted to adapt ESA to European security requirements and allow the Union to fully pursue its needs. This eventually resulted in the 2011 administrative agreement between ESA and the European Defence Agency [EDA], allowing the Union to develop a full range of space capabilities together with ESA (Oikonomou, 2012). Recently, the EU has further developed its capacity to handle space-related matters through the launch of the Directorate-General for Defence Industry and Space [DG DEFIS] and the EU Agency for the Space Programme [EUSPA].

In this context, the EU has developed two space capabilities with notable strategic implications: Space Situational Awareness [SSA] and Governmental Satellite Communication [GOVSATCOM]. The former aims to network national Space Surveillance and Tracking assets monitoring space debris, while the latter aims to provide EU institutions and member states' authorities with resilient and robust governmental satellite communications capacities (Celerino, 2023).

With a view directed towards internalization and the pursuit of strategic autonomy, the EU has increasingly allocated more political and security aspects on EUSPA's shoulders while establishing the EU Space Programme to enhance the Union's space components (Celerino, 2023). This has recently led to the launch of several new initiatives, including IRIS², which the following section deals with in depth.

The Avant-garde IRIS² and its Advantages

IRIS² is to be a multiorbital internet connectivity network of satellites. Demystified, this means an extensive network of satellites in different orbits that provide continuous low-latency satellite internet coverage worldwide (European Commission, 2023b). The concept is not new and is currently commercially available, albeit not using multi-orbital satellites and with other slight differences (Starlink, 2023). The system is intended to merge public, private, and defence interests by ensuring that the infrastructure is available to all actors.

From a defence perspective, the main benefit is to allow for satellite internet communication, which is highly versatile, difficult to trace, and comparatively hard to disrupt (Kim, Pérez-Peña & Kramer, 2023; Khurana et al., 2023). A unique benefit for satellite communications is that the signal is difficult to jam, even in the case of Starlink, which is a civilian product with no intended protection against jamming (Withington, 2023).

Additionally, if the latency is low enough and the communication is hard enough to trace, it also allows drone operators to work far from the front regardless of whether the operating side has air superiority. As for public interests, the main benefit is for the satellite network to provide redundancy should standard internet infrastructure be disabled by deliberate action or catastrophe (European Commission, 2023a). Further, it would provide internet access to operations in areas where internet infrastructure is unreliable, as well as provide more secure and stable internet access to EU delegations and member state embassies (European Commission, 2023a). Lastly, the private interests raised refer to the provision of mass-market broadband access and communications systems for long-range commercial transport (European Union, 2023).

The project appears to heed lessons learned from the Russo-Ukrainian war, where the destruction and sabotage of physical infrastructure has forced essential services, citizens, and armed forces to switch to space-based internet (Kim, Pérez-Peña & Kramer, 2023). The conflict has shown that this is both feasible and a boon for resilience but has also drawn attention to the need for political ownership of the system. This is because, as mentioned earlier, a lack of viable alternatives to Starlink has left Ukraine beholden to private interests which have already led to service restrictions due to the company's CEO being pressured by the Russian government (Brunnstrom, Landay, Stewart & Popeski, 2023). The satellite system's vulnerabilities and resilience in a state of war vis-à-vis a space-capable state actor will be expanded in the subsequent section.

Recent experiences, such as the suspected sabotage of undersea cables in the Gulf of Finland (Kauranen & Solsvik, 2023), have shown that the EU's internet infrastructure is susceptible to hybrid attacks, stressing the need for EU action. As for the system's security, it is powered by a quantum key distribution system developed through EuroQCI, which is a sub-project of IRIS². The system uses quantum mechanics to create and transmit encryption keys that cannot be intercepted without being changed, as observing the photons en route alters their properties (European Commission, 2023c). The encryption keys are thereby distributed in a way that makes eavesdropping render the key invalid and alerts the receiver of the interception (European Commission, 2023c).

Resilient, Secure, Vulnerable?

While space systems are lauded as highly resilient, they have vulnerabilities that malignant or disruptive actors can exploit. Given the strategic relevance of space, some states already have and are developing counter-space asset arsenals that can disrupt, degrade or destroy space-based systems to disable the enemy's space-based capabilities (Harrison et al., 2022). As stated in the Combined Space Operations Vision 2031, which guides US, UK, Canadian, New Zealander, Australian, French, and German collaborative space operations, threats derive from "the lack of widely accepted norms of responsible behaviour" and historical practice that "increases the possibility of misperceptions and the risks of escalation" (Combined Space Operations, 2022, p. 1).

Physical anti-space weapons can be divided into kinetic and non-kinetic categories. Kinetic weapons, such as bullets and missiles, cause physical damage and are aimed at permanently disabling either ground stations or satellites in orbit (Harrison et al., 2022). Non-kinetic weapons damage the satellite or ground system without making physical contact, disabling them by blinding sensors, overheating components with lasers or using high-powered microwave or nuclear weapons to disrupt or even destroy systems (Harrison et al., 2022).While the former are generally visible and comparatively attributable, this is not necessarily true for the latter, which might also leave attackers unaware of their actions' efficacy.

Furthermore, there are two vectors of attack whose primary foci are not to cause physical damage but to electronically – and often temporarily – disable systems instead. The first is electronic weaponry, which disrupts radio signals used by space-based systems; this includes jamming and spoofing, which are both reversible and relatively easy to carry out (Harrison et al., 2022). Electronic attacks can also be difficult to detect and trace, which makes attribution and situational awareness challenging (Harrison et al., 2022). The second vector is cyber-attacks, which do not target signals but the software or data themselves. Targets for cyber operations include everything from space-based assets to ground stations, equipment, and command structures. Cyber-attacks can be carried out by a wide range of actors, such as firms, individuals, or states. Unique to cyber-attacks is that they are virtually free bar personnel and education costs and that vulnerabilities to these attacks are difficult to predict (Harrison et al., 2022). For example, Ukraine's wartime satellite internet was originally provided by Viasat, which was disrupted to the point of inoperability by cyber-attacks launched in tandem with the onset of the full-scale invasion (Khurana et al., 2023). The replacing service, Starlink, has not faced any considerable service disruptions, notwithstanding the self-inflicted interruptions of service over Russian-occupied territory (Srivastava, Olearchyk & Schwartz, 2022). Lastly, cyber-attacks are often deniable and rarely clearly attributable: even when an attack is traced, it can be difficult to ascertain whether it was state-sponsored.

Conclusion

In evaluating IRIS² in the context of the EU's space policy, this paper finds that IRIS² addresses gaps in capability, strengthens European autonomy, and is both ambitious and going well. Notwithstanding, there are several issues concerning the capability which will be dealt with below.

The system is a breath of fresh air for military use: jointly controlled, not beholden to private interests, and secure. There are, however, two possible issues. The first is that EU ownership reduces certainty in the consequences of an attack on the system. An attack on a single state's military communications satellite is an act of war, but this is not necessarily clear when it is an EU satellite that is attacked. This uncertainty raises risks, as the hostile actor might under- or overestimate the response, which could have disastrous consequences. While the EU has a defined strategy for threats to EU space assets, actions taken are beholden to a unanimous council decision (Council of the European Union, 2021). This approach does not seem ideal considering the issues of reaching unanimous decisions in foreign policy without reducing them to the lowest common denominator (Biscop, 2019).

The second issue is that placing military communications infrastructure in space is, in effect, militarising space. This incentivises rivals to develop anti-satellite capabilities, which in turn further militarises space. However, the thinking here is abundantly clear: "The EU is committed to preventing such an arms race and has been actively advocating for reducing space threats through norms, rules, and principles of responsible behaviours. At the same time, the EU has to cope with new security challenges, including in the space domain" (European Commission, n.d.). In other words, the Union prefers a demilitarised space domain but is faced with the reality of that not being the case.

As for commercial interests and how widespread usage of the system will be, some things remain less than obvious. While the mass-market component is evident (European Union, 2023), it is generally unclear how it would work and whether the EU would now become an internet service provider. The same questions reign when it comes to uptake as, although the system has far-reaching benefits, states have no obligation to use the system and might sectorally opt-out, for instance, if they want to retain control of their communications systems. In the same vein, questions arise about whether NATO forces can seamlessly adopt an EU-developed military communications system shared with non-members.

These issues are however far from insolvable. Strategic uncertainty can be reduced by a simple declaration from member states stating exactly how they would treat an attack on EU satellites and space infrastructure. Similarly, the mass-market component can be addressed by deciding the format in which it would occur, and the uptake can be foreseen by member states creating adaptation and implementation plans for the system as a redundancy. In gauging interest in its space policy, the EU has, in fact, been proactive. The most notable instance of this is the establishment of the EU Space Information Sharing and Analysis Centre (ISAC), a network of public entities and private enterprises with different backgrounds designed to strengthen and improve the security and resilience of the project's Members. In this context, the importance of Small and Medium Enterprises (SMEs) and start-ups has been particularly stressed, along with the benefits that could be derived (European Commission, 2023d).

The Centre's success will be reliant on how well it organises collaboration on cybersecurity, information sharing, and providing access to experts. It is still unclear, though, to what extent this network could generate economic benefits and who would receive said benefits. Regardless, with IRIS^2 the EU is making inroads to establish itself as a world leader in space policy, even surpassing the capabilities of all other actors. No matter how the project continues, its ambition is no small feat.

Bibliography

Biscop, S. (2019). European Strategy in the 21st Century: New Future for Old Power. Milton: Routledge.

Brunnstrom, D., Landay, J., Stewart, P., & Popeski, R. (2023, September 8). Musk says he refused Kyiv request for Starlink use in attack on Russia. Reuters. https://www.reuters.com/world/europe/musk-says-he-refused-kyiv-request-use-starlink-attack-russia-2023-09-08/.

Celerino, C. (2023). EU Space Policy and Strategic Autonomy: Tackling Legal Complexities in the Enhancement of the 'Security and Defence Dimension of the Union in Space'. European Papers Vol. 8, 2023, No 2, pp. 487-501. https://www.europeanpapers.eu/en/europeanforum/eu-space-policy-and-strategic-autonomy.

Combined Space Operations. (2022). Combined Space Operations Vision 2031. https://media.defense.gov/2022/Feb/22/2002942522/-1/-1/0/CSPO-VISION-2031.PDF.

Council of the European Union. (2021). COUNCIL DECISION (CFSP) 2021/698 of 30 April 2021 on the security of systems and services deployed, operated and used under the Union Space Programme which may affect the security of the Union, and repealing Decision 2014/496/CFSP. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021D0698.

Directive 2022/2557. (2022). Directive (EU) 2022/2557 of the European Parliament and of the Council of 14 December 2022 on the resilience of critical entities and repealing Council Directive 2008/114/EC. http://data.europa.eu/eli/dir/2022/2557/oj.

European Commission. (2022). COM/2022/60 Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions: Commission Contribution to European Defence. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52022DC0060.

European Commission. (2023a, March 24). IRIS^2: the new EU Secure Satellite Constellation. https://defence-industry-space.ec.europa.eu/eu-space-policy/iris2_en.

European Commission. (2023b, March 31). IRIS^2 Industry Information Day - Presentation. https://defence-industry-space.ec.europa.eu/system/files/2023-03/IRIS2%20Industry%20Information%20Day%20-%2030%20March%202023.pdf.

European Commission. (2023c, June 19). EuroQCI Concept of Operations (ConOps). https://digital-strategy.ec.europa.eu/en/miscellaneous/euroqci-conops-concept-operations.

European Commission. (2023d, October 2). Call for Expression of Interest - EU Space ISAC. https://defence-industry-space.ec.europa.eu/funding-and-grants/calls-proposals/call-expressions-interest-eu-space-isac_en.

European Commission (n.d.). EU Space Strategy for Security and Defence for a stronger and more resilient European Union. Defence Industry and Space. Retrieved on 30 November 2023, from https://defence-industry-space.ec.europa.eu/eu-space-policy/eu-space-strategy-security-and-defence_en.

European Union. (2023). IRIS²: Infrastructure for resilience, interconnectivity and security by satellite [Fact Sheet]. https://defence-industry-space.ec.europa.eu/system/files/2023-03/IRIS%C2%B2_Factsheet%20%28EN%29.pdf.

Harrison, T. et al. (2022). Space Threat Assessment 2022. Center for Strategic and International Studies, https://www.csis.org/analysis/space-threat-assessment-2022.

Kauranen, A. & Solsvik, T. (2023, October 11). Finland says 'outside activity' likely damaged gas pipeline, telecoms cable. Reuters. https://www.reuters.com/markets/commodities/finnish-government-hold-news-conference-suspected-pipeline-leak-media-2023-10-10/.

Khurana, M., Frenkel, S., Reinhard, S., Satariano, A., & Metz, C. (2023, July 29). Elon Musk's Unmatched Power in the Stars. The New York Times. https://www.nytimes.com/interactive/2023/07/28/business/starlink.html.

Kim, V., Pérez-Peña, R., & Kramer, A. E. (2023, September 8). Elon Musk Refused to Enable Ukraine Drone Attack on Russian Fleet. The New York Times. https://www.nytimes.com/2023/09/08/world/europe/elon-musk-ukraine-starlink-drones.html.

Oikonomou, I. (2012). The European Defence Agency and EU military space policy: Whose space odyssey? Space Policy, 28(2), 102–109. https://doi.org/10.1016/J.SPACEPOL.2012.02.008.

Regulation 2023/588. (2023). Regulation (EU) 2023/588 of the European Parliament and of the Council of 15 March 2023 establishing the Union Secure Connectivity Programme for the period 2023-2027. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R0588.

Regulation 2019/452. (2019). Regulation (EU) 2019/452 of the European Parliament and of the Council of 19 March 2019 establishing a framework for the screening of foreign direct investments into the Union. https://eur-lex.europa.eu/eli/reg/2019/452/oj.

Reillon, V. (30 January, 2017). European space policy: Historical perspective, specific aspects and key challenges. Think Tank of the European Parliament. https://www.europarl.europa.eu/thinktank/en/document/EPRS_IDA(2017)595917.

Srivastave, M., Olearchyk, R., & Schwartz, F. (2022, October 7). Ukrainian forces report Starlink outages during push against Russia. Financial Times. https://www.ft.com/content/9a7b922b-2435-4ac7-acdb-0ec9a6dc8397.

Starlink. (2023). World’s most advanced broadband satellite internet. Starlink. https://www.starlink.com/technology.

Withington, T. (30 May, 2023). Ukraine’s Favourite Dish. European Security & Defence. https://euro-sd.com/2023/05/articles/30035/ukraines-favourite-dish/.

Transitional Segment

In successfully addressing EU capability gaps concerning the protection of civilian assets, IRIS² stands as a pioneering program within the realm of space security and defence. However, it is crucial to recognize that IRIS² is not the sole European initiative at the forefront of advancing capabilities at the intersection of space and security. In fact, various European "space powers" have been independently funding their initiatives that bridge the gap between civilian uses of space and security considerations. Over the past several years, these nations have demonstrated their commitment to harnessing the strategic potential of space by establishing dedicated space commands: either as separate entities or integrated within their existing defence structures. This trend reflects a growing acknowledgement among European countries that space is emerging as the next strategic frontier, demanding dedicated efforts and investments to safeguard national interests and assets in this critical domain. The following paper will illustrate advancements in space security with a focus on military-oriented aspects. As the collective pursuit of space-related security initiatives continues to unfold, it underscores the shared commitment to fortifying European capabilities and resilience in the increasingly complex landscape of space activities.

Europe's Future Capabilities in Space and in the Higher Atmosphere: HYDEF Hypersonic Interceptors, Satellite Resilience, and Space Commands

Written by: Christos Loizou and Vittorio Ippolito
Edited by: Chiara Nasonte
Supervised by: Emile Clarke

Introduction

In the ever-evolving landscape of modern warfare, the significance of space in military operations has reached unprecedented heights. As nations gear up for multi-domain operations, the theatres of battle extend far beyond the traditional land, sea, and airfields. The critical role of space for the defence sector has forced EU member states to upgrade their capabilities in this area.

In this paper, we briefly show how the armed forces of European states increased their interoperability in space and the upper atmosphere. To do this, we refer to the new European space commands, the investments of European countries, military exercises concerning the space domain and, finally, the most recent developments concerning European high-atmosphere hypersonic missile interceptors.

Space and the Modern Battlefield

The modern battlefield is characterised by the increasingly intense need to conduct multi-domain strategies. There are five areas of operations: Maritime, Land, Air, Space, and Cyberspace (NATO, 2023). Recent armed conflicts have highlighted the critical role of the use of space by both sides.

The EU emphasises that the war in Ukraine highlighted the key role of space-based connectivity in the conduct of military operations (Clapp & Evroux, 2023). In the case of the war in Ukraine, the use of satellites for observation and transmission of information proved crucial. Russia launched cyberattacks to weaken space-based assets used by Ukraine, while an hour before the invasion a multi-faceted attack was launched against the private satellite provider Viasat's KA-SAT network, which provides high-speed satellite internet coverage for Europe. The attack intended to weaken Ukraine's command and control capabilities. Ukraine's military capabilities are also boosted by Starlink, which gives artillery forces information that soldiers upload via encrypted chat (Clapp & Evroux, 2023).

In the case of the escalation of the war between Israel and Hamas in the Middle East, the media reported that Israeli Defence Forces (IDF) successfully thwarted an Iranian-manufactured ballistic missile, which was probably launched from Yemen, using the Arrow anti-missile system. The media reported that the interception and destruction of the missile occurred above the Kármán line, a well-recognised space boundary located 100 kilometres above sea level (Barber, 2023). Media sources referred to this incident as the first instance of space warfare in history (The Jerusalem Post, 2023).

Furthermore, Russia, China, and the United States are all investing in hypersonic missile technology, a sector deeply interconnected with threat detection from space and sub-orbital spaceflight (Hill, 2023). The word 'hypersonic' refers to any aerial object – be it an aircraft, a missile, a rocket, or a spacecraft – capable of reaching Mach 5, circa 6000 km/h, while flying in the atmosphere (Hill, 2023). According to GlobalData, "Russia seems to be the furthest ahead, having launched Kh47M2 'Kinzhal' missiles on Ukraine from a MiG31K" (Hill, 2023). As we discuss later, Europe is currently working on endo-atmospheric interceptor systems that aim to counter such weapons.

Latest European Capability Development Priorities in the European Defence Fund

Current events only confirm the prioritisation of Europe's already high level of investment in space capabilities, which have been at the top of the Union's agenda for at least the past eight years. In fact, between 2017 and 2019, the European Defence Fund (EDF) provided more than €3 million to the preparatory action on defence research (PADR), a multi-domain study that included space resilience (Clapp & Evroux, 2023). The value appreciation of space capabilities was reflected in the European Defence Agency's (EDA) 2018 Capability Development Priorities and again reiterated in EDA's 2022 Coordinated Annual Review Defence (CARD) report (Clapp & Evroux, 2023; EDA, 2018; EDA, 2022).

Space operations were newly included in the EU Capability Development Priorities report of 2023, the latest revision of the EU Capability Development Plan (CDP), which has undergone consistent updates since its first release in 2008 (EDA, 2023; EDA, 2018). Some of the priorities listed in these reports are formation superiority and management, intelligence, surveillance and reconnaissance, Earth observation, positioning, navigation and timing (PNT), space situational awareness (SSA), satellite communication, and cyber-defence (EDA, 2018; Clapp & Evroux, 2023). These development priorities are now set to become a reality thanks to funding opportunities provided by the European Defence Fund.

In 2019 and 2020, the European Commission spent close to €90 million on space capability projects within the European Defence Industrial Development Programme (EDIDP) (Clapp & Evroux, 2023). The European Defence Fund put particular emphasis on the prioritisation of navigation warfare (NAVWAR) during its first-ever call for proposals in 2021, amassing a total of €171 million in European Commission investments to pursue nine different projects focusing on NAVWAR space defence (Clapp & Evroux, 2023). In 2021, the EDF approved Navguard, a ground and space-based security system for Galileo's Public Regulated Service (PRS) encrypted navigation service (EUSPA, 2023b), and two other projects, EPW and RFSHIELD, to protect satellite communications (EDF, 2022a).

In 2022, three notable initiatives stood out from EDF's calls: SPIDER, a feasibility study on satellite constellation; REACTS, a scalable network of fully interoperable Responsive Space Systems (RSS), and ODIN's EYE II, a space-based early missile warning system (EDF, 2023b; Clapp & Evroux, 2023). Finally, in 2023, the European Defence Fund released a call for proposals after announcing a budget of €125 million worth of funding for research in threat surveillance for the protection of space-based assets and initial development of operative capacity for Space situational awareness (EDF, 2023a). The development of a European endo-atmospheric interceptor in the air and missile defence domain proved to be one of the most relevant projects in the 2023 call, after appearing in calls from previous years (EDF, 2023a; EDF, 2022b). European endo-atmospheric interceptors are discussed in a dedicated section later in this paper.

Moving away from priorities and funding, we can now complete our analysis with an overview of development and implementation projects sponsored by the EU's Strategic Compass and the Permanent Structured Cooperation (PESCO).

EU Strategy for Threats in the Space Domain: the Role of the Strategic Compass and of PESCO

The EU's Strategic Compass highlights the need to prepare for a more competitive and contested space environment due to the increasing dependency on space systems and services that make EU member states more vulnerable to threatening behaviour by strategic competitors (EEAS, 2022a).

The Strategic Compass refers to the preparation of a new EU Space Strategy for security and defence. On this basis, the Commission and the High Representative of the Union for Foreign Affairs and Security Policy developed the first EU Space Strategy for Security and Defence. The new strategy refers to the threats and the way to respond to them, the resilience and protection of space systems and services, partnerships for responsible behaviours in space, as well as proposing to maximise the use of space for security and defence purposes (European Commission, 2023; Fiott, 2022).

According to the European Commission (2023), the main threats in space that put space systems and their ground infrastructure at risk are robotic arms, radiation, space debris and micrometeorites, kinetic and non-kinetic SIG INT, kinetic anti-satellite (ASAT) weapons, cyberattack sabotage, non-kinetic laser or directed energy weapons, and electronic warfare.

The European Union aims to counter these threats through its Permanent Structured Cooperation (PESCO), often by using EDF funding. Four projects fall under PESCO's space label: the Common Hub for Governmental Imagery (COHGI) coordinated by Germany, the European Military Space Surveillance Awareness Network (EU-SSA-N) coordinated by Italy, the Defence of Space Assets (DOSA) coordinated by France, and the EU Radio Navigation Solution (EURAS) also coordinated by France (PESCO, n.d. – a).

COHGI is set to establish a common hub for the exchange of classified governmental imagery between EU member states and EU agencies in collaboration with the European Union Satellite Centre (EU SatCen) (PESCO, n.d. – b). EU-SSA-N will develop an autonomous EU military Space Surveillance Awareness (SSA) network, which is interoperable with the already-existing EU Space Surveillance and Tracking (EU SST) for the protection of European space assets from natural and manmade threats (PESCO, n.d. – c). DOSA has the objective of increasing the EU's operational efficiency in space manoeuvrability, space resilience, and space military training for current and future European space assets (PESCO, n.d. – d). Finally, the EURAS project aims to develop the EU's military positioning, navigation and timing (PNT) capabilities in the context of Galileo's PRS dual-use technology (PESCO, n.d. – e). Many of these projects are a direct answer to the Union's prioritisation guidelines discussed in the previous paragraph. It can be concluded that there is a promising synergy between EU institutions, from the prioritisation and decision-making process up to the funding and development stage (Fiott, 2022).

Having this background mapping in mind, now we discuss the Timely Warning and Interception with Space-based Theatre Surveillance (TWISTER) project by PESCO, which entails endo-atmospheric interceptors and space-based early warning systems.

PESCO, the EDF and OCCAR working together for Hypersonic Endo-atmospheric Interceptors

Endo-atmospheric interceptors are one of the most tangible European space-related defensive weapons that are currently under development. They represent an excellent example of European organisational, industrial, and procurement interoperability for common equipment. Overall, Europe's push to gain this capability answers two pressing strategic concerns: countering Russian hypersonic weapons, described by GlobalData as the most advanced of this kind, and gaining advanced autonomy from a worryingly stretched American ally, currently focused on several geopolitical theatres at once (Hill, 2023).

European hypersonic interceptors, which are also included in PESCO's TWISTER project, received EDF funding through a dedicated HYDEF call, now under the management of the Organisation for Joint Armament Co-operation (OCCAR) (Hill, 2023; Clapp & Evroux, 2023). As a testament to interoperability and dialogue among transatlantic allies, TWISTER is a contribution to NATO Ballistic-Missile Defence (BMD) (PESCO, n.d. – f).

TWISTER is a PESCO project led by France with the participation of Finland, Germany, Italy, the Netherlands, and Spain, which is classified in the 'Enabling, joint' category for the air and space domain (PESCO, n.d. – f). TWISTER aims to counter a wide spectrum of complex and evolving air threats, specifically high-velocity missiles travelling through the higher atmosphere. To do so, the project seeks to establish better detection and tracking capabilities for the European Union through space-based early warning systems (PESCO, n.d. – f). These systems are tasked with identifying the threat, which is then to be countered by the aforementioned endo-atmospheric interceptors. In this way, TWISTER aims to take advantage of both the space domain for detection purposes and the air domain for kinetic interception purposes.

The European Union confirmed its interest in this kind of defensive weapon in the 2021 EDF EU HYDEF call, offering a total maximum EU contribution of almost €100 million (EDF, 2022b). The EU HYDEF's goal is to design a European hypersonic interceptor "targeting the 2035+ threats, weapon and sensor systems" (EDF, 2022b) through a weapons programme that collaborates directly with TWISTER. An MBDA-led consortium named HYDIS presented the first study proposal for an endo-atmospheric interceptor to the EDF in May 2023 (Analisi Difesa, 2023). In July, the consortium obtained a positive evaluation from the European Commission and opened the HYDIS² panel, a platform reuniting interest groups, expertise from the defence sector, European institutions, SMEs, and universities (Analisi Difesa, 2023; MBDA, 2023).

The European Commission officially withdrew from HYDIS' management in August 2023, delegating the Organisation for Joint Armament Co-operation (OCCAR) and its member states – Belgium, France, Germany, Italy, Spain, and the United Kingdom – with the indirect management of the initiative (Salerno-Garthwaite, 2023). On 31 October 2023, the OCCAR signed a contract with the HYDIS consortium to kick-start HYDEF development, marking the official start of the project (Hill, 2023). The programme subsequently tailored its scope to the detection and interception of enemy hypersonic cruise missiles (HCMs) and agile hypersonic glide vehicles (HGVs). On 11 December 2023, the OCCAR took control of the project by signing a contribution agreement, ultimately starting HYDIS' concept phase (Salerno-Garthwaite, 2023).

MBDA, the coordinating contractor, leads the designing process following the directions of its four co-founding member countries – France, Italy, Germany, and the Netherlands – while also complying with PESCO's TWISTER programme objectives (Salerno-Garthwaite, 2023). HYDIS represents a consortium of 19 associates with 30 subcontractors in 14 European countries. To date, the HYDIS consortium is made up of the following partners: ArianeGroup, Avio, Avio Aero, Bayern-Chemie, CIRA, DLR, GKN Fokker, LYNRED, MBDA España, MBDA France, MBDA Germany, MBDA Italia, OHB System AG, ONERA, ROXEL France, THALES LAS France, TDW, THALES Netherlands, and TNO (Salerno-Garthwaite, 2023; Hill, 2023).

Lastly, HYDIS stands as a fundamental contributor to MBDA's internal AQUILA concept for an endo-atmospheric hypersonic interceptor capable of reaching an altitude of 100km, which is the previously mentioned Kármán line that conventionally sets the border between Earth's higher atmosphere and space (Salerno-Garthwaite, 2023; Analisi Difesa, 2023).

EU Space Commands and Space Exercises

After having discussed projects stemming from the European Union, we now shift our attention towards the initiatives of EU member states in the context of interoperable space commands and space exercises.

In 2019, the United States created the first Space Force in the world, separating the space domain into its own dedicated branch within the Armed Forces (United States Space Force, 2023). In the case of Europe, realising the importance of space for defence, several national Armed Forces of EU member states started to create Space Commands and Forces. The structure and organisation of Space Commands vary from country to country.

In 2019, France created the French Space Command, which is part of the French Air and Space Force. In the same year, the official Space Defence Strategy was also published. Italy established the Italian Space Operations Command in 2020, while Germany created a separate command dedicated to space in its Armed Forces in 2023 (Defense News, 2021). Spain renamed the Spanish Air Force to the Spanish Air and Space Force in 2022 (El Espanol, 2022). Other examples of creating separate commands or directorates for space defence exist in most European states, such as Greece, which established the Space and Communications-Informatics Directorates in 2021 (Defence Redefined, 2021).

Consequently, an increasing necessity to carry out space exercises emerged among EU member states. France is organising the largest exercise of its kind, the AsterX 2023. The exercise takes place at the Cité de l'Espace in Toulouse and is based on a realistic and complex environment and focused on integration, interoperability, and cooperation (Ministère des Armées, 2023). The objectives of the latest AsterX 2023 were to train the units of French Space Command (CDE) in space surveillance and the protection of national space assets, to test the structure and connectivity of future military space operations Command and Control (C2) in a Multi-Domain Operations context, to validate operating concepts and coordination with the French National Centre for Space Studies and industrial partners, and to develop and reinforce joint operations in cooperation with international partners (Ministère des Armées, 2023).

The exercise is being conducted in parallel with the large Orion exercise. France, Italy, Germany, Belgium, and the United States participate in AsterX (NATO, 2023), while other states participate as observers as Cyprus. Based on the AsterX scenario, the European External Action Service (EEAS) annually conducts the Space Threat Response Architecture Exercise (STRA-22) (EEAS, 2022b). The STRA exercise tests and improves the EU’s responses to threats against the systems and services deployed under the various components of the EU Space Programme. It involves various operational actors including the member states, the EEAS, the EU Space Programme Agency (EUSPA/Galileo Security Monitoring Centre), the Commission, and the Council of the European Union (EUSPA, 2023a).

Conclusion

In 2023, the European Defence Agency commissioned a long-term assessment of the Capability Development Plan (CDP) in order to investigate future capability development priorities for the European Union beyond 2040 (EDA & Isdefe, 2023). In this report, EDA lists space technology and hypersonic weapons among the leading races for technological superiority in the future (EDA & Isdefe, 2023). Contributing factors to the development of hypersonic interceptors, such as the interconnection of cross-domain combat, the necessity of early warning cognitive superiority in cyberspace, and the pervasiveness of multilayer manoeuvrable engagement, are also present in the assessment (EDA & Isdefe, 2023). Finally, there is a section describing space capabilities as the "future battlefield" (EDA & Isdefe, 2023) in the long-term capability trends segment of the report.

As we have seen, EU member states have begun to take the defence of space assets as a primary strategic priority. Consequently, European allies have founded Space Commands, have financed PESCO and EDF initiatives, and are starting to realise the importance of interoperability in the space domain.

The organisation of the AsterX and STRA exercises shows positive steps in this direction. The significant participation of the United States in these initiatives demonstrates the willingness of EU Space Forces to be consistent with NATO plans for this stage of space capability development.

The fact that there is a large gap between the space capabilities of EU member states prevents the Armed Forces of each state from following a common model in the training of their Space Commands. However, this should not prevent the direct dialogue of the competent officials, as it happens in the land forces.

As space threats continue to evolve, the consolidation of national space forces and the reinforcement of EU space capabilities remain imperative for safeguarding the security interests of the European Union.

Bibliography

Analisi Difesa. (2023, August 2). Il progetto del consorzio HYDIS² per l'intercettore ipersonico proposto per un finanziamento dalla Commissione Europea. https://www.analisidifesa.it/2023/08/il-progetto-del-consorzio-hydis%C2%B2-per-lintercettore-ipersonico-proposto-per-un-finanziamento-dalla-commissione-europea/.

Barber, H. (2023, November 5). How Israel shot down a ballistic missile in space for the first time. The Telegraph. https://www.telegraph.co.uk/world-news/2023/11/04/how-israel-shot-down-ballistic-missile-in-space-houthis/.

Clapp, S., & Evroux, C. (2023, November). EU space strategy for security and defence. European Parliament. https://www.europarl.europa.eu/RegData/etudes/BRIE/2023/754598/EPRS_BRI(2023)754598_EN.pdf.

Defence Redefined. (2021, December 8). Hellenic National Defence General Staff (HNDGS) | Establishment of Space and Communications-Informatics Directorates. https://defenceredefined.com.cy/hellenic-national-defence-general-staff-hndgs-establishment-of-space-and-communications-informatics-directorates/.

EDA & Isdefe. (2023, September). Enhancing EU Military Capabilities Beyond 2040. https://eda.europa.eu/docs/default-source/eda-publications/enhancing-eu-military-capabilities-beyond-2040.pdf.

EDA. (2018). 2018 CDP Revision. The EU Capability Development Priorities. https://eda.europa.eu/docs/default-source/eda-publications/eda-brochure-cdp.

EDA. (2022, November). Coordinated Annual Review on Defence report. https://eda.europa.eu/docs/default-source/eda-publications/2022-card-report.pdf.

EDA. (2023). The 2023 EU Capability Development Priorities. https://eda.europa.eu/docs/default-source/brochures/qu-03-23-421-en-n-web.pdf.

EDF. (2022a, July 20). European Defence Fund 2021 Calls for Proposals - Results. https://defence-industry-space.ec.europa.eu/funding-and-grants/calls-proposals/european-defence-fund-2021-calls-proposals-results_en.

EDF. (2022b). EU HYDEF. https://defence-industry-space.ec.europa.eu/system/files/2022-07/Factsheet_EDF21_EU%20HYDEF.pdf.

EDF. (2023a, March 30). Factsheet on EDF calls 2023. https://defence-industry-space.ec.europa.eu/system/files/2023-03/Factsheet_EDFCalls2023_.pdf.

EDF. (2023b, June 26). Result of the EDF 2022 Calls for Proposals. https://defence-industry-space.ec.europa.eu/funding-and-grants/calls-proposals/result-edf-2022-calls-proposals_en.

EEAS. (2022a). A Strategic Compass for Security and Defence. https://www.eeas.europa.eu/eeas/strategic-compass-security-and-defence-1_en.

EEAS. (2022b, March 13). Space: EU carries out Space Threat Response Architecture Exercise 2022 (STRA-22). https://www.eeas.europa.eu/eeas/space-eu-carries-out-space-threat-response-architecture-exercise-2022-stra-22_en.

El Español. (2022, June 27). El Ejército del Aire cambia de nombre tras 83 años y pasa a llamarse Ejército del Aire y del Espacio. https://www.elespanol.com/espana/20220627/ejercito-aire-cambia-nombre-anos-llamarse-espacio/683431859_0.html.

European Commission. (2023). EU Space Strategy for Security and Defence. https://defence-industry-space.ec.europa.eu/eu-space-policy/eu-space-strategy-security-and-defence_en.

EUSPA. (2023a, March 17). Securing the EU Space Programme starts with EUSPA. https://www.euspa.europa.eu/newsroom/news/securing-eu-space-programme-starts-euspa.

EUSPA. (2023b, August 21). PRS. https://www.euspa.europa.eu/european-space/galileo/services/prs.

Fiott, D. (2022, November). The Strategic Compass and EU space-based defence capabilities. European Parliament.
https://www.europarl.europa.eu/RegData/etudes/IDAN/2022/702569/EXPO_IDA(2022)702569_EN.pdf.

Hill, J. (2023, November 2). OCCAR signs hypersonic interceptor contract, kick-starting HYDEF development. Airforce Technology. https://www.airforce-technology.com/news/occar-signs-hypersonic-interceptor-contract-kick-starting-hydef-development/?cf-view.

MBDA. (2023, June 20). Aquila: MBDA to Lead Consortium for European Interceptor Against Hypersonic Threats. https://www.mbda-systems.com/press-releases/aquila-mbda-to-lead-consortium-for-european-interceptor-against-hypersonic-threats/.

Ministère des Armées. (2023). Presentation of AsterX 2023. https://air.defense.gouv.fr/asterx/dossier/presentation-asterx-2023.

NATO. (2023, October 5). Multi-Domain Operations in NATO – Explained. https://www.act.nato.int/article/mdo-in-nato-explained/.

PESCO. (n. d. – a). Projects. Retrieved December 13, 2023, from: https://www.pesco.europa.eu/#projects.

PESCO. (n. d. – b). Common Hub for Governmental Imagery (COHGI). Retrieved December 13, 2023, from: https://www.pesco.europa.eu/project/common-hub-for-governmental-imagery-cohgi/.

PESCO. (n. d. – c). European Military Space Surveillance Awareness Network (EU-SSA-N). Retrieved December 13, 2023, from: https://www.pesco.europa.eu/project/european-military-space-surveillance-awareness-network-eu-ssa-n/.

PESCO. (n. d. – d). Defence of Space Assets (DOSA). Retrieved December 13, 2023, from: https://www.pesco.europa.eu/project/defence-of-space-assets-dosa/.

PESCO. (n. d. – e). EU Radio Navigation Solution (EURAS). Retrieved December 13, 2023, from: https://www.pesco.europa.eu/project/eu-radio-navigation-solution-euras/.

PESCO. (n. d. – f). Timely Warning and Interception with Space-based Theater Surveillance (TWISTER). Retrieved December 14, 2023, from: https://www.pesco.europa.eu/project/timely-warning-and-interception-with-space-based-theater-surveillance-twister/.

Salerno-Garthwaite, A. (2023, December 12). OCCAR takes control of EU's hypersonic interceptor as HYDIS enters Concept Phase. Airforce Technology. https://www.airforce-technology.com/news/occar-take-control-of-eus-hypersonic-interceptor-programme-as-hydis-enters-concept-phase/?cf-view.

The Jerusalem Post. (2023, November 7). Israel downing Houthi missile is first instance of space warfare. https://www.jpost.com/israel-news/defense-news/article-771910.

United States Space Force. (2023). About the Space Force. https://www.spaceforce.mil/About-Us/About-Space-Force/.

Transitional Segment

So far, there has been a comprehensive discussion on the numerous projects and aspirations within the space domain that Europe holds. The European Union, the European Space Agency and the European Union Agency for the Space Programme possess an impressive array of interconnected projects spanning civilian, military and dual-use dimensions. However, little has been given to the actual means available to Europe to translate these ambitions into reality.

At the end of 2023, the European Space Agency found itself in a transitional phase. The retirement of its main carrier rocket, Ariane 5, and the impending retirement of its smaller counterpart, Vega, marked a significant shift. The two rockets set to inherit their legacy, Ariane 6 and Vega-C, have encountered delays and setbacks. The absence of a carrier launch vector leaves Europe without the possibility to independently launch payloads and satellites that stand at the basis of its new ambitious programmes.

In short, high-profile projects like IRIS^2 will not be possible without Europe's independent access to space. Multi-domain military programs like HYDEF/HYDIS hypersonic interceptors are not an exception. Even though missiles traverse the atmosphere without a carrier vehicle, their cross-domain function requires early warning and threat detection systems provided by ad-hoc space satellites. Europe would consequently lag behind in all terrestrial domains that rely on space capabilities.

Overall, the strategic consequences of depending on private contractors would be ever direr for all European space defence projects. Lacking an available rocket, Europe was already forced to request SpaceX's private services for the future launch of Galileo GNSS satellites, one of Europe's most venerable strategic space assets. Software updates and technology upgrades of already available assets can only do so much: the only way to effectively modernise satellites to accommodate new projects is simply to build them and to launch them into space. Europe's aspirations are now all dependent on the long-delayed but upcoming debut of Ariane 6, the latest rocket built by the European Space Agency, now coming to the rescue of European independence in space.

The Ariane 6 Rocket: Europe’s Civilian and Military Sovereignty in Space at Stake. Private Competition and Reusability in the Future of European Space Policy

Written by: Vittorio Ippolito
Edited by: Chiara Nasonte
Supervised by: Emile Clarke

Introduction

Ariane 6 is set to be the next flagship launch vehicle of the European Space Agency (ESA). On 30 November 2023, after years of delays and unfortunate circumstances, ESA Director General Josef Aschbacher finally announced that the rocket’s first flight will take place in the summer of 2024 (Foust, 2023d).

Ariane 6 is designed to carry into orbit payloads commissioned by private contractors, national governments, ESA member states and the European Union Space Programme (EUSPA). It aims to replace the recently retired Ariane 5 rocket, which was entrusted with the delivery of Europe’s heaviest and most advanced payloads during its 117-flights-long career from 1996 to 2023(ESA, n.d. - a).

The birth of the project and the subsequent retirement of Ariane 5 were directly related to the increase of competitiveness by private agencies such as SpaceX, which prompted ESA to reimagine Ariane in a new space economy where states’ interests clash not only between each other but also with emerging non-state actors. Europe’s objective is, indeed, to possess an efficient and cost-effective main launch vehicle capable of resisting competition or, at the very minimum, capable of defending Europe’s independence in the launch of payloads in space.

Ariane 6 aspires to be a highly innovative vehicle qualified to carry heavier and more numerous payloads than ever before, while at the same time cutting operational costs to competition-like levels (ArianeGroup, n.d.). However, major setbacks, a Vega-C launch failure and years of delays severely hampered the programme, leaving ESA in a state of limbo where Ariane 5 has already been retired at a time when Ariane 6 is not ready yet.

Before exploring the unfortunate circumstances that orbit around the project, it is beneficial to analyse the process of Ariane 6’s development and its projected capabilities.

Development and Contractors of Ariane 6

The initiative to develop Ariane 5's successor was greenlit by a ministerial meeting during the ESA Council in late 2014. The member states that are directly involved in the development of the launcher are Austria, Belgium, France, Germany, Ireland, Italy, the Netherlands, Norway, Romania, Spain, Sweden and Switzerland (ESA, n.d. - b).

The design and procurement process for the architecture of Ariane 6 is being directly overseen by ESA itself, while ArianeGroup, comprised of an even partnership between Airbus from Germany and Safran from France, was again confirmed as the prime contractor in collaboration with various other smaller European partners tasked with building rocket components (ArianeGroup, n.d.; ESA, n.d. - b). The auxiliary solid rocket boosters are being co-developed by Europropulsion, a 50/50 joint venture between ArianeGroup and Avio (ESA, n.d. - b). ArianeGroup selected Eiffage Énergie Systèmes for the construction of an automated factory capable of manufacturing engine nozzles for the rocket, in collaboration with EOS' expertise on engine injector heads (Aerospace Technology, n.d.). Thales Alenia Space and SABCA are some of the other major contractors working on propulsion systems; their responsibilities are, respectively, thrust vectoring actuators electronics and thrust vectoring controls systems. In addition, Réaltra Space supervises onboard live telemetry and Arteche is in charge of relay systems supply (Aerospace Technology, n.d.).

As it was for Ariane 5, the European Space Agency will manage launch requirements for institutional missions such as those of member states and EUSPA, while industry representatives are expected to identify the analogous requirements for the commercial market (ESA, n.d. - b). In 2016, ESA signed an agreement worth €3 billion with ArianeGroup, at the time still known as Airbus Safran Launchers, and the French Space Agency (CNES) for the development of Ariane 6 and its launch complex in Europe's Spaceport in Kourou, French Guyana (Aerospace Technology, n.d.).

Ariane 6's Technical Characteristics, Mission Profile and Payload Capabilities

Ariane 6 will be a 60-metre-tall expendable, modular and heavy-lifting launcher weighing up to 900 tonnes when fully loaded and capable of flying in two main configurations: Ariane 62 and Ariane 64. Ariane 62 will utilise two P120C strap-on solid rocket boosters (SRBs), carrying 10,300kg to low Earth orbit (LEO) or 4,500kg to the further away geostationary transfer orbit (GTO). Meanwhile, the Ariane 64 configuration will have a doubled auxiliary power with four SRBs, carrying an even heavier payload weighing up to 20,600kg to LEO or 11,500kg to GTO (ESA, n.d. - b; Aerospace Technology, n.d.). Ariane 62 will house payloads in 14m-sized or 20m-sized fairings, while the more powerful Ariane 64 will only deliver payloads that require the 20m-sized fairing. Both available fairings sit on the very tip of the rocket with a diameter of 5,4m and protect the payload during ascent shocks, thanks to a carbon fibre-polymer composite shell (ESA, n.d. - b). The fairing is then jettisoned when the rocket reaches an altitude where atmospheric friction is no longer a concern.

Ariane 6 will be comprised of two liquid fuel core stages plus a solid propellant booster stage consisting of the above-mentioned SRBs in radial symmetrical attachment to the lower core stage (ESA, n.d. - b; Aerospace Technology, n.d.). In order to carry the rocket from the launch pad to the upper atmosphere, the lower stage relies on up to 135 tonnes of combined thrust provided by one liquid-fuelled, Ariane 5-derived Vulcain 2.1 engine and by two or four solid-propelled P120C SRBs (ESA, n.d. - b). The SRBs are then depleted and detached from the core stage during the first part of the ascent. When the lower stage runs out of fuel, it is discarded in a vertical separation to let the upper stage continue the gravity turn and payload orbit insertion.

The upper stage draws power from the four-times re-ignitable Vinci engine, fuelled by cryogenic liquid oxygen and hydrogen (ESA, n.d. - b; Aerospace Technology, n.d.; ArianeGroup, n.d.). The upper stage's multiple ignition technology gives Ariane 6 the capability to deliver different payloads in different orbits, allowing for a greater number of satellites per mission, greater efficiency and cost reductions in operations and satellite complexity (Aerospace Technology, n.d.; ArianeGroup, n.d.). Payload carrier structural elements will allow small satellites under 200kg to 'piggyback' the space ascent of the main payload, opening opportunities of launch ridesharing for small companies, which otherwise would not afford a dedicated mission (ESA, n.d. - b). The last ignition of the Vinci engine could be saved to safely deorbit the upper stage, as to have closer to zero impact on space debris orbiting Earth. Having now reached a general understanding of the characteristics of Ariane 6, the next paragraph divulges into the contextual drawbacks that link these technical specifications to European politics.

Major Setbacks for Ariane 6: Political Meddling, Technical Delays and Global Calamities

On 6 November 2023, ESA held an inter-ministerial meeting during Seville's Space Summit on the next generation of European launchers, Ariane 6, and Vega-C. It appears that German, French and Italian ministers have finally resolved long-standing disputes over launch sites, budgeting and schedules of future Ariane 6 flights (Fonte, 2023; ESA, 2023). Some key words emerging from the summit were: "paradigm shift" (Berger, 2023b), "relaunch" (Fonte, 2023) and even, quoting ESA Director General Josef Aschbacher: "light at the end of the tunnel" (Hepher, 2023). This shows Europe's strong will to regain its access to space after the drawbacks of the last few years, resulting in ESA and EUSPA temporarily losing the means to independently send payloads in space since July 2023. Just a month after the meeting, in fact, Aschbacher followed with the announcement of a possible Ariane 6 inaugural launch between 15 June and 31 July 2024 (Foust, 2023d; Hepher & Lipinski, 2023).

France apparently managed to lobby more public support for the rocket, brokering €340 million in yearly grants for the project, while promising to reduce industry costs by 11% (Hepher & Fonte, 2023; Hepher, 2023; Fonte, 2023). This agreement should ensure the future production of a second batch of Ariane 6 launchers, appeasing German concerns about the sustainability of Airbus' contracts and the weight of France in the programme (Hepher & Fonte, 2023). Italy was also apparently satisfied with promises of up to €21 million worth of annual support for its domestically produced Vega-C rocket, after demanding a bigger role for Avio in the ArianeGroup-dominated ESA (Hepher & Fonte, 2023; Fonte, 2023).

For context, the generational transition from Ariane 5 to Ariane 6 and from Vega to Vega-C has been quite troubled. Ariane 5 ended its career with prestigious missions, such as this April's launch of Jupiter Icy Moons Explorer (JUICE) and the 2021 launch of NASA's James Webb Space Telescope (ESA, n.d. - c; ESA, n.d. - d). Ariane 5 proved to be one of the most reliable launches on the market, boasting a 96% success rate in its 117 flights completed in the span of twenty years (Anderson, 2023). Great expectations for its successor, Ariane 6, have been kept on hold for four years, as its first flight was originally planned for 2020, the year of the unforeseen Covid-19 pandemic (Fonte, 2023).

A few years later, another global event sabotaged Europe's access to space, as the Russian invasion of Ukraine stalled collaboration with Moscow's space agency, Roscosmos. The war ultimately compromised Europe's access to the extremely reliable Soyuz rocket, forcing the European Commission to cancel future launches of EUSPA's Galileo, Europe's Global Navigation Satellite System (GNSS), which had extensively relied on Soyuz launches from French Guyana (Posaner & Cerulus, 2023). Recent news suggested that the European Commission was in the final stages of finalising a deal with SpaceX for the launch of two Galileo satellites, originally planned for Ariane 6 (Foust, 2023c).

During Ariane 6's four-year delay, Vega Consolidation (Vega-C), Ariane's Italian-built junior partner, made its debut in succession of the Vega rocket. After a positive test flight, Vega-C was unfortunately lost during its maiden commercial mission on 12 December 2022 (France24, 2022). The programme has been on hold since. Furthermore, the prime contractor for Vega-C, Avio, reported additional problems emerging from a Zefiro 40 test fire earlier this June, the same engine that malfunctioned during the rocket's first mission (Foust, 2023b). As an immediate consequence, Vega-C will probably return to fly in 2024 and the EarthCARE spacecraft launch, an ESA Earth science mission, has been moved from Vega-C to SpaceX's Falcon 9 (Foust, 2023c). Ariane 6 hot fire test runs suffered severe delays until a final success on 23 November 2023 (Emir, 2023). The crucial general propellant capability test was also finally successful this October after having been delayed twice (Rabie, 2023; Jones, 2023b). With the completion of these capability assessments, the road is now opened for the aforementioned long-awaited inaugural launch, now planned for mid-2024 (Hepher & Lipinski, 2023).

Figure 1 – Europe's rockets (Photo credit: ESA - D. Ducros). From left to right: Vega (about to be retired), Vega-C (flight suspended until 2024), Soyuz (now unavailable), Ariane 5 (Retired), Ariane 62 (coming in 2024), Ariane 64 (coming in 2024)

The Irrefutable Importance of Ariane 6 for European Scientific, Military and Strategic Interests

The long wait for Ariane 6 and Vega-C put the very future of European space strategic interest at stake. EUSPA and ESA have already been forced to rely on SpaceX for important scientific payloads in the past, and more will follow in the next two years. In 2020, the private company placed into orbit Sentinel-6A Michael Freilich, which is an oceanographic satellite part of EUSPA's Copernicus programme tasked with measuring rising sea levels. The second part of the mission, Sentinel-6B, is planned for 2025, and will once again fly on a Falcon 9 (Costa, 2020). Still, the mission is the result of a collaboration with NASA, so the adoption of an American rocket is not too surprising.

However, in July ESA's Euclid space telescope had to fly with SpaceX not out of choice, but because Ariane 5 was just days away from its retirement. Euclid is designed to explore dark energy and dark matter in galaxies up to 10 billion light-years away and it was the most expensive payload ever carried by a Falcon 9 (ESA, n.d. - f). In 2024, SpaceX was commissioned with two other high-profile payloads: the already mentioned Earth Cloud, Aerosol and Radiation Explorer (EarthCARE) and another mission, Hera, tasked with a post-impact survey of NASA's DART asteroid deflection test (Earth Online, n. d.; Hera Mission, n.d.).

Nonetheless, the most sensitive payload by far are the two Galileo satellites that will fly on a Falcon 9 in 2024. Although Galileo is the only Global Navigation Satellite System (GNSS) in the world to not be military-operated, some of its technology is particularly sensitive to European strategic interests and still benefits military applications due to its dual-use nature. The exact requirements for Galileo's military domain are not publicly available, but EUSPA and ESA are looking to sign an ad hoc legally binding security agreement with the United States and SpaceX on this matter (Hecker et al., 2018; Posaner & Cerulus, 2023).

SpaceX's Fierce Competition

The company's business model has been extremely successful because of a fundamental strength that no other space actor, state-owned or private, has currently mastered to such a level: reusability. All previous traditional launchers such as those from the Ariane rocket family, with the notable exception of the retired Space Shuttle Orbiter Vehicle, were expendable, meaning that every stage of the rocket was simply discarded mid-air after exhausting its duty and rebuilt from scratch for the following mission. However, SpaceX's Falcon 9 rocket has been capable of recovering and re-flying its first stage since 2014, dramatically reducing cost operations and, consequently, pricing for clients. At the time of writing, SpaceX has managed to recover 236 Falcon 9 first stages via vertical powered landings, counting 211 total re-flights (SpaceX, n.d. - a). SpaceX has also successfully flown the Falcon Heavy rocket variant, also largely reusable, and is planning to operate a fully reusable superheavy launch system for future solar system-wide missions, Starship.

Ariane 6 will be capable of putting a maximum of 20,600kg to low earth orbit for an estimated price of $4.7 thousand per kilogramme, a capacity that Falcon 9 could only reach in an expendable configuration, meaning on condition of not reusing its first stage (Brown, 2022; Howell, 2023). However, Falcon 9 could still have an economical edge by re-flying and not recovering a booster from a previous mission or by undercutting Ariane in the market of smaller payloads. Therefore, in its best conditions, Falcon 9 could deliver a slightly smaller payload than Ariane, but at a guaranteed price of $2.7 thousand per kilogramme (Howell, 2023).

In addition, SpaceX's Falcon Heavy, albeit completing only eight flights so far, has been proven capable of delivering 63,800kg to LEO while reusing the three Falcon 9 boosters, which make up its first stage, for as little as $1.6 thousand per kilogramme (Brown, 2022; SpaceX, n.d. - b; Howell, 2023). Finally, the future Starship system aims to bring 100,000kg to LEO, whilst simultaneously becoming the world's most powerful rocket and the world's first fully reusable launcher system, reducing costs even more. On 18 November 2023, SpaceX conducted a second Starship test flight, in which the rocket reached space for the first time and successfully demonstrated hot-staging. SpaceX later terminated the flight after losing control of both stages (Dinner, 2023).

Ariane 6’s Role as an Alternative in the Private Space Market

Although SpaceX’s achievements in corporate profits are impressive, it is important to remain focused on Ariane 6’s real purpose, which is to serve the interests of EU member states. Ariane 6 competing power is not a simple matter of EUR per kilogramme as another nonquantifiable currency, interest, will probably make this rocket indispensable for a variety of actors, not only for European states. Ariane 6 will soon be, in fact, ESA’s workhorse for the largest single commercial launch contract in history. This order will entail a total of over 80 launches mainly split among ESA, Blue Origin and United Launch Alliance to deploy Amazon’s 3,236-strong Kuiper satellite constellation. Ariane 6 will be in charge of 18 of these launches (Foust, 2023a; ArianeGroup, 2022), while recent indiscretion speculates that SpaceX will take care of three more (Wattles, 2023).

Jeff Bezos, the founder of Amazon, overwhelmingly chose Ariane 6 over Falcon 9 not because of pricing or availability, but because SpaceX’s Falcon 9 and Starlink constellation satellites are direct competitors of private space operator Blue Origin, another company he founded. Interestingly, the personal rivalry between Bezos and Musk became so fierce that Amazon shareholders went as far as suing their own company for ignoring SpaceX’s vastly reliable and inexpensive rockets as a viable option (Sheetz, 2023; Wattles, 2023). It should not be underestimated, then, how much Ariane 6 could be relevant, not only as a means for European states’ interests but also for the equilibrium of private space markets.

All things considered, Ariane 6 may be delayed, but it is off to an impressive start. A few weeks ago, during the ministerial meeting in Seville, ESA member states raised the production queue of future launchers from 16 to 42 units, as numerous institutional and commercial payloads are already crowding the schedule (Hepher & Fonte, 2023). The competition with private space operators is fierce, but Ariane 6 has the potential to become an important player in the new space arena, boasting a record-breaking commercial debut that directly benefits from private rivalries. Moreover, in the upcoming deal with Amazon, ESA plans to deploy 40 satellites per launch in an excellent display of Ariane 6’s new capabilities. This could be an excellent opportunity to attract potentially interested commercial contractors.

Furthermore, the reduced availability of Russia’s Soyuz removes a trusted launcher partner from Europe, but could also represent an opportunity for former Soyuz contractors to consider Ariane 6 and Vega-C as alternatives (Lo Campo, 2023). Finally, it should be noted that even though SpaceX is highly competitive, Ariane 6 is set to cut its launch costs by circa 40% compared to Ariane 5 (Simpson, 2023). Some commentators contest this claim, especially citing heavy subsidies that ESA member states are expected to provide for the rocket, but a factual evaluation will only be possible at the moment of the rocket’s full operability (Berger, 2023a).

Europe’s Bid for a Reusable Rocket: Ariane Next and SALTO

Regarding the matter of a reusable European rocket, during a conference in 2021, French Economy Minister Bruno Le Maire went so far as to state that: “In 2014 there was a fork in the road, and we didn’t take the right path. [...] We should have made the choice of the reusable launcher. We should have had this audacity” (Posaner, 2021). In retrospect, Ariane 6 was probably designed as a traditional launch vehicle because the stars had not yet aligned for a public actor to venture into the space reusability arena. It should be kept in mind that the ESA has to balance public funds responsibility and member states’ industry interests, which are not always prone to risky innovation. This was especially true back in 2014, a time when rocket reusability was just being pioneered. Furthermore, delays are frequent in state-funded space agencies. For example, NASA’s SLS rocket was delayed by six years and is now long over its budget projections (Jones, 2023a).

Once again, Ariane 6 has the right premises to be a formidable launcher, but, by the time of its retirement, rocket reusability will probably be an irrefutable staple of space competitiveness – some claim it already is. Europe ought to not remain behind in the new space race for reusability, cost-efficiency and liberalisation in the access to space. Now that Europe will soon ensure an independent means to reach space again for the next two decades, reusability should become a top priority for ESA’s future technology. ArianeGroup, indeed, is already working on a solution by developing Ariane Next, a possible reusable successor to Ariane 6.

Ariane Next has one main objective: halving the operational costs of Ariane 6 by the 2030s through the reusability of the rocket’s first stage (CNES, 2020). ESA’s Future Launchers Preparatory Programme (FLPP) chose Europe’s first liquid methane engine, Prometheus, over a liquid oxygen alternative after a long debate on how to address propulsion concerns (Patureau de Mirand et al., 2019; ESA, n.d. - e). Themis, the reusable first stage demonstrator, already conducted a successful hot-fire test with Prometheus in June 2023 (Iacopino, 2023). The project is managed by reuSable strAtegic space Launcher Technologies & Operations (SALTO), a consortium involving twenty-six industrial partners and twelve countries, under the coordination of ArianeGroup and with funding from the European Commission’s Horizon Europe programme (SALTO, n.d. - a).

Future SALTO demonstrators will be capable of performing short take-offs, 250-metre-high altitude hovering, and controlled landings. These so-called ‘hop-tests’ are expected to be hosted by 2025 at the Reusability test facility at Esrange Space Center in Kiruna, Sweden (Cowing, 2023; SALTO, n.d. - b). The Esrange Space Center was inaugurated in January 2023 by the Swedish King Carl XVI Gustaf, the President of the European Commission Ursula von der Leyen and the Swedish Prime Minister Ulf Kristersson. Esrange stands as the first orbital launch complex in the contiguous European Union (Iacopino, 2023; SALTO, n.d. - b).

Conclusion

Needless to say, the fact that Europe has to rely on a private third party for its most sensitive payloads is of major concern. As discussed in this paper through the analysis of different political and technological scenarios, the gap in European space access autonomy is starting to show its most dire strategic drawbacks. At the same time, it is also very clear that ESA and European institutions have recognised the urgency of regaining independence in space.

ESA's inter-ministerial meeting during this November's European Space Summit gave new promising momentum for Ariane 6's debut by solving disputes among participating member states. Moreover, ESA managed to broker a contract with Amazon, providing a great starter role for Ariane 6 in the domain of private space competition vis-à-vis the agency's latest dependence on SpaceX. Ariane 6 has completed crucial tests for flight eligibility, culminating with the already mentioned successful long-duration hot-fire static test on 23 November 2023 and with the announcement of an upcoming maiden flight set for next summer (Emir, 2023; Foust, 2023d). Finally, interest in the valorisation of Ariane Next and SALTO is a testimony to Europe's realisation of the importance of rocket reusability in the agenda of future European space policy.

Overall, it could be argued that the drawbacks of Ariane 6's development are being positively interpreted by ESA and EUSPA as a lesson rather than a defeat, building an important starting point to address upcoming challenges. Perhaps, the long-awaited "light at the end of the tunnel", in the words of ESA Director General Josef Aschbacher (Hepher, 2023), is finally about to shine on a renewed European future in the darkness of space, hopefully by August 2024. The eyes of the continent are now pointed at the sky, looking for that light in the engine plume of an Ariane 6 circling a blue firmament of twelve golden stars.

Bibliography

Aerospace Technology. (n.d.). Ariane 6 Launch Vehicle. Retrieved November 23, 2023, from: https://www.aerospace-technology.com/projects/ariane-6-launch-vehicle/.

Anderson, C. E. (2023, July 11). Goodbye to Ariane 5. National Air and Space Museum. https://airandspace.si.edu/stories/editorial/goodbye-ariane-5#:~:text=Its%20117%20launches%20over%20more,reliable%20launchers%20on%20the%20market.

ArianeGroup. (2022, April 5). Arianespace signs unprecedented contract with Amazon for 18 Ariane 6 launches to deploy Project Kuiper constellation. Retrieved November 23, 2023, from: https://www.arianespace.com/press-release/arianespace-signs-unprecedented-contract-with-amazon-for-18-ariane-6-launches-to-deploy-project-kuiper-constellation/.

ArianeGroup. (n.d.). How do you build Ariane 6 rockets?. Retrieved November 23, 2023, from: https://www.ariane.group/en/news_kid/how-do-you-build-ariane-6-rockets/.

Berger, E. (2023a, October 12). Oops—It looks like the Ariane 6 rocket may not offer Europe any launch savings. Ars Technica. https://arstechnica.com/space/2023/10/oops-it-looks-like-the-ariane-6-rocket-may-not-offer-europe-any-launch-savings/.

Berger, E. (2023b, November 6). Ariane 6 cost and delays bring European launch industry to a breaking point. Ars Technica. https://arstechnica.com/space/2023/11/ariane-6-cost-and-delays-bring-european-launch-industry-to-a-breaking-point/.

Brown, M. (2022, January 24). Ariane 6 vs. SpaceX: How the rockets stack up. Inverse. https://www.inverse.com/innovation/ariane-6-vs-spacex.

CNES. (2020, September 15). [Lanceurs] Ariane Next Regarde Vers La Prochaine Décennie. Retrieved November 25, 2023, from: https://ariane6.cnes.fr/fr/lanceurs-ariane-next-regarde-vers-la-prochaine-decennie.

Costa, J. (2020, December 20). NASA Awards Launch Services Contract for Sentinel-6B Mission. NASA. https://www.nasa.gov/news-release/nasa-awards-launch-services-contract-for-sentinel-6b-mission/#:~:text=The%20Sentinel%2D6B%20mission%20currently,continuity%20of%20ocean%20topography%20measurements.

Cowing, K. (2023, March 16). SALTO project will advance forward Europe's first reusable rocket. SpaceRef. https://spaceref.com/space-commerce/salto-project-will-advance-forward-europes-first-reusable-rocket/.

Dinner, J. (2023, November 18). SpaceX Starship megarocket launches on 2nd-ever test flight, explodes in 'rapid unscheduled disassembly' (video). Space.com. https://www.space.com/spacex-starship-second-test-flight-launch-explodes.

Earth Online. (n.d.). EarthCARE. Retrieved November 25, 2023, from: https://earth.esa.int/eogateway/missions/earthcare.

Emir, C. (2023, November 24). ESA's Ariane 6 rocket aces critical hot-fire test. Interesting Engineering. https://interestingengineering.com/science/esa-ariane6-static-fire-test.

ESA. (2023, November 2). Watch the Space Summit live. Retrieved November 23, 2023, from: https://www.esa.int/About_Us/Corporate_news/Watch_the_Space_Summit_live.

ESA. (n.d. - a). Ariane 5. Retrieved November 23, 2023, from: https://www.esa.int/Enabling_Support/Space_Transportation/Launch_vehicles/Ariane_5.

ESA. (n.d. - b). Ariane 6. Retrieved November 23, 2023, from: https://www.esa.int/Enabling_Support/Space_Transportation/Launch_vehicles/Ariane_6.

ESA. (n.d. - c). Juice factsheet. Retrieved November 24, 2023, from: https://www.esa.int/Science_Exploration/Space_Science/Juice_factsheet.

ESA. (n.d. - d). webb. Retrieved November 24, 2023, from: https://www.esa.int/Science_Exploration/Space_Science/Webb.

ESA. (n.d. - e). Unveiling vehicles and technologies for future space transportation. Retrieved November 25, 2023, from: https://www.esa.int/Enabling_Support/Space_Transportation/Future_space_transportation/Unveiling_vehicles_and_technologies_for_future_space_transportation?s.

ESA. (n.d. - f). euclid launch kit. Retrieved November 25, 2023, from: https://esamultimedia.esa.int/docs/science/Euclid-LaunchKit.pdf.

Fonte, G. (2023, November 6). Italy, France and Germany agree on launches of Ariane 6 and Vega-C. Reuters. https://www.reuters.com/technology/space/italy-france-germany-agree-launches-ariane-6-vega-c-2023-11-06/.

Foust, J. (2023a, September 12). Kuiper launch companies say they can meet Amazon's schedule. SpaceNews. https://spacenews.com/kuiper-launch-companies-say-they-can-meet-amazons-schedule/.

Foust, J. (2023b, October 2). ESA delays Vega C return to flight to late 2024. SpaceNews. https://spacenews.com/esa-delays-vega-c-return-to-flight-to-late-2024/.

Foust, J. (2023c, November 7). EU finalizing contract with SpaceX for Galileo launches. SpaceNews. https://spacenews.com/eu-finalizing-contract-with-spacex-for-galileo-launches/.

Foust, J. (2023d, November 30). ESA sets mid-2024 date for first Ariane 6 launch. SpaceNews. https://spacenews.com/esa-sets-mid-2024-date-for-first-ariane-6-launch/#:~:text=At%20a%20Nov.%2030%20briefing,in%20the%20spring%20of%202024.

France24. (2022, December 21). Vega-C rocket lost shortly after lift-off in French Guiana. France24. https://www.france24.com/en/live-news/20221221-vega-c-rocket-lost-shortly-after-lift-off-in-french-guiana.

Hecker, P., Bestmann, U., Schwithal, A., & Stanisak, M. (2018, October). Galileo Satellite Navigation System. EPRS – European Parliamentary Research Service. https://www.europarl.europa.eu/RegData/etudes/STUD/2018/614560/EPRS_STU(2018)614560_EN.pdf.

Hepher, T. (2023, October 31). Europe's space agency boss sees progress on Ariane 6 launcher. Reuters. https://www.reuters.com/technology/space/europes-space-agency-boss-sees-progress-ariane-6-launcher-2023-10-31/.

Hepher, T., & Fonte, G. (2023, November 7). Europe targets competitive shake-up in space launch deal. Reuters. https://www.reuters.com/technology/space/europe-urged-not-repeat-tech-underdog-role-ahead-space-talks-2023-11-06/.

Hepher, T., & Lipinski, P. (2023, November 30). Europe's new Ariane 6 rocket to launch June 15-July 31, 2024. Reuters. https://www.reuters.com/technology/space/europes-new-ariane-6-rocket-launch-between-june-15-july-31-2024-2023-11-30/.

Hera Mission. (n.d.). Hera Mission. Retrieved November 25, 2023, from: https://www.heramission.space/.

Howell, E. (2023, July 3). Ariane 5's Final Flight – A Look Back as Ariane 6's Costly Succession Looms. SpaceRef. https://spaceref.com/space-commerce/ariane-5-final-flight-look-back-ariane-6-costly-succession-looms/#:~:text=Will%20Ariane%206%20be%20worth,9%20at%20%242.7%20per%20kilogram.

Iacopino, L. (2023, August 8). SALTO: the new European project ready to work with reusable rockets. SALTO. https://salto-project.eu/salto-the-new-european-project-ready-to-work-with-reusable-rockets/.

Jones, A. (2023a, May 26). NASA's Artemis moon rocket will cost $6 billion more than planned: report. Space.com. https://www.space.com/nasa-sls-megarocket-cost-delays-report.

Jones, A. (2023b, September 1). Crucial test of Europe's long-delayed Ariane 6 rocket delayed. Space.com. https://www.space.com/esa-ariane-6-testing-delay.

Lo Campo, A. (2023, April 19). Vega-C, il razzo italiano attende di ripartire. BFCspace. https://bfcspace.com/2023/04/19/vega-c-il-razzo-italiano-attende-di-ripartire/.

Patureau de Mirand, A., Bahu, J. M., & Louaas, E. (2019). Ariane Next, a vision for a reusable cost efficient European rocket. EUCASS. https://www.eucass.eu/doi/EUCASS2019-0949.pdf.

Posaner, J. (2021, January 15). Europe's lack of rocket 'audacity' leaves it scrambling in the space race. Politico. https://www.politico.eu/article/europe-arianespace-rocket-space-race/#:~:text=%E2%80%9CThe%20European%20space%20adventure%20is,should%20have%20had%20this%20audacity.%E2%80%9D.

Posaner, J., & Cerulus, L. (2023, April 17). EU turns to Elon Musk to replace stalled French rocket. Politico. https://www.politico.eu/article/eu-elon-musk-replace-stalled-france-rocket-galileo-satellite/.

Rabie, P. (2023, September 5). Launch Uncertainty Lingers as Ariane 6 Rocket Undergoes Engine Test. Gizmodo. https://gizmodo.com/ariane-6-rocket-european-space-agency-delays-1850805673.

SALTO. (n.d. - a). SALTO - reuSable strAtegic space Launcher Technologies & Operations. Retrieved November 25, 2023, from: https://salto-project.eu/.

SALTO. (n.d. - b). Test facility. Retrieved November 25, 2023, from: https://salto-project.eu/test-facility/.

Sheetz, M. (2023, September 1). Bezos snubbed Musk's SpaceX for huge satellite launch contract, Amazon shareholder says. CNBC. https://www.cnbc.com/2023/09/01/bezos-snubbed-musk-spacex-satellite-contract-lawsuit.html.

Simpson, C. (2023, July 11). Ariane 5 retirement leaves Europe facing an 'acute launch crisis'. Spaceflight Now. https://spaceflightnow.com/2023/07/11/ariane-5-retirement-leaves-europe-facing-an-acute-launch-crisis/.

SpaceX. (n.d. - a). Falcon 9. Retrieved December 4, 2023, from: https://www.spacex.com/vehicles/falcon-9/.

SpaceX. (n.d. - b). Falcon Heavy. Retrieved November 24, 2023, from: https://www.spacex.com/vehicles/falcon-heavy/.

Wattles, J. (2023, December 1). Amazon taps SpaceX for satellite launch even though Jeff Bezos is right there. CNN Business. https://edition.cnn.com/2023/12/01/business/amazon-spacex-kuiper-launch-scn/index.html.

Transitional Segment

Ariane 6 emerges as a crucial facilitator for Europe's future strategic interests in space. But why is this launcher such a pressing urgency? Why is Europe yearning to regain a means of power for its space policy? The answer could be attributed to the current global events and the expanding influence of space militarization in conflict zones.

One of the major drivers behind European defence investments in space is the rising relevance of the domain in neighbouring conflicts, such as the Russo-Ukrainian interstate war and the asymmetric war between Israel and Hamas. For instance, the Russian hypersonic missile Kh-47M2 Kinzhal, a multi-domain technology that likely relies on GLONASS GNSS satellite navigation, has already represented a formidable threat during the Ukrainian conflict.

Notably, discussions on European hypersonic missile interceptors gained momentum shortly after Moscow unveiled the Kh-47M2 Kinzhal in 2018. The acceleration of HYDEF/HYDIS development can be connected to Russia's successful uses of Kinzhal in Ukraine. Additionally, Israel's interception of an enemy ballistic missile using an Arrow missile interceptor in space further fueled the urgency for European capabilities.

In concluding the paper's findings, Europe's space policy vis-a-vis the use of the space domain during the war in Ukraine has been contextualized. In further analysis, some nuances in Russia's use of its GLONASS GNSS impacted by international sanctions and isolationism will be explored severely. The discussion introduces a direct comparison with the space assets available to Ukraine, now involving third-party non-state stakeholders, such as SpaceX's Starlink private satellite constellation.

The paper's analysis ultimately concludes with a discussion around the root cause behind much of Europe's recent defence modernisation across all domains, including space: war in Ukraine.

Space Lessons Learned from the War in Ukraine

Written by: Harold Degeert
Edited by: Clelia Vettori
Supervised by: Emile Clarke

Introduction

With each passing conflict, the space industry is gaining more and more relevance in the operation command chain, especially during interstate wars. The war in Ukraine is the perfect example of this, revealing the most significant trajectories in the space domain, and highlighting flaws and rapid developments; in a nutshell, this war is shaping the future of space, especially in the military sector. The focus of this paper will be first on the Russian entanglement in the conflict, followed by an analysis of the Ukrainian rapid adaptation of the new rules in space guided by Western help, and finally, conclusions will be drawn from the very interesting evolvement of the space industry in this war.

The Russian Space Industry

The invasion of Ukraine has highlighted the failure of the Russian military space programme. Indeed, one of its main issues is its lack of an efficient satellite constellation, either for positioning, communication or reconnaissance. In fact, as of December 2022, the Russian army only owns 174 satellites (Union of Concerned Scientists, 2023), of which only 15 are made for intelligence collection: eight of these are electronic intelligence satellites, five are optical imaging satellites and two are radar imaging satellites. In comparison, 20 years ago, during the war in Iraq, the United States alone possessed 30 intelligence satellites, to which we need to add commercial satellites and the satellites of the coalition of the willing (Luzin, 2022). Moreover, the Iraqi theatre was smaller and less urbanised than Ukraine: this analogy emphasises the important lag that Russia has accumulated in this sphere.

The imagery component is considered the weakest part of the Russian space sector, so weak that in November 2022 the private military company Wagner bought two high-resolution optical satellites from the Chinese giant Chang Guang Satellite Technology Co. Ltd., together with the possibility of buying imagery from their 100 satellites constellation on demand (AFP, 2023). The mercenary group had to buy those particular satellites because of the lack of intelligence offered by the Russian State. A small number of satellites means low revisit rates, which restrain Russia's situational awareness on the battlefield. With limited information, monitoring Ukrainian movements, gains, and losses becomes problematic, while missile strikes and plane missions are rendered less efficient. For example, in the early stages of the invasion, Russia unleashed salvos of missile strikes on Ukrainian territory with a total of 1,100 missiles in the first 21 days. However, this operation was not sufficient in disabling all high-priority targets, especially the anti-air defences, which is one of the reasons why the Russians failed to obtain air superiority. This failure is likely the result of a lack of satellite imagery which led to inefficient reconnaissance-strike complexes as the Russian doctrine of long-distance strike relies on near real-time intelligence (Jones, 2022). Consequently, the Russians wasted precious missile stocks on non-strategic targets.

Furthermore, the lack of precision in Russian strikes resulting from poor rocket guidance and poor target positioning reconnaissance may have occurred because of the issues encountered by their positioning, navigation and timing system (GLONASS). This system's constellation is composed of 28 ageing satellites, some of which are close to their retirement date and will be difficult to renovate given Western sanctions, as up to 90% of the electronics with which they are made are imported (Dobrynin & Krutov, 2022).

After a chaotic path of underfunding and subsequent restoration of the programme, the GLONASS system was only officially incorporated into the Russian army in 2016. This late adoption may explain the lack of GLONASS receivers in the Russian army. Ground vehicles are forced to use maps from the 1980s, while some Russian aeroplanes have been caught using American GPS receivers in the cockpit (Cozzens, 2022).

Moreover, Russia owns 46 military communication satellites, of which more than 30 have exceeded their warranted lifetime, and 37 civilian satcoms (Luzin, 2022). With an estimated 420,000 Russian soldiers in Ukraine right now (AFP, 2023), the number of Russian satcoms is not sufficient to guarantee the successful conduct of efficient operations on Ukrainian territory. In addition to this, Russian satcoms had to endure Ukrainian jamming, which further reduced their capabilities. The alternative to communication satellites i.e., the encrypted ground communication system MK VTR-01, is unlikely to be able to compensate for this lack of satellite communication (Conell, 2023). This significant scarcity of means of communication may have resulted in the use of radios and cell phones by Russian troops on the front, not only to contact their families at home but also to conduct operations despite the enormous risk of being listened to by the enemy or being spotted and targeted by missiles or artillery (Porter, 2023).

The Ukrainian Space Industry

Even though Ukraine has a noteworthy space industry, compared to Russia the Ukrainian satellite constellation is poor. In fact, Ukraine did not have any military satellites of its own at the start of the war and had to rely on the best that NewSpace had to offer.

For instance, commercial imagery showing enemy troops gathering at its border facilitated Ukraine's communication efforts and greatly helped to raise international opinion in its favour (Chance, 2021). This was also the case for the Bucha massacre, when satellite images provided by Maxar together with photos taken on the ground helped contradict claims of Russian innocence (Hern, 2022). Helping Ukraine has been a kind of trophy sought by all New Space companies to showcase their capabilities.

Thus, Ukraine has been able to rely on commercial space services with numerous satellites from the early stages of the war, allowing for a very high revisit rate. For example, Planet Labs has more than 200 optical satellites, while Maxar has over 285 satellites. Besides that, in August 2022 the Ukrainian government, due to fundraisers and donations, managed to purchase the "people's satellites", a synthetic aperture radar from the Finnish ICEYE company, accessing their 27 satellite constellation (Werner, 2022). All these constellations separately provide up to 15 revisits a day, while Russia can acquire one revisit every three days at best (Luzin, 2022). Moreover, Ukraine only ordered footage pertinent to the war, thus spending less money. This easy accessibility to commercial data and the help of Western intelligence agencies (Lindley-French, 2023) has given Ukraine an enormous advantage over Russia.

However, what made the most headlines in the media was the entry of Starlink's mega constellation into the conflict. On the first day of the invasion, the Russians managed to hack thousands of Viasat's modems from the KA-SAT network with wiper malware (Groll & Vasquez, 2023). The Ukrainians relied on this service for their military communications and thus, when additional Russian strikes hit other communication facilities, the Ukrainian military command was left disorganised (Howel O'Neill, 2022). The Ukrainians quickly turned to Starlink for help: the company provided receivers and granted its service for little cost in the beginning but it has now been taken under the wing of the US Department of Defense, as Starlink declared not being able to afford losing 20 million a month (Roulette & Stone, 2023).

Starlink has been a great help for civilians and the military. Nonetheless, it has now a monopoly on Ukrainian communications, and this dependency endangers Ukrainian strategy. For example, Starlink decided to not back up any assault operations on Russian territory which includes the Crimean Peninsula. Parts of the Ukrainian operations are under the rule of the US government and sometimes must comply with the will of Elon Musk (Lyngaas, 2023).

Finally, for positioning and navigation purposes Ukraine can rely on proven GPS and Galileo with plenty of cheap compatible equipment such as small drones. At first, Russia did not make much use of its jamming capabilities, either because Ukraine had an overwhelming majority of Soviet-era GPS-less equipment, or because the Russians were relying too much on GPS systems themselves (Goward, 2022). However, with the increasing arrival of Western equipment which are GPS and Galileo guided, Russia has intensified its signal jamming operations (Axe, 2023).

Conclusion

The war in Ukraine has showcased the tools and different opportunities offered by New Space. The intelligence offered by Western space programmes and private space companies has played an enormous role in Ukraine's successful resilience. The growing reliance on the private market when state-owned space equipment is lacking is the main trajectory drawn by both sides in the conflict.

Even though Russia is maintaining a constant budget for its space programmes while also planning ambitious projects such as the launch of 600 Sfera satellites (Comsat) over the next few years (Connell, 2023), the war in Ukraine has brought to light underlying issues in the Russian space sector. Considering the recent troubles and failures of both civilian and military programmes, the future of Russian space might not be so bright: especially if we take into account the recent Western sanctions, which might be the final blow to this dying space giant (Privalov & Vidal, 2023).

However, Russia is well aware of its position behind the Americans, Europeans, Chinese and now Indians. A weak Russia in space is even more unpredictable as Russian doctrine recognises the importance of hindering the enemy's space capabilities when entering a conflict. In a hypothetical scenario where Russia continue their space downfall, and in the worst-case contingency of a wider conflict with NATO, which has the ability to lean on unmatched proprietary and commercial space assets, Russia will have much to gain and almost nothing to lose from the opening of a new front in space. No matter the space debris and equipment self-destruction it might result in, in such a scenario, Russia's top strategic priority could well be blinding NATO forces by mobilising the full strength of its countermeasure arsenal (Connell, 2023). In general, disrupting Western satellites is likely in the plans of other probable future adversaries such as China too (Penent, 2023).

Russia may already be prepared for this scenario as they have maintained Chayka, the radio terrestrial navigation system (Cozzens, 2022) that can still work in a space-devastated world. Simultaneously, the West is recklessly relying on satellite positioning. Indeed, space dependence has long been considered a weakness, thus making the disruption of satellites the perfect target to massively impact specific military operations and the Western economy more generally.

New Space's proposed solution to this threat is an increase in the number of satellites, which is intended to reduce the significance of any single one (Borowitz, 2022). In fact, in a mega constellation, the strategic importance of every satellite loss is diluted, which means that a potential adversary could well waste its missile stocks and still not endanger the capabilities of the constellation.

Should it choose to follow this path, Europe must bear in mind that relying too heavily on a large non-European private company implies putting operational plans in the hands of a foreign private actor supervised by its own government. Therefore, it is crucial for the European Union to push even more to foster domestic space entities.

Bibliography

AFP. (2023, September 9). More than 420,000 Russian troops in occupied areas: Ukraine. Agence France Press. https://www.barrons.com/news/more-than-420-000-russian-troops-in-occupied-areas-ukraine-3586c2b3.

AFP. (2023, October 5). Chinese Firm sold satellites for intelligence to Russia's Wagner contract. Agence France Press. https://www.thedefensepost.com/2023/10/05/chinese-firm-satellites-wagner/?expand_article=1.

Axe, D. (2023, October 31). The Russians installed a GPS-jammer in Ukraine. The Ukrainians Blew It Up With A GPS-Guided Bomb. Forbes. https://www.forbes.com/sites/davidaxe/2023/10/31/the-russians-installed-a-gps-jammer-in-ukraine-the-ukrainians-blew-it-up-with-a-gps-guided-bomb/.

Borowitz, M. (2022). The military use of small satellites in orbit [Briefings de l'Ifri]. Institut Français des Relations Internationales. https://www.ifri.org/sites/default/files/atoms/files/m._borowitz_military_use_small_satellites_in_orbit_03.2022.pdf.

Chance, M. (2021, December 9). Ukrainian military report says Russia boosted troops to 120,000 near border. CNN. https://edition.cnn.com/2021/12/08/europe/ukraine-russia-boosts-troops-intl/index.html.

Connell, M. (2023). The role of space in Russia's operations in Ukraine [Report]. Centre for Naval Analyses. https://www.cna.org/reports/2023/11/Role-of-Space-in-Russias-Operations-in-Ukraine.pdf.

Cozzens, T. (2022, February 17). Russia expected to ditch GLONASS for Loran in Ukraine invasion. GPS-world. https://www.gpsworld.com/russia-expected-to-ditch-glonass-for-loran-in-ukraine-invasion/.

Cozzens, T. (2022, May 13). Downed Russian jets found with GPS receivers taped inside. GPS-world. https://www.gpsworld.com/downed-russian-jets-found-with-gps-receivers-taped-inside/.

Dobrynnin, S., Krutov, M. (2022, April 11). In Russia's war on Ukraine, effective satellites are few and far between. Radio-Free-Europe Radio Liberty. https://www.rferl.org/a/russia-satellites-ukraine-war-gps/31797618.html.

Goward, D. (2022, July 22). Why isn't Russia doing more to jam GPS in Ukraine?. C4isrnet. https://www.c4isrnet.com/opinion/2022/07/22/why-isnt-russia-jamming-gps-harder-in-ukraine/.

Groll, E., Vasquez, C. (2023, August 10). Satellite hack on eve of Ukraine war was coordinated, multi-pronged assault. Cyberscoop. https://cyberscoop.com/viasat-ka-sat-hack-black-hat/.

Hern, A. (2022, April 18). Satellite images of corpses in Bucha contradict Russian claims. The Guardian. https://www.theguardian.com/world/2022/apr/05/satellite-images-of-corpses-in-bucha-prove-russian-claims-wrong.

Howell O'Neill, P. (2022, May 10). Russia hacked an American satellite company one hour before the Ukraine invasion: The attack on Viasat showcases cyber's emerging role in modern warfare. MIT technology review. https://www.technologyreview.com/2022/05/10/1051973/russia-hack-viasat-satellite-ukraine-invasion/.

Jones, S.G. (2022). Russia's Ill-Fated Invasion of Ukraine: Lessons in Modern Warfare [Brief]. Center for Strategic and International Studies. https://www.csis.org/analysis/russias-ill-fated-invasion-ukraine-lessons-modern-warfare.

Lindley-French, J. (2023, June 27). The Russo-Ukraine-Western Intelligence War. Aspenia. https://aspeniaonline.it/the-russo-ukraine-western-intelligence-war/.

Luzin, P. (2022, May 24). Russia's Space Satellite Problems and the War in Ukraine. The Jamestown Foundation. https://jamestown.org/program/russias-space-satellite-problems-and-the-war-in-ukraine/.

Luzin, P. (2022, December 15). Russia's Military Space Program: 2022 Results. The Jamestown Foundation. https://jamestown.org/program/russias-military-space-program-2022-results/.

Lyngaas, S. (2023, September 11). 'How am I in this war?': New Musk biography offers fresh details about the billionaire's Ukraine dilemma. CNN. https://edition.cnn.com/2023/09/07/politics/elon-musk-biography-walter-isaacson-ukraine-starlink/index.html.

Penent, G., Schlumberger, G. (2023). How the war in Ukraine is changing the space game [Notes de l'Ifri]. Institut Français des Relations Internationales. https://www.ifri.org/en/publications/notes-de-lifri/how-war-ukraine-changing-space-game.

Porter, T. (2023, September 11). Russian soldiers have to buy their own radios and phones in battle but the systems are incompatible and proving useless: reports. Business Insider. https://www.businessinsider.com/russian-soldiers-buy-own-radios-phones-tech-useless-incompatible-reports-2023-9?r=US&IR=T.

Privalov, R., Vidal, F. (2023). Russia in Outer Space: A Shrinking Space Power in the Era of Global Change. Elsevier. https://www.sciencedirect.com/science/article/pii/S0265964623000462#sec5.

Stone, M., Roulette, J. (2023, June 1). SpaceX's Starlink wins Pentagon contract for satellite services to Ukraine. Reuters. https://www.reuters.com/business/aerospace-defense/pentagon-buys-starlink-ukraine-statement-2023-06-01/.

Union of Concerned Scientists. (updated 2023, January 1). UCS Satellite database: In-depth details on the 6,718 satellites currently orbiting Earth, including their country of origin, purpose, and other operational details [Database]. Union of Concerned Scientists. https://www.ucsusa.org/resources/satellite-database.

Werner, D. (2022, August 18). Ukraine gains enhanced access to Iceye imagery and data. Space-News. https://spacenews.com/iceye-ukraine-sar/.

Part Two: International and European Union Space Law

Orbiting a Solution to Anti-Satellite Weapons

Written by: Oliver Leicester
Edited by: Clelia Vettori
Supervised by: Cecilia Rosa Yáñez

Introduction

One of the many problems that the scientific community is facing today is space debris. Space debris is exceptionally dangerous as it can cause the Kessler Effect, a scenario where objects in space collide, creating an exponentially growing mount of rubble orbiting the planet. What is especially concerning is the use of anti-satellite weapons (ASATs), which leave hundreds of thousands of debris items in space, putting astronauts and other satellites at risk. If states continue to test their ASAT weapons or use them to attack other satellites, this could have a dramatic impact on all space actors as well as future generations. This study will explore why the international community has not banned the use of ASATs yet and it will investigate how to achieve this outcome through an in-depth analysis of space-related treaties.

The Kessler Effect

Debris is one of the most significant issues affecting the future use of outer space. In the 1970s, Donald J. Kessler suggested that there is a maximum safe amount of space debris which can exist in Low Earth Orbit (LEO). Once the overall number of rubble in LEO reaches that specific level, it will trigger a cascading effect where collisions between objects create exponentially more debris (Santamaria 2022, para.1 and Lutkevich 2020, para. 2). This outcome is called the Kessler Effect or Kessler Syndrome. This scenario would create a considerable risk for the continued use of space, particularly in LEO, "as the likelihood of collisions between high-speed pieces of debris and satellites or space operations would increase dramatically" (Lutkevich 2020, para. 3). In essence, the Kessler Effect serves as a warning that debris in space can create a domino effect which endangers any future use of space.

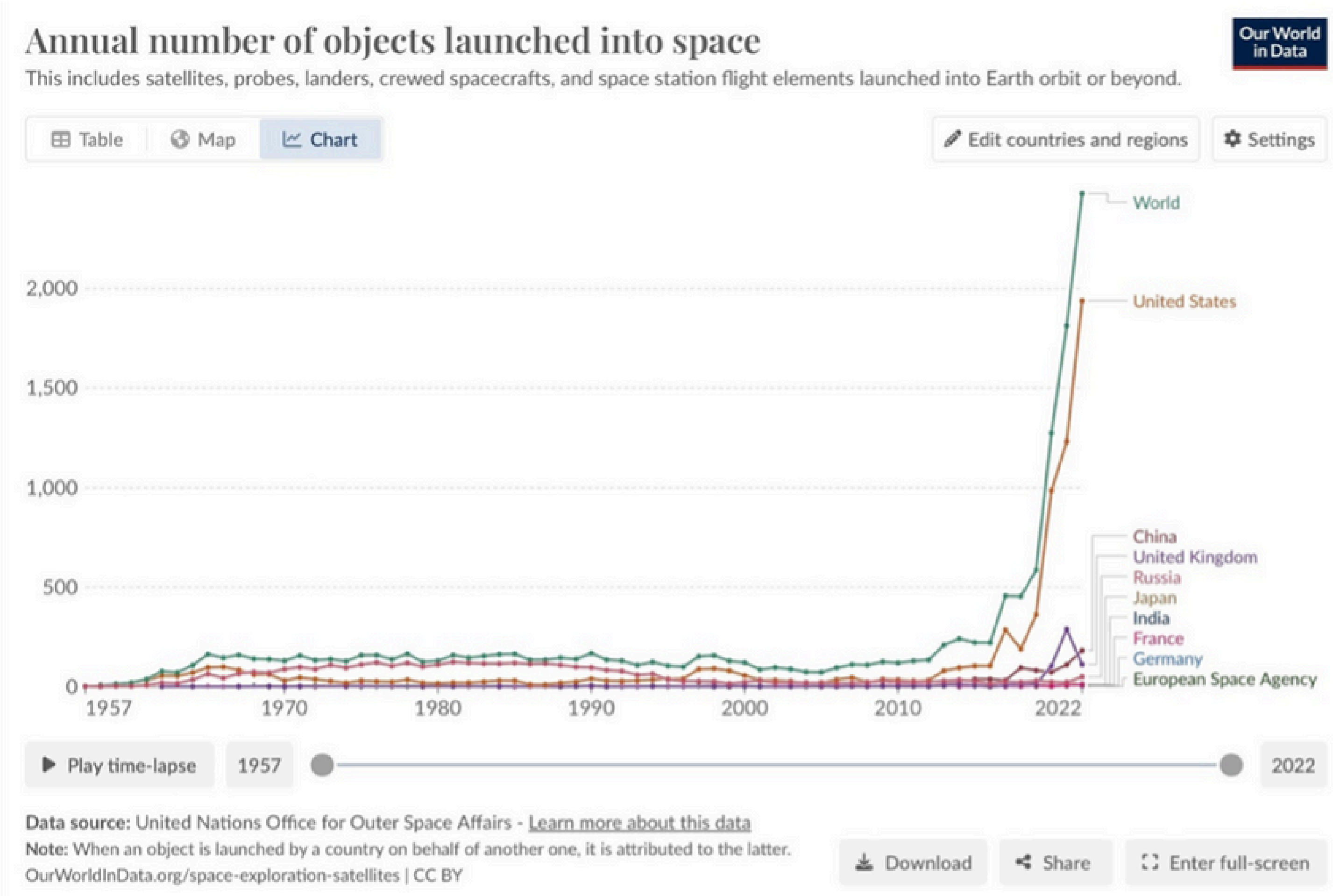


Figure 1. Annual number of objects launched into space, Our World in Data 2023

As a result, space traffic is a topic of serious concern for scientific bodies internationally (Delgado 2023, para. 4 and Impey 2023, para. 15). Figure 1 shows that since 2018, the number of objects launched into space has increased exponentially from roughly 450 to 2,400 globally each year. This growth can be partially explained by Space X's Starlink programme which, according to Article VIII of the 1967 Outer Space Treaty, is under US jurisdiction. Space X's Starlink programme accounts for 50% of active satellites currently in orbit (McKinsey 2023 para. 5), and as more satellites are launched into orbit, the likelihood of collisions also increases. This leads many in the scientific community to worry that space traffic and space debris will create far greater issues down the line (Delgado 2023, para. 4 and Impey 2023, para. 15).

Anti-Satellite Weapons

As discussed, the threat of accidental satellite collisions concerns scientists and experts globally (Delgado 2023, para. 4 and Impey 2023, para. 15). Equally worrying for the international community is the development, testing and maintenance of brute force ASATs. These weapons can create vast amounts of space debris which could lead directly to the cascading effect described by Kessler. In November 2021, the Russian Federation tested an ASAT missile, a PL19 Nudol, on one of their "now-defunct Soviet-era COSMOS 1408" (Panda 2021, para. 2), making it the third test of its kind since 2007 (Panda 2021, para. 2). Russia's test in 2021 was responsible for a "massive debris field" in LEO according to the US Space Command (Dickinson 2021, para. 1). In fact, this test created 1,500 trackable pieces of debris and likely hundreds of thousands of smaller pieces (Dickinson 2021, para. 1), highlighting the unsustainability of such experiments.

ASATs can be divided into two types: weapons that destroy satellites with brute force and weapons that do not do so. Brute force satellites either hit the satellite directly or can explode close enough to the satellite to cause it damage (Smith 2022, para. 7). ASATs like this can be any object capable of reaching the necessary altitude e.g., drones, missiles, or other satellites (Smith 2022, para. 7). Direct-ascent ASATs can strike objects by predicting their trajectory; therefore, they are not necessarily required to enter orbit. In contrast, co-orbital satellites are launched into orbit, where they manoeuvre to the target before striking (Satnews 2022, p. 3; Way 2022, para. 4). Hence, co-orbital satellites can be launched into space years before they are activated (Satnews 2022, p. 3; Way 2022, para. 4).

Non-brute force ASAT weapons are designed to shut down or damage the function of a satellite without creating space debris. Of course, this still leaves the satellite in orbit and sometimes unable to manoeuvre around other objects to avoid collisions. However, this is a far safer and more sustainable alternative to the previously discussed brute-force ASATs. Non-brute force ASATs use a range of techniques to immobilise satellites: for example, high-powered lasers can be targeted to blind their optical functions, that is their ability to collect visual data (Way 2022, para. 6). High-powered lasers can also be used to damage a satellite by overheating its parts e.g., solar panels (Way 2022, para. 6). Electronic attacks include temporary actions such as jamming the data transmitted by satellites (Way 2022, para. 8). Moreover, exploding a nuclear weapon in space creates an electromagnetic pulse (EMP), which in turn is one of the most effective ways to disable a satellite. The EMP has an immediate impact on the functioning of the satellite in orbit, while the radiation from the attack quickly degrades its components (Way 2022, para. 5). However, the 1963 Treaty Banning Nuclear Tests in the Atmosphere, in Outer Space and Under Water (Partial Test Ban Treaty) bans the use of nuclear weapons in space. Considering the risk of collateral damage to a state's own satellites and the fact that this treaty is widely ratified, EMPs are not viewed as conventional ASAT weapons. Nonetheless, it is worth discussing EMPs as China and North Korea have not yet ratified the 1963 Treaty despite possessing nuclear weapons.

ASAT Test Ban

In December 2022, the United Nations adopted a resolution calling for countries to ban ASAT tests (Foye and Hernández 2022, para. 1). The resolution passed with 154 Members voting in favour, eight against and ten abstaining (Foye and Hernández 2022, para. 4). The resolution is not legally binding; however, it reflects a momentum shift in opposition to ASAT testing and international concerns about space debris. This resolution was championed by the US as a step to curb a space arms race (Foye and Hernández 2022, para. 4). After Russia's test in 2021, Vice President Kamala Harris announced that "developing a shared understanding of what constitutes safe and responsible space activities contributes to a more stable space environment" (Harris 2021, para. 4). This commitment protects US' national security interests and long-term space exploration interests, in space science and space-enabled economic development (Harris 2021, para. 5). Harris emphasised the US' interests in securing a test ban for ASAT weapons; yet, it is precisely the US' strategic advantage in ASAT weapons which is causing concerns to other powerful states. When opposing the resolution, Belarus, Bolivia, China, Cuba, Iran, Nicaragua, Russia, and Syria "noted that the US already possessed ASAT weapons" (Foye and Hernández 2022, para. 6).

This is a crucial factor in the debate over ASAT testing bans: in fact, the US conducted multiple ASAT tests to develop their current capabilities in ASAT technology, thus creating a considerable amount of space debris. In the 1980s, the US developed their own ASAT weapons (Kestenbaum 2007, para. 9), while as recently as 2008, during Operation Burnt Forest, the US Navy destroyed a malfunctioning satellite, producing over 150 pieces of debris (Kang 2007, para. 4). The US has conducted multiple tests on their ASAT technology involving brute force weaponry, contradicting the "safe and responsible" space activities which Harris referenced in her speech (Harris 2021, para. 4). Consequently, states which are currently testing their ASAT technology could accuse the US of being hypocritical in this context (Foye and Hernández 2022, para. 6). Moreover, the US' strategic advantage in ASAT technology could be considered partly responsible for provoking an arms race in this field (Foye and Hernández 2022, para. 6).Although the resolution passed, it is this strategic imbalance in ASAT technology which will undermine attempts to pass a legally binding treaty on ASAT weapons control.

Legality of ASAT Weapons

As discussed, the UN Resolution to stop the testing of ASAT weapons is not legally binding, and no international laws are preventing their use in this capacity. However, using ASATs against another state would be against international law: indeed, attacking a state's satellite would be equivalent to attacking the state itself because states retain jurisdiction over any of their objects launched into space (Outer Space Treaty 1967 Article VIII). This would be viewed as an act of aggression and, therefore, a violation of Article 39 of the 1945 UN Charter, which is a well-established source of international law. Applying international law in this context would be largely reactionary to the initial attack, by which time multiple states may have used their ASAT weapons. In this scenario, the Kessler effect would likely be too late to prevent. Therefore, the international community and international legal bodies should take a proactive approach to making ASAT weapons illegal. This chapter will analyse the existing international law which applies to outer space and explore how it could be applied to ASAT technology.

Five UN treaties were created during the Cold War establishing the foundation of international space law (O'Grady 2016, p.2). There are other sources of international space law supported by subsequent treaties and domestic laws, but this chapter will focus on the UN "space treaties". Unlike the other treaties, the 1972 Liability Convention outlines a dispute resolution mechanism through a "Claims Commission" (O'Grady 2016, p.3). The process has some flaws, such as its lengthy progression and lack of impartiality requirements for adjudicators (O'Grady 2016, p.3). Furthermore, and most significantly, the process is not binding unless the parties to the dispute agree otherwise (O'Grady 2016, p.4). However, it sets a basis within the treaties for jurisdiction to be applied over international space law. In 1996, the Office for Outer Space Affairs (UNOOSA) and the Committee on the Peaceful Uses of Outer Space (COPUOS) proposed to establish a special chamber of the International Court of Justice (ICJ) to hear disputes related to outer space activities (O'Grady 2016, p.4). As space use increases, so does the legal framework surrounding it: in the coming years and decades, bodies such as the ICJ and the International Criminal Court (ICC) will have more power to make rulings on space law, drawing on treaties and international customs.

The five UN space treaties could provide enough of a legal basis for these international legal bodies to ban the use of ASAT weapons without creating a separate ASAT-focused treaty. For example, Article III of the 1967 Outer Space Treaty states that activities in outer space must be "in the interest of maintaining international peace and security" (Outer Space Treaty, 1967). Launching an ASAT weapon into space to target a satellite would count as conducting an "activity". In space, which contradicts the "maintenance of international peace" claim. All states that have or are developing ASAT weapons signed this treaty: therefore, an international legal body may conclude that ASAT weapons contradict their obligations under Article III (Outer Space Treaty, 1967), effectively making their use illegal internationally.

Article IV of the Outer Space Treaty forbids states from placing nuclear weapons and weapons of mass destruction into orbit. This would be an imaginative interpretation of this treaty, but an international legal body could label ASAT weapons as weapons of mass destruction and, as such, illegal to use in space. Considering the enormous risks that ASAT weapons pose in causing the Kessler Effect, it is undisputable that they could cause "mass destruction." This is specifically relevant to brute force ASATs which have the potential to produce massive amounts of space debris. However, it may also be applicable to ASATs which do not use brute force. Satellites are constantly making corrections to avoid collisions with other satellites. Non-brute force ASATs that shut down satellites' function could be considered similarly dangerous as they may prevent a satellite from being able to avoid collisions. As anticipated, arguing that this type of ASAT would be illegal as a weapon of mass destruction is a very liberal interpretation of Article IV. However, when looking at Article III and Article IV combined, it shows that the document always intended for space to be left independent of military activities. An international legal body may therefore decide that ASAT weaponry contradicts the principles of the 1967 Outer Space Treaty.

The principle of jurisdiction could also be used to reinterpret the treaty law in space to make ASATs illegal. In fact, according to Article VIII of the 1967 Outer Space Treaty, states retain jurisdiction over an object launched into outer space. Applying this logic to ASAT tests, states such as the US (Dickinson 2021, para. 1) and Russia (Panda 2021, para. 2) have been destroying objects under their jurisdiction as they would be entitled to in a military exercise conducted on land. States continue to hold jurisdiction over objects and their “component parts” throughout their presence in space (Outer Space Treaty 1967 Article VIII). The component parts may, in this case, apply to space debris caused by ASAT weapons tests. The fact that states maintain jurisdiction over all the pieces of space debris that they produced could make them legally responsible for any potential damages caused to other states. Article VII of the Outer Space Treaty highlights that each state party is internationally liable for damages caused to another state party of the treaty. The 1972 Liability Convention reaffirms this principle in more detail in Articles II and VIII: the focus of these articles seems to set a precedent for how states can receive compensation in the event of accidental damage in space. Therefore, it will be interesting to see how dispute mechanisms evolve in determining liability for damaged objects in orbit (O’Grady 2016, p.3): in the future, these dispute mechanisms and international legal bodies may take a more holistic interpretation of the term “damage” from these treaties. The cost of littering LEO with space debris from satellites will cause many states to “suffer damage” (Liability Convention 1972 Article VIII) such as the potential risks to their astronauts or objects in orbit, the added costs associated with this risk, and future costs to humanity of a world where LEO is too dangerous to use. Dispute mechanisms and international legal organs may be willing to hear the cases where these “damages” have been suffered even from states which do not have active space operations (Liability Convention 1972 Article VIII (1) and Article VIII (3)).

An international legal custom may be established through successive cases where states practicing ASAT tests are found liable for causing damages to the international community. International customs are a source of international law which all states must abide by, even if they have not signed or ratified an international treaty. To establish a custom, there must be relevant state practice demonstrating that states are not acting in a specific way, in this case using brute force ASAT weapons. Secondly, there must be an opinio juris which proves that states have not been using these weapons specifically because they believed they were bound by international obligations not to do so. For example, their obligations under the UN Charter or the Liability Convention may have led states to believe they could not use brute force ASAT weapons against one another or for testing purposes. If dispute mechanisms and international legal bodies consistently decide that states are liable for testing brute force ASAT weapons, this could establish an international custom against their testing or use in general.

Future Treaties in Space Law

As previously explored, the resolution which called for states to stop testing ASAT weapons was not successful in uniting the international community against their use. The resolution was not legally binding, and many notable states with ASAT programmes voted against it: thus, a treaty seeking to ban the testing and use of ASATs would likely face similar challenges. It is just as likely that states that are currently developing their ASAT technology would not sign the treaty, meaning any obligations found in the document would not apply to them. However, considering the problem that congestion is causing to all relevant states using LEO, gathering widespread support for an Anti-Congestion Treaty seems more likely. In fact, China has complained to the UN Space Agency that, on two occasions, the Chinese space station has had to take evasive action to avoid hitting Starlink's satellites (Zurich 2022, para. 6). This topic has far more international support: perhaps in drafting a treaty to prevent space congestion, the grey areas concerning space debris and dispute settlements will be addressed. This does not directly affect the use of ASAT weapons; still, defining these laws may give international legal bodies the tools to make rulings against the legality of these weapons in the future.

Conclusion

There has never been more international interest in finding a solution to a congested and cluttered space. As a framework to address congestion is developed, the risks of ASAT weapons will inevitably face similar coverage. Unfortunately, it is unlikely that states will agree to sign a treaty banning the testing and use of ASAT weapons. However, this paper has explored some alternative methods for ASAT technology to become illegal under international law. The future developments in dispute mechanisms regarding space and the actions of international legal bodies such as the ICJ will be essential in this process. By reinterpreting existing space treaties, these bodies could decide that the current use of ASATs violates states' obligations under international law. Finally, as time progresses, international legal customs halting the use of ASAT weapons may develop.

Bibliography

Delgado, C. (2023, June 29). Scientists Sound Alarm Over Growing Amount of Junk in Space. Discover. https://www.discovermagazine.com/environment/scientists-sound-alarm-over-growing-amount-of-junk-in-space.

US Space Command Public Affairs Office. (2021, November 15). Russian direct-ascent anti-satellite missile test creates significant, long-lasting space debris. US Space Command. https://www.spacecom.mil/Newsroom/News/Article-Display/Article/2842957/russian-direct-ascent-anti-satellite-missile-test-creates-significant-long-last/.

Etkind, M., & McGuinness, J. (2021, November 15). NASA Administrator Statement on Russian ASAT Test. NASA. https://www.nasa.gov/news-release/nasa-administrator-statement-on-russian-asat-test/.

Figure 1: Our World in Data. (n.d.). Annual number of objects launched into space 2023. https://ourworldindata.org/grapher/yearly-number-of-objects-launched-into-outer-space.

Foye, H., & Rosa Hernández, G. (2022, December). UN First Committee Calls for ASAT Test Ban. Arms Control Association. https://www.armscontrol.org/act/2022-12/news/un-first-committee-calls-asat-test-ban.

The White House. (2022, April 18). FACT SHEET: Vice President Harris Advances National Security Norms in Space [Statement]. https://www.whitehouse.gov/briefing-room/statements-releases/2022/04/18/fact-sheet-vice-president-harris-advances-national-security-norms-in-space/.

Impey, C. (2023, September 3). Analysis: Why trash in space is a major problem with no clear fix. PBS. https://www.pbs.org/newshour/science/analysis-why-trash-in-space-is-a-major-problem-with-no-clear-fix.

Kang, B. (2021, October 28). Race to clutter space proceeds apace. PressReader. https://www.pressreader.com/india/the-free-press-journal/20211028/282282438512231.

Kestenbaum, D. (2007, January 19). Chinese Missile Destroys Satellite in 500-Mile Orbit. NPR. https://www.npr.org/2007/01/19/6923805/chinese-missile-destroys-satellite-in-500-mile-orbit.

Lutkevich, B. (2020, March). Kessler Syndrome. TechTarget. https://www.techtarget.com/whatis/definition/Kessler-Syndrome.

McKinsey & Company. (2023, July 28). What is space junk? McKinsey & Company. https://www.mckinsey.com/featured-insights/mckinsey-explainers/what-is-space-junk.

O'Grady, R. (2016). 'Star Wars: the Launch of Extranational Arbitration'. Arbitration: The International Journal of Arbitration, Mediation and Dispute Management. https://www.mayerbrown.com/-/media/files/news/2016/11/star-wars-the-launch-of-extranational-arbitration/files/artogradystarwarsnov0416/fileattachment/artogradystarwarsnov0416.pdf.

Panda, A. (2021, November 17). The Dangerous Fallout of Russia's Anti-Satellite Missile Test. Carnegie Endowment for International Peace. https://carnegieendowment.org/2021/11/17/dangerous-fallout-of-russia-s-anti-satellite-missile-test-pub-85804.

Santamaria, G. (2022, February 11). The Kessler Effect, the potential danger of the domino effect for space debris. Solar Mems. https://www.solar-mems.com/the-kessler-effect-the-potential-danger-of-the-domino-effect-for-space-debris/.

Satnews. (2022). Types of Counterspace Weapons. Space Threat Assessment. http://www.satnews.com/images/*CSIS/CSISCounterspace_Weapons2.pdf.

Smith, M. (2022, August 10). Anti-satellite weapons: History, types and purpose. Space.com. https://www.space.com/anti-satellite-weapons-asats.

United Nations General Assembly, Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies. (1967). RESOLUTION ADOPTED BY THE GENERAL ASSEMBLY 2222 (XXI), The Outer Space Treaty.

United Nations General Assembly. Convention on International Liability for Damage Caused by Space Objects (1971). RESOLUTION ADOPTED BY THE GENERAL ASSEMBLY 2777 (XXVI). The Liability Convention.

Charter of the United Nations (1945). ISBN No. 9789211012835.

Way, T. (2022, June 12). Counterspace weapons 101. Aerospace Security. https://aerospace.csis.org/aerospace101/counterspace-weapons-101/#:~:text=There%20are%20four%20distinct%20categories,physical%2C%20electronic%2C%20and%20cyber.

Zurich. (2022, July 05). Space congestion: An increasingly contested and crowded frontier. Zurich. https://www.zurich.com/en/media/magazine/2022/from-moonshot-to-musk-how-the-rules-of-the-game-are-changing-in-space.

Transitional Segment

Expanding upon the conclusions derived from the intricate examination of prevailing international space law frameworks outlined in the preceding paper, the following one embarks on a journey into an increasingly complex domain: the evolving sphere of military activities in outer space. While the previous work provides a meticulous overview of the legal principles underpinning peaceful space exploration and resource utilization, the following pages delve into the multifaceted challenges stemming from the militarization of space and the proliferation of anti-satellite weapons.

Navigating through this discourse underscores the pressing need for a fundamental reevaluation of space governance—one that not only upholds the aspirations of spacefaring nations but also addresses the real threats of potential conflict and the essential need to maintain peace and security beyond Earth. The basic principles outlined in the previous paper provide an important context for understanding the complexities of military actions in space. While one emphasises space as a place for peaceful collaboration, the other reveals a landscape filled with uncertainties, where political tensions and technological advancements create new dangers. This shift from space law to space militarization highlights the delicate balance between international cooperation and geopolitical competition. Furthermore, by examining the details of ASAT development and deployment, it becomes clear that the lack of clear legal frameworks for military activities in space poses significant challenges to maintaining peace and security. While existing treaties like the Outer Space Treaty of 1967 lay a foundation, they often fall short in addressing the nuances of modern space warfare.

Therefore, there is an urgent need for the international community to come together and create a comprehensive legal framework that not only reduces the risks of ASAT weapons but also promotes a peaceful environment for cooperation and exploration in outer space.

Legal Dimensions of the Militarization of Space: An Examination of International Space Law

Written by: Gloria Bertasini & Cecilia Rosa Yáñez
Edited by: Alex Marchan
Supervised by: Emile Clarke

Introduction

Space law is a complex system governing outer space activities which comprises international treaties, conventions, United Nations General Assembly resolutions, as well as rules and regulations of international organisations. This paper will lay the international legal framework of space law, examining key documents like the Outer Space Treaty (OST) of 1967. Beyond this legal framework, the paper explores the militarisation of outer space, scrutinizing the intersection between space law and the evolving military activities taking place in outer space.

International Legal Framework

The fundamental legal framework of space law is composed of five international treaties and five sets of principles governing outer space. In addition, the UN General Assembly (UNGA) resolutions and the UN Committee for Peaceful Uses of Outer Space (UNCOPUS) documents in outer space serve as subsidiary means for interpreting and applying these treaties and principles. Customary international law also constitutes a component of space law (Xinmin, 2014).

I. The UN Treaties

Commencing with the fundamental legal instrument often referred to as the “Magna Carta of space”, the 1967 Outer Space Treaty (OST) underpins the existing framework (Johnson-Freese & Burbach 2019). Pertinently, the OST mandates that parties utilise the Moon and other celestial bodies for peaceful purposes, with the term “peaceful purposes” being subject to varied interpretations due to the dual-use nature of space technology for both civil and military applications (Johnson-Freese & Burbach 2019). Moreover, the treaty establishes a prohibition of the placement of nuclear weapons or other weapons of mass destruction in orbit, on the Moon, or on other celestial bodies. Notably, the OST does not preclude the weaponisation of space but specifically prohibits testing or deploying weapons of mass destruction, except on the Moon and other solid bodies, where no state has demonstrated an inclination for such placement. This may go in hand with the fact that the treaty discourages claims of sovereignty over the Moon, mandates open access to space installations and vehicles to representatives of other states and imposes liability on states for damage caused by objects launched from their territory. Moreover, according to the treaty, all parties agree to conduct outer-space activities in accordance with international law.

Turning to other treaties governing outer space activities, the Rescue Agreement has two aspects: first, the recovery and return of astronauts, and second of space objects and their components. The Rescue Agreement has some relevance to the militarisation of outer space. Astronauts engaging in hostilities during wartime lose the benefit of being treated under the Rescue Agreement. Instead, they qualify as prisoners of war under international humanitarian law (Pope, 2021). Moreover, the Liability Convention establishes a compensation regime for victims of damage caused by space objects belonging to Launching States. Nonetheless, it not only applies to the State Parties of the Convention but also to international intergovernmental organisations. To have a better perspective on the Liability Convention, the term “space object” includes the launch vehicle and its components and parts, which likely cover space debris. Meanwhile, the definition of “damage” extends to satellites and other objects that may be the targets of a space weapons attack.

Another fundamental treaty is the Registration Convention, which builds upon the preference expressed by states in the other treaties for a mechanism to identify space objects and expands the scope and practical effect of Article 8 of the OST. It requires the “registration of objects launched into space” with the UN. Lastly, the Moon Agreement stipulates that the Moon and other celestial bodies “should be used for peaceful purposes, that their environments should not be disrupted, and that the UN should be informed of the location and purpose of any station established in those bodies” (UNOOSA, 1966). However, this last treaty had limited legal effect due to the low number of signing states.

II. UN Principles

In addition to these treaties, the United Nations has established a series of principles of space law collected in five declarations, to regulate activities in outer space and ensure equitable and responsible use of space resources. Notably, the Declaration of Legal Principles Governing the Activities of States in the Exploration and Uses of Outer Space adopted in 1963, serves as a foundational document outlining fundamental principles for space exploration. This declaration may highlight the key principle of the peaceful use of outer space, which may be inconsistent with the militarisation of space.

Regarding the other principles, we have the Broadcasting Principles established in 1982, which govern the use of artificial earth satellites for international direct television broadcasting, emphasising the need for cooperation and responsible practices. It can also be added to the Remote Sensing Principles adopted in 1986 and seen as a relevant step in establishing a wider range of tools and cooperative measures. It provides guidelines for remote sensing of Earth from space, emphasising this technology’s peaceful and beneficial applications (UNIDIR, 2013). Moreover, the Nuclear Power Sources Principles, established in 1992, address the use of nuclear power sources in outer space, focusing on safety and international cooperation. Finally, the Benefits Declaration adopted in 1996, underscores international cooperation in space exploration for the benefit of all states, particularly considering the needs of developing countries (UNIDIR, 2013).

III. Customary International Law

In the context of customary international law in space law, the development of jus cogens requires state and international court practices. Establishing jus cogens related to outer space is challenging and often linked to public interest, common international interests, and public morality. The current outer space law is built on the premise of global public interest, as evidenced in Article I OST, which suggests UNGA resolutions and OST principles possess a customary nature. These principles include non-appropriation of outer space, sovereign equality of states in outer space, freedom of use of outer space, non-installation and use of nuclear weapons and weapons of mass destruction in outer space and recognising space as the "province of mankind" (Rathore & Gupta, 2020, p.4). Another fundamental aspect of customary international law revolves around the idea of employing outer space for peaceful purposes. This principle underscores the significance of non-aggression and non-militarization, emphasizing the imperative to use outer space for the collective well-being of all nations cooperatively and harmoniously, while actively discouraging any hostile or military endeavours.

The acknowledged jus cogens principles in outer space law encompass the exploration and use of outer space for the benefit of all peoples, freedom of exploration and use of outer space, and the prohibition of appropriation (Rathore & Gupta, 2020).

Overview of Military Space Activities

Substantial progress has been made in exploring outer space since the ground-breaking launch of the first artificial satellite Sputnik-I in 1957. As advancements in space technology continue and more countries achieve new capabilities in space, the potential for tension and conflict may arise, particularly in terms of military applications. Throughout history, space has been utilised for military purposes, with early space-age militaries using space technologies for intelligence, surveillance, and reconnaissance. As space becomes increasingly integral to military operations, it has evolved into a distinct strategic domain, making militaries vulnerable to various forms of targeting. This changing landscape has led some to argue that a conflict in space is inevitable (Ramey, 2000; Zhao & Jiang, 2019), creating concerns among nations seeking to protect their space assets and posing threats to those of their adversaries. This intensified competition risks escalating tensions and conflicts in space and underscores the pressing need for updated legal regulations that adeptly navigate and address emerging challenges and actors (Blake, 2014, p.98).

Despite the achievements, the regulatory framework for space activities has failed to keep pace with advancements. Since the adoption of the Moon Agreement, there has been a notable absence of specific treaties addressing the military aspects of space endeavours or regulating potential inter-country tensions in the event of a conflict. Therefore, it is imperative to recognise that while outer space lacks national sovereignty and falls beyond national jurisdiction, it should not be perceived as a lawless frontier. Despite the relevance of the OST in space law, its applicability to contemporary military, civilian, and commercial space activities is constrained, given its Cold War-era origins with a focus on state-centric space endeavours. The United States and the Soviet Union, having witnessed uncontrollable effects from early space-age weapons tests, acknowledged the necessity of mutual restraint and committed to self-restraint to ensure continued access to space for their respective objectives.

This recognition prompted the inclusion of Article IV of the OST, specifying that the Moon and all celestial bodies in space should be utilised “exclusively for peaceful purposes” (Treaty on the Principles Governing, 1967). The universally recognised principle of peaceful uses of outer space, defined as “nonaggressive” and “non-military” (Vlasic, 1991) is considered a part of customary international law in space law.

I. Armed Conflict in Outer Space

In examining the militarisation of space, the absence of cohesive laws regulating military space activities is noted, resulting in unclear, inconsistent, and often overlapping policies (Tronchetti, 2015, p. 331). The intertwining of military and civilian interests in space activities poses intricate legal and operational challenges that necessitate thorough consideration and effective regulation. Considering the swift advancements in space technologies and the heightened focus on national security, the issue of space weaponisation, coupled with the potential for armed conflict in outer space, stands out as a pressing matter that cannot be overlooked (Blake, 2014, p.134; Zhao & Jiang, 2019, p.2). Armed conflict in outer space is contingent upon the advancement of space militarisation; in other words, the possibility of a conflict can become a reality only if the militarisation reaches an advanced stage capable of using force in outer space (Grego, 2021). It is essential to note that space militarisation should not be conflated with space weaponisation (Zwarte, 2018, p.354). Space militarisation refers to utilising space resources to support and enhance military capabilities. On the other hand, space weaponisation is the development and deployment of space weapons, such as anti-satellite and antiballistic missile weapons, which involves the creation and installation of armaments either in outer space or on Earth to target objects in outer space (Ramey, 2000, p.6).

Another issue regarding undefined aspects of space law is the uncertainty surrounding certain vital concepts, such as jus bellum and jus in bello. While jus ad bellum (the law on the use of force) and jus in bello (international humanitarian law or the law of armed conflict) apply to space activities, the lack of clear definitions for specific terms and scenarios in space law poses challenges (Blake, 2014, p.129). Considering Article III OST, all endeavours in space must adhere to international law, effectively extending the reach of established legal frameworks into outer space. This implies that principles governing the just use of force and the laws of armed conflict apply to space activities. However, due to the distinct nature of space compared to other settings, applying jus ad bellum and jus in bello to military acts in space is not always clear. In other words, it is difficult to define terminology and circumstances for applying ideas like the just use of force and the norms of armed conflict. Space activities can vary from communication satellites to prospective military operations, with no apparent differentiation in their conformity with these ideals. In the hypothetical situation of a government conducting an anti-satellite test to display defence capabilities, the lack of exact terminology makes it problematic to determine whether such activities violate the principles of jus ad bellum or jus in bello. Moreover, assessing proportionality in the vastness of space and addressing potential collateral damage, such as debris striking other satellites, complicates the application of these principles. This ambiguity could cause diplomatic problems, especially if nearby countries receive a threat. Resolving conflicts becomes difficult without an agreed-upon legal framework for space activities, underscoring the critical need for a comprehensive and well-defined legal structure in space law.

II. Legal Dimensions of Conflict and Defence in Outer Space

Given the severe potential impact of armed conflicts on the rule of law in outer space, research on relevant legal issues becomes crucial. In the context of armed conflict in outer space, using ground-based or space-based weapons is considered a “use of force” under international law (Blake, 2014, p.130). The UN Charter, a fundamental element of the global legal framework applicable to all international law realms, including space law, is particularly significant. Despite being crafted before the space age, various international instruments can be adapted to accommodate evolving contexts and technological progress, justifying the incorporation of the UN Charter into matters of outer space (Ramey, 2000). The UN Charter provides explicit regulations on using force through Article 2(4)[1] and the exception in Article[2], creating a solid foundation for international law governing its use (Zhao & Jiang, 2019). Moreover, Article III of the OST[3] extends these international law principles to using power in space activities, especially during armed conflicts. While UNCOPUOS consistently opposes the right of self-defence in outer space, some argue that with space weapons capable of causing more extensive damage, states should have the right to self-defence and be allowed to take preventive measures (Blake, 2014). Although there are no specific provisions in both general international law and space law regarding the prohibition of self-defence in outer space, it can be inferred that spacefaring nations have the right to self-defence in this context. International legal norms do not prohibit asserting the right to self-defence in outer space. On the contrary, withholding this right would place spacefaring nations at a disadvantage in safeguarding national security and pursuing their interests in the outer space domain. Consequently, the right to self-defence should be deemed applicable in space activities.

[1] All Members shall refrain in their international relations from the threat or use of force against the territorial integrity or political independence of any State, or in any other manner inconsistent with the Purposes of the United Nations.
[2] The exceptions pertain to the threat or use of force, which must align with the exercise of the inherent right of national self-defence as acknowledged by Article 51 of the UN Charter, or it must be carried out in accordance with authorization from the UN Security Council.
[3] The exceptions pertain to the threat or use of force, which must align with the exercise of the inherent right of national self-defence as acknowledged by Article 51 of the UN Charter, or it must be carried out in accordance with authorization from the UN Security Council.

III. Developing New 'Legal' Frameworks

In the dynamic space exploration arena, ongoing efforts are being made to establish regulatory frameworks for military operations in this celestial domain. A notable initiative in this endeavour is the Woomera Manual on the International Law of Military Space Operations, which stands out as a comprehensive guide designed to define legal principles governing military activities in space. Distinguished by its approach, the Woomera Manual navigates critical issues in space law, such as the definition of ‘outer space’ and the parameters of activities falling under the umbrella of ‘peaceful purposes’. The manual's primary purpose is to elucidate the application of customary international law and treaty law in space operations. Its goal is to provide clear and comprehensive guidance for decision-makers involved in space activities, promoting peace and security in outer space. Its structure mirrors national military manuals and enhances its utility as a reference point for military operators and decision-makers, promoting international consistency and clarity. It has played a pivotal role in shaping various states’ rules of engagement and national manuals. However, ongoing debates surround the role and impact of such a manual, raising a fundamental question: Do these projects constrain or legitimise warfare? Particularly pertinent concerns linger about the potential challenges a manual may pose in this domain, where activities are mandated for ‘peaceful purposes’.

Conclusion and the Way Forward

To summarise, international law must be re-evaluated considering the dynamic character of space activities, focusing on the right to self-defence in space. The obsolete United Nations space treaties, originally drafted to address the concerns associated with weapons of mass destruction, are today inhibiting progress in the face of a rapidly expanding global space economy. Urgent action is needed to create clear rules protecting national security while encouraging international collaboration. As we negotiate the treacherous terrain of space law, we must recognise the crucial significance of rapid collaboration, research, and policy formation to secure the safety and success of future space activities. The evolution of space activities demands a proactive approach to address challenges, and the international community must work together to create a framework that balances the interests of spacefaring states while fostering the responsible use of outer space for the benefit of all.

Bibliography

Blake, D. (2014). Military strategic use of outer space. In New Technologies and the Law of Armed Conflict. Springer.

De Zwart, M. (2018). Outer Space. In W. H. Boothby (Ed.), New Technologies and the Law in War and Peace. (pp. 337–358). Cambridge: Cambridge University Press.

Johnson-Freese, J. & Burbach, D. (2019). The Outer Space Treaty and the weaponisation of space. Bulletin of the Atomic Scientists, 75 (4), 137-141. https://doi.org/10.1080/00963402.2019.1628458.

Grego, L. (2021). The Case for Space Arms Control. In: de Zwart, M., Henderson, S. (eds) Commercial and Military Uses of Outer Space. Issues in Space. Springer, Singapore. https://doi.org/10.1007/978-981-15-8924-9_7.

Pope, R. (2021). Space weapons and the increasing militarisation of outer space: whether the legal framework is fit-for-purpose. Auckland University Law Review, pp. 27, 263–301. http://www.nzlii.org/nz/journals/AukULawRw/2021/11.html.

Ramey, R. A. (2000). Armed Conflict on the Final Frontier: The Law of War in Space. Air Force Law Review, 48, 1–158.

Rathore, E. & Gupta, B. (2020). Emergence of Jus Cogens Principles in Outer Space Law. Astropolitics, 18 (1), 1–21. https://doi.org/10.1080/14777622.2020.1723353.

Tronchetti, F. (2015). 'Legal Aspects of the Military Uses of Outer Space', in F. von der Dunk and F. Tronchetti (eds.) Handbook of Space Law, 331–381, Edward Elgar Publishing.

U.N. Charter art. 2, para. 4.

U.N. Charter art.51.

United Nations Institute for Disarmament Research (UNIDIR). (2013, May 30). A Brief Overview of Norms Development in Outer Space. Retrieved from https://unidir.org/wp-content/uploads/2023/05/a-brief-overview-of-norms-development-in-outer-space-en-462.pdf.

United Nations Office for Outer Space Affairs. (1966). Treaty on principles governing the activities of states in the exploration and use of outer space, including the moon and other celestial bodies.

Vlasic, I. A. (1991). The legal aspects of peaceful and non-peaceful uses of outer space. In B. Jasani (Ed.), Peaceful and Non-Peaceful Uses of Space: Problems of Definition for the Prevention of an Arms Race (pp. 37–54). Routledge.

Xinmin, M. (2014, November 17). The Development of Space Law: Framework, Objectives and Orientations [Speech at United Nations/ China/ APSO Workshop on Space Law].

Zhao, Y., & Jiang, S. (2019). Armed Conflict in Outer Space: Legal Concept, Practice and Future Regulatory Regime. Space Policy. https://doi.org/10.1016/j.spacepol.2019.01.004.

Treaty on the Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon, and Other Celestial Bodies. (1967). 610 U.N.T.S. §205. https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/outerspacetreaty.html, Article I.

Transitional Segment

As highlighted in the previous paper, the growing concern within the scientific community regarding space debris and the potentially catastrophic consequences of space collisions, epitomised by the Kessler Effect, underscores the urgent need for comprehensive regulation of outer space activities. Anti-satellite weapons pose a significant risk by generating debris, exacerbating the already critical situation in Low Earth Orbit, where collisions can trigger cascading effects. Despite international apprehension, ASAT testing continues, prompting discussions on how to achieve a ban on such weapons.

Meanwhile, the EU recognises the imperative of establishing a legal framework, the EU Space Law, to address challenges like satellite proliferation and security threats. However, as it will be discussed, uncertainties persist regarding the legal basis for this framework, given the restrictions on full harmonisation in EU treaties. Policy options under consideration range from non-binding standards to a binding framework, all aimed at promoting safety, resilience, and sustainability in space endeavours.

With a specific focus on managing space traffic and reducing debris, the EU Space Law aims to positively contribute to international law and reinforce the EU's role as a significant player in the space domain. Thus, while the international community grapples with the challenges posed by ASAT weapons, the EU strives to establish a robust regulatory framework to ensure responsible and sustainable activities in outer space, thereby addressing the broader concerns raised by the scientific community regarding space debris and its consequences.

An EU Space Law on the Horizon: Decoding Legal Foundations and Navigating Policy Frontiers

Written by: Elena Valente and Irene Verduci
Edited by: Chiara Nasonte
Supervised by: Cecilia Rosa Yáñez

Introduction

In recent years and through the dissemination of documents, strategic initiatives, and legislative measures, the European Union recognised the need for a substantial space regulation framework that would ensure responsible and sustainable activities in outer space. Member States [MSs] have begun drafting national laws to meet space-related challenges such as satellite proliferation, risks of congestion and collision, and security threats against space assets (European Commission, 2023a). To mitigate fragmentation, the EU is ready to establish a dedicated legal framework that aligns with international space law within its legal system. As a matter of fact, in the EU Space Strategy for Security and Defence of March 2023, the Commission announced that it is working on the proposal for an EU Space Law. This legal instrument will be available in early 2024 and will allegedly envisage common EU rules for the safety, resilience and sustainability of space activities and operations. The risk of fragmentation in the absence of a regulatory framework can impact the competitiveness, security, and worldwide influence of EU industries in international fora (European Commission, 2023a). This mesmerising topic has attracted interest from academia, industry, and the private and public sectors which expressed their views through a targeted consultation.

However, tangible concerns surrounding the legal basis as well as the legitimacy of the legal framework manifestly emerge, casting ambiguities over the discourse. Although the creation of a harmonised European Space Law is extremely useful from a political perspective, full harmonisation in the field of outer space is specifically forbidden by the founding treaties of the EU, as revised by the Lisbon Treaty in 2007 (Potter, 2023). The second section of this paper will delve into this thorny topic, which has also been deconstructed thanks to informal talks with EU law experts. Section three discusses the likely content and policy options that the Commission could implement. The Commission could use several main policy standards with a certain level of grip on the MSs, such as non-binding standards, a binding framework or a binding framework with non-binding measures. These are all suitable as long as they comply with the three proposed pillars, namely security, resilience, and sustainability. In the final section, further remarks highlight the paper's fundamental points and conclusions are drawn.

The Legal Conundrum: A Foundation for the New Framework

In the realm of international legal obligations, the EU has always recognised only an array of customary international law principles, omitting to consistently consider all the different international space law treaties setting the foundation of this legal domain (Bertasini & Yáñez, 2023; von Der Dunk, 2017). However, most of these principles are exclusively conveyed in a singular primary source, the Outer Space Treaty of 1967, binding on the EU because of its customary nature. Substantiating this, the EU also asserted that "the 1967 Outer Space Treaty and the principles developed in the United Nations framework are the cornerstone of the global governance of outer space [...]" (European Commission, 2023b).

At the Union stage, the Treaty on the Functioning of the European Union [TFEU] plays a significant role in allocating legal competencies, i.e. effective powers on law-making, to the Union, the MSs or both jointly. Within the TFEU, outer space is defined as a shared competence between the Union and the MSs, a point underscored in two Articles. Firstly, Article 4(3) specifies that "...in areas of research, technological development and space, the Union shall have the competence to carry out activities, in particular, to define and implement programmes; however, the exercise of that competence shall not result in Member States being prevented from exercising theirs".According to this provision, the MSs can legislate if the Union has not yet exercised its right to do so and, following the principle of sincere cooperation, they are restrained from adopting measures that could potentially contradict existing EU norms or values. The second mention occurs in Article 189 which propels the promotion of scientific and technical progress, industrial competitiveness, and the implementation of a European space policy. Notwithstanding Article 189's thrust towards common policies and regulations in the area, paragraph 2 of the Article expressly precludes the possibility of harmonising MSs' laws and regulations, establishing this as a shared competence with significant restrictions (Wouters & Hansen, 2013).

The conundrum concerning the legal basis for the new framework presents an enduring uncertainty even among experts and officials for various reasons. Indeed, the introduction of a new EU legislation mandates reliance on at least one existing provision, making it pivotal to determine the most suitable article, or combination of articles, to serve as the legal basis of the upcoming EU Space Law. Inevitably, the subsequent question arises as to whether the amendment of the treaties is a de minimis condition to bridge the gap and promote a harmonised regime. To address these questions, this research refrains from championing either the interests of the MSs or the EU and adopts a neutral stance instead.

On a first note, the amendment of the treaties does not seem mandatory at this stage considering the Commission's objectives. Nevertheless, to maintain geopolitical competitiveness, it proves beneficial to establish a treaty provision that accommodates future law-making endeavours. In the meantime, an alternative approach has to be determined; the most plausible scenario to reconcile all the interests at stake involves dividing the upcoming space law into several segments, each supported by a distinct legal basis. Whether this constitutes the ultimate approach is yet to be ascertained, especially as this fragmentation is not devoid of complications. However, such an approach would help consolidate and streamline regulatory barriers for both companies and public and private enterprises. Several scholars, having examined the TFEU, recommended a patchwork approach, arguing that no single article could satisfactorily justify a comprehensive EU legal strategy for space.

Nonetheless, several primary law articles, coupled with non-binding measures, could serve as means to control certain space activities; the following elucidates the key examples. Firstly, as highlighted earlier, paragraph 1 of Article 189 TFEU allows for the formulation of a common European space policy to advance scientific and technical progress, industrial competitiveness, and the execution of EU policies. Although paragraph 2 strictly excludes harmonisation policies, it requires the Parliament and Council to establish necessary measures to achieve the objectives outlined in paragraph 1, implying the feasibility of alternative initiatives. These could encompass decisions, best practices, codes of conduct, and non-binding standards (Potter, 2023). Secondly, Article 114 TFEU could serve as an appropriate legal basis when disparities among MSs' legislations hinder fundamental freedoms and directly impact the functioning of the internal market, eventually allowing for the implementation of anti-competitive regulation restrictions. Yet, this Article is applicable except where otherwise provided in the Treaty and, as a consequence, other inherently applicable treaty provisions are considered to take precedence (Potter, 2023). Thirdly, Articles 170 and 171 TFEU address the EU's capacity to develop and execute "trans-European networks in the areas of transport, telecommunications, and energy infrastructures." They also outline the available mechanisms for their promotion, including the establishment of objectives, guidelines, and "any measures that may prove necessary to ensure interoperability." When contemplating telecommunications and potential space exploration, Articles 170 and 171 are deemed appropriate provisions to rely on (Potter, 2023). Fourthly, Article 352 TFEU, the so-called flexibility clause, is acknowledged as a potential source of harmonisation, but it is not recognised as a suitable legal basis for a common EU Space Law. Paragraph 3 states that "measures based on this Article shall not entail harmonisation of Member States' laws or regulations in cases where the Treaties exclude such harmonisation" and, as seen above, Article 189(2) specifically prevents any harmonisation policies (Potter, 2023). Finally, relying on Article 2(4) TFEU as the basis to justify a space legal framework seems insufficient. Even though this Article bestows upon the Union the power to define and implement a Common Foreign and Security Policy [CFSP], it remains silent on the type of competence applicable to CFSP measures (Potter, 2023).

Since outer space assets serve both civilian and military purposes, the defence domain emerges as another pivotal area to be taken into consideration in light of the upcoming legislation. This sector, highly sensitive and firmly protected by the MSs, is intricately linked to the space field. With internet infrastructure installed in space to maximise broadband and secure connectivity, and satellites having both peaceful and non-peaceful applications, the EU would welcome a legal basis that can progressively circumvent restrictions. It is clear that the CFSP, being essentially an intergovernmental action, lacks the authority to pass legislation on this matter (Bennett, 2023). Therefore, the Union might attempt to adopt all the provisions discussed earlier as general laws, hoping that in the current political environment, the MSs either accept them, allowing the EU to legislate, or at least abstain from challenging them legally.

Policy Options and Policy Frameworks for the New EU Space Law

The upcoming EU Space Law is designed to address challenges in the space domain. This section investigates the potential policy standards and viable policy options, aiming to grasp their implications. Certain options may find more appreciation and favour with specific stakeholders, such as the space industry or the MSs. With multiple interests at stake, assessing likely options to identify the preferable ones would necessitate adopting a specific perspective, potentially involving taking sides. The analysis hereby avoids taking this approach, choosing instead to step back and give a general perspective on the range of options available to the Commission regarding the framework and the policy proposals already put forward.

The precise scope of the legislation is yet to be clearly defined. It may include national and EU programmes, missions conducted by European actors or operators, and services provided within the Union's territory (Galland, 2023). The primary focus of its application revolves around competition, which could be adversely influenced by unregulated international entities operating in the EU market alongside regulated European entities (Galland, 2023).

I. Policy Frameworks

The Commission could employ three main policy standards, each involving a certain degree of control over the MSs: non-binding standards, a binding framework, or a binding framework with non-binding measures (European Commission, 2023c). The main concept behind this approach is to face issues by setting scopes of action, requirements to be met, and concrete measures that can effectively fulfil the requirements. To elucidate this process, the Commission has provided examples for each standard, one of which is applied to the standards below, offering a comparative view of the approaches.

Non-binding standards would encompass a collection of best practices, standards, and guidelines intended to tackle key risks related to space safety, resilience, and sustainability in space activities (European Commission, 2023c). As an illustration, concerning the risks associated with satellite collisions, the set requirements would include satellite tracking; a concrete measure to mitigate clash risks could involve satellite operators registering with a Collision Avoidance Service Provider while also providing their name to an EU registry (European Commission, 2023c). The aim of this approach is to engage all companies that have previously participated in similar initiatives and help governments establish mechanisms for certifying companies. This strategy is envisioned to ultimately reduce deceptive advertising by corporations and encourage a positive shift in their behaviour (European Commission, 2023c).

A binding framework would involve the proposal of an EU regulation with key provisions linked to the three pillars of safety, resilience, and sustainability. Building upon the previous example with the same scope and requirement, in addition to registering with providers and providing their name to an EU registry, satellite operators could be required to report changes to manoeuvres (European Commission, 2023c). Like any regulation, this framework would evolve into a set of rules and requirements binding on every Member State at the national level. Such an approach would ensure the development of an EU single market for goods and services related to space activities, achieved through the introduction of harmonised rules aimed at fulfilling the abovementioned objectives (European Commission, 2023c).

A binding framework with non-binding measures would be a refined version of a binding framework. Apart from the previously mentioned regulation, this approach would introduce a proposal for a Directive with measures directly targeting the space industry (European Commission, 2023c). Said measures would bolster the established objectives by offering economic incentives for space companies, ultimately motivating them to surpass the requirements and setting the stage for excellence. This third option opens the door to further policy action in the form of bilateral agreements. By engaging in bilateral agreements at the international level, the EU would seize the opportunity to shape the global landscape of outer space legislation through policy initiatives (European Commission, 2023c).

II. Policy Options

Three pillars have been proposed to encompass the full spectrum of space activities: safety, resilience, and sustainability (European Commission, 2023c). While safety and resilience are crucial for the viability of the European space sector in the long run, the sustainability pillar aims to guarantee compliance with environmental standards and promote responsible behaviour (Galland, 2023). The focus of the new framework is initially on establishing safety requirements to ensure the security of private and public parties, as well as individuals. Moreover, it is anticipated to organise security measures, particularly in terms of cybersecurity and risk management strategies. Also, it is foreseen to safeguard space infrastructure from potential threats and improve its resilience (Galland, 2023). At the same time, with sustainability being a recent focus for the EU, reaching environmental objectives even in space activities, such as reducing space debris, would reaffirm its leadership in this field (Galland, 2023). Concurrently, the Commission is prepared to face practical challenges in the space domain, including satellite proliferation and risks of congestion and collision (European Commission, 2023a). Considering the widespread proliferation of satellites and space activities, Space Traffic Management emerges as an urgent topic to be addressed and an EU Space Law has the potential to regulate this policy area by establishing standards for coordination, monitoring, and tracking of space entities, which hold international value as well (Galland, 2023). Managing this matter effectively could safeguard space assets and reduce the risk of damage caused by orbital debris (Galland, 2023).

Conclusion

Space policy has entered the spotlight worldwide by virtue of its potential for secure, safe, and resilient infrastructure. Recognising this, the European Union has embarked on the development of a new space programme (Sintorn & Verduci, 2023). This choice has called for a harmonised legal framework, preventing future discrepancies in MSs' approaches and facilitating a unified regulation of the space sector. Thus, the Commission has announced the drafting of an EU Space Law, possibly coming in early 2024. However, the initial challenge in issuing this new law lies in determining the framework's legal basis. Currently, there is no single Article in the Treaties that can, by itself, provide such a legal basis. Nevertheless, the TFEU offers ample material to regulate outer space activities through a mosaic approach, tailoring specific articles to address specific activities. Several articles will likely be used to regulate specific activities, justifying various provisions and policies. While solving the legal basis issue constitutes the preliminary step for legislative action, additional concerns arise upon investigating EU Space Law. The third section has scrutinised the most likely policy frameworks and options for adoptions showing their potential outcomes. Overall, a non-binding-only framework does not appear to be the most advantageous choice, considering the EU's imperative to compete with other more advanced international space powers and keep up with their advancements. On the contrary, a binding framework or a combination of both options seems to be the most desirable scenario, providing a common ground in a timely and effective manner. The proposed three-pillar structure aligns directly with the chosen framework, serving as a generic outline for policy options.

Even though the decisions regarding the legal basis, the precise array of proposals, and the type of policy framework remain uncertain, the scope of this paper was to highlight the relevant elements at stake, as raised by both public and private stakeholders. The significant strides in the space field in recent years have been essential for the EU to withhold its role as a key player in the international arena. However, the Union has gone even further by creating what is meant to be a new system unmatched by other countries worldwide. Lastly, the expected legal framework holds the potential to make a positive contribution to International Law, benefitting the international community as a whole. The set of space laws outlined by the Commission strikes as ground-breaking, but a final assessment is yet to be made and awaits publication.

Bibliography

Bennett, C. (2023). The Lisbon Treaty's Dual-Use Conundrum: A Barrier to EU Space Endeavour?. European Law Blog. https://europeanlawblog.eu/2023/12/12/the-lisbon-treatys-dual-use-conundrum-a-barrier-to-eu-space-endeavour/.

Bertasini, G. & Yáñez, C. R. (2023) Legal Dimensions of the Militarization of Space: An Examination of International Space Law. Finabel. https://finabel.org/legal-dimensions-of-the-militarization-of-space-an-examination-of-international-space-law/.

Consolidated version of the Treaty on the Functioning of the European Union. (2012). OJ C326/47. https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:12012E/TXT:en:PDF.

European Commission. (2023a). Q&A on an EU Space Strategy for Security and Defence. https://ec.europa.eu/commission/presscorner/detail/en/QANDA_23_1603.

European Commission. (2023b). European Union Space Strategy for Security and Defence, Joint Communication to the European Parliament and the Council. Directorate-General for Defence Industry and Space. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52023JC0009.

European Commission. (2023c). Policy Options. https://defence-industry-space.ec.europa.eu/system/files/2023-09/Policy%20Options.pdf.

Galland, C. (2023). Eurospace Position Paper: European space industry contribution to the future "EU Space Law". Eurospace. https://eurospace.org/eurospace-position-paper-contribution-to-the-future-eu-space-law/.

Potter, S. (2023). Approaching Harmonization: Examining the European Union's Efforts to Create a Common EU Space Law and Assessing its Potential Legal Foundations. European Union Law Working Papers. https://law.stanford.edu/wp-content/uploads/2023/05/EU-Law-WP-77-Potter.pdf.

Sintorn, M. & Verduci, I. (2023). IRIS^2: The Dawn of EU Leadership in Space?. Finabel. https://finabel.org/iris%c2%b2-the-dawn-of-eu-leadership-in-space/.

von der Dunk, F. G. (2017). The European Union and the Outer Space Treaty: Will the Twain Ever Meet?. University of Nebraska College of Law. https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1089&context=spacelaw.

Wouters, J. & Hansen, R. (2013). The Other Triangle In European Space Governance: The European Union, The European Space Agency And The United Nations. Leuven Centre for Global Governance Studies. https://ghum.kuleuven.be/ggs/publications/working_papers/2013/130woutershansen.

Concluding Remarks

In a fast-developing world of technological breakthroughs and geopolitical uncertainty, the space sector undoubtedly stands as a critical pillar of European defence. As explored throughout this Food For Thought Paper, Finabel recognises that greater European development in the sector, coupled with the integration of space capabilities into the European defence architecture, will be indispensable in responding effectively to future security challenges. By conquering and integrating space, Europe can ensure strategic autonomy, and ultimately safeguard its interests on the international scene.

As demonstrated by Russia's war of aggression in Ukraine and the more than two years of subsequent combat, the space domain has the potential to provide an unparalleled contribution to armed conflict. In Ukraine specifically, whether it has been through its capacity to provide intelligence, surveillance and reconnaissance to military forces, or its ability to provide network connection to soldiers on the ground, the space domain has played an enormous role in facilitating Ukraine's resilient defence. Equally, the conflict has also demonstrated the dangers of relying on privately owned space infrastructure, acting as a further incentive for Europe to push forward in fostering more domestic space entities. After all, reduced reliance on third parties in this realm could be crucial in shaping the outcome of future military operations for Europe, and subsequently ensure the safety of European citizens and allies. The establishment of $IRIS^2$ marks a crucial step in this realm, with the goal of providing a reliable satellite-based internet system for strategic EU areas for civilian and military use and, as a result, boosting the European Union's capabilities and autonomy. The Ariane 6 rocket also promises to be key in boosting Europe's autonomy in operating in space, acting as an efficient and cost-effective main launch vehicle defending the continent's independence in the launch of payloads in space. However, more broadly, fragmentation in the realm of European space governance remains an overarching challenge in achieving this goal as, depending on the specific space area in question, European space interests are reflected by a variety of diverse sources, namely, by its individual states, the EU itself, and the ESA. If Europe is to assert itself as a global player in the space domain, effective multilateralism and improved coordination of space activities will be key to attaining success.

As well as emphasising cooperative mechanisms and the advancement of common space policies, the development of comprehensive regulatory frameworks remains fundamental to ensuring the security and responsibility of space assets. In the context of the potential weaponisation of outer space, emerging threats such as anti-satellite weapons could disrupt the domain for all due to the Kessler Effect, for example. Moreover, existing international legislation regarding the militarisation of space is often unclear and inconsistent, and thus urgent action is needed in creating a legal framework that balances the interests of spacefaring states while encouraging responsible use of the arena. Through its proposal for an EU Space Law, the European Union is aiming to make positive strides in this realm, by attempting to regulate outer space to ensure the arena's safety, sustainability and resilience in the future.

Nonetheless, Europe still faces challenges in establishing resilient space infrastructure. In the words of Josep Borrell, the EU's High Representative for Foreign Affairs and Security Policy, "without security, there can be no future in space" (European Commission, 2023). Hence, Europe must build upon promising steps taken such as the EU's 2023 Space Strategy in defending space assets and deterring hostile activities in space in order to establish free access to the domain. The genesis of exercises between EU Space Forces, the founding of European Space commands and renewed emphasis on the importance of interoperability between member states is evidence of increased European attention in this realm. After all, as explored throughout this FFT, space offers unparalleled opportunities for advancing the continent's strategic interests through enhanced security and innovation. Perhaps, after all, once the Europe firmly establishes itself in the arena,, the EU will be better situated to successfully navigate the contested security environment and ensure that generations to come can enjoy a world characterised by peace, safety, and prosperity.

Additional Sources

Basham, S. L. (2024, February 9). The critical role of space in modern warfare and the imperative of joint space capabilities in Europe. U.S. European Command. https://www.eucom.mil/article/42685/the-critical-role-of-space-in-modern-warfare-and-the-imperative-of-joint-space-capabilitie.

Council of the European Union. (2023, March 10). Joint Communication European Parliament-Council on the European Union Space Strategy for Security and Defence. https://data.consilium.europa.eu/doc/document/ST-7315-2023-INIT/en/pdf.

Eagleson, D. (2023, October 24). Protecting our critical satellite infrastructure: the importance of space-based infrastructure to humanity and its status within NATO. NATO Review. https://www.nato.int/docu/review/articles/2023/10/24/protecting-our-critical-satellite-infrastructure-the-importance-of-space-based-infrastructure-to-humanity-and-its-status-within-nato/index.html#:~:text=Space%20has%20long%20been%20an,programme%20for%20almost%20two%20decades.

ESPI. (2022, October). The War in Ukraine from a Space Cybersecurity Perspective. European Space Policy Institute. https://www.espi.or.at/reports/new-espi-short-report%E2%80%95the-war-in-ukraine-from-a-space-cybersecurity-perspective/.

EEAS. (2022, March). A Strategic Compass for Security and Defence. European External Action Service. https://www.eeas.europa.eu/sites/default/files/documents/strategic_compass_en3_web.pdf.

European Commission. (2023, March 10). An EU Space Strategy for Security and Defence to ensure a stronger and more resilient EU. European Commission. https://ec.europa.eu/commission/presscorner/detail/en/ip_23_1601.

Ogden, T., Knack, A., Mélusine, L., Black, J. & Mavroudis, V. (2024, February). The Role of the Space Domain in the Russia-Ukraine War and the Impact of Converging Space and AI Technologies. Centre for Emerging Technology and Security. https://cetas.turing.ac.uk/publications/role-space-domain-russia-ukraine-war.

Siddiqi, A. A. (2000). Challenge to Apollo : The Soviet Union and the Space Race, 1945-1974. NASA History. https://www.nasa.gov/wp-content/uploads/2023/06/sp-4408.pdf.

Steer, C. (2020, January 8). Why Outer Space Matters for National and International Security. Centre for Ethics and the Rule of Law, University of Pennsylvania. https://www.law.upenn.edu/live/files/10053-why-outer-space-matters-for-national-and.

UCS. (2023, May 1). UCS Satellite Database. Union of Concerned Scientists. Retrieved on March 18, 2023). https://www.ucsusa.org/resources/satellite-database#.XG6yv3RKiUk.