ESPI

European Space Policy Institute

Full Report

European Space Strategy in a Global Context

Report:
Title: "ESPI Report 75 - European Space Strategy in a Global Context - Full Report"
Published: November 2020
ISSN: 2218-0931 (print) • 2076-6688 (online)

Editor and publisher:
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Design: copylot.at

Cover page picture credit: shutterstock, ImageFlow

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1 Introduction

1.1 Background

Europe — the member states, the EU, the European Space Agency (ESA), the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) — is one of the most experienced actors in the international arena and operates a highly regarded space programme. Through its different constituents, it has mastered a wide array of capabilities and achieved many successes with breakthrough missions and programmes, such as the ESA-led Rosetta or BepiColombo missions, the EU´s Copernicus and Galileo flagship programmes, and world-leading commercial solutions for telecommunications and launch services.

Remarkably, all these successes have not been piloted by a single, unified European space strategy, but rather by a tangle of different and inherently contending space strategies. There is an ESA strategy, as defined and approved by the ESA Council at Ministerial level every three to four years; an EU space strategy, which was enacted by the European Commission in 2016 and enriched with the political orientations of the Council and European Parliament, and many national space strategies adopted by the member states of the two organisations. Equally remarkable, there is neither a general coordination mechanism for decision-making, nor a coherent political control on the implementation at pan-European level.

Be this as it may, important convergences and a set of common objectives shared across all stakeholders can be derived around the overarching ambition to "promote [Europe's] position as a leader in space, increase its share on the world space markets, and seize the benefits and opportunities offered by space". Towards this, a set of common goals and underlying requirements have been consensually identified, namely:

- To maximise the integration of space into European society and economy by increasing the use of space technologies and applications to support public policies, providing effective solutions to the big societal challenges faced by Europe and the world and strengthening synergies between civilian and security activities.
- To foster a globally competitive European space sector by supporting research, innovation, entrepreneurship for growth and jobs across all member states and seizing larger shares of global markets.
- To ensure European autonomy in accessing and using space in a safe and secure environment and, in particular, to consolidate and protect its infrastructures, including against cyber threats.

This strategic framework also accounts for the need to integrate the activities of different stakeholders (European Union, European Space Agency, member states) into a coherent framework to ensure effective and efficient delivery.

The ongoing consolidation of the European space programme – as reflected in the recent EU Regulation for the Space Programme, the ongoing negotiations for the next Multiannual Financial Framework (MFF), as well as the ESA Space19+ Ministerial Council – shows the willingness of European stakeholders to follow this path through important organizational and programmatic responses.

However, in achieving these objectives, not only will Europe be confronted with internal issues, but, equally important, with international ones. The internal dynamics of the EU are certainly an important driver in the formulation and successful execution of the European space strategy.

Yet, external dynamics must not be neglected; the specific ways other states are moving should be assessed together with the impact of their actions as well as the opportunities to engage them in various areas such as:

- Multilateral discussions (UN and other international organisations) to guarantee the responsible and sustainable exploration and use of outer space by a broader community;
- Bilateral dialogues with major space powers on the cooperative ventures expected to take shape in the next years, in particular in the area of science and exploration;
- Development of space business taking into consideration recent trends observed globally.

This effort is necessary if Europe wants to remain up-to-date in a fast-changing international space environment. In an ever-changing space sector, strategic reflection is indeed a continuous process that needs to take account of several considerations including international perspectives. From this standpoint, an analysis of boundary conditions to be taken into account to guarantee the successful integration of European ambitions in a global context would be beneficial to support internal reflections on how to best organize the European approach to space.

1.2 Objective and scope of the study

The overarching objective of this report is to provide a reflection on the fitness of the current European space strategy with regards to the unfolding changes in the global space sector and discuss possible key diplomatic actions to better promote Europe's positions and strategic interests in the international arena. Consistent with this overarching purpose, this report is more specifically intended to:

- Review the current European strategic framework for space activities and examine the potential implications of recent and proposed developments from inside and outside Europe;
- Assess major trends behind the unfolding transformations of the global space sector and identify the challenges these transformations are posing to the fulfilment of the objectives set forth in the European space strategy
- Address the role that space diplomacy – in its political, economic and security dimensions – can play to cope with these challenges and better promote Europe's positions and strategic interests in the international arena.
- Discuss key actions to reinforce European space diplomacy and secure the effective delivery of the European space strategy in the international context.

For the purpose of this research, the concept of "European space diplomacy" is understood as the set of measures that could be taken by different European stakeholders in the domain of space including member states, European institutions (ESA, EUMETSAT, the European Union and its agencies) and other relevant European organizations. The implementation of this "European space diplomacy" and the level of coordination between its different components is discussed in this report as one of several elements for consideration.

In terms of scope, this study focuses on high-level policy concerns related to the implementation of the European space strategy in the international arena, and in particular on the challenges Europe is confronted with in meeting the strategic objectives thereof. While these challenges are certainly manifold and driven by both endogenous and exogenous drivers, the study limits the analysis to the external ones. Particular emphasis is hence given to two major pillars of the strategy, namely the competitiveness of the European space sector and Europe´s ability to access and use space in a safe and secure manner, as these two are inherently impacted by international developments and policies or actions aimed at their pursuit necessitate being developed while having the global context in mind.

Similarly, while there can be many actions to tackle the identified challenges, the analysis is limited to the actions that can be taken on the international stage, in particular through the use of diplomacy and cooperation.

1.3 Scope and Methodology

The starting point of the study has been to dissect what the major axes of the European space strategy are and how unfolding transformations in the international context are relevant for the successful implementation of the strategy.

In order to identify the current stakes for Europe, the study fist performed an environmental mapping of the meta-trends shaping international space activities and their relevance for the European space sector. Building on this, the research identified the challenges these transformations present to the successful implementation of the European space strategy. In doing so, the research showed that two particular objectives are put at stake due to their inherently international dimension, namely Europe´s ability to: a) foster a globally competitive and innovative space industry, and b) access and use space in a safe and secure manner

Moving forward, the study discussed ways to address these challenges and mitigate associated risks by means of diplomatic actions and, finally, it identified the underlying requirements for making these actions effective. The logic and process of the study is encapsulated in the diagram below.

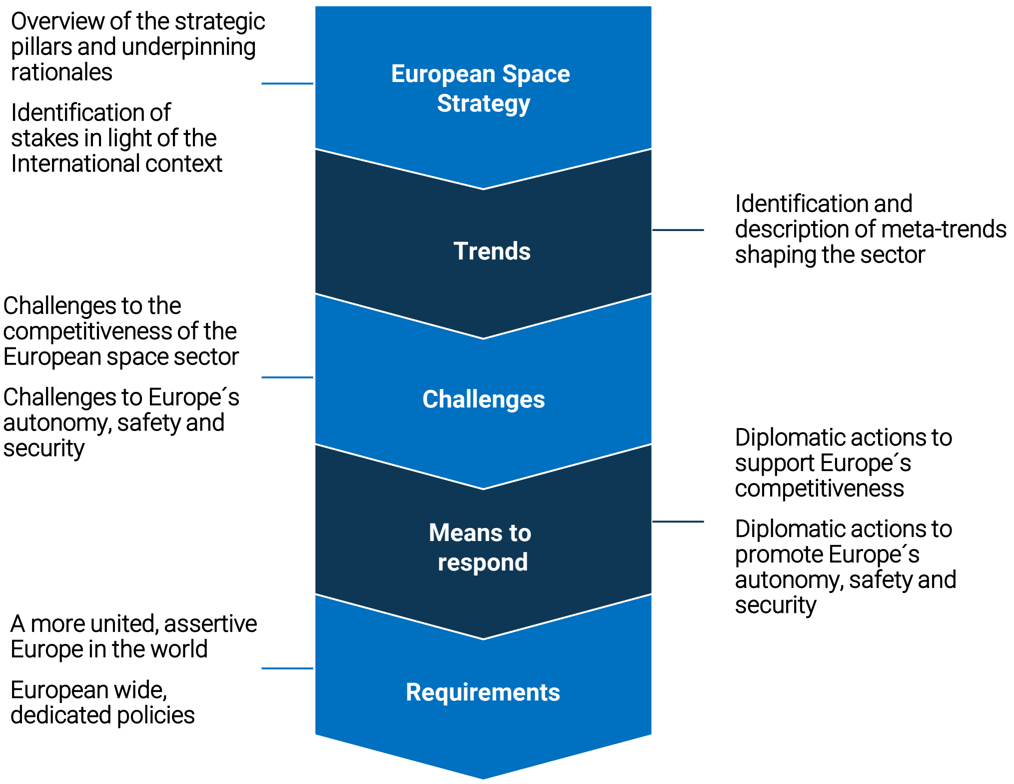

Figure 1: Organisation of the study

This study has been mainly carried out through desk research of publicly available documents, external and internal databases, conference proceedings and other bibliographic sources, spanning both sectorial and general contributions impacting European space activities. Given the transversal nature of the research´s scope, the study also draws extensively on previous ESPI research and analyses.

The research has been complemented and19 strengthened by a number of targeted interviews, conducted under Chatham House Rules, with a variety of high-level stakeholders and representatives of the space industry, national and pan-European space institutions, space policy experts, and academics.

The research has further benefited from the organization of the thirteenth ESPI Autumn Conference in 2019, [1] which gathered high-level policy and industry stakeholders to address the topic of space diplomacy, in its political, economic and security dimensions.

Entitled "European Space Strategy in a Global Context: The Role of Space Diplomacy", the 2019 Autumn Conference more specifically discussed ways to strengthen Europe's role as a global actor and to promote international cooperation. Additional focus was placed on the role of space diplomacy to support the goals of the European space industry, and on the contributions space diplomacy can bring to harvest opportunities in the security and defence realms.

The Conference was organized in three sessions: 1) European Space Diplomacy: Policy Perspectives; 2) Space Diplomacy for Business; and 3) Space Diplomacy for Security and Defence, sparking thought-provoking discussions and key recommendations that have been duly reflected in this report.

[1] Inaugurated in 2007, the ESPI Autumn Conference is an annual event organized by the European Space Policy Institute, where high-level policy and industry stakeholders in the space sector gather together to discuss issues that affect Europe and the rest of the world. Its objective is to pave the way to stimulate ideas in order to contribute to the reflection of European actors as well as to support the work of the Institute. Through the diversity of its participants, it is also a means to create bonds between people involved in the European space sector.

2 The European space strategy: overview

Europe — the member states, the EU, the European Space Agency (ESA), the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) — is one of the most experienced actors in the international space arena and operates a highly regarded space programme.

Through its different constituents, Europe has mastered a wide array of capabilities that address the whole range of space activities, including access to space, telecommunications and operational Earth observation, space sciences, and navigation and human spaceflight.

There are many achievements to look back on, including breakthrough missions such as the ESA-led Rosetta or BepiColombo, the EU´s Copernicus and Galileo flagship programmes as well as world-leading commercial telecommunications and launch service systems.

2.1 Which European Space Strategy?

When looking at Europe´s outstanding achievements in space it is remarkable that these successes have not been guided by a single unified European space strategy, but rather by a tangle of different and inherently contending space strategies that reflect the rather complex interplay of the distinct constituencies composing the triangular structure of the European space governance:

- The strategy of ESA, an intergovernmental organisation, which over the past 40 years has taken the lead in promoting European cooperation "in space research and technology and their space applications" and carrying out the major European space endeavours, though lacking political clout.
- At a second tip there is the space strategy of the EU, which has only recently started to position itself as an additional and effective space player, demonstrating the willingness – and with the Lisbon Treaty also the legitimacy – to assert political leadership in promoting scientific and technological progress, industrial competitiveness and the implementation of its policies.
- At the third tip, there are the different strategies of the member states of both organisations which, despite a common basis do not exactly coincide.

Each player in this configuration has its own specific competences and interests, as reflected in their specific strategies. Notwithstanding the institutional mismatch between the various actors and the core interests in their respective strategies, important convergences and a set of common objectives shared across all stakeholders have progressively consolidated over the years.

This consolidation was eventually reflected in the Joint EU/ESA Statement on the shared vision and goals for Europe in space" adopted on 26 October 2016. [2] Despite not being legally-binding, this document is key, as it not only represents an agreement between ESA and the EU on a number of common goals for the European space sector, but – having received explicit support also from member states – represents a European-wide convergence on a shared strategic vision for space activities. Its overarching vision, stated goals and underlying requirements are identified, as graphically captured in Table 1.

Picture 1: Signing of the "Joint EU/ESA Statement on the shared vision and goals for Europe in space" (Credit: ESA)

[2] *Joint statement on shared vision and goals for the future of Europe in space by the European Union and the European Space Agency* (October 2016). Retrieved from: https://ec.europa.eu/docsroom/documents/19562/attachments/1/translations/en/renditions/native.

<table>
<tr><td>Overall Ambition</td><td colspan="3">The overarching ambition stated in the document is that "Europe remains a world-class actor in space and a partner of choice on the international scene." By 2030, Europe should be able to fully benefit from its space solutions to implement policies, to strengthen European values and security, improve knowledge and foster prosperity".</td></tr>
<tr><td>Strategic pillars</td><td colspan="3">The three strategic pillars on the way towards the overarching ambition are:</td></tr>
<tr><td></td><td>To maximize the integration of space into European society and economy, by increasing the use of space to support public policies, providing solutions to the big societal challenges and strengthening civil-security synergies</td><td>To foster a globally competitive European space sector, by supporting research, innovation, entrepreneurship for growth and jobs across all Member States, and seizing larger shares of global markets.</td><td>To ensure European autonomy in accessing and using space in a safe and secure environment, and in particular consolidate and protect its infrastructures, including against cyber threats.</td></tr>
<tr><td>Essential foundations</td><td colspan="3">These three pillars are underpinned by the "solid foundation of excellence in science, technology and applications, expressed through an environment of outstanding education and skills and a thorough knowledge base".</td></tr>
</table>

Table 1: Core components of the European space strategy emerging from the 2016 Joint EU/ESA Statement

2.2 Behind the strategy: a unique approach to space…

The overarching vision and three strategic pillars are the by-product of a specific approach to space that makes Europe a *unicum* in the international arena. Unlike all the other space faring nations for which strategic autonomy and prestige considerations have been the primary justifications for public expenditures, European public investments in space have been primarily subject to the logic of economic return, being conceived as an enabler of economic growth and job creation in Europe, fostering its innovation potential, supporting scientific progress and responding to public policy objectives.

Admittedly, at the onset of its journey into space, European efforts were also primarily driven by political rather than economic considerations. This is well evidenced, for instance, by the very decision to develop an indigenous European means of accessing space, following the well-known refusal of the U.S. to launch the French-German Symphonie satellites. Yet, quite ironically, it was in that very initial stage of politically-set decisions that the logic of commercial gains became deeply entrenched in the European approach to space. This can be mainly explained by the remarkable success of Ariane on the open market of launch services, as well as the key position that the European space industry has gained on the telecommunications satellites commercial market (see below). Even though there are visible differences between European actors [3] and successive policy evolutions, the European approach to space has gradually evolved into a wide-encompassing policy framework. When considering the various drivers pertaining to European space policy it can be easily noted that:

[3] The most prominent being between France and Germany. While the former has been often prone to space-related investment on pure political grounds, the latter has conversely championed an economic-driven approach. The views expressed in the June 2018 Proposal for the establishment of the EU Space Programme are also evidence of this divergence in mind-set.

- Science is a historical driver but has reached its limits to further stimulate growth. Space science budgets are, however, steady and enable critical technological progress.
- Security and defence are mostly structured in Europe at national level and, unlike all other major space powers, cannot be relied upon as a major driver for European space strategy so far, since there is also no strong security & defence policy at EU level.
- Prestige is certainly at work as a driver for all manned space-related activities but, as far as Europe is concerned, is not very effective in stimulating public investments.
- Economy appears to be the key decision factor driving past and current European space agendas

In short, European space activities have traditionally been – and continue to be – primarily centred on harnessing industrial and socio-economic benefits, justifying expenditure in space with its cascading positive effects on the overall economy and society. ESA's industrial policy and its mandatory geo-returns – with their impact on the development of national industrial capacities – have always represented this well, but this is also the case for the more recent EU-led efforts in space, namely Copernicus and Galileo, as the two programmes are explicitly seen as enabling tools of the EU's socio-economic policies. In fact, the linchpin of the European Union's space programme is within the remit of the Commissioner for Internal Market – a reminder that European activities in space, and in particular those developed at the communitarian level, are and will be significantly driven by the political willingness to fully exploit the socio-economic value of the European space infrastructure.[4]

The value of the European space infrastructure, which is the product of continuous and substantial investment by public and private actors, lies first and foremost in the substantial socio-economic benefits that it enables across a multitude of economic and strategic sectors for Europe. Indeed, space assets have become instrumental for the implementation of key European policies, in both direct and indirect ways.[5]

Examples of these contributions include, among others, the Common Agricultural Policy (CAP) to foster agricultural productivity, viable food production, reduction of agriculture environmental footprint and farmers' access to ICT; the Common Fisheries Policy (CFP) to support the sustainable exploitation of fisheries resources; the EU Road Safety framework to enable competitive, sustainable, secure and safe transport services; the EU Digital Agenda to bridge the digital divide in Europe; the Energy Union to give consumers secure, sustainable, competitive, and affordable energy (PwC, 2016); and the various environment-related policies.[6] Additionally, the uptake of space technology plays a huge part in Innovation Policy, laying the foundations for the cross-pollination of space technologies with ground technologies, and the development of new services in which space systems are key enablers (e.g. 5G networks, precision agriculture, forestry, air traffic management, smart energy grids, and autonomous vehicles).[7]

In short, space assets are today used in the vast majority of European policy areas and support the European effort to tackle modern societal and environmental challenges in multiple ways. The magnitude of benefits they enable varies between policy areas but can be critical when space assets provide a particularly efficient, and sometimes irreplaceable, means to achieving policy objectives.

Europe´s reliance on space is the consequence of Europe's efforts to fully exploit space applications within its various economic sectors. The exploitation of space services stimulates growth and provides

[4] Marco Aliberti, Matteo Capella & Tomas Hrozensky. *Measuring Space Power: A Theoretical and Empirical Investigation on Europe*. Springer, 2019.
[5] Space infrastructure can either contribute directly to the implementation of policies (i.e. space-based solutions are used directly by the EU to achieve flagship objectives), or indirectly (i.e. space-based solutions are used by actors of target sectors to improve productivity or reduce the environmental footprint, for example, which supports the achievement of EU objectives).
[6] Notably, in an historical juncture when other countries and actors are backing off from environmental science and studies, Europe has emerged as a leading actor in meteorology and environment monitoring, providing access to vital data worldwide.
[7] Marco Aliberti, Martin Sarret, Tomas Hrozensky & al. *Security in Outer Space: Perspectives on Transatlantic Relations*. ESPI Public Report n°66 (October 2018). Available at: https://espi.or.at/publications/espi-public-reports

Europe with considerable benefits at the macroeconomic level. Financial assessments of the downstream sector and economic benefits to end-user sectors assess that more than 10% of the EU GDP is linked to the space infrastructure and that the total economic benefit is around € 53.5 billion per year in Gross Value Added, supporting 1 million workers directly or indirectly (PwC, 2016).

Overall, the role played by European space infrastructure in bringing significant benefits to European society and its criticality to the fulfilment of a variety of European Union and member state governmental objectives explains the prominence of economic considerations in the European space strategy.

This prominence is duly reflected in the first two pillars of the European strategic framework, but even the safety and security objectives are first and foremost driven by socio-economic rationales, as summarised in Table 21.

Strategic Goals	Drivers
Maximize the integration of space into European society and economy	Unlock the cross-sectoral added-value of space-based technologies and services to the benefit of these and other Union's policies
	Capitalize on the impact of investments pursued in space infrastructures and optimize efficiency of public decision-making
	Foster a vibrant space industry and the emergence of new economic activities befitting society at large
Foster a globally competitive and innovative European space sector	Larger size of commercial markets to compensate for the limited domestic demand for space products
	Generate higher commercial revenues
	Lead worldwide S&T innovation
Reinforce European autonomy in accessing and using space in a safe and secure environment	Protect the value of the European space infrastructure
	Contribute to a service-oriented policy
	Reinforce European autonomy and leadership

Table 2: Europe´s strategic goals and underlying rationales

2.3 … reflecting a unique situation worldwide

The pillars of the strategy also reflect a unique situation worldwide. Indeed, when benchmarking Europe with other major spacefaring nations, clear structural differences come to the fore. The most important is that Europe lacks a significant and continuous level of public demand in space infrastructure and services. Whereas in all the other space powers institutional demand constitutes a very important and protected market used to fuel domestic industrial competitiveness, in Europe this demand is comparatively smaller as duly reflected in the space budgets. Indeed, the European institutional budget for civil and military space activities – in terms of R&D financing programmes and the institutional purchase of space products and services – represents a tiny fraction (approx. six to seven times smaller) than that of the United States, for instance. This is primarily because–there are few European space military programmes as compared to all other space powers, less developed synergies between civil and defence sectors, and no European interest in an autonomous human spaceflight programme (i.e. human rated systems).

As a consequence of this specific situation, unlike its international competitors, the European space industry is highly reliant on commercial business and export sales to sustain itself.

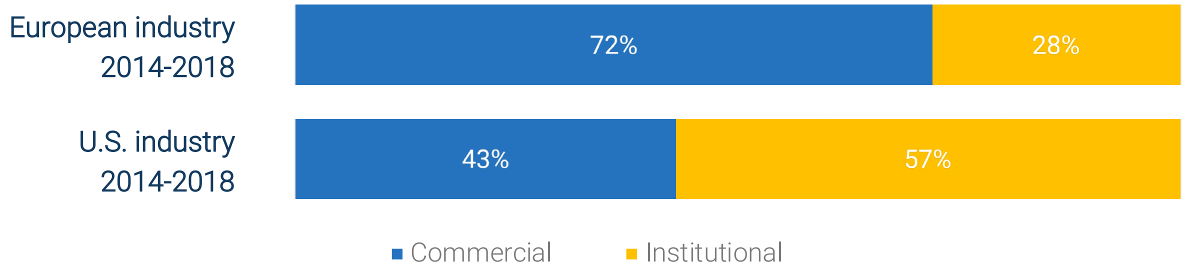

Figure 2: Distribution by market of the spacecraft mass produced by European and U.S. industries (2014-2018)

According to the estimates provided by ASD-Eurospace, between 2014 and 2018, 72% of the spacecraft mass produced by the European space industry was devoted to commercial activities, against 28% to local institutional markets (which represented about 65% of the estimated sales in value). This is in stark contrast with the situation in other space powers, even those that are highly active on commercial markets, such as the United States (see Figure 2).

Notwithstanding – or exactly because of – the limited institutional demand and higher exposure to the hazards of commercial markets, the European space sector has emerged as an undisputed worldwide leader for its efficiency and competitiveness. Indeed, the space sector is one of the few industrial sectors where Europe remains extremely competitive with respect to such traditional players as the United States and Russia as well as the rapidly emerging powers (i.e. China and India).

A few figures illustrate this. With only 4% of the global space workforce (corresponding to approx. 45,000 jobs in Europe), Europe is the 4th space manufacturing power worldwide and provides about 15% of worldwide spacecraft production. Specifically, the European space industry produced 17% of global satellite industry output and launched about 16% of the space infrastructures in 2018.

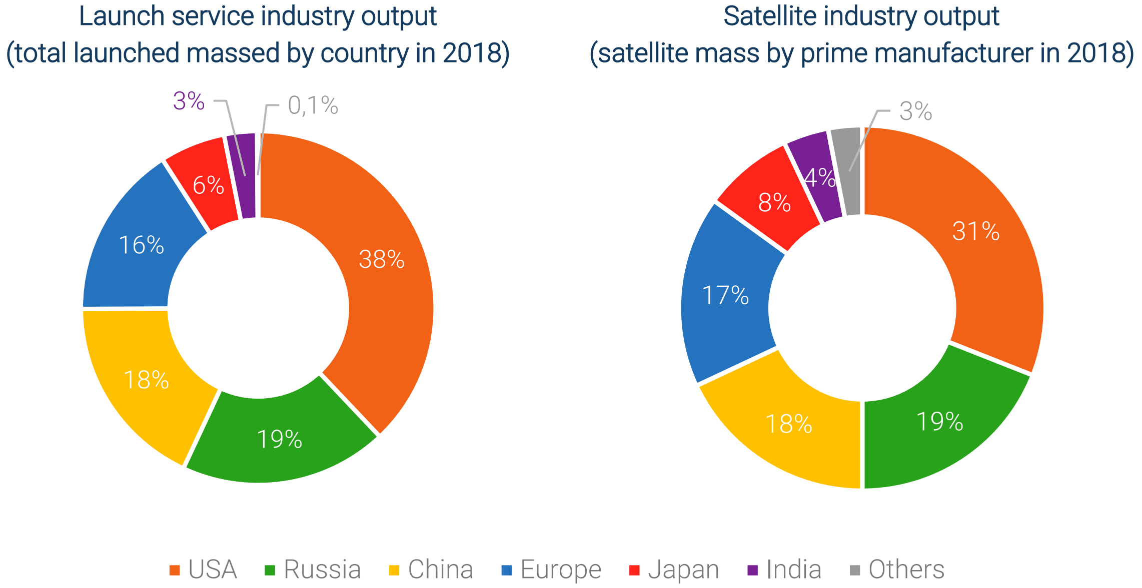

Figure 3: Industry output of the major space actors worldwide (source: ESPI database)

This ability is also reflected on the commercial markets: European companies capture a significant market share (approximately 50%) of the accessible launch services market and a stable share (approximately 30%) of the open satellite manufacturing market.[8] Over the past decade, European spacecraft exports have risen up to almost $1 billion per year (i.e. a 30% growth), providing a net surplus of $355 million per year to the European trade balance and making Europe the second global satellite exporter, right after the United States.[9] Europe is also home to the leading satellite operators, such as the SES Group and Eutelsat, which operate more than 140 telecommunications satellites, retaining a prominent position on global markets, in particular for satellite telecommunications.

Along its traditional "primes", Europe can also boast a thriving entrepreneurial space ecosystem, encompassing an increasing number of start-ups, dedicated incubators – i.e. the ESA Business Incubation Centres (BICs) – as well as business angels and venture capitalist networks that are increasingly interested in space. This undeniable success is the result of the multiple efforts carried out by European institutions (mostly the EU and ESA) to create larger entrepreneurial and customer bases, widen the European space downstream market, and eventually boost further the European economy's linkages with space.[10]

What is perhaps even more remarkable is that the dominant position Europe enjoys on global markets has been achieved under very effective budgetary conditions: the European budget, which represents only 12% of global space expenditures, indeed suggests that "the European way" to space sector development has been, so far, highly successful.[11]

As detailed in Chapter 3, however, the space sector is undergoing profound transformations that may question the long-term viability of this European way and the successful fulfilment of the objectives set out in the space strategy. In line with the scope of this report, this study will further consider predominantly the latter two strategic pillars, as these two are inherently impacted by international developments and policies or actions aimed at their pursuit necessitate development while having the global context in mind. This is not comparably required in the first strategic pillar, which displays a rather internal focus within the European environment and towards European public policies, industrial sectors and, eventually, households and citizens.

[8] More precisely, 42% of the GEO commercial launch market and 27% of the open satellite manufacturing market (est. 2017).
[9] Pierre Lionnet. "Two decades of satellite exports. 2019 edition". ASD-Eurospace (September 2019)
[10] Copernicus and Galileo-related initiatives are for instance used to help spread the adoption and development of space-based solutions; competitions are held to incentivise researchers, entrepreneurs and start-ups in solving specific space applications challenges; and more than 15 ESA BICs provide support to develop space-based solutions and spinoffs.
[11] In addition, the contribution of space to the trade balance of Europe (a surplus of €350 million per year) is remarkable if compared to the workforce responsible for the positive impact

3 The evolving global spacescape

The global space sector is undergoing profound transformations that will have repercussions on both the positioning of Europe in the international space arena and the fulfilment of the objectives set forth in its space strategy. Consistently, this chapter analyses the major trends that are broadly affecting the space sector in order to assess their impact on Europe. Three meta-trends encompassing a number of specific trends have been more specifically identified:

- A rapidly expanding space sector
- A disruptive technological context
- A more challenging operational and geopolitical environment

Each of these meta-trends is made up of numerous sub-trends that, in turn, are likely to affect particular domains or space activities.

3.1 A rapidly expanding space sector

3.1.1 The expansion of actors and activities

One of the most striking trends characterising the evolution of the space sector in recent years is the steep increase in the number of entities - both public and private - capable of conducting space activities. Regarding the public sector's involvement, recent years have seen the emergence of a considerable number of new space-faring nations (i.e. countries that have developed access to space capabilities, or more likely, launched their first satellites), as well as the establishment of several new space agencies. In the past 5 years alone, 8 countries have established their national space agencies (see Figure 4).

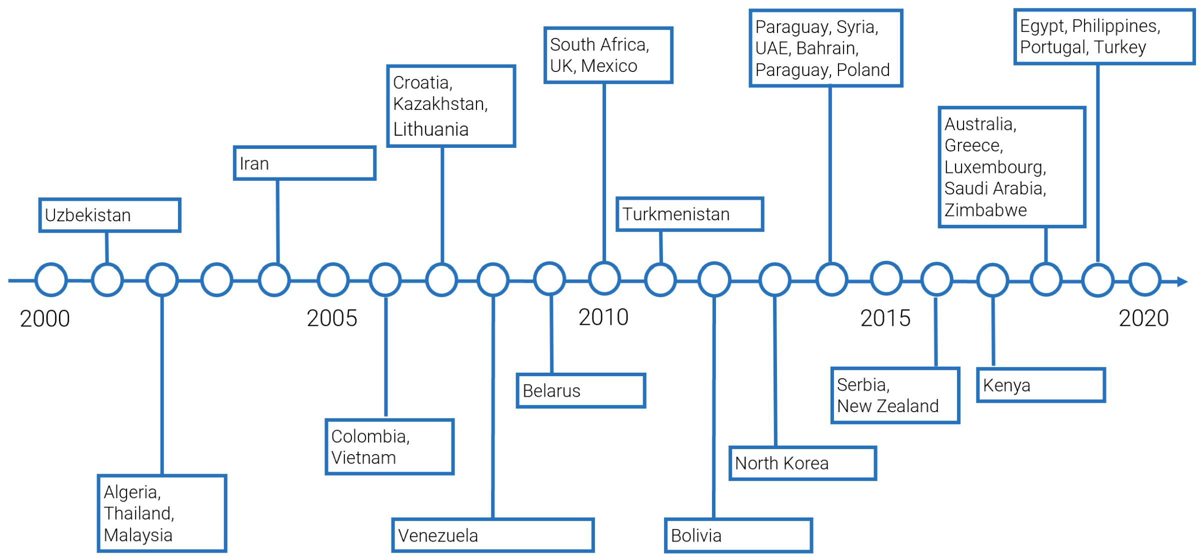

Figure 4: Multiplication of worldwide space agencies (source: ESPI database)

Consistent with these developments on the institutional side, the number of countries undertaking space activities has moved from being a very exclusive club to a much wider group of developed and developing countries, with very diverse capabilities. A clear indication of this is the growth in the number of countries with a satellite in orbit, which in only a decade has increased from 50 in 2008 to 82 in 2018. [12]

[12] OECD. *The Space Economy in Figures: How Space Contributes to the Global Economy.* OECD Publishing, 2019.

As a result of this growing engagement by both developing and established space actors, the number of orbital launches has witnessed an appreciable acceleration in the last few years and has now reached the same level of the early 1990s, when more than 100 launches were performed annually. Even more striking is the number of spacecraft placed into orbit, particularly after 2013. More than 470 spacecraft were launched both in 2017 and 2018, and a record was reached in 2019 (489 satellites launched), while only 110 spacecraft were launched on average per year between 2000 and 2013.

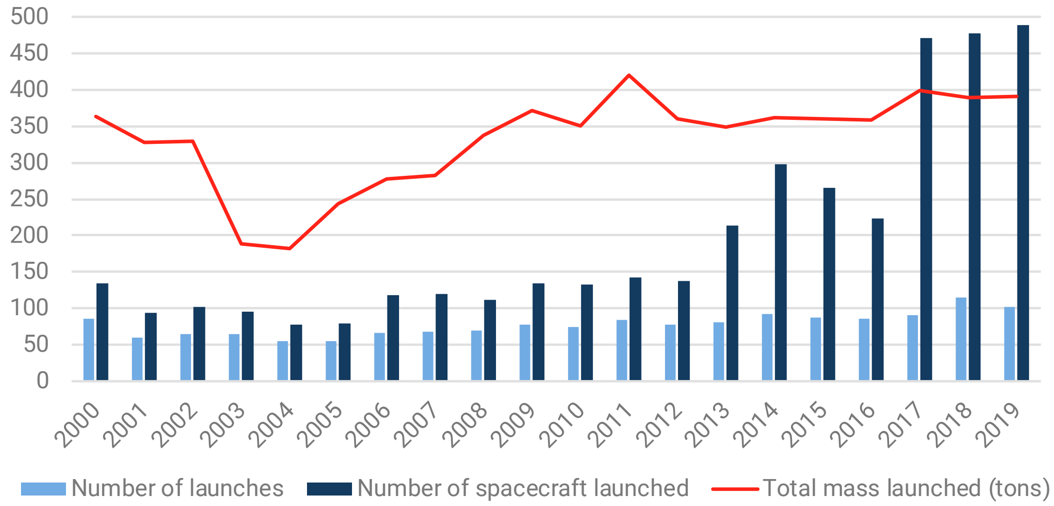

Figure 5: Evolution of the space activity since 2000 (source: ESPI database)

The skyrocketing number of objects launched to space has not translated into a proportional increase in the number of launches and the total mass put in orbit. The main reason is that this upsurge concerned mainly very small spacecraft, in particular cubesats, with a mass below 10kg sent through rideshare launches (see Figure 6XX). Since the launch of the first cubesats in 2003, ESPI estimates that more than 1100 of these small spacecraft have been launched for various purposes, including mostly educational, commercial and research missions (military and civil).[13] Cubesats correspond to approximately 30% of all objects launched since 2003 but only 0.1% of the total mass put in orbit in the same period. The rise of cubesats and other miniaturized space systems is obviously just one of the factors underpinning the current intensification of space launches. Another important one is represented by the launch of the so-called "mega-constellations" (see below).", which may bring launch activity to an entirely new stage.

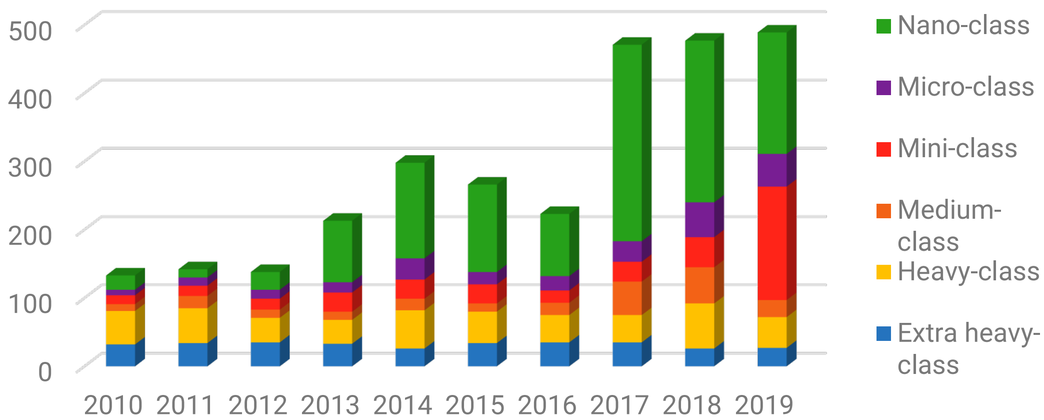

Figure 6: Growth of number of objects launched into space by mass class (Source: ESPI Database)

[13] ESPI database, launch data available until 31 August 2019

As a direct result of this upsurge in global space activity, it comes as no surprise that the overall number of operating satellites has doubled in less than a decade. According to the Union of Concerned Scientists (UCS), there were 923 operating satellites at the beginning of 2010 and there are now more than 2700.[14]

Distribution of satellites by country / region of operator	Distribution of satellites by orbit	Distribution of satellites by purpose
• United States: 1406 • Russia: 170 • China: 375 • Europe: 396 • Japan: 80 • India: 58 • Others: 302	• LEO: 2030 • MEO: 137 • Elliptical: 58 • GEO: 560	• Communications: 1370 • Earth Observation: 791 • Science: 112 • Navigation: 150 • Technology Demonstration: 350 • Mission Extension: 1 • Other missions: 5

Table 3: Breakdown of 2787 operating satellites as of 01 August 2020 (source: UCS database)

Satellites are mainly located in Low Earth Orbit (LEO) and in the Geostationary belt (GEO) and most of them provide operational capabilities for telecommunication, Earth observation or navigation.

Despite the significant growth of Chinese activity, the United States is still responsible for most of the operating satellites. The last inventory estimated that 50.4 % of active satellites are owned and/or operated by U.S. organizations (NASA, NOAA, NRO, military, private sector, universities…).

Equally important, the number of operating satellites is expected to continue to dramatically increase, in line with space activity growth predictions[15], expecting thousands or even tens of thousands of new satellites to be launched in 2020s. It was already the previous decade, more precisely the past 5 years, which saw an unprecedented increase in orbital traffic. As visualised in Figure 7, the number of operating satellites has almost tripled since 2010, reaching close to 3000 operating satellites by the end of 2020.

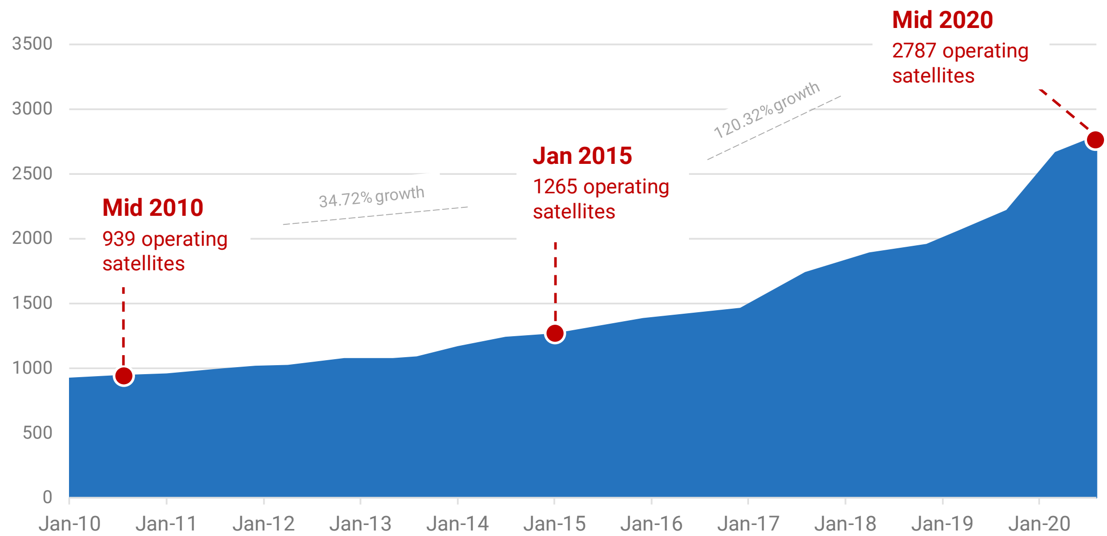

Figure 7: Evolution of the number of operating satellites (source: UCS Database archives)

[14] Union of Concerned Scientists. *UCS Satellite Database* (August 2020). Retrieved from: https://www.ucsusa.org/resources/satellite-database

[15] See, e.g., forecasts and estimations by Euroconsult (https://digital-platform.euroconsult-ec.com/product/satellites-to-be-built-launched/?_amc-currency=USD), SpaceWorks (https://www.spaceworks.aero/wp-content/uploads/Nano-Microsatellite-Market-Forecast-9th-Edition-2019.pdf), or AGI (https://www.youtube.com/watch?v=oWB7ZySDHg8).

At the cornerstone of this massive growth projected in the next few years there are the constellations of small satellites (<500kg). aiming generally to provide various communications (satellite broadband, IoT…) or Earth observation (optical or radar imagery, AIS, weather data…) services from Low Earth Orbit.

The impact of these new commercial endeavours is potentially enormous. If implemented as expected, SpaceX's Starlink constellation will, alone, correspond to the total mass launched to orbit over the last 5 years (human spaceflight excluded) and to all spacecraft launched since 1992.[16] An overview of the major large LEO constellations projects is provided in Table 4:

Current and planned constellation projects	Country of O/O	Number of satellites	Satellite mass (kg)	Operational altitude	Project status
Aistech	ES	120	2U/6U Cubesats	unknown	Development
Amazon Kuiper	US	3,236	unknown	590 - 630 km	Development
AST & Science	US	240	Unknown, with 900m^2 antenna	720 km	Development
Astrocast	CH	80	3U/6U Cubesats	500 - 600 km	Demonstration
Galaxy Space	CN	<1,000	227 kg	500 - 1000 km	Demonstration
GW-A59	CN	6,080	unknown	508 - 600 km	Development
GW-2	CN	6,912	unknown	1,145 km	Development
Hongyan	CN	320	300 kg	1,100 km	Demonstration
Hongyun	CN	864	250 kg	1,000 km	Demonstration
Iridium-NEXT	US	72	860 kg	780 km	In operation
Jilin-1	CN	138	42 - 237kg	535 - 579km	Deployment
Kepler	CA	140	3U Cubesats	575 km	Development
KLEO Connect	DE	300	unknown	1,100 km	Development
OneWeb	UK	648	147 kg	1,200 km	Deployment
Planet Doves	US	150	3U Cubesats	370 - 430 km	In operation
Satellogic Aleph-1	AR	300	37kg	470km	Deployment
Sfera	RU	640	unknown	870 km	Development
SpaceX Starlink	US	11,928	260 kg	550 km, 336 - 346 km	In operation (public beta)
Spire	US	175	3U Cubesats	385 - 650 km	In operation
Swarm	US	150	0.25U CubeSats	300 - 550 km	Demonstration
Telesat LEO	CA	298	unknown	1,000 km	Development
Theia	US	120	unknown	800 km	Development

Table 4: Selected current and planned LEO constellations with 50+ satellites (source: ESPI Database)

[16] Sebastien Moranta, Tomas Hrozensky, Marek Dvoracek. *Towards a European Approach to Space Traffic Management*. ESPI Public Report n°71 (January 2020). Retrieved from: https://espi.or.at/publications/espi-public-reports

3.1.2 A growing and diversifying space economy…

The above-described expansion of activities has been accompanied by a consistent increase in global funding for space activities, both from public and – even more strikingly – private entities.

Public investments continue to represent the bulk of funding in space activities. National governments invest in space activities via procurement and grants mechanisms to public agencies, research institutes, universities and the private sector to support a variety of objectives, including national security and defence objectives as well as socio-economic reasons, and motives of national prestige.[17]

According to conservative estimates (i.e. estimates based on less than 50 selected countries with large space programmes), global institutional funding for space activities reached USD 86 billion in 2018, as compared to an estimated USD 62 billion in 2008 (Figure 8).

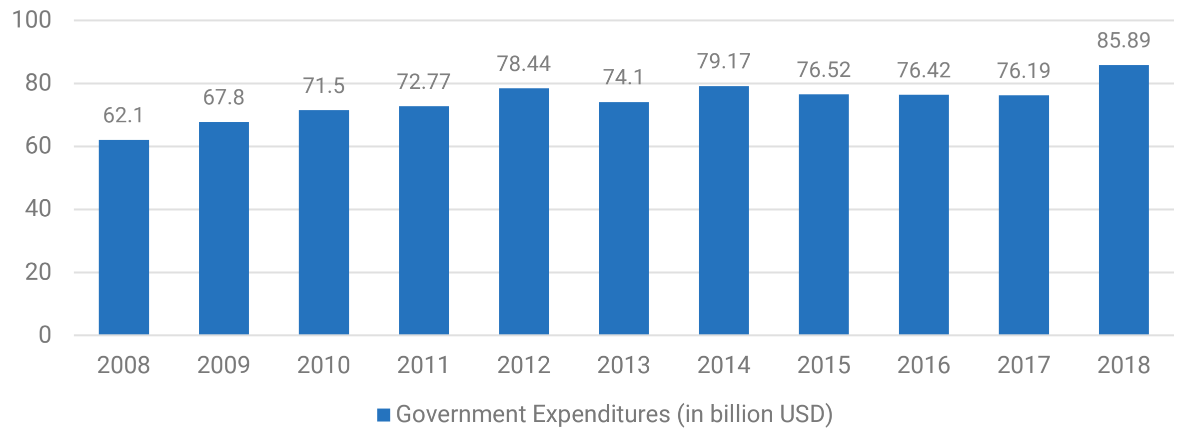

Figure 8: Evolution of government expenditures (2008-2018) (source: The Space Report)

Although overall funding has correspondingly increased over the past 10 years, it is important to note that its distribution has changed. While institutional funding of the largest space programmes has remained stable or increased slightly, most medium and smaller programmes have increased their spending, as shown when comparing the breakdown of government expenditures in 2008 and 2018.

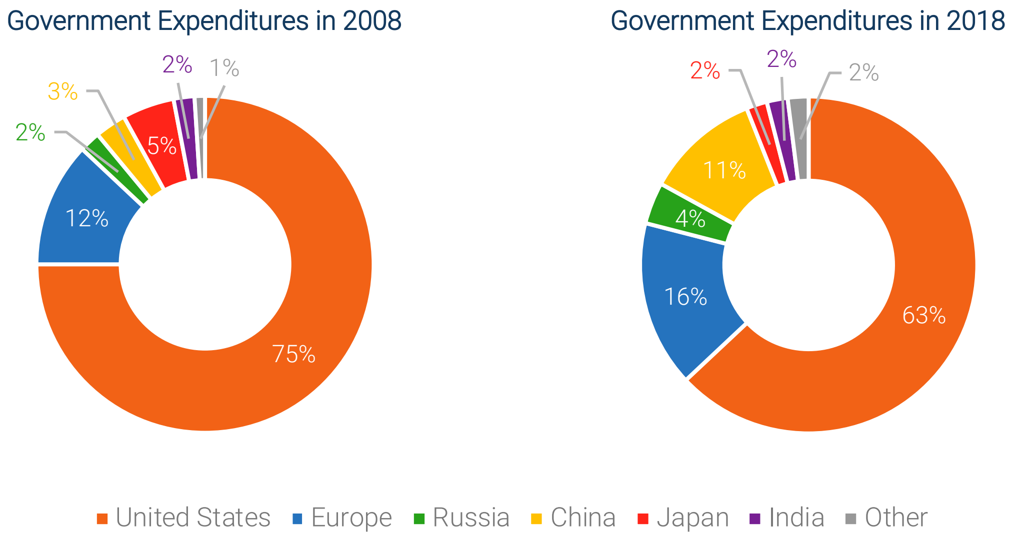

Figure 9: Share by country of the world government civil and military expenditures on space programmes in 2008 (source: ESPI SPIT 2008/2009) and 2018 (source: The Space Report 2019)

[17] OECD. *The Space Economy in Figures: How Space Contributes to the Global Economy*. OECD Publishing, 2019.

The United States remains the largest space power, although its share of global space spending substantially decreased, passing from 75% in 2008 to 61% in 2018. In parallel, other countries increased their shares, developing advanced space programmes, with a wide portfolio of activities. The most evident case is China, whose share of the global space activities budget increased from 3% in 2008 to 9% in 2018.

While governments continue to be the main source of funding for space, over the past few years private funding has also grown tremendously, "with unprecedented private capital flows in the space sector from angel and venture capital investments".[18]

The high profitability of satellite telecommunications services over the past 15 years has paved the way for private financing in other domains of space activities, such as for instance Earth Observation. Private investment in space activities, however, has also been stimulated by the rapid growth of the venture capital (VC) market as well as by technological advancements and lower entry barriers (including lower costs for accessing space, the development of smallsats and the deployment of mega-constellations).

The amount of funding has exponentially increased over the past few years. In 2018, a record €2.7 billion was invested in start-up companies, about €576 million more than in 2017, with 82 start-ups reporting private investment. Although the amount is still very small compared to public funding, it is worth underlining that it is a seven-fold increase compared to 2008, when less than €400 million was invested through private funding.

As reported by the OECD, the number of investment transactions also grew globally, from 200 investment deals in 2011 to over 1,400 in 2017 and so did the number of investors, which grew from less than 20 in 2008 to 187 in 2018.[19]

Concerning the typology of investors, VC is the main form of private funding, constituting 55% of the investors in the period 2014-2018. The second largest share is corporations (around 21%) while angel investors represent 16% of investors on this period. Other sources of funding are private equity (4%), banks (2%) and altruist donors (2%).

3.1.3 ... driven by a new sectoral dynamic

The increased level of investment and intensification of worldwide space efforts by both public and private stakeholders are directly linked to and driven towards a more wide-ranging approach to space. Usually referred to as *NewSpace*, this new sectorial dynamic encompasses a broad range of diverse, interrelated trends. The term generally indicates a commercially-driven approach to space, marked by ambitious undertakings aimed at capturing space markets with innovative schemes and business models. In this new ecosystem, private actors are playing a more prominent role, pursuing the eventual goal of conducting space business independently from governments.

Although the term "New Space" is primarily used to describe the evolving nature of the private space industry in the U.S. context, other parts of the globe are also experiencing a similar dynamic. In the European context, for instance, the buzzword Space 4.0 has been used by ESA to indicate an adaptive transition into the new, increasingly interconnected and participatory, space age.[20] It adds one component to the trends previously mentioned: the involvement of an increasing number of space-faring nations investing in the acquisition of turnkey space capabilities or even in the development of a domestic space industrial base.

[18] OECD. *The Space Economy in Figures: How Space Contributes to the Global Economy.* OECD Publishing, 2019.
[19] Ibid.
[20] ESA. "Council Meeting Held at Ministerial Level on 1 and 2 December 2016 – Resolutions and Main Decisions" (2016). Retrieved from: https://esamultimedia.esa.int/docs/corporate/For_Public_Release_CM-16_Resolutions_and_Decisions.pdf.

Similar to the description of industrial ages, ESA's conceptualisation categorises the history of the space sector into distinct chapters, distinguished by their activities, the actors and their interactions, and the overall development and operation ecosystem.

Space 4.0, building on the previous three chapters of the space age, can be characterised by the multiplication of actors and their means of interaction, and can be entitled the "Age of Participation" within the space sector.[21]

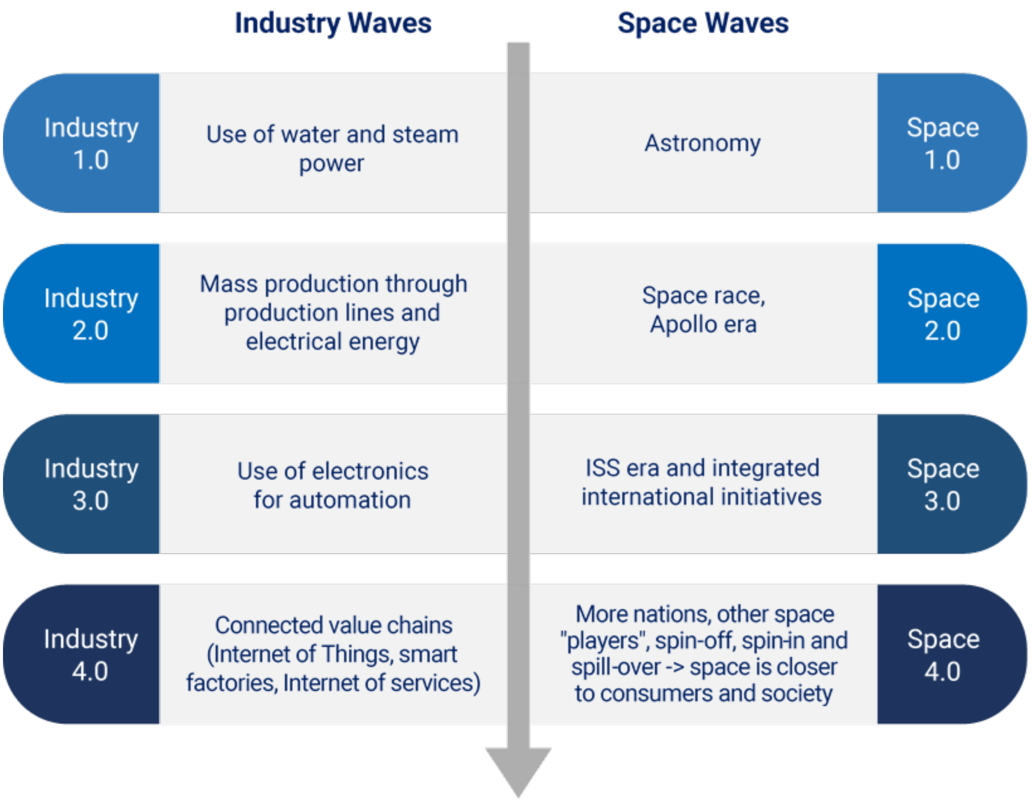

Figure 10: Industry waves and space waves (as viewed by ESA DG)

The overarching objective of Space 4.0 is to foster and increase the interconnectivity between "science, industry, politics and society,"[22] broadening the scope of the space sector in terms of active participants, and further integrating it into the wider society.

Overall, aside from the terminology, it is clear that the global space sector is witnessing a new sectorial dynamic, the most salient features of which are summarised in the Table 5 below.

New entrants
• A significant number of companies have recently entered or emerged in the space sector. These new entrants usually fall into two categories: ○ Non-space companies including in particular large ICT companies eager to expand their activities and build on cross-fertilization between ICT and space applications; ○ New space companies or start-ups leveraging private and/or public funding to initiate innovative business models addressing new or existing markets with disruptive solutions.

[21] *Ibid.*
[22] *Ibid.*

Innovative industrial approaches
• Many new commercial actors have been adopting new methods for the development and production of space systems as part of their innovative business models. • These innovative approaches principally aim at cutting down costs with the underlying objective of creating conditions either to disrupt existing markets with aggressive pricing for example, or to address new mass markets (see below "Market disruption solutions"). • The techniques adopted by NewSpace players include industrial organisation optimisation, supply chain rationalisation, vertical integration, miniaturisation, proven technologies re-use, economies of scale, production line automation and digitisation, use of COTS, etc.
Market disruption solutions
• NewSpace companies tend to adopt disruption rather than optimisation as the backbone of their business strategy. These solutions are not necessarily based on new technologies but rather on revisited concepts giving way to an alternative innovation dynamic. Typical of NewSpace offerings include integration/customisation, flexibility, availability, de-complexification or lower prices, among others. • NewSpace endeavours often address well-known shortcomings of the current space sector offer but the profitability and sustainability of the business models still has to be demonstrated.
Substantial private investment
• The value of private investment in space businesses has increased, most prominently in the USA. Various sources of investment exist, including venture capital firms, business angels, private equity companies and banks, each with different investment mechanisms. • Focused on the development of business ventures, private investment complements well the already large U.S. public budgets by addressing short-term industrial objectives and supporting start-up and scale-up phases.
New industry verticals and space markets
• Various promising new markets have been identified for business ventures including, e.g. global connectivity, geo-information services, micro-launchers, space tourism and space mining. • Even if the economic viability of new markets remains uncertain today, the development of projects to address them has already impacted the overall sector, including historical players.
Innovative public procurement and support schemes
• Public policies implemented in recent years, in particular in the U.S., have been instrumental in the emergence of NewSpace. These public policies included, in particular, the implementation of new public procurement schemes enabling a radical optimisation of industrial organisation leading to an improvement in cost-effectiveness. • In this new context, most agencies have started to readjust their roles and adapt their industrial policy and procurement to foster the emergence of private endeavours.

Table 5: Key features of the NewSpace dynamic

As evidenced from the above textbox, the so called NewSpace dynamic is rather intricate and cannot be summarized as a simple and sudden emergence of new space business endeavours. NewSpace actually encompasses various trends including technical, political, and business trends, having contributed, together, to an increasingly more prominent role for private actors in the space sector.

3.1.4 The evolving role of public stakeholders

The progressive rise of private actors has not entailed a withdrawal by public stakeholders, but only a transformation of their role. Indeed, space agencies rely more than ever on private actors to accomplish their missions, at least in certain domains. Indeed, even if early-stage R&D, technology maturation and space science remain their realm, other phases of space missions are now increasingly delegated to private actors. The most prominent example of this change of behaviour is the management of human spaceflight in the U.S, which awarded contracts to Boeing and SpaceX to develop manned capsules that NASA will procure to transport astronauts to the ISS.

In Europe, the change of relationship with industry appeared with the development of Ariane 6, which gave more room to manoeuvre to industry and a greater degree of autonomy for the design of the rocket, as well as more responsibility in its development. The new approach takes the shape of various types of public-private partnerships, which lead to the sharing of costs and risks between the public agency and industry, and to the transfer of control of key programmes characteristics from the former to the latter.

Reaffirmed focus on technology development	Increased dynamism and autonomy of the industry enable agencies to reaffirm a strong focus in funding and leading the **development of space programmes, maturation of early-stage technologies and scientific research**
From Customer to Consumer	In those major space domains where industry can afford to sustain more risks, agencies are conducting a **shift from their traditional support to the offer side to support demand**

Table 6: The expanding role of agencies at the two sides of their mission

The relationship between public stakeholders and the private sector has thus changed. Instead of directly subsidising industry, space agencies and other public organisations continue to support the private sector through their participation in funding rounds, the establishment of anchor customers contracts, or the development of joint initiatives (e.g. the CNES-Arianespace's Arianeworks acceleration platform to boost innovation for future launcher development). Public actors have become enablers of private endeavours.

Greater industry autonomy allows space agencies to re-focus on technological development, such as pioneering space programmes, and maturation of early-stage technologies and scientific research, while mature technologies are left to the industry. In addition, space agencies will retain a major role in managing the public-private "spacescape" of the coming decades, especially in the strategic (proposing and implementing space policy), regulatory (supporting the development of regulations) and representation (nationally and internationally) dimensions.

3.2 A disruptive technological context

The structural changes of the "expanding" space sector are associated with a more disruptive technological context. The technological factors underpinning this profound change are diverse and span across the space systems value chain – from production, through operation and service provision, up to application potential. Specificities of space technologies compared to technologies of other industrial sectors are diminishing. The integration of space systems with terrestrial systems is deepening and expanding to more sectors and policy domains.

Space technologies and access to space, in addition, are progressively becoming more affordable. The technological advances on many fronts (primarily miniaturization of electronics, software advancements and COTS availability of components) and expansion of actors engaged in space (states, universities, private companies…) bring about new alternatives in accessing and using space. This improved availability presents itself in multiple domains:

- Basic technologies, components, materials,
- System integration,
- Launch services, as well as
- Handling of operations.

According to Frost & Sullivan[23], there are 10 technological mega-trends that will shape the space sector, mostly in its economic considerations, by the 2030s:

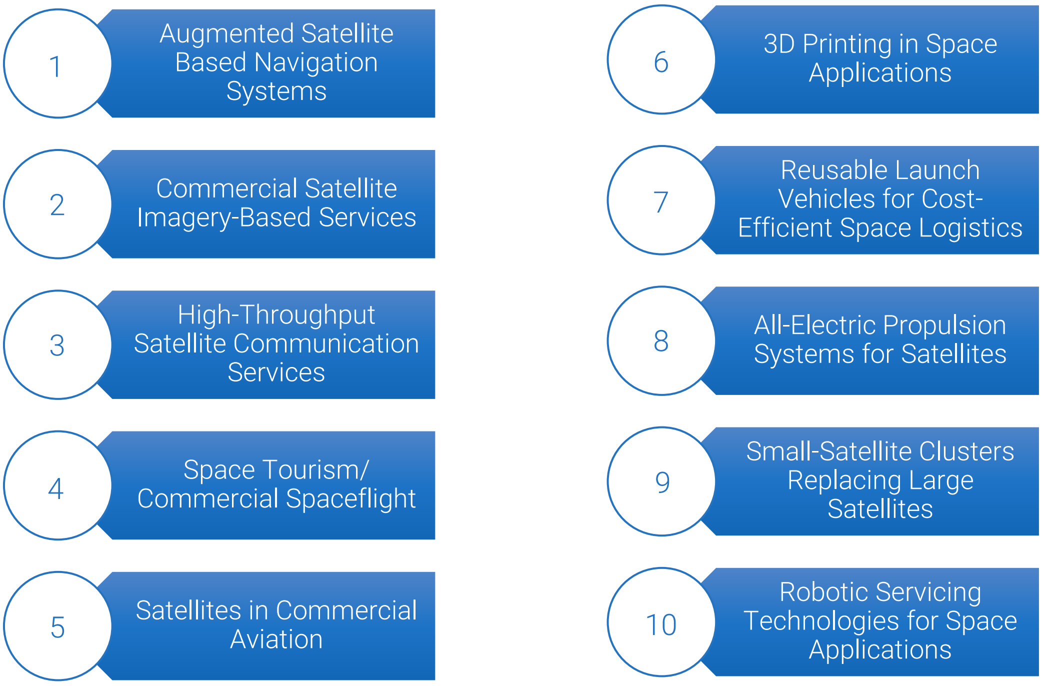

Figure 11: Space Mega-Trends by 2030s by Frost & Sullivan

Beyond the commercial space economy, however, it can be expected that technological developments will also shape space security (non-kinetic counterspace capabilities, deeper integration of space in security applications) and space science and exploration (new lunar missions, Mars settlement, solar system exploration).

[23] Frost & Sullivan. *Space Mega Trends: Key Trends and Implications to 2030*. 2015

3.2.1 Change of paradigm in space technology production

Breakthroughs in hardware and spacecraft design have shifted the production paradigm towards affordable and miniaturised space systems while preserving and expanding capabilities and unlocking new services and application areas. Electrical, Electronic, and Electromechanical (EEE) components of space systems are increasingly produced on the basis of commercial-of-the-shelf (COTS) approaches.[24] For many of the new entrants in the space sector, price and long lead-times of fully-qualified components are too costly or impractical. This leaves COTS components as the preferred alternative.

With a similar transversal impact across the space sector, the miniaturisation of electronics has dramatically scaled down the size of space systems over recent years, up to 0.25U cubesat formats (Swarm Technologies' SpaceBEE picosatellites). *In combination with the COTS-approach, Constellations of Small Satellites, in particular in LEO, become possible, featuring both new capabilities as well as existing capabilities at much lower costs."* [25] In response to the growing demand for small satellite missions, the launch segment has experienced a dramatic increase in the development of micro-launchers, with some of them already established on the commercial market (e.g. Rocket Lab's Electron).

Another new trend relates to the emergence of spacecraft mass-production, resembling automotive manufacturing on assembly lines with greatly improved manufacturing output. This responds to the evolving needs of space operators - deployment of large satellite constellations, small satellite missions with short duration. Additionally, it also lowers the cost of procurement and thus contributes to reducing the costs of access to space. The mass-production approach surpasses the traditional unique, slow-paced and tailor-made technology development for individual purposes. The first mass production facility opened mid-2019 and it is no surprise that it was built to support a mega-constellation project (i.e. OneWeb-Airbus Joint Venture Oneweb Satellites).

Miniaturisation, COTS availability, mass production and, of more specific importance for the space sector, the re-usability factor have brought about much more affordable access to space. It has been a game changer, greatly lowering financial and capital requirements to enter space activities. Both the upstream and downstream sectors are affected by this facilitated accessibility. In the upstream, launch prices are getting lower, launch opportunities are more versatile and spacecraft can be obtained through multiple ways. In the downstream, the availability of unencrypted satellite signals and open source satellite data, particularly in the PNT and EO domains facilitates entry into the sector for both state and non-state actors, which can offer new services, including for commercial purposes.

In addition to manufacturing-related transformations, the backbone of space exploration and utilisation, namely space-ground communication links, have experienced several new trends. Innovation makes existing technologies more capable and at the same time, new communication technologies and techniques are being developed and brought-into-use, including for commercial purposes. These include:

- High- and very high-throughput GEO satellites
- Higher frequency bands (V-, Q- or W-bands) approaching or entering commercial utilisation
- Hybridisation of networks, exploiting infrastructures in different orbital regimes
- Utilisation of optical communications, including cross-satellite links
- Payload digitalisation enabling a quick change of frequency or coverage

[24] COTS *"represents a transition from the traditional specialised prototype or low-volume development and production established in the space sector towards the exploitation of the benefits of existing mass production technologies. Therefore, the approach speeds up development times and lowers substantially production costs, in particular in cases where mission profiles allow also for a lowering of the traditional safety and reliability standards."* The Association of European Space Research Establishments (ESRE). *ESRE Whitepaper: Selected Trends and Space Technologies Expected to Shape the Next* Decade (November 2017). Retrieved from: https://www.esre-space.org/wp-content/uploads/2018/01/ESRE_Whitepaper_-2017.pdf
[25] *Ibid.*

3.2.2 Integration of broader breakthrough technologies in the space sector

Although some space system technologies are endemic to the space sector (e.g. propulsion systems), advancements throughout the space sector are also largely enabled by universal technological developments. In recent years, some of these new concepts have been increasingly integrated into space, adding to the emergence of new services and their applications:

- Big data and data science

  Advances in the EO segment have opened up the link between space and big data. *"Big Data from Space refers to the massive spatio-temporal Earth and Space observation data collected by a variety of sensors and the synergy with data coming from other sources and communities. This domain is currently facing sharp development with numerous new initiatives and breakthroughs from intelligent sensors' networks to data science application. These developments are empowering new approaches and applications in various and diverse domains influencing life on Earth and societal aspects, from sensing cities, monitoring human settlements and urban areas to climate change and security."* [26]

- Automation / Artificial intelligence / Machine Learning

  Handling vast amounts of data, processing complex calculations or executing time-consuming processes becomes more dependent on automation capabilities throughout numerous scientific sectors, industrial fields and public policies. As the various automation applications already bring results and open avenues for new applications both in space and beyond, it is anticipated that the space sector will become more reliant on such capabilities. Automation in space is emerging most prominently in:

  - The processing of Earth observation data into value-added analytics services
  - Space robotics (particularly with regards to the anticipated emergence of satellite servicing)
  - Scientific experiments, reducing the need for human involvement
  - The management of conjunction warnings in space, including collision avoidance

- 5G Connectivity and Internet of Things (IoT)

  The emergence of these new communication paradigms impacts the perspectives of satellite connectivity. Major satellite operators are regularly promoting the relevance of satellite infrastructure in the roll-out of future telecommunication networks, with 5G as the most recent example. *"Satellites' coverage can massively increase the service area by extending terrestrial networks through portable nodes like a satcom-enabled van or providing backhaul connectivity: linking small local networks to the main fibre spine."*[27] The globally growing demand for improved connectivity in terms of data volume, availability (spatial and temporal) and speed creates new avenues of opportunities for the satellite industry. Within machine-to-machine communication, namely the IoT trend, innovative small satellite start-ups are emerging to meet the growing demand.

In addition, there are also prospects for the adoption by the space sector of some additional concepts, such as blockchain, quantum and cloud computing. In each of these fields, some initiatives at programmatic or commercial level have been kick-started and further activities can be expected.

[26] Pierre Soille, Sveinung Loekken & Sergio Albani (eds.). *Proceedings of 20019 Big Data from Space (BiDS'19) – Turning Data into Insights.* Joint Research Centre (2019). Retrieved from: https://ec.europa.eu/jrc/en/publication/proceedings-2019-big-data-space-bids19

[27] "Space-enabled Internet of Things shown in Berlin". ESA (November 2018). Retrieved from: https://www.esa.int/Applications/Telecommunications_Integrated_Applications/Space-enabled_Internet_of_Things_shown_in_Berlin

3.2.3 The evolving role of the terrestrial component

The common denominator of many of the aforementioned new services and applications provided thanks to, or in cooperation with, space infrastructures, is profound integration and reliance on the ground component. Indeed, the expanding space sector is changing established practices with respect to the expectations towards space systems' ground segment, to the integration of space with terrestrial or aerial communication networks and to the use of local or open sources of data, mostly of geospatial nature. This evolving role of the "ground" within space considerations is threefold:

- As an enabler of ambitious space capabilities

There is now a growing demand for capable ground segments to achieve and sustain current plans for future LEO, GEO or hybrid satellite systems providing communications or Earth observation services. These relate to gateways architecture, end-user terminals, novel antenna technologies (e.g. flat-panel antennas) and even cable data storage or command & control solutions. The capabilities of ground segments are already evolving; however, future improvements will be required, mainly in terms of flexibility and adaptability. The ground systems business has already undergone transformations in recent years resulting from a massive increase in data volume and technological progress. Innovative business cases are being introduced, such as "infrastructure as a service".

- As a contributor to space-based data and services

In Earth Observation applications (geospatial imagery, weather forecast…), the integration of space data with terrestrial sources (various types of ground-based data collection, such as drone imagery or meteorology stations, and open-source data) is becoming more pervasive and provides additional added-value for different purposes ranging from climate monitoring, through illicit crop monitoring, and up to international treaty verification mechanisms.

- As a competitor to satellite connectivity

Besides space's numerous synergic and enabling functions in the broader telecommunications sector, the future of connectivity is bringing about anticipated confrontation between space and terrestrial (fibre or wireless) systems. Most recently, this has been demonstrated by two developments, both related to spectrum allocation regulations.

In November 2019, U.S. spectrum regulator, the Federal Communications Commission, decided to clear the lower 280 MHz of the C-band spectrum (3.7 GHz – 4.2 GHz) traditionally allocated to fixed satellite services. This newly available portion of the C-band spectrum will be auctioned to terrestrial network operators in December 2020 to allow for swifter and more robust roll-out of 5G networks.

The same month, the quadrennial ITU World Radio Conference took place. With plenty of spectrum-related discussions, it highlighted the scarcity of radio spectrum in view of emerging applications dependent on its usage, e.g. Intelligent Transport Systems (ITS), Railway Radiocommunication (RSTT), Radio Local Area Networks (RLAN), 5G or High-Altitude Platform Stations (HAPS). Spectrum sharing by different applications might naturally lead to increased interference risks. For instance, in the 24 GHz band, new provisions adopted at the WRC-19 raised concern in the meteorology community, as *"International standards for wireless technology could degrade crucial satellite measurements of water vapour."*[28]

Technologies have thus developed, but the environment in which space systems operate is also changing and becoming more unpredictable, due to its contested and competitive nature, and to the increasing congestion that characterises outer space.

[28] Alexandra Witze. "Global 5G wireless deal threatens weather forecasts". Nature (November 2019). Retrieved from: https://www.nature.com/articles/d41586-019-03609-x

3.3 A more challenging operational and geopolitical environment

The sizeable dependence of societies on the continuing utilisation of services provided through space are translating into societal, economic and security challenges. With new unprecedented developments in the military space domain as well as in world politics at large, operating in space will likewise get more challenging. Moreover, the anticipated trends (continuing increase in launch activity and orbital traffic) further amplify operational hazards. Various measures to mitigate growing risks have been completed or are underway, but ongoing developments do not bode well for the future.

3.3.1 Increasing congestion and risks of collisions and interferences

The increase in spaceflight has been producing a more complex and dynamic orbital traffic, both in terms of functional space objects as well as space debris. As seen, the UCS database of operational space objects lists more than 2,000 active spacecraft in various Earth orbits[29]. Increased activities in space are not distributed evenly across all orbital regimes traditionally utilized for space missions. The LEO region is most significantly affected by growing physical congestion, which results from its confined area and the extensive launch traffic in recent years (see Figure 12)[30].

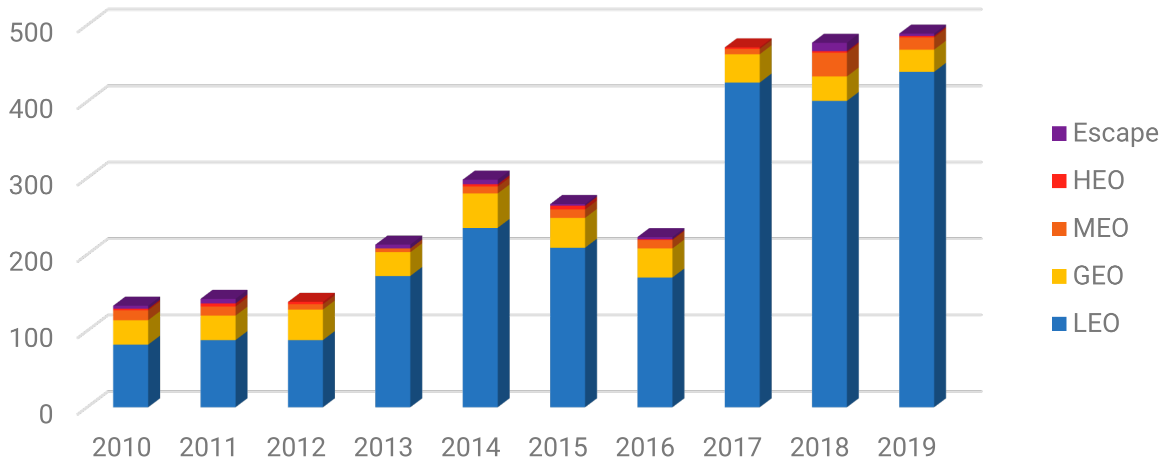

Figure 12: Evolution of the number of objects launched into orbits (Source: ESPI Database)

However, operational satellites actually account for a very small fraction of the total population of objects currently in orbit. In other words, only a very small portion of the space traffic is actually "operationally useful" or "economically valuable". Active satellites have to share space with inactive satellites and rocket bodies as well as countless fragments of various size, nature and origin.

Indeed, the vast majority of objects currently in orbit are "space debris". Current ESA estimations of the number of debris objects provide following figures:

- 34 000 objects >10 cm
- 900 000 objects from 1 cm to 10 cm
- 128 million objects from 1 mm to 1 cm[31]

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[29] Union of Concerned Scientists. "UCS Satellite Database" (last updated: April 2020). Retrieved from: https://www.ucsusa.org/resources/satellite-database

[30] Though GEO scores lower in evolution of objects launched and in number of all tracked objects (according to data from ESA's Space Environment Report), other important factors conditioning the risk of collisions, such as object mass and area are, in general, larger in GEO region. GEO operations has been conventionally characterised by utilisation of large satellites. The trend of miniaturisation, though, is becoming more pervasive also in GEO, which is expected to welcome more small satellite missions.

[31] ESA's Space Debris Office. "Space debris by the numbers" (last updated: February 2020). Retrieved from: http://www.esa.int/Our_Activities/Operations/Space_Debris/Space_debris_by_the_numbers

Operating satellites therefore represent only 7% of space objects larger than 10 cm and a negligible portion of the total population. In terms of mass, however, operating satellites still account for more than 35% of the total 8,400 tons of objects in Earth orbit. The evolution of the population of catalogued tracked space objects clearly shows an upward trend, as displayed in Figure 13.

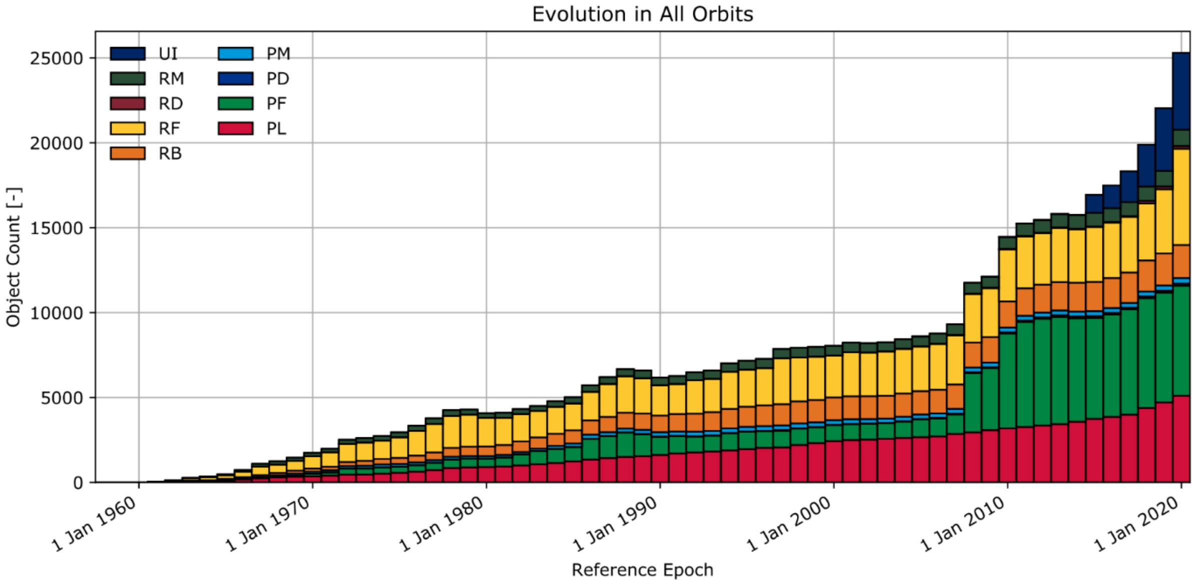

Figure 13: Evolution of the number of catalogued anthropogenic space objects in all orbits (Source: ESA's Annual Space Environment Report[32], September 2020)

The number of space debris has actually increased even more steeply than the population of operating satellites over the last decade, in particular as an outcome of a few orbital explosions and collisions such as the Chinese ASAT kinetic test on the decommissioned weather satellite Feng Yun 1C in 2007 and the collision between the Russian satellite Cosmos 2251 and the American satellite Iridium 33 in 2009. Together, these two events increased the space debris population by 40%.

Although the congestion of the space environment is affecting space activities at large, the level of risk is much higher in LEO where most constellations and CubeSats are deployed or planned to be deployed and where past explosions and collisions took place. Together with the Geostationary belt, LEO is considered a protected region with regard to the generation of space debris by the IADC space debris mitigation guidelines.[33] This region of space below 2,000 km, has close to 60% of space objects regularly tracked. The most densely crowded areas are polar regions (particularly with inclinations of 97° to 100° and altitudes around 800 km). The high spatial density (number of objects in a 1 km-side cube) in LEO is related to various factors including human activity and orbital dynamics. The deployment of large LEO constellations (LLCs) will further contribute to ever-denser traffic in LEO. [34]

The congestion of the space environment naturally creates risks for space operations - in particular concerning collision and interference hazards. The consequences of a collision between two objects in space can be dramatic. When orbiting at high velocity, even the smallest piece of debris can have devastating consequences as it can reach a relative speed of 27,000 km/h. An object as small as 5 mm can disrupt or even completely incapacitate a satellite. This means that each debris is a serious hazard to operational systems in orbit, and also to astronauts.

[32] Available at https://www.sdo.esoc.esa.int/environment_report/Space_Environment_Report_latest.pdf
[33] Inter-Agency Space Debris Coordination Committee. *IADC Space Debris Mitigation Guidelines*, September 2007. Retrieved from: https://www.unoosa.org/documents/pdf/spacelaw/sd/IADC-2002-01-IADC-Space_Debris-Guidelines-Revision1.pdf
[34] Glenn Peterson, Marlon Sorge & William Ailor. *Space Traffic Management in the Age of New* Space. The Aerospace Corporation (April 2018). Retrieved from: https://aerospace.org/sites/default/files/2018-05/SpaceTrafficMgmt_0.pdf

Besides terminating costly missions and creating potentially high financial losses, catastrophic collisions can cause the creation of a larger number of debris, which will further increase the chances of new collisions, and so on. The modelling work done by various space agencies points out that the situation continues to worsen; that even without new additional launches debris-on-debris and debris-on-active-satellite collisions will continue to expand the population of debris and that this chain reaction (or cascading effect) will eventually reach a critical point in which the population of artificial debris will grow at a rate faster than that at which debris is removed from Earth orbit through natural decay.

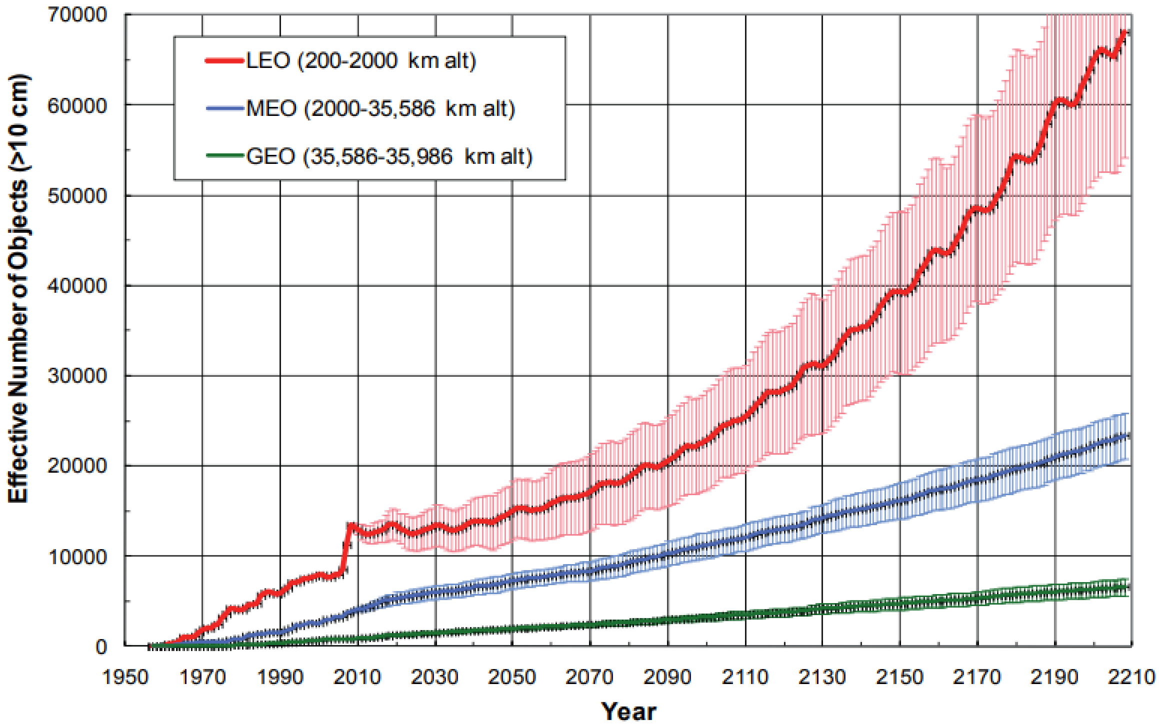

Figure 14: Evolution of the number of objects in orbit if no new satellites were launched – Kessler syndrome (credit: NASA)[35]

The risk of collision increases for large objects in dense areas such as LEO polar orbits. The congestion of some orbits therefore translates into an increasing risk of collision between space objects. In comparison to hundreds of conjunction warnings with debris that operators receive every day, collision threats between active objects remain less likely. However, with the anticipated growth of active objects, collision threats between active and also manoeuvrable objects are bound to increase significantly. To illustrate, a study on "the orbital debris collision hazard for proposed satellite constellations", estimates that the OneWeb constellation could lead to one catastrophic collision every 25 years and that the Space X Starlink constellation (based on 4,025 satellites) could lead to as many as one catastrophic collision every 20 months[36].

3.3.2 Growing geopolitical tensions extending into the space environment

The various risks to the safety of the operational environment are further exacerbated by broader strains on security and stability stemming from the broader geopolitical dynamics. Developments in the space sector do not take place in isolation from the broader international context. Be it competitive or conflictual

[35] NASA. *Orbital Debris Quarterly News*, vol 14., issue 1, January 2010. Retrieved from: https://orbitaldebris.jsc.nasa.gov/quarterly-news/

[36] Duncan Steel. "The Orbital Debris Collision Hazard for Proposed Satellite Constellations" (April 2015). Retrieved from: http://www.duncansteel.com/archives/1515

developments or, on the contrary, the warming of relations between actors, international politics spills over into the very specific segment of space activities. Recently, increasing geopolitical tensions have affected prospects for space cooperation and competition.

New geographical pockets of instability and insecurity, re-emerging trade disputes and the diminishing appetite for multilateralism[37] all reduce international trust, transparency and willingness to cooperate, which is essential for ambitious space programmes.

More uncertainty, less stability and reduced transparency affect space-related activities and generate worrisome prospects for peaceful international coexistence in the space domain.

Closely related to the decline of multilateralism, is the expanding wave of populism, nationalism and disinformation in the transatlantic sphere, which shapes political and military developments in a growing number of countries. While global military expenditure continues to grow, new means of warfare are increasingly being explored and utilized (hybrid operations, information warfare, cyber-attacks…).

As an accompanying trend, the utilisation of economic tools in inter-state confrontation has recently gained in magnitude. Some examples include the several rounds of economic sanctions issued against the Russian Federation by many countries from the transatlantic domain as a follow-up to the annexation of Crimea in 2014 and, under the Trump administration, new episodes of U.S. "trade wars" with China and the European Union are shaping the practices of foreign policy.

The instability of the world order is also amplified by new hotbeds of geopolitical tensions.They take various forms such as cross-border warfare, armed insurgencies, and civil protests and riots. Outcomes of these new conflicts together with unresolved conflicts of the past produce further deterioration of living conditions for local inhabitants and generate new troublesome developments, such as cross-border migration flows and internal displacement.

All in all, rising tensions and changes in the balance of power are reviving a new era of great power competition that extends into outer space. This is primarily reflected in the expansion of military space activities.

Expanding military space activities

The intensity of military space activities is seeing a resurgence in several forms, including dual-use. The relevance of space for military operations, including in space, has been increasingly recognised by major space powers over the past decade and new countries have been launching their pioneering military space efforts in support of a range of general or country-specific objectives.

The cadence of military payload deployment has been somewhat stable over the last decade (with an abrupt growth in 2018), not fully mirroring the overall increase in the number of spacecraft. Yet, the military space sector is experiencing a rising number of actors, documented by 23 countries that have engaged in military or dual-use activities over the past decade (compared to 13 countries with military or dual-use payloads in 2000-2009[38]).

This evolution is visualized in Figure 15 (which excludes 24 Galileo launches and 5 Copernicus launches on behalf of the EU).

[37] The multilateralism of the globalised world has been challenged by a number of recent developments. The United Kingdom has left the EU in January 2020 and prospects for new rounds of further enlargement are blurry. Likewise, the relevance of NATO is undergoing a challenging period. Since 2017, the United States has quitted a series of multilateral arrangements, such as the Paris Climate Agreement, the Joint Comprehensive Plan of Action (the Iran Nuclear Deal) or the Intermediate-Range Nuclear Forces Treaty (INF). In addition, the effectiveness of the UN Security Council *vis-à-vis* various brewing conflicts around the globe is at best, questionable.

[38] Data from the ESPI Launch Activity Database.

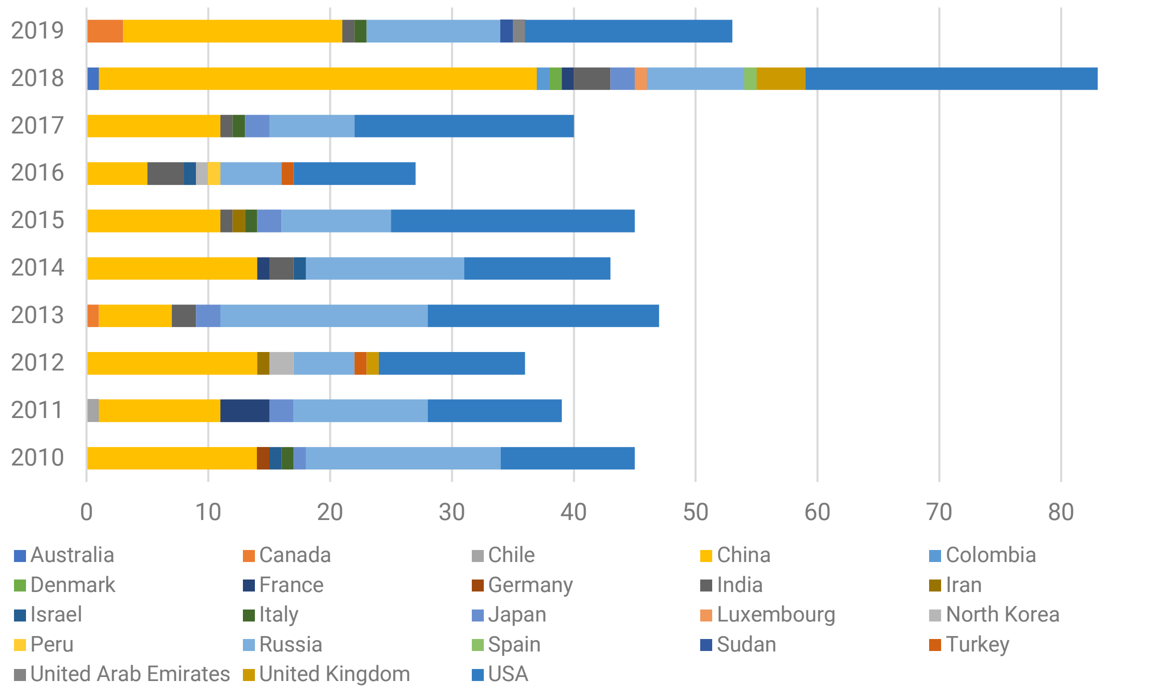

Figure 15: Military and dual-use payloads launched in 2010 - 2019 by customer country (Source: ESPI Database)

Space capabilities now routinely support the conduct of military ground, sea and air operations. Services provided by space infrastructures are also increasingly integrated in a number of safety and security applications, including those used by the armed forces or for national security purposes.

The expanding use of space applications in the conduct of military operations on the ground is mirrored by new ways of operating in space that impact the relationship between civil and military actors. Dual-use assets have become common place, military payloads are embedded on board civil satellites, and some military forces extensively procure services and products from commercial operators, at least for non-sensitive operations. Similarly, to reinforce the resilience of critical space systems, new architecture designs are emerging. For instance, governments are now considering constellations of small dispersed satellites to avoid the concentration of capacity in a few powerful but vulnerable satellites, as well as the development of responsive launch capabilities for the quick replenishment of failed assets.

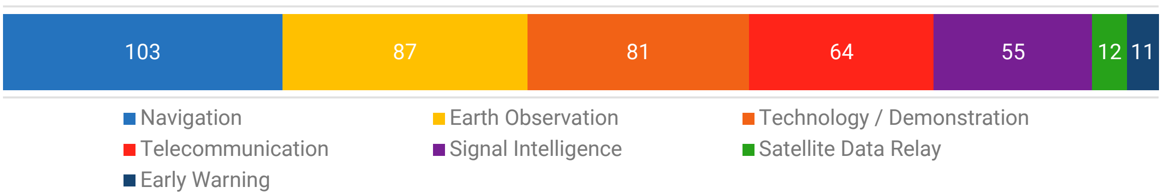

Figure 16: Military and dual use payloads 2010 - 2019 by mission category (Source: ESPI Database)

In parallel, threats have multiplied. Beyond the unintentional hazards created by the growing congestion of key orbits and debris, space assets have become potential military targets. All major space powers have invested in the elaboration of means to physically disrupt others' space capabilities. Several anti-satellite (ASAT) technologies have been developed and tested in actual conditions over the last few years, including China (2007), the United States (2008) and India (2019). Beyond "Kinetic kill", Rendezvous and Proximity Operations (RPO) technologies are another means of impairing spacecraft. There has been progress in research on directed-energy weapons. Cyber threats to space systems are also rapidly increasing, against ground installations, but against the space segment as well.

Facing the multiplicity of such new threats will most likely not rely solely on technical countermeasures but could likely include the elaboration of various strategies of deterrence, political alliances, or attempts to agree internationally on some "rules of the game" for space operations. Many nations are already reconsidering their postures and doctrines regarding space. A global trend resulting in the integration of space as a warfighting domain, comparable to land, sea and air, is emerging. The United States, Japan and France are renewing the place of space in their military organisation; some major powers are challenging the U.S. "space dominance" doctrine, seen as a "space supremacy" goal. As a consequence, space increasingly appears as a field of political and technological rivalry that could become an arena of conflict. Some major developments are summarised in the Figure 17 below.

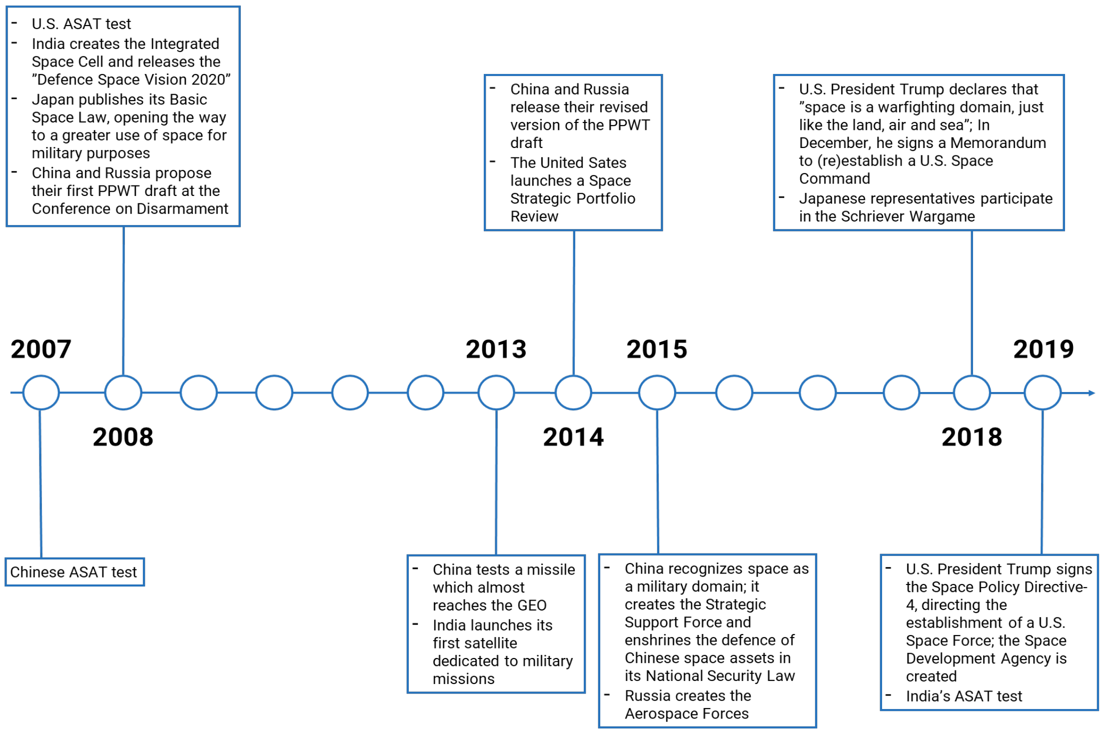

Figure 17: Major extra-European events in space security between 2007 and 2019

As the figure shows, over the last decade all major space powers have started to emphasize the higher significance of space in a military context. Several underlying trends can be identified in this respect:

- Strategic thinking: Reflecting growing geopolitical tensions, all major space powers have adopted more assertive postures, in order to improve and exhibit their readiness to act in space and through space and have emphasized the importance of deterrence as a strategy to face potential adversaries. Moreover, western countries have taken steps to start reinforcing their cooperation to face threats, avoid casualties in space and quickly recover from an attack thanks to mutual assistance.
- Operational level: All major space powers have, or expect to, reorganize their armed forces, to give a greater place to units dealing with space, especially at operational level. This enhances their capacity to use space for security and defence purposes on Earth (through better integration with other branches of the military, for instance), but also aims at developing the protection of their assets in space (through better space situational awareness, among others).
- Capability development: These developments have led states to envisage other ways to exploit dual-use space assets (e.g. RPO technologies) or to implement technologies that have both offensive and defensive applications (e.g. lasers). With the noticeable exception of kinetic weapons, most on-going technological developments are related to capabilities aimed at disrupting, rather than destroying, space assets.

With specific respect to this latter trend, the 2019 Secure World Foundation Report on Global Counterspace Capabilities highlights that *"the evidence shows significant research and development of a broad range of kinetic (i.e. destructive) and non-kinetic counterspace capabilities in multiple countries. However, only non-kinetic capabilities are actively being used in current military operations."* [39]Indeed, the evolution of state postures is backed by the development of capacities aimed at disrupting space systems. The ongoing intensification of research on counterspace weapons was showcased by the March 2019 Indian ASAT test and the July 2020 Russian test. There is also evidence of ongoing ASAT programs, particularly with regards to non-kinetic ASAT tests and dual-use capabilities, potentially suited for counterspace purposes.

Beyond their implications for possibly increased deployment of weapons in space, ASAT weapon tests are also heavily scrutinised due to their contribution to space debris creation. The space environment is more uncertain, in part because ASAT technologies are now available to a larger number of actors, who could get them thanks to the spreading of space and ballistic missiles technologies. However, the current trend is heading primarily towards a growing investment in these weapons by established space powers. Though only four countries have demonstrated kinetic ASAT capabilities in the past – the USA, Russia, China, India –, technically less demanding forms of counterspace capabilities (electronic warfare or cyber) are considered to be available to more actors, including non-state actors.

Ambivalent dual-use technologies with "dormant" military potential are also growing in significance. The issue of dual-use applications, which is central to military reflections on space, is best illustrated by the rise of rendezvous and proximity operation (RPOs) technologies. This technology could be used in the future for in-orbit servicing, as well as active debris removal, which could increase the security of space assets by eliminating the most important unintentional threat facing space systems.

On the one hand, RPO technologies appear thus essential to the future of space by making it sustainable, a reason for states to invest in it. However, on the other hand, RPO devices can be quickly repurposed to be used as a weapon against an adversary's satellites in case of conflict. Therefore, some tests have created concern. These include China with its 2010, 2013-2014 and 2016 experiments, which were publicized as maintenance or active debris removal tests, Russian and U.S. unusual moves close to the satellites of other nations in recent years, sometimes deliberately avoiding being spotted, and missions of the U.S. X37-B project.

Growing competition in space

The increasing geopolitical tensions and growth in military space activities create a number of misperceptions that inevitably impact interstate relations in the space arena. Whereas international cooperation continues to be a defining feature of civil space relations between both established and emerging players, competition dynamics are also substantially on the rise, as exemplified the revival of the notion of "a new space race" between the United States and China.

Despite China's declared interest in avoiding a space race or a strategic arms race, when looking at three main arenas of competition that defined the first space race (competition for soft power, competition over the military capability of hard power, and competition about the provision of services or public goods), all these ingredients seem already ingrained in China-U.S. relations.

In the area of human spaceflight and exploration, the road of U.S.-China cooperation is blocked by the Chinese exclusion policy of NASA and the current geopolitical context does not seem to offer promises of change. Actually, the road of an open competition seems to have been already paved by the adoption

[39] Brian Weeden and Victoria Samson. *Global Counterspace Capabilities: An Open Source* Assessment. Secure World Foundation (April 2019). Retrieved from: https://swfound.org/media/206408/swf_global_counterspace_april2019_web.pdf

of the U.S. Space Policy Directive 1 and ongoing implementation of the Lunar Orbital Platform-Gateway (LOP-G) venture.

With regard to the acquisition of military space capabilities, an escalation of competitive trends is apparent. In response to the astonishing growth in Chinese military space capabilities the U.S. has been expending significant resources in military measures intended to defeat potential Chinese counter-space initiatives and reduce the risks of a "Pearl Harbor in space". For most commentators, the potential for inadvertent escalation is real and, sooner or later, the prisoner´s dilemma in which the US and China look trapped may inevitably trigger a space arms race.

Finally, with regard to the provision of international space services and public goods, new market realities have emerged, providing clear indications of increasing competition between the two giants. China is gradually, yet continuously, gaining market segments at the expense of the traditional space powers, above all the U.S., and its approach to cooperation is indirectly challenging the "rules of engagement" in the provision of commercial space services set by the West. This is visible not only in the Asian region, which could become the backyard of China's aerospace industries, but also in Africa and Latin America, where Beijing has reached out to many international partners and customers. Further competition in this arena can hence be expected.

In sum, in the three main arenas of competition that defined the first space race, Sino-American relations can easily be regarded as incipiently confrontational and channelled along a trajectory similar to that taken by the two original space antagonists. While other trajectories might eventually become possible, these confrontational dynamics are already directly or indirectly impacting other actors as well as the broader international space landscape and its governance prospects. [40]

3.3.3 Ambivalent space governance developments

The governance of space activities has difficulty in keeping up with technological developments and the changing characteristics of the global space sector. The current international legal framework based on the legacy of UN space treaties, individual national regulatory frameworks and increasingly common soft law instruments does not provide a universal set of common rules for engagement in space. Particularly difficult and open to interpretation is the regulation of new types of space activities (commercial utilisation of space resources, space tourism, active debris removal, large NGSO constellations), since appropriate instruments have not been developed.

On the one hand, the unwillingness of states to develop new legal instruments or revisit provisions of the existing ones creates a rather dim outlook for the adoption of new binding instruments at international level. On the other hand, some advances in soft law, bottom-up initiatives and TCBMs have been recently reached, primarily through the adoption of new international guidelines and standards (space debris, long-term sustainability) and self-regulation initiatives by industry.

From a legal standpoint, their actual effectiveness can be easily challenged. Nevertheless, they represent willingness towards up-to-date rulemaking and delineate the current perimeter of maximum possible agreement regarding the platform, legal force and content. Content-wise, the 21 Guidelines on the Long-term Sustainability of Outer Space Activities, adopted recently in the UN COPUOS and UN General Assembly, are tackling some of the key issues conditioning the safety, security, and sustainability of space activities. Future work within the UN COPUOS on this issue has started, and some countries have pledged to incorporate the provision of LTS guidelines into their national regulatory frameworks for space.

[40] Marco Aliberti. *When China Goes to the Moon…*. Springer, Vienna, 215.

A. Policy and regulatory framework for space activities	
A1.	Adopt, revise and amend, as necessary, national regulatory frameworks for outer space activities
A2.	Consider a number of elements when developing, revising or amending, as necessary, national regulatory frameworks for outer space activities
A3.	Supervise national space activities
A4.	Ensure the equitable, rational and efficient use of the radio frequency spectrum and the various orbital regions used by satellites
A5.	Enhance the practice of registering space objects
B. Safety of space operations	
B1.	Provide updated contact information and share information on space objects and orbital events
B2.	Improve accuracy of orbital data on space objects and enhance the practice and utility of sharing orbital information on space objects
B3.	Promote the collection, sharing and dissemination of space debris monitoring information
B4.	Perform conjunction assessment during all orbital phases of controlled flight
B5.	Develop practical approaches for pre-launch conjunction assessment
B6.	Share operational space weather data and forecasts
B7.	Develop space weather models and tools and collect established practices on the mitigation of space weather effects
B8.	Design and operation of space objects regardless of their physical and operational characteristics
B9.	Take measures to address risks associated with the uncontrolled re-entry of space object
B10.	Observe measures of precaution when using sources of laser beams passing through space
C. International cooperation, capacity-building and awareness	
C1.	Promote and facilitate international cooperation in support of the long-term sustainability of outer space activities
C2.	Share experience related to the long-term sustainability of outer space activities and develop new procedures, as appropriate, for information exchange
C3.	Promote and support capacity-building
C4.	Raise awareness of space activities
D. Scientific and technical research and development	
D1.	Promote and support research into and the development of ways to support sustainable exploration and use of outer space
D2.	Investigate and consider new measures to manage the space debris population in the long term

Table 7: 21 UN Guidelines on the Long-term Sustainability of Outer Space Activities (UN Doc. A/74/20, Annex 2)

At national level, regulatory developments are proceeding at different speeds. The number of countries with national space laws, either comprehensive or specific, is increasing. Recently, countries including Finland, Ukraine, New Zealand, and the UAE have confirmed this trend by adopting new national legislations. Established spacefaring countries such as the United States, China, France or Luxembourg are enhancing their existing legal frameworks and regulatory processes with new instruments to accommodate to new types of activities and allow for commercial expansion.

Newcomers in the space domain do not always adopt sound legal instruments, which drives concerns regarding the proper adherence of launches and payloads licensed in such country to baseline safety standards. Some other countries have developed legal regimes that go beyond the international requirements, either to further increase safety requirements or allow for innovative commercial activities. This incoherence in national legal frameworks for space activities creates risks of "flags of convenience" (private actors choosing to license through the least demanding regulatory framework, possibly at the cost of reduced adherence to safety measures) or risks of overregulation damaging competitiveness and commercial perspectives.

The regime for coordination of in-orbit traffic (including crisis situations such as high-risk conjunction warnings) is rather outdated and poised to lead to increased orbital collisions risks, if no innovative solutions are created and implemented. Current practices revolve mostly around e-mail distribution of conjunction data messages and ad-hoc e-mail or phone call coordination between operators. There are as yet no established sound protocols for collision avoidance procedures (in particular when two active spacecraft are subject to a conjunction warning), and the contemporary international legal regime for space does not provide for any "rights of way" in orbit.

On the other hand, recent developments have also brought about positive effects in space safety, security, stability and sustainability. These stem from the numerous activities and processes undertaken by different platforms, including civil-military collaborative frameworks (e.g. EU SST), industry groupings (e.g. CONFERS, Space Safety Coalition, etc), international standardisation bodies (e.g. ISO, ECSS), space agency programmes (covering, for instance, SSA capabilities, spacecraft design, collision avoidance manoeuvres…) as well as private initiatives for commercial SSA services and active debris removal.

4 Challenges for Europe

The unfolding transformations of the global space sector are bound to have important implications for the strategic objectives set forth in the European space strategy. Two objectives in particular are put at stake due to their inherently international dimension, namely Europe´s ability to

- Foster a globally competitive and innovative space industry
- Access and use space in a safe and secure manner

4.1 International challenges to the competitiveness of Europe´s space sector

Most of the trends presented in Chapter 3.1 are bound to exercise a significant impact on the international competitiveness of the European space sector, posing a number of new challenges or magnifying already existing ones. The challenges for Europe on the way towards fostering a globally competitive and innovative space industry can be categorized as follows:

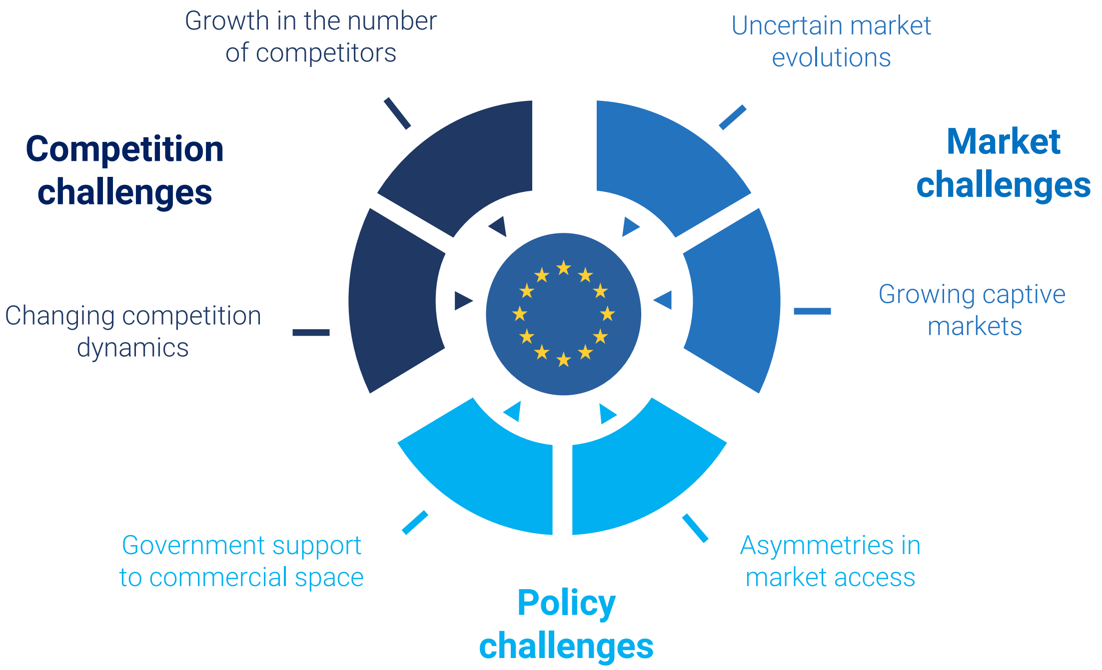

Figure 18: Challenges for Europe to ensure the competitiveness of the space industry

Each of the identified challenges further translates into concrete risks negatively impacting Europe´s strategic objective of fostering a globally competitive and innovative European space sector to increase its share on the world space markets A more detailed description is provided below.

4.1.1 Competition challenges

Growth in the number of competitors

The most visible challenge faced by the European space industry is the sharp increase in the number of competitors that has been brought about by the very expansion of actors and activities described in Chapter 3. Although also associated with inherent opportunities for the future growth of the European industry (e.g. increasing demand for European products and services from new emerging space nations), this expansion has also fostered a growth in the number of competitors.

Europe is already faced with strong international competition, but new competitors are arising due to the greater involvement of the private sector in space activities and the emergence of New Space, the rise of new "spacefaring" nations bringing new ambitions in space, and the return on the commercial markets of actors that had been previously inactive.

The growth in competition is premised on the more aggressive space strategy pursued by all major space powers (see section 4.1.3), which are now increasingly emphasising the importance of international space markets and hence directly or indirectly challenging Europe's leading positions, particularly in the commercial launch market and in the satellite manufacturing market.

The increased focus on commercial markets among space powers

The evolution of space policy strategies in major countries reflect as a common denominator the ambition to capture a greater share of the international market:

- The United States views its commercial space sector as a key to the success of its space dominance doctrine. Consistent with this, the U.S. government has taken a hands-off regulatory approach in nurturing the development of the commercial space industry. This is clearly reflected in the recent adoption of Space Policy Directives that are meant to streamline the regulatory process. The declared objective is to "unshackle the American industry and ensure (it will) remain the leading global provider of space services and technology".
- China is driven by the resolve to affirm itself as "a space power in all respects". Consistent with this overarching goal, the 2016 White Paper underlines that China will encourage and support Chinese enterprises to participate in international commercial activities.
- Russia is continuing a fundamental reform strategy of its industrial structure to completely reshape and streamline industry to meet all military security requirements, while increasing the share of Russian companies in the worldwide market and maintaining their scientific potential. In 2015, Russia announced government plans to effectively support Russian corporations on the international market of space services and in 2017, Roscosmos SC was mandated to "decrease budget expenditures by increasing export potential".
- In Japan, commercial markets have traditionally been considered outside the reach of the national industry. In the 2015 Basic Space Plan, however, the government recognised that in order for Japan's space industry to expand in scale and compensate its limited domestic demand, it is essential to capture the growth of overseas markets, particularly in emerging countries. Ensuring access to these growing overseas markets is now a major axis of Japan's industrial strategy.
- India's space strategy continues to be primarily premised on meeting domestic requirements, but commercialisation of space-based products and services is now seen as a complementary instrument to better seize the utilitarian benefits stemming from the Indian space programme while contributing to generating revenues, boosting the growth of a private industrial ecosystem, and furthering India's economic expansion and productivity gains.

Looking at the launch service market, Europe has historically had a principal competitor in Russia, with most of the market shares disputed between Ariane and Proton launchers. However, over the past few years the commercial launch market has experienced an abrupt change in the main competitors.

The most visible and structural change is the abrupt advent of SpaceX, which in the span of a couple of years has imposed itself as a fierce competitor on the commercial launch market. Thanks to its large backlog of U.S. institutional payloads and the significant support received from the U.S. government through the COTS programme, the company has been able to pursue an aggressive penetration pricing strategy in the commercial market, thereby threatening the position of established launch providers. Since the launch of its first GTO commercial satellite (SES-8) in 2013, SpaceX has built a significant commercial backlog for Falcon 9, winning many customers that formerly would have been all but certain clients of Arianespace launch consortium or of ILS. [41]

In parallel to the successful comeback of the U.S. on the commercial market, a series of failures of the Proton and Zenit rockets in 2012 and 2013 led potential customers to avoid signing new launch service contracts with ILS and Sea Launch. In 2014, for the first time, no commercial launches were booked on the Proton-M and Zenit launch services, an occurrence signalling the end of the longstanding Ariane-Proton duopoly. Among its most immediate effects, the commercial success of Falcon 9 – combined with the string of failures of Proton and Zenit – has created a situation where commercial satellite launch contracts since 2014 have been exclusively signed by Arianespace and SpaceX. While in the heavy GTO segment Ariane still holds almost a monopoly, competition has already become stiffer in the market for smaller GTO payloads (below 5,000 kg), with Falcon 9 strongly competing against all GTO launch providers. Also, in the LEO segment, whose commercial offer was entirely dominated by converted Russian ICBMs (Dnepr and Rockot), the market penetration of SpaceX has proved successful.

An even more striking trend is the abrupt change in the main competitors on the commercial market. New competitors are entering the commercial market as demonstrated by the efforts currently undertaken by many launch service providers that have previously been mostly inactive. In Japan, MHI has announced its intention to compete on the commercial market with the support of export financing mechanisms and by offering packages (satellite construction and launch) to emerging nations. In the United States, ULA has started to proactively revitalise its efforts to capture commercial payloads, motivated at least in part by the astonishing success of SpaceX.

China has started to offer a portfolio of alternative launch solutions for its platforms (restricted on the international market by U.S. export controls regulations) and also India has been winning several commercial launch contracts for its PSLV rocket, partly motivated by the government planned hand-over of exploitation responsibilities to industry as well as the resolve to offset operational costs. Even if ITAR restrictions continue to limit the impact of Chinese launch vehicles and domestic demand limits the availability of the PSLV, it should not be overlooked that these launch vehicles are still benefiting from low production costs, allowing them to possibly undercut the prices that are currently being offered.

Moreover, significant development programmes are currently underway in all the major spacefaring nations. In the new decade, the new GTO-capable vehicles will be Ariane 62/64, Vulcan, Falcon 9/Heavy, H-III, Long March 5/7, GSLV Mk-III, and Angara A5, alongside previous generation vehicles until their respective phase-outs. Non-GTO vehicles will be represented by Vega-C, Epsilon-II, Long March 6/7, Minotaur-C, Antares, Falcon 9, PSLV, Soyuz 2.1v and Angara 1.2.

The next few years will be thus characterised by a larger offer of launch vehicles. As major development efforts are progressing towards operational readiness, offering increased flexibility and promising cost reductions, competitive pressures are expected to further stiffen and to challenge the position of established actors.

It should be highlighted however that this growing competition is taking place in a market whose overall demand in the GTO segment is assumed to remain stable over the medium term. Additional supply could thus potentially lead to a situation of overcapacity similar to that of the early 2000s, consequently leading to the emergence of a buyer's market, in which prices would be the strongest differentiator between providers.

[41] Peter B. de Selding. "Satellite Operators Press ESA for Reduction in Ariane Launch Costs". Space News (April 2014). Retrieved from: https://spacenews.com/40193satellite-operators-press-esa-for-reduction-in-ariane-launch-costs/

Historical Competitors	Current/Emerging Competitors
Europe (Arianespace) Russia (ILS)	Europe (Arianespace) United States (SpaceX, ULA) Russia (ILS, Glavkosmos) India (Antrix) China (CGWIC)

Table 8: Historical and Emerging competitors in the launch service markets

An equally challenging situation is arising in the commercial satellite manufacturing industry. Until recently, most of the competition in this market centred on six commercial prime contractors from Europe and the United States, namely: Airbus Defence & Space and Thales Alenia Space from Europe, and Space/Systems Loral (Maxar), Boeing, Lockheed Martin and Orbital ATK (now Northrop Grumman) from the United States. While also competing with a number of smaller commercial prime contractors – e.g. Japan's Mitsubishi Electric Corporation (MELCO) – these six primes have traditionally reigned over the largest market share, insulating their competitive positions by differentiating their products and by increasing switching costs in the form of ground equipment upgrades for their customers.[42]

Notwithstanding the already intense rivalry between these prime contractors in Europe and the United States, in recent years the competition has further intensified with the entrance into the commercial market of additional national prime contractors. In particular, three notable national prime contractors, CASC through its CGWIC commercial arm of China, ISRO of India through its Antrix commercial arm, and ISS Reshetnev & Khrunichev State Research and Production Space Center of Russia, have begun entering the commercial market, carving out a niche market in low cost commercial satellites.

Among these new competitors, it is now widely accepted that the Chinese space industry poses an increasing threat to the position held by the European industry. China has indeed started to explore the international satellite manufacturing market by competing for commercial contracts, although so far only with governments of emerging space nations searching for low-cost alternatives. Yet, it seems that it is only a matter of time before China has the means to gain even more market share from the top satellite integrators. The quality of Chinese satellites, i.e. capacity, reliability, and lifetime, has significantly improved, while remaining low-cost due to the lower wages of skilled technicians and operators in the country and strong government support. With China having won several contracts from telecommunication operators in developing countries with its DFH-4 commercial communication satellite, it has become the main emerging competitor in the commercial satellite marketplace. In addition, the imminent introduction of a new Chinese high-end satellite platform and of a small full-EP platform may also raise the interest of established satellite operators to turn to Chinese solutions.

The next country expected to make major steps forward is India. While the focus of India's satellite manufacturing industry is still mainly to serve domestic customers, it has shown incremental space advancements and technological breakthroughs that have allowed it to emulate the technological level of Western spacecraft manufacturers. In addition, skyrocketing domestic demand and other factor endowments such as the low cost of labour and favourable exchange rates are providing a strong basis to offer competitive solutions and break into the international market, most likely emerging as a fierce competitor in the short to medium term.

[42] That differentiation, developed with a focus on cost reduction and increased capabilities for customers, is robust among mature prime contractors whose customers (i.e. major commercial satellite operators) also compete for market share, expanding coverage into emerging regions. The latest differentiated satellites marketed by the main competitors include cutting-edge technologies such as electric propulsion, high-throughput, and low-latency, among others, with each technology having the potential to change the game within the commercial space sector.

Besides these large space players, contractors from new countries, such as Turkey, Israel and Saudi Arabia, are expected to break into the international market in the short to medium term and challenge the European position (see Box). Particularly in the current environment of contraction in the conventional GEO satcom sector, this excessive growth in the number of commercially active satellite manufacturers may lead to an oversupply, possibly blunting Europe's competitive edge and causing a decline of its market share in the global commercial satellite manufacturing industry.

Historical Competitors	Current/Emerging Competitors
Europe (ASD, TAS, OHB) United States (Lockheed Martin, Boeing, Northrop Grumman, Maxar)	Europe (ASD, TAS, OHB) United States (Lockheed Martin, Boeing, Northrop Grumman, Maxar) China (CASC/CGWIC) Russia (Reshetnev, RKK Energia, Khrunichev) Japan (MELCO, NEC) India (Antrix) Saudi Arabia (Taqunia Space) Argentina (Invap) Israel (Israeli Aerospace Industries)

Table 9: Historical and Emerging competitors in the commercial spacecraft manufacturing

All in all, European prime contractors increasingly appear to be in a watershed period, faced with increasing competition from the traditional U.S. competitors, while simultaneously being pressured by low cost manufacturers catering to emerging regions that seek less sophisticated technology at a discounted price. Moreover, competitors in the United States have the luxury of responding to a giant well of domestic institutional investment when commercial demand dries up; and new commercial competitors in China, India, and Russia are state-financed and thus to some extent cushioned from commercial pressures. Considering the scarcity of new contracts and the uncertain demand prospects, the level of competition, and the challenges posed by the so-called New Space primes, maintaining a significant role in this domain will become more and more challenging.

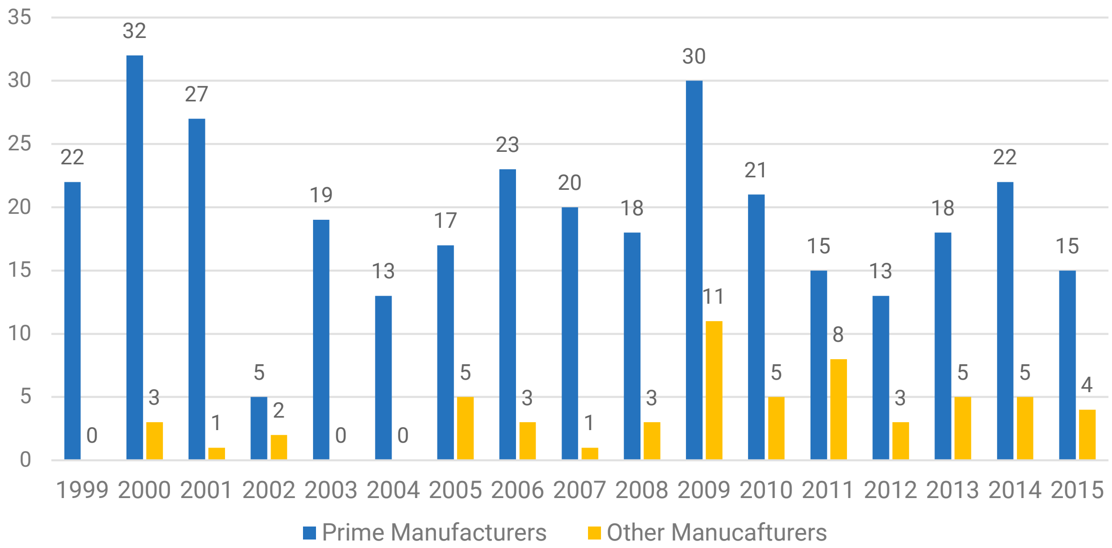

Figure 19: Commercial communication GEO satellites ordered by year (source: ESPI Database)

Changing competition dynamics

Another major challenge for the competitiveness of European space industry are the changing competition dynamics brought about by unfolding technological shifts and the closely interwoven advent of New Space, which is premised on these shifts.

Although acknowledged as an inherent opportunity, it is also undeniable that the emergence of new private actors with ambitious strategies that give prevalence to market disruption is a non-negligible competitive threat for well-established traditional space industries in Europe. From an industrial perspective, the influence of New Space goes well beyond the sole New Space endeavours initiated recently. It actually also impacts the behaviour of historical commercial players (i.e. manufacturing industry, launch service providers and satellite operators) eager to seize the opportunities offered by this new trend but also increasingly challenged by new and aggressive competition.

Specifically, the challenge does not simply stem from the entry into the commercial markets of a plethora of new actors, including large Information and Communications Technology (ICT) firms, start-ups and new business ventures; but rather from the combination of these new entrants with the adoption of innovative industrial approaches, and disruptive market solutions offering, for example, integrated services, lower prices, reduced lead times, lower complexity or higher performance among other value proposition features.[43.]

Such new entrants are challenging the historical approach adopted for space programmes with new processes, business models and solutions. Their emergence creates new challenges for well-established industry players who are forced to adapt their strategy to take into account this new competition.

More companies are already operating across boundaries, in geographical terms (exporting on the worldwide market), in sectorial terms (offering services across the vertical markets), and in technological terms (utilizing a blend of different technologies). Not only New Space companies embrace agile approaches, short development cycles and COTS, but they are also open to technology spin-ins from other sectors so as to accelerate development.

In many instances, the products and services in the process of being developed by Europe's competitors are based on technological breakthroughs that are not always sustaining (i.e. evolutionary), but often disruptive, and hence bound to significantly affect existing markets or ultimately overtake these markets.

Among these technologies, a visible example is rocket reusability as adopted by SpaceX and Blue Origin, which will likely become a key determinant for the competitiveness of commercial launch service providers. However, there are many more instances of technological breakthroughs that will be a game changer for several business models. Among these, those that are expected to exercise the greatest impact are summarised in Table 10, together with the affected business model segments.

Even though "European firms remain competitive with regard to many innovations that have impacted the space industry, such as micro- and nanoelectronics, digital transformation and convergence, and optical and ubiquitous communications, this leadership has rarely translated into a commercial advantage within the space sector". According to the EIB, "one of the reasons for this dissonance between European innovation and competitive advantages is the fact that specific technology champions are not active enough in space or the associated technology transfer is not effective enough.[44]

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[43] Alessandra Vernile. *Executive Summary. The Rise of the Private Actors in the Space Sector*. ESPI, 2018.

[44] "An example of this type of shortfall can be seen within the micro- and nanoelectronics/ advanced telemetry and telecommand area, where the highly innovative automotive and aviation industries are working on an ever-increasing sensor suite to perform health monitoring and predictive maintenance of systems. On the other hand, this European expertise is not materialising in the form of companies offering these services/ applications/systems within the space domain". Source: Alessandro de Concini and Jaroslav Toth. *The future of the European space sector. How to leverage Europe's technological leadership and boost investment for space ventures.* European Investment Bank (2019), p. 49

Additionally, risk capital funds are in limited supply for ventures that are looking to commercialise their innovative technologies. The scarcity of scale-up funding in Europe is a critical shortfall, which often leads to a flight of talent and companies to the U.S., where the financing landscape is currently more favourable.[45]

	Launcher industry	Satellite Manufacturing	Satellite Services	Ground Equipment	National Security	Crewed and robotic Space Science and Exploration	Space Tourism (incl. Habitation)	Energy, Mining, Processing and Assembly
Acceleration of generation change/obsolescence				X				
Advanced manufacturing technologies/3D printing						X	X	X
Micro- and nanoelectronics/advanced telemetry and telecommand				X				
Agile development and industrial standard implementation		X		X		X		X
Artificial intelligence (AI)/Man-machine interface (MMI)			X	X				X
Change detection and data fusion			X		X			X
Digital transformation and convergence				X				
Evolved expendable/reusable launcher systems	X					X	X	X
Miniaturisation and nanotechnology	X	X	X	X	X	X	X	X
Optical and ubiquitous communications					X	X		X

Table 10: Trends impacting business model segments (source: adapted from EIB)

It should also be highlighted that most European initiatives to support innovation have focused mostly on product concepts and the early stage of innovation, with a Technology Readiness Level (TRL) between 1 and 5. However, later phases of the technological process (high TRL) should also be properly covered to ensure the ultimate availability of these technologies and relieve the users from the financial burdens and risks associated with the full qualification of the required technologies. In this respect, qualification and in-orbit validation are essential steps to bring innovative technologies to the right level for risk-free implementation in European programmes and for commercialisation. Therefore, more attention should be given to the maturity and readiness aspects. This is a challenging task, since it requires harmonisation of potentially conflicting priorities as well as an institutionally funded mechanism that can completely bring European technologies within an application or operational programme.[46]

It is worth highlighting that the issue of maturation of technologies was seriously addressed in the United States with the creation of the Defense Advanced Research Projects Agency (DARPA) in 1958. To date, no equivalent structure can be found in Europe, although the envisaged establishment of a European Innovation Council (EIC) well underscores Europe's need to support the qualification and commercialization of high-risk, high-impact technologies.

[45] Alessandro de Concini and Jaroslav Toth. *The future of the European space sector. How to leverage Europe's technological leadership and boost investment for space ventures.* European Investment Bank (2019)
[46] Marco Aliberti, Matteo Capella & Tomas Hrozensky. *Measuring Space Power: A Theoretical and Empirical Investigation on Europe*. Springer, 2019.

In the absence of adaptation to these new technological developments and, more broadly, sectorial trends, the principal risks are that:

- European institutions will not be able to adequately support their industry and research communities to retain and grow their positions in the global space sector, with this possibly resulting in a failure to create new markets that are led by the European industry.
- "Traditional space" companies may see a progressively reduced importance, also due to the political attractiveness that "new space" companies exert on institutional stakeholders. Perceived as more dynamic, younger, more reactive and proposing attractive and concrete solutions, new space companies may somehow "distract" the political attention needed to sustain the space sector.
- Much of the supply chain may be captured by a few, large non-European players and some European companies might disappear completely from the market.

4.1.2 Market challenges

Uncertain market evolutions

Another major challenge for the competitiveness of European space industry is the disruption of traditional business models and markets brought about by the unfolding technological (r)evolution described in Chapter 3, the closely interwoven advent of New Space that is premised on this revolution, and the uncertain changes in the demand conditions in commercial space markets.

Whereas most sectors are experiencing profound changes in user requirements and demand conditions, the most evident case in point is the global telecommunications sector, which has traditionally been instrumental in sustaining the entire European space industry, but whose profound transformation is now having uncertain ripple effects along the entire value chain.

The SATCOM sector is undergoing a complete transformation, as market and technology forces converge, and newer technologies emerge. There have been changes in user demand with the emergence of new connectivity requirements increasingly pressing satellite operators to align with the concept of universal access. Perhaps the largest change currently affecting satcom is the major shift from watching broadcast and satellite broadcast television to watching non-linear television over the Internet.

Since reaching a peak in 2015, satellite TV broadcasting has been in decline. However, this decline has come at a time of significant oversupply in the market for both conventional Fixed Satellite Service (FSS) capacity and High Throughput Satellite (HTS) capacity, leading to falling prices for capacity to be sold in the market. The prices for new contracts are estimated to have fallen by 30-60% over the past four years[1].The contraction in satellite TV revenues and the falling prices resulting from oversupply have had a ripple effect throughout the industry, hitting satellite operator turnover, and, as a consequence, generating an even harder effect on satellite manufacturing.

Revenues of all major satellite operators – which are the principal source of business for satellite manufacturers – have indeed been decreasing, with 2019 being the sixth consecutive year of revenue contraction[1]. The cumulative revenue contraction is estimated to be in the order of 15.9%, compared to the peak in 2013 and approx. 41.7% down on where it should have been by now had the previous "business as usual" growth continued. As a consequence, "the satellite operators' businesses are now at a certain degree of risk, and a round of mergers and acquisitions, asset stripping and reorganisations started in 2018, albeit with limited completions.

Contraction of revenue in the satellite operator sector (the principal source of commercial GEO satellite orders) has also had a significant knock-on impact on conventional satellite manufacturers, which are no longer sustained by the "business as usual" model of 20-25 large GEO satellite orders per year and are now struggling amid a multiyear slump in geostationary satellite orders. Nowadays both GEO satellite orders and the backlog of GEO satellites are at an all-time low; a situation that puts conventional satellite manufacturers' businesses at risk. The effects of this multiyear slump in GEO satellite orders are already visible on the major U.S. and European primes, which over the past 2 years have announced significant layoffs due to weak sales. The first one was Maxar/SSL, which in February 2019 announced that it would dismiss roughly 3% of its employees and withdraw from the GEO manufacturing business. Maxar was followed in September 2019 by Thales Alenia Space (TAS), which announced it would cut around 6% of its workforce, and eventually by Airbus Defence and Space (ADS), which in February 2020 decided to cut about 7% of its workforce (2,362 positions).[1]

In parallel, the non-GEO mega-constellation sector is developing as a source of disruption but also alternative growth to the stagnation of the traditional GEO satcom sector. New actors with strong backers are emerging, together with an unprecedented level of innovation, new models of development and a shift of risk/responsibility, which demand more and faster developments from the supply chain. The paradigmatic change in the production of satellite and satellite equipment transcends and has a high potential impact on the core satcom manufacturing sector.

Indeed, the geostationary (GEO) satellite market is now at a crossroads: whereas for almost 50 years the vast majority of satcom services has been provided by progressively larger GEO satellites (with about 350 such satellites in use as of 2019), nowadays two main directions are simultaneously unfolding: larger satellites integrating maximum capacity (VHTS / UHTS – Very / Ultra High Throughput Satellites) and flexible programmable satellites that are lighter, take advantage of the low-cost high-volume production introduced with mega-constellations, and provide customers with the capacity to adapt to evolving demands of the market.

All in all, the sector is facing unprecedented uncertainties that further stiffen dynamic competition fuelled by the opportunities that the digital transformation of many economic sectors offers to satellite communications.

Growth in the size of captive markets

Besides uncertain market evolutions, another key challenge for the competitiveness of the European space industry is the growth in the size of institutional captive markets.

Worldwide, the space market cannot be considered as an open business, and the open commercial market, where European industry has been very successful so far, represents just a fraction of the total.

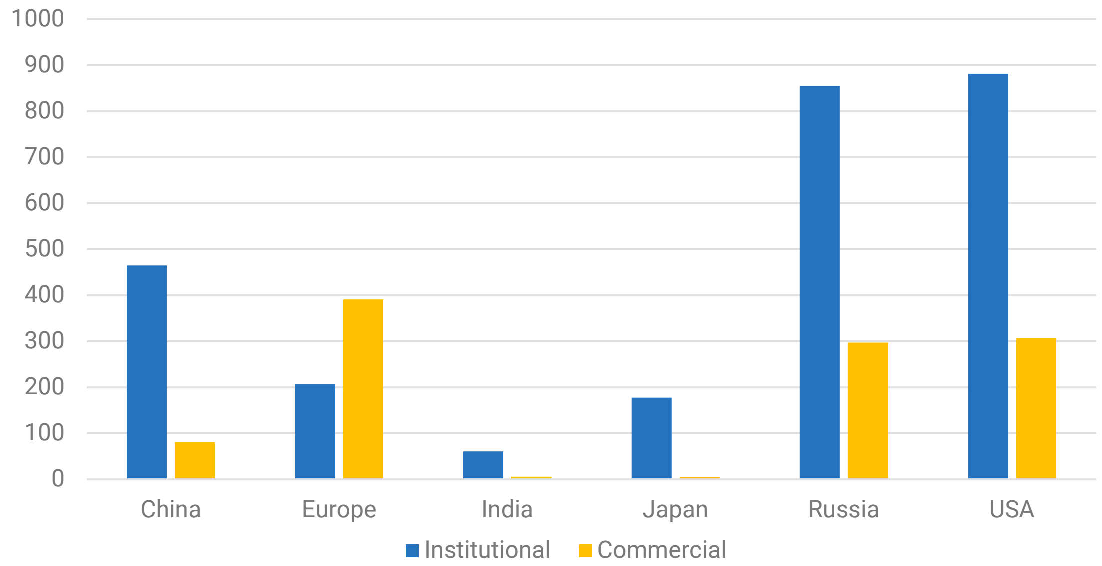

Figure 20: Commercial and institutional launches in mass (2010-2019, in metric tons)

According to ASD-Eurospace, only 36% of total space activity worldwide in the past two decades is represented by open markets, i.e. markets that can be served by international competitive contracts, while 64% (in mass) comprises institutional captive markets. These "captive" markets are a source of concern for European industry for a twofold reason: a) they cannot be accessed by European satellite manufactures or launch service providers and b) they create a negative externality to the "open" commercial markets to the detriment of European industry. In fact, the volume of orders in these "captive" institutional market produces a distortion of competition because it allows competitors to generate larger scale production which allows them to offer lower prices on export markets (see next section).

Whereas this challenging situation is widely acknowledged by European stakeholders, the rapid expansion of space activities, particularly among emerging competitors such as China and India, translates into greater volume asymmetries and a reduced competitive advantage for Europe, since its space domestic market (for launchers and spacecraft) remains one of the smallest among the major space powers. China has more than doubled its annual launch rate reaching 39 launches in 2018 and 34 in 2019 - the highest rate worldwide - that in addition is almost exclusively focused on domestic payloads. India conducted the fifth largest number of launches in 2018 (7), and equalled Europe at the fourth place in 2019 with 6 launches. This growth of the institutional captive markets is a global success enabler and – just like unfair price competition through national subsidies and price dumping – it can have the effect of distorting the terms of competition across commercial markets to the detriment of European services.

Another challenging dynamic is the expansion of the industrial capabilities of emerging nations, whose institutional demand may progressively become captive to domestic pressures, thus reducing demand for European products and services. While in the launch service market only a dozen countries have been able to establish a launch capacity to serve institutional needs, over the past few years more and more emerging space countries have acquired the capacity to domestically manufacture satellites (even geostationary satellites) and hence have successfully transcended the need to rely on the commercial space market to purchase products.

Among others, countries such as Turkey, Argentina, Brazil, which have formerly been important customers of Europe, have established national capacity to operate indigenously integrated satellites. Although trade in satellites has seen growth over the past two decades (see Focus Box[47]), a major risk is that these markets become captive markets for European space providers and satellite operators.

Satellite exports

- Satellite exports have been growing in value and number since the 1990s.
- The United States is the main exporter of satellites worldwide, the main destination for U.S. satellite exports being Europe.
- European countries provide the largest destination market for satellite exports (worth $5 billion in the past decade).
- In the meantime, Europe is a net exporter of satellites. Europe is the 2nd global satellite exporter, after the USA: as a result, satellites are net positive contributors to the EU global trade surplus.
- However, Europe has persistently suffered from a trade deficit on satellites with the United States (>$2 billion in the decade).
- U.S. exports to Europe were more than double European exports to the United States.
- This deficit is compensated for by the trade surplus on satellite markets with other countries (e.g. Saudi Arabia, Canada, Brazil…).

[47] Pierre Lionnet. *Two decades of satellite exports*. (September 2019). Retrieved from: https://eurospace.org/wp-content/uploads/2019/10/two-decades-of-satellite-exports.pdf

4.1.3 Policy challenges

The challenges posed by the growth in the number of competitors and uncertain market developments are closely intertwined – and further exacerbated – by another major challenge, namely the competitive distortions that Europe´s competitors directly or indirectly apply to sustain their national industries.

As emphasised in Chapter 3 above, public agencies in all the major space countries heavily support their space industry sector through specific national policies. Support practices that are common to most countries include

- the direct injection of funding to finance R&D and stabilise industrial activities (i.e. subsidies),
- share of assets to cover fix operational costs to maintain space infrastructure (e.g. the launch infrastructure),
- institutional programmes that support technological developments and allow industry to reduce non-recurring costs
- policies and regulations to limit foreign competition and sustain competitiveness of national industry, including:
  - industrial and procurement policies making use of anchor tenancy arrangements
  - policies that "prescribe" the use of specific space-based services
  - export control regulations,
  - trade policies and economic diplomacy,

Procurement policies: asymmetries in market access

Among the policy challenges confronting the competitiveness of the European industry, a major source of concern is the widespread and intensifying use of anchor tenancy arrangements, generally defined as "arrangements in which a government agrees to procure sufficient quantities of a commercial space product or service needed to meet government mission requirements so that a commercial venture is made viable". [48]

The implementation of these arrangements – typically in the form of strict procurement rules for governmental satellites and launch services – has two important consequences:

- on the one hand, it ensures predictability for national industry through long-term commitments on the demand side.
- on the other, it prevents national markets from becoming accessible to foreign suppliers

The recurring demand of institutional customers for domestic supply remains nowadays "the first guaranteed basis to stabilize industry´s activity" [49] and sustain international competitiveness by generating economies of scale that will in turn allow amortization of fixed operational costs thus enabling lower price offers on export markets (see Focus Box). Put in other words, the volume of orders from "captive" institutional markets acts as a source of distortion of competition, because it creates an externality to "open" commercial markets.

Besides generating distortions to the competition terms (through volume asymmetries), the preference granted by most institutional customers to national suppliers contributes to creating challenging asymmetries also in terms of market access.

Institutional markets are often not accessible to European spacecraft manufacturing industries and launch service providers. According to the estimates of ASD-Eurospace, over the past two decades only

[48] Definition provided by article 51 of the United States Code, entitled National and Commercial Space Programs
[49] ASD-Eurospace. *Towards a "Space Economic Diplomacy" – Contribution of the European Space Industry*. Position Paper (2017)

36% of the total space activity worldwide (expressed in mass) has been an accessible market to European suppliers. In fact, the largest share (64%) of global space markets remains associated with institutional programmes subject to strict procurement rules (preference clauses) that hence prevent these markets from being accessible to any foreign supplier[50]. In particular, all institutional missions of USA, Russia, China, Japan and India – which represent the largest portion of the total market – have been satisfied by domestic suppliers. Hence, by default, they have precluded any competition from European suppliers.

Conversely, the European institutional market – whose size is already more limited compared to the U.S., Russia and China – has been often open to competitive bids. Europe is indeed the only major spacefaring actor for which a "domestic preference clause" for institutional missions is not systematically implemented, with both commercial and institutional actors often purchasing from foreign suppliers.

As a result of these diverging dynamics, whereas foreign suppliers have had – and continue to have – easy access to European markets and customers, Europe struggles to penetrate foreign institutional and commercial markets.

To illustrate, over the past decade, 16 U.S. satellites have been sold to European customers, whilst only 2 European satellites have been sold to U.S. operators, with Europe hence suffering from a trade deficit on satellites with the United States (see Focus Box)[51].

A similar situation can be observed in the launch service market. Over the past two decades, the totality of Russian launch demand has been exclusively served by Russian launchers, whereas 40% of Europe's total launch needs have been satisfied by Russian launchers. Moreover, several European countries have also turned to U.S. launchers (most notably, Space X's Falcon 9) for their institutional missions, *de facto* making Europe the only space actor in the institutional field that simultaneously finances the development of an autonomous fleet of launchers, and yet often purchases launch vehicles from foreign providers.

Competitive distortions in the launch service markets

A Unlike Arianespace, whose business success is strongly connected to its performance on commercial and foreign institutional launch markets, launch service providers from all the major space power benefit from strong public support during exploitation of their launchers.

This support during exploitation on the commercial market has typically materialised in two forms. The first and more direct is the direct injection of public funding that helps cover a part of the exploitation costs. Governments typically consider these costs as "sunk", or unrecoverable. As a consequence, the actual cost of a launcher in terms of operations is not necessarily reflected in the offering price, as would happen if launchers were "just another commodity".

Governments of Arianespace's competitors also cover the costs associated with maintaining launch infrastructures. China, Russia and India finance the totality of costs associated with the exploitation, maintenance and adaptation of launch facilities, while in the United States, the Air Force, NASA and state governments shoulder the bulk of these expenses. Conversely, Arianespace contributes to the direct funding of Europe's spaceport through more than €200 million external procurements per year (fixed costs) dedicated to the exploitation and maintenance of the Kourou spaceport.

The second and perhaps more important form of support is the guarantee of a stable and predictable launch business base that is ensured through the captivity of institutional payloads to domestic launch systems: American, Russian, Chinese, Japanese and Indian Launch *(continued on next page)*

[50] *Ibid.*
[51] Lucas Buthion European Space Diplomacy. *13th ESPI Autumn Conference*. Vienna: September 2019.

(continued from previous page) Service Providers all benefit from long-term procurement contracts ensuring exclusive access to their respective civil and military governmental market. Clearly, the size of this market is a strong success enabler.

For the sake of comparison, "the US captive institutional market, civil and military, represents more than $5 billion per year for domestic launch related procurement activities, while the European institutional market, which too often has been open to competitive bids, represents only around €500 million per year".[52] Figure 21 below shows the asymmetries in the volume of captive launches in Europe and other major space powers.

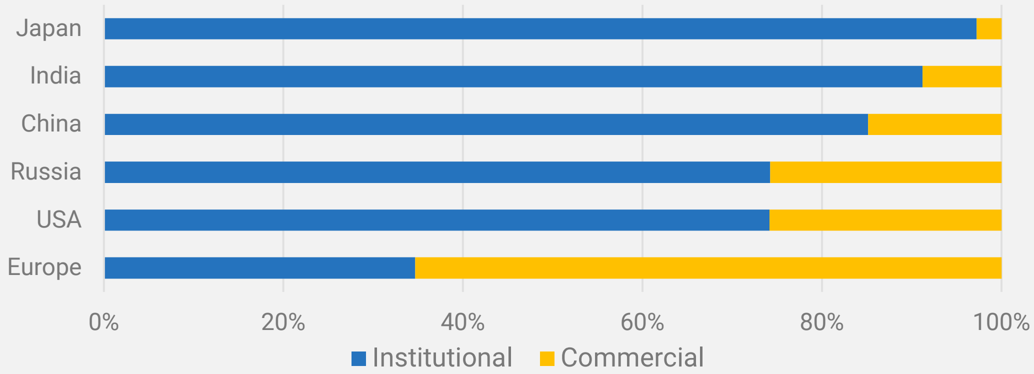

Figure 21: Percentage of captive launches (by volume) in several countries

As evident from Figure 21, all Arianespace competitors can benefit from a larger institutional market for launch services, a market that enables them to amortize fixed costs over more launches and creates economies of scale enhancing the competitiveness of a given launcher.

The competitive advantage offered by the asymmetry in volumes of captive launches is further exacerbated by the fact that institutional launches are typically offered at significantly higher prices than those applied to the commercial launches. For instance, the prices paid by the U.S. government for Space X's Falcon 9 are substantially higher than those charged to commercial operators and have been estimated to correspond to more than two times that of commercial prices. More specifically:

- The price for commercial and foreign institutional launches ranges from $45 to $75 million with prevailing offers around $55-60 million
- The price for institutional launches for NASA and DoD ranges from $82 to $112 million, with prevailing offers above $100 million.

Thanks to the large backlog of institutional payloads and "extra" revenue generated by the more rewarding institutional contracts, foreign launch service providers are able to pursue aggressive penetration pricing strategy on the open market with the sole objective of killing all competition.

All in all, the extent of public support is so wide and engrained in the structure of the launch business that even for internationally competed launch contracts, the commercial space launch market cannot be correctly labelled as a "free and fair" trade environment.

These cases reflect a unique and worrisome situation, which – in light of the limited institutional demand – will make it increasingly challenging for Europe to sustain the current level of excellence of its launch and space manufacturing industry.

[52] Eurospace. *Eurospace position paper on aggregation of European institutional launch services*. (July 2018). Retrieved from: https://eurospace.org/wp-content/uploads/2018/07/eurospace-pp-on-aggregation-of-european-institutional-launch-services_july-2018.pdf

Use of economic diplomacy

Besides securing an institutional domestic market for their space industries, foreign competitors are also increasingly adopting aggressive market penetration strategies to support the competitiveness of their industry by favouring space exports.

Together with price dumping and unfair price competition through national subsidies, trade policy and economic diplomacy have become important instruments that major countries have turned to in order to support and expand the positions of their national space industry worldwide.

These tools have been particularly important for those countries seeking to circumvent export control restrictions, as in the case of China, or those countries seeking to compensate the limited domestic demand, as in the case of Japan. The key features and tools used in the economic diplomacy of China and Japan are shown in the Focus Box below.

Examples: space economic diplomacy in China and Japan

China

Excluded from competing in the international launch services market for any major Western satellite, China has developed an original strategy to capture launch service and satellite manufacturing contracts in emerging countries, mostly under larger economic schemes including other infrastructure projects. More specifically, the China Great Wall Industry Corporation (CGWIC) – a subsidiary of China's state-owned Enterprise CASC – has made a business case of selling all-inclusive 'In Orbit Delivery Contracts'. These contracts include satellite manufacturing, insurance, and launch on-board the Chinese Long March rocket. They also often include the construction of ground segment facilities, the training of satellite operators, and financing in the form of a generous loan.

Different packages are offered, such as Long March 3 for GEO satellites DFH-4 platforms (5.2t, 10.5kW); Long March 5 for GEO satellites using DFH-5 platforms (7t, 20kW); Long March 2 for small remote sensing satellites, and also a payload piggyback option or a rideshare on Long March 11 are envisioned. CGWIC has been successful in selling these inclusive satellite packages to fast-growing developing countries in Asia, Africa and South America. Since the signature of the first commercial in-orbit delivery contract (Nigcomsat-1) in 2004, CGWIC has exported several DFH-4 communication satellites to the governments of emerging space nations, including Venezuela, Pakistan, Bolivia, Laos, Belarus, DR Congo, Nicaragua, Sri Lanka, Thailand, and Ethiopia. Although China has been mainly focusing on selling GEO communication satellites, it has also started to export smaller EO satellites, such as VRSS-1, the first Venezuelan remote sensing satellite, which was launched in 2012.

It is important to highlight that China's space diplomacy targets those countries in which China has a particular strategic interest, for example oil exporters, as well as African nations and neighbouring countries, in exchange for their natural resources and raw materials. These satellite contracts are often based on barter agreements with other clauses included in the contract. In the case of Nigeria, oil deals, political connections, influence in Africa and hard currency were factors influencing the agreement. Exporting satellites is therefore more than a money-maker; it is part of China's overall space diplomacy to improve space collaboration and deepen cooperation in all areas with developing countries in order to strengthen bilateral ties. *(continued next page)*

This is also the case within the framework of the "Asia-Pacific Space Cooperation Organization" (APSCO) programmes, China's *primus inter pares* position allowed the country to increase the demand for launching satellites using its Long March rockets. Such strategy fits within the broader effort of China to use space to emerge as an alternative to the United States, and claim the political leadership of developing countries, both in the African and Asian contexts.[53]

Japan

Over the past years, Japan has activated its diplomatic channels and put in place a variety of measures to capture the growth of overseas markets, which are mainly expanding in emerging countries.

The first and most notable measure lies in the establishment of a "Task Force on Space System Overseas Development" composed of actors from the government and the private sector involved in the space sector. This Task Force's role is to examine specific overseas expansion measures from a strategic perspective, identifying the potential needs of the partner countries in terms of equipment, services and human resources so as to propose appropriate solutions.[54]

A second measure for promoting overseas markets access lies in the promotion of package sales (which comprise launch service, satellite systems, personnel training, etc.) especially in emerging countries. This practice has thus far achieved mixed results, but Japan is strengthening this measure by tailoring the package according to partner countries' needs. Towards this, Japan is holding direct dialogues with user agencies in the partner countries to better understand their needs and is devising additional support tools, including the development of a service business using the traded satellite systems; the development of human resources; support to the space policy development in the partner countries; the comprehensive utilization of various government support measures, including government development funds, Official Development Assistance (ODA), and other government funds (OGF); and the establishment of a local subsidiary dedicated to aftercare services such as maintenance as part of the package. Consistent with these measures, Japan has already implemented cooperation in human resource development with Vietnam, UAE and Turkey, and has held consultations with the UAE, Thailand, Indonesia, Myanmar and Australia for formulating strategic projects.

A third measure concerns the strengthening of industrial cooperation to improve and accelerate downstream applications & services development, particularly in the field of PNT and remote sensing. The cornerstone of such cooperation services is the Asia-Pacific region, where Japan is promoting the use of its Quasi-Zenith Satellites System (QZSS) to contribute to PNT information services, disaster prevention, and improving the efficiency of agriculture, forestry and fisheries industries. In this regard, Japan has already started to launch pilot projects to promote the utilization of QZSS among ASEAN countries, including Thailand, Vietnam and Indonesia. Moreover, in cooperation with the Task Force on Space System Overseas Development, Japan has started promoting cooperation for establishing networks of electronic reference stations in the Asia-Pacific region.

A fourth measure includes mechanisms to support the creation of partnerships between industrial players in Japan and third countries. The development of these partnerships is seen as an instrumental move to help the promotion of Japanese technologies around the world, thus opening more opportunities for Japanese businesses outside the national market. Among these mechanisms, of particular interest is "S. Booster in Asia" a space business contest for Asia-Pacific countries launched in 2019 by the Cabinet Office. The contest invites space-based business ideas from entrepreneurs and individuals in the region to promote mutually beneficial business activity and collaboration with the space community in Japan. These measures are considered a precious opportunity for companies in Japan to explore new business potential with other Asian countries.

[53] Marco Aliberti, *When China Goes to the Moon…* 2015. Springer: Vienna
[54] Marco Aliberti & Sara Hadley. *Securing Japan. An Assessment of Tokyo strategy for space.* ESPI Public Report n°74 (July 2020). Retrieved from: https://espi.or.at/publications/espi-public-reports

This active involvement of governments in space economic diplomacy plays a substantial role in the performance of their domestic industry on commercial markets and directly challenges the position gained by the European space industry.

In particular, the "package agreements" proposed by the Chinese and Japanese space industries but strongly backed at the political level, have already won many customers in emerging markets that traditionally would have been all but certain clients of European or U.S. suppliers.

The risk is hence that these instruments may in the future impede the further penetration of both Europe's satellite manufacturers and launch service providers in the emerging markets of Latin America, Africa, and the Asia-Pacific.

The risk is further intensified by what can be labelled the "European paradox": the fact that although Europe has a strong level of exposure to these commercial markets, it is also the one making the least use of economic diplomacy instruments to sustain its interests by supporting and expanding the positions of its domestic space industry worldwide.

Export controls measures and regulatory reforms

Another major international challenge for the competitiveness of the European industry is posed by the increasingly active involvement of governments in regulatory affairs. Just as price dumping and unfair price competition can have the effect of distorting competition across a whole industry, so too can government policy, laws and regulations restrict the penetration of space markets by European industries or generate extraterritorial effects putting European space companies at a competitive disadvantage.

Among these tools, export control regulations are the most visible challenge. Export control remains a major hindrance factor for global competition. While most governments apply export control measures for sensitive items, the most visible controls put in place are those applying to the export of U.S. manufactured goods. Since most commercial satellites use U.S. components, the measures are an effective tool for controlling, case-by-case, the participation of non-U.S. competitors on the commercial satellite and launch services markets.

By regulating the exports of technology and equipment with military applications, the U.S. Government thereby imposes unilateral and stringent controls that provide the U.S. with a tool for potential extraterritorial coercive responses, both by limiting the export of critical U.S. technology as a competitive tool and by even further limiting the access of European competitors to foreign institutional markets.

This situation is mainly due to Europe's high dependence on non-European critical components and technologies, which in itself is already an important hindrance factor for Europe's competitiveness (see Focus Box on the next page). However, It has to be highlighted that as far as commercial applications on global open markets are concerned, not one single case of denial of export license has been opposed to any European space company so far. Nevertheless, it remains clear that the implementation of ITAR processes comes along with heavy bureaucracy, unpredictable delays and a great deal of uncertainty.[55]

All in all, export restrictions remain highly relevant to the European satellite manufacturing industry, particularly since satellite components sourced from the United States have the potential to keep a European prime contractor from selling satellite technology to export-restricted countries such as China, or to limit the available options for procuring cheaper launch services from other low-cost regions.

Besides export control measures, indirect challenges are also posed by the extraterritorial effects implied in the regulatory reforms promoted by some countries, particularly the United States, which has already

[55] ESPI. "Space Policy Directive 2: ITAR, an instrument of U.S. dominance". ESPI Executive Brief n°27 (December 2018). Available at: https://espi.or.at/publications/espi-executive-briefs

stated the willingness to "prioritize regulatory reforms that will unshackle American industry and ensure we remain the leading global provider of space services and technology".[56]

Europe's dependence in the context of industrial competitiveness

Europe's dependence is in itself an already challenging element for Europe's competitiveness. In fact, relying on sources outside Europe creates complications for European industry in terms of communication and quality control, and also introduces more risks with respect to the sustainability of supply. Reliance on components developed outside Europe can result "in longer lead times, increased costs and the potential non-availability for some European satellite manufacturers to high end technologies and or the detailed knowledge to use the technologies in the most optimal way".[57]

The lack of access to leading edge technologies inevitably produces limitations on the performance and output of European systems, which directly affects the competitiveness of European industry.[58] Besides affecting the cost and level of performance of industrial production and generating cost over-runs, dependency may also put on-time deliveries at risk, because of the "cumbersome paperwork to be performed, as well as the highly variable implementation of export control regulations".[59]

Because the dual-use and highly sensitive nature of most space technologies implies their subjection to export restrictions as strategic and defence-related items, the risk is that some of them may in the future become completely unavailable from exporters, or subject to even more burdensome procurement delays that can have serious effects on European space programmes.

A specific challenge in this regard is posed by the unilateral development of operational standards and best practices to promote safe and responsible behaviour in space. In this respect, the SPD-3 policy states that "a critical first step [...] is to develop U.S.-led minimum safety standards and best practices [...] and to use them to inform and help shape international consensus, practices, and standards." The work has already started with industry and experts' consultations launched by the DoC, FAA and FCC. Ultimately, these standards will be integrated into the U.S. regulatory framework including, in particular, certification and licensing procedures and will be promoted internationally.

As highlighted in a previous ESPI study, "although Europe shares U.S. willingness to promote safe and responsible behaviour in space, the unilateral development of U.S.-led standards poses an obvious risk of competitive disadvantage for the European industry. These standards will include specifications applicable at all stages of launcher and satellite operation. Compliance with these specifications will be a condition to get necessary certifications and licenses, for example by the FAA and FCC, and will inevitably create a disadvantage for European companies seeking to serve U.S. customers in the telecom domain, to compete on open U.S. satellite and launch markets, and also to participate in U.S. space programmes.

The promotion of such U.S.-led standards as a basis for the establishment of common global best practices could extend their influence on other markets. The impact on commercial markets would be particularly severe if insurance companies decided to consider compliance with these standards in the

[56] In February 2018, the re-established U.S. National Space Council adopted a second Space Policy Directive on "Streamlining Regulations on Commercial Use of Space". The objective of the SPD-2 is to ensure that "(...) regulations adopted and enforced by the executive branch promote economic growth; minimize uncertainty for taxpayers, investors, and private industry; protect national security, public safety, and foreign policy interests; and encourage American leadership in space commerce". The Directive addresses five areas: 1) commercial launch and licensing, 2) commercial remote sensing, 3) creation of an Office of Space Commerce within the Department of Commerce, 4) radio frequency spectrum management, and 5) export licensing.

[57] European Space Agency and European Commission. *European Space Technology Master Plan* (2018)

[58] Letizia Caito. *European Technological Non-Dependence in Space.* ESPI Public Report n°51 (September 2015). Available at: https://espi.or.at/publications/espi-public-reports/category/2-public-espi-reports

[59] Jean-Jacques Tortora. "European Autonomy in Space: The Technological Dependence". In Cenan Al-Ekabi, *European Autonomy in Space*. Vienna: Springer, 2015, p. 165-172.

calculation of premiums for satellites and/or launch services. The risk would be even greater if compliance with these standards required or implied the use of SSA/STM capabilities that only U.S. actors can provide. Such a situation would dramatically increase the power of SSA data sharing agreements as political and commercial levers and assert U.S. commercial dominance on SSA/STM markets. It is therefore clear that Europe must play a role in the development of STM standards and best practices to protect European industry interests and safeguard European strategic autonomy and freedom of action.

There could, however, be an opportunity to promote common standards and best practices provided that Europe plays an active role in their development. Such standards and best practices could form a second backbone for transatlantic cooperation. European and international standardization bodies (e.g. ECSS, ISO) could play an essential role to promote a coherent European contribution to the definition of common practices favourable to future programmatic cooperation, industry-to-industry collaboration and fair competition on international markets[60].

Government support to the consolidation of New Space

The competition challenge posed by the emergence of NewSpace is further amplified by the support measures put in place by all major space actors to stimulate the consolidation of this new dynamic. As already shown in previous ESPI studies, the success of NewSpace is indeed primarily dependent on the support public institutions offer, with New Space often seen as a mere new acquisition policy.

These support measures constitute an inherent challenge for the European upstream and downstream space providers and satellite operators, as they will certainly lead to the rise of new, potentially fierce competitors. Indeed, from a competition standpoint, the steady emergence and growth of new private actors outside Europe is a rising threat to the historical European industry position on global markets.

Certainly, European institutions have also been particularly proactive in fostering space entrepreneurship and private investment trends in Europe. This considerable effort is shared by the European Space Agency, the European Union, national institutions and other public bodies. In line with their respective strategies, the approach adopted by public actors consists principally in:

- Stimulating business opportunities: e.g. competitions, strategic partnerships, etc.
- Supporting product and technology innovation: e.g. grants, incubators, independent expertise, etc.
- Helping to raise capital: e.g. public funding (grants, loans, subsidies, prizes), partnerships with investment firms/institutions, etc.
- Building networks: e.g. hubs, conferences, business missions, etc.

European institutions are continuously exploring new mechanisms (e.g. in access to finance)[61] and their effort is now yielding concrete results, with various success stories emerging across Europe and positioning Europe as a competitor to other NewSpace ecosystems, including that of the U.S..

This notwithstanding, it is undeniable that Europe is lagging behind in its capacity to trigger and embrace private business leadership. In particular, the gap between the New Space dynamic in the United States and in Europe is still considerable. The United States appears to be in a pole position with the vast majority of endeavours taking place there. Although private investment and space start-ups in Europe have exhibited massive growth since 2014, the emergence of this dynamic remains slower and in general more cumbersome. Some elements can be highlighted to explain Europe's more limited role within New Space:

[60] Sébastien Moranta, Tomas Hrozensky & Marek Dvoracek. *Towards a European Approach to Space Traffic Management*. ESPI Public Report n°71 (January 2020). Available at: https://espi.or.at/publications/espi-public-reports

[61] Recent public actions include, among others, the introduction by the EU of a dedicated equity instrument (InnovFin Space Equity) or the creation of national equity funds such as the new Luxembourg Space Fund or the CosmiCapital fund launched by CNES. Pioneer in the support to entrepreneurship with the introduction of Business Innovation Centres in 2000, ESA also recently signed a cooperation agreement with the European Investment Bank, marking yet another milestone.

- European initiatives to foster entrepreneurship and/or leverage a more prominent role of private actors in space programmes are rather recent in comparison to the United States.
- Socio-economic conditions and cultural behaviour in Europe are considered, in general and beyond the space sector, to be less prone to entrepreneurship.
- Specific technology champions and space enthusiast tycoons are not active enough in space
- Even though the very first space-focused funds in the world appeared in Europe (UK, FR, IT, LU), their investment power is still small compared with the U.S. and Chinese ones. The overall private investment base is smaller in Europe and high-risk funds are not readily available [62] U.S. private investment alone is higher than available European funds, therefore creating a new pressure on the European space industry.
- The landscape of space sector support mechanisms is rather fragmented, with entrepreneurs finding it hard to navigate through the different possible funding options.
- European market fragmentation and lower demand (in particular from institutional markets) affect the potential viability of business models
- Existing support instruments are principally oriented towards the offer side. They are particularly effective in the early stages of product and business development but show some limits when getting closer to the market.

Overall, there appears to be two missing elements in the European approach to support New Space: creating a sustainable market for space-based services (i.e. promoting a "demand-pull" approach) and exploring new procurement approaches such as anchor tenancies or "innovation partnerships" to address the lack of a market (or at least of a primary market that would drive secondary ones).

Support to New Space in major countries

All major space-faring actors are supporting the emergence of New Space through a variety of measures:

- Creation of business-friendly space regulations. Examples include:
  - The United States promulgated the Space Act in 2015 in order to promote the entry of private companies into the space market.
  - Japan issued two dedicated laws: the Space Activities Act, and the Remote Sensing Data Act in 2016
  - China enacted the *Notice on Promoting the Orderly Launch of Commercial Vehicles* of 2019
  - India has drafted a Space Activities Bill, now under government review
- Growing utilisation of competitions, prizes and awards to incentivise private ventures (e.g. NASA Lunar Lander Challenge, USAF Pitch Day in the United States; S-Booster in Japan, etc.)
- Investment programmes to ease access to finance (United States, Japan, China)
- Initiatives to encourage the entrance of private actors into the space market.
- Mechanisms to promote the use of space data and technologies of NewSpace companies
- Mechanisms to connect actors in the space economy and spin-in/spin-off innovation. Examples include:
  - Tansa X in Japan
  - Skolkovo Space Cluster in Russia
  - Kerala Space Park in India

[62] Grants are indispensable to develop the technologies; however, high-risk, medium-term financing systems need to be in place to get technologies on the market and through the "valley of death". The lack of financiers such as VC funds is a critical shortfall within Europe, often leading to a "firm brain drain" to Silicon Valley or elsewhere. Start-ups leave just before they become scale-ups and create both jobs and wealth. Source: Alessandro de Concini and Jaroslav Toth. *The future of the European space sector. How to leverage Europe's technological leadership and boost investment for space ventures.* European Investment Bank (2019)

4.2 International challenges to Europe´s autonomy, safety and security

Besides impacting the competitiveness of European industry, the unfolding transformations of the global space sector have a distinctive impact on Europe´s strategic objective of reinforcing its autonomy in accessing and using space in a secure and safe environment to safeguard the benefits and opportunities offered by space and promote its position as a leader in space. Specifically, the identified meta-trends and sectorial trends translate into several challenges for Europe on the way towards ensuring its ability to achieve the overarching objective, as graphically captured in the Figure 22:

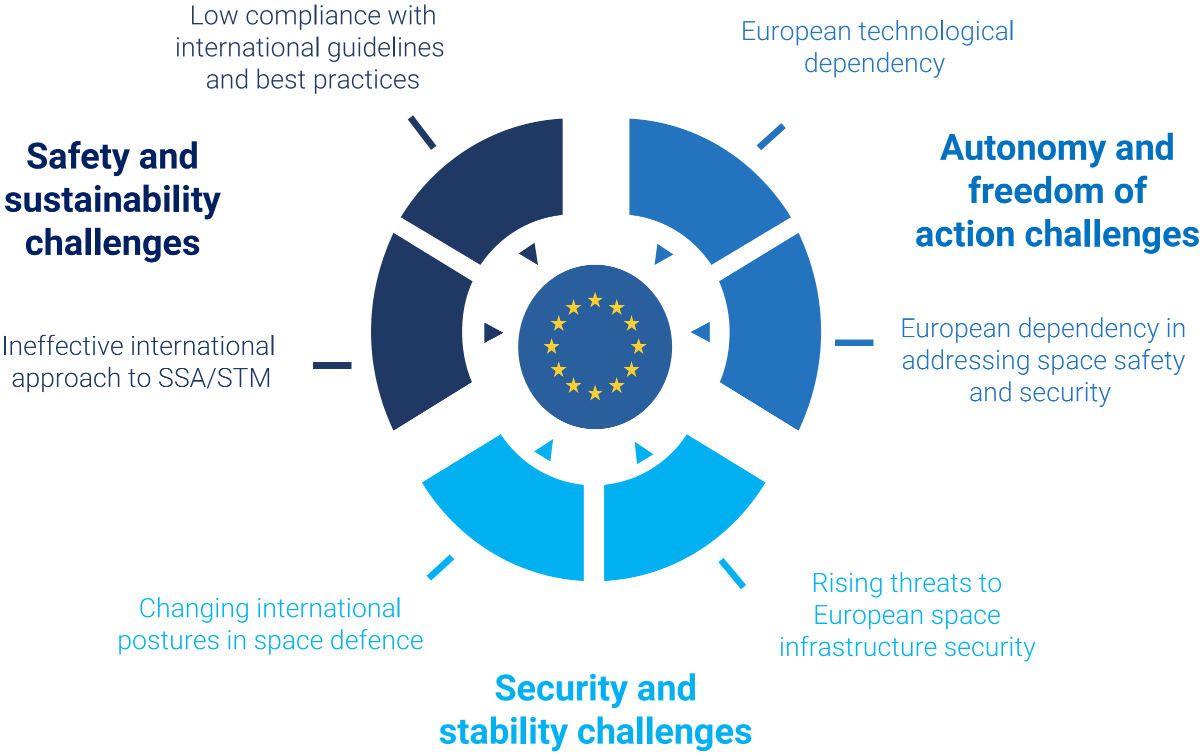

Figure 22: Challenges for Europe to ensure its ability to access and use space in safe and secure manner

Each of the identified challenges further translates into concrete risks that have a negative impact on the strategic objective of accessing and using space in safe and secure manner. A more detailed description of these different challenges and risks is provided below.

4.2.1 Safety and sustainability challenges

Safety and sustainability issues are strongly intertwined in the space domain. Ensuring the safety of space operations is indeed a necessary condition to preserve a sustainable operating environment in the future, and vice versa. As a consequence, preserving the safety and sustainability of the space environment requires complementary measures and capabilities to prevent, detect, characterize and respond to operational hazards.

As seen in Chapter 3, the space operating environment is changing, marked by a rapidly growing traffic of active satellites and debris and by the emergence of new concepts such as mega-constellations, CubeSats and on-orbit services. A congested space environment naturally amplifies the number of risks for space operations, in particular concerning collision and interference hazards. With respect to these risks several key points should be highlighted:

- Each piece of debris constitutes a potentially serious hazard to operational systems in orbit, and also to astronauts. A collision with a larger object, be it an operating satellite or a large chunk of debris can be even more disastrous leading to a total fragmentation of the object(s) and to a more or less substantial increase of the debris population, beyond the orbital plane of the two objects.
- Any orbital collision can have dramatic consequences for an operating satellite and/or for the space environment if the impact involves the creation of new fragmentation debris.
- The risk of collision is increasing sharply, together with the growing space activity and number of objects in orbit;
- This risk is not evenly distributed, and some orbits are more affected than others, in particular in the Low Earth Orbit region;
- The launch of large constellations is expected to increase collision risks substantially, even in case of partial deployment and full compliance with current preventive measures.

All in all, the congestion of the space environment is a broad safety and sustainability issue, affecting space activities at large. There is wide understanding within the international community that these prospects could dramatically increase the risks and cost of space operations, hamper commercial developments and even discourage future investments in space activities.

In this context of growing risks for space operations, the adequacy of current solutions to monitor space, detect hazards and prevent them as well as the suitability of current regimes governing space activities proves to be very limited.

Low compliance with international space safety and sustainability guidelines and best practices

Today, the prevention of risks of collision and other space safety and sustainability issues consists of a complex set of laws, regulations, standards and other binding and non-binding rules followed in different ways by international players.

Among the tools to prevent the escalation of collision risks, the principal one has been the definition and implementation of a set of principles outlining how space systems should be designed, operated and disposed of to mitigate their impact on the space environment, in particular regarding the generation of space debris. These principles were codified in 2002 by the Inter-Agency Space Debris Coordination Committee (IADC). These international space debris mitigation guidelines, revised in 2007, were endorsed by the United Nations Committee for Peaceful Use of Outer Space (UN COPUOS) and later by the General Assembly in 2007. There is a strong consensus among experts on the effectiveness of these guidelines if properly followed, as graphically shown in Figure 23.

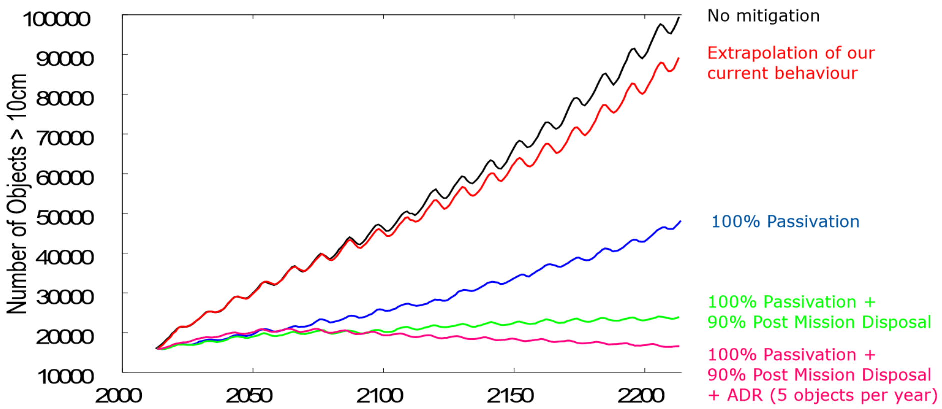

Figure 23: Effectiveness of spacecraft passivation and post-mission disposal measures (Source: ESA)[63]

[63] Holger Krag. *Managing Space Traffic for the Sustainable Use of Space* (February 2019). Retrieved from: https://espi.or.at/downloads/send/62-the-way-ahead-towards-operational-space-traffic-management/410-managing-space-traffic-presentation.

Even though some fundamental principles have been consensually adopted in international frameworks, the enforcement of these principles is left to the goodwill of governments, agencies and private companies, raising the inevitable question of the level of compliance.

A distinct challenge relates to problematic adherence to post-mission disposal guidelines put in place through these frameworks (IADC guidelines, UN Space Debris Mitigation and LTS guidelines, national regulations). According to the ESA Space Environment Report, "between 30 and 60% of all payload mass estimated as reaching end-of-life during the current decade in the LEO protected region does so in orbits that are estimated to adhere to the space debris mitigation measures [and] between 15 and 25% of payloads reaching end-of-life in a non-compliant orbit attempt to comply with the space debris mitigation measures. Between 5% and 15% do so successfully."[43] The report therefore suggests that the level of compliance with international guidelines for space debris mitigation is still rather low. In addition, experts estimate that the overall level of compliance could be negatively affected by the skyrocketing number of CubeSats launched every year that are rarely compliant with debris mitigation guidelines.[64] The level of compliance of large constellations also remains to be seen. While many large constellation operators repeatedly promise to be exemplary in this respect, collision hazards are inevitably bound to increase.

For instance, in a recent study on "the orbital debris collision hazard for proposed satellite constellations", it was estimated that the OneWeb constellation could lead to one catastrophic collision every 25 years and that the Space X Starlink constellation (based on 4,025 satellites) could lead to as much as one catastrophic collision every 20 months. This estimation is consistent with another study by NASA that attempted to calculate and forecast risks of collisions for different constellation scenarios, taking also into account the level of compliance with existing debris mitigation rules:

- Black scenario: Baseline, large constellations are not launched and 90% of satellites are compliant with Post-Mission Disposal (PMD) rules.
- Other scenarios: Large constellations are launched (8300 satellites) and replenished for 20 years and:
    - Green scenario: 99% of constellation satellites are compliant with PMD rules
    - Blue scenario: 95% of constellation satellites are compliant with PMD rules
    - Red scenario: 90% of constellation satellites are compliant with PMD rules

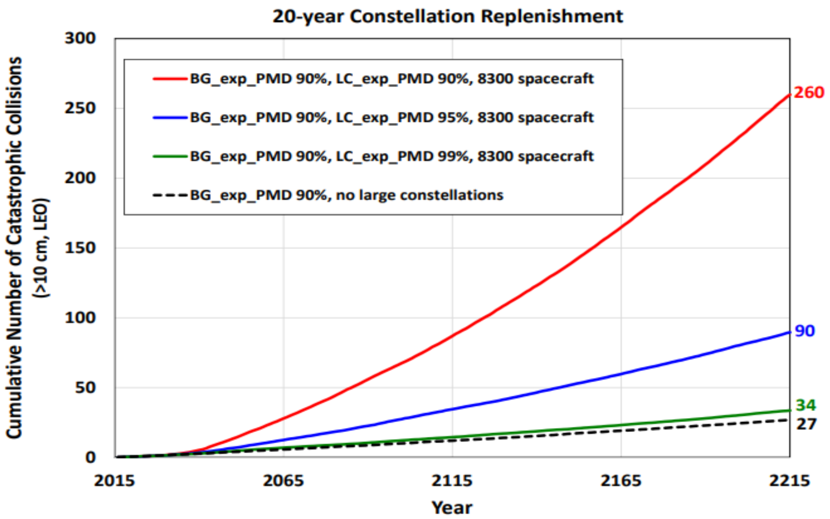

Figure 24: Cumulative number of catastrophic collisions according by scenarios (Source: NASA)[65]

[64] Christophe Bonnal. "Ensuring future sustainability of space operations: the orbital debris question". Communication to the United Nations Committee on the Peaceful Uses of Outer Space (February 2019). Retrieved from: https://www.unoosa.org/res/oosadoc/data/documents/2019/aac_105c_12019crp/aac_105c_12019crp_7_0_html/AC105_C1_2019_CRP07E.pdf
[65] NASA. *Orbital Debris Quarterly News*, vol 22., issue 3, September 2018. Retrieved from: https://orbitaldebris.jsc.nasa.gov/quarterly-news/

This model only shows catastrophic collisions involving objects larger than 10cm and leading to a total fragmentation of the target. Non-catastrophic collisions that result in lower damage to the target and a limited generation of debris would be much more numerous but are not shown here. These are rather optimistic scenarios based on the assumption of a very high level of compliance with PMD rules, which, unfortunately, are not systematically implemented.

Inadequate international solutions for SSA/STM

The protection of operating satellites from collisions requires the capability to properly detect, evaluate and respond to collision risks. The capability to monitor space objects and to predict and alert risks of collision is known as Space Surveillance and Tracking (SST) in Europe, which is one of the three pillars of Space Situational Awareness (SSA)[66]

SSA forms the foundation of space safety and sustainability as it enables safe and efficient space operations and promotes stability by reducing mishaps, misperceptions, and mistrust. SSA is an inherently international and cooperative venture as it requires a network of globally distributed sensors as well as data sharing between satellite owner-operators and sensors networks. Improved global SSA capabilities are a prerequisite to a future STM system, generally defined as the operational, policy, and regulatory measures taken to minimize the impact of space debris and on-orbit congestion in space activities.

However, the current level of cooperation on SSA/STM related issues remains rather limited, inevitably confronting Europe with a number of challenges to properly detect, evaluate and respond to collision risks.

A first challenge concerns the capacity to monitor a higher number of objects, at least those that pose a serious threat to safety/sustainability of space operations. Currently, the most advanced SSA capabilities (i.e. U.S. capabilities, shared partially with selected partners) can effectively track objects larger than 5-10cm in LEO and 0.3-1m in GEO. This is still insufficient with respect to the potentially damaging impact of smaller pieces of space debris in case of potential collisions - the lethal not-tracked population. Given the huge kinetic energy released on impact as a result of tremendous relative orbital velocities of resident space objects, even objects much smaller than the current trackability threshold pose significant risks to the safety of space operations or even sustainability of the space environment:

A second challenge is related to the limited accuracy of current SST data and the resulting uncertainty of conjunction analyses and collision risk evaluations. The issue was well explained in a recent report of the Aerospace Corporation: "there is uncertainty in the predictability of object locations during a conjunction. As a result, there is a predicted location for each object, but in reality, the object could actually be anywhere within an oblong "bubble" surrounding that predicted location[67]. The uncertainties that form this bubble are the result of a combination of inaccuracies in the sensor measurements and errors in predicting how the object will move in its orbit to the point of the conjunction." The level of uncertainty is very high with bubbles 100,000 times bigger than the objects. This leads to many collision risk alerts, which are difficult to manage

Conjunction analyses can be refined, using additional observations and extra analyst time to reduce uncertainties but current SST capabilities eventually reach their limits. As a consequence, satellite operators depend on rather inaccurate data[68] to decide whether to execute a collision avoidance

[66] Other SSA pillars include Space Weather (SW), which concerns the study of natural events in space that can affect space-borne systems or ground infrastructure; and Near Earth Objects (NEO), which concerns the detection and monitoring of asteroids and comets in order to assess and respond to potential threats to life and property on Earth.
[67] Glenn Peterson, Marlon Sorge & William Ailor. *Space Traffic Management in the New Space Age* (April 2018). Retrieved from: https://aerospace.org/sites/default/files/2018-05/SpaceTrafficMgmt_0.pdf.
[68] Emmanuel Delande, Moriba Jah & Brandon Jones. *A New Representation of Uncertainty for Collision Assessment* (January 2019). Retrieved from: https://www.dropbox.com/s/mit74j1q07t89cq/A_new_representation_of_uncertainty_for_collision_assessment.pdf?dl=0.

manoeuvre. This would not be a major problem if such manoeuvres did not have a significant cost in terms of disruption to the mission or reduced system lifetime. Evaluating collision risks more precisely and singling out those that justify a manoeuvre is therefore essential. The collision avoidance manoeuvre itself must also be properly planned. Indeed, such a manoeuvre impacts all other potential conjunction assessments. In a worst-case scenario, it could lead to an even higher risk of collision with another object.

On top of these technical challenges, the effectiveness of SST capabilities is further limited by difficulties in processing data into actionable information for all. Standardization of data formats, processing algorithms and models for data fusion from various sources are few of the main outstanding issues in the SST domain on the way towards more advanced, suitable capabilities.

In the case of a collision risk between two operating satellites, coordination between operators may also be a source of problems, as recently showcased by the Aeolus/Starlink conjunction.

On September 2, 2019, ESA manoeuvred its Aeolus satellite to avoid a potential collision with a SpaceX Starlink satellite. The event provided an excellent illustration of the limits of current best practices for space operations coordination.

The ESA operations team had contacted SpaceX approximately one week ahead of the anticipated close approach between the two objects which had a 1 in 50,000 collision risk probability. On 28 August, SpaceX informed ESA via e-mail that it did not intend to move the Starlink satellite. As the date of close approach drew closer, the ESA team calculated a significant increase in the collision risk probability (above 1 in 1,000). ESA claimed that subsequent inquiries to SpaceX remained unanswered and that, given the situation, ESA operations team decided to execute a collision avoidance manoeuvre. Later, after the event became public, SpaceX blamed a bug in the company's warning system, which prevented the operator from seeing the follow-on correspondence on this probability increase.

The situation showed the limits of current practices for space traffic coordination based on e-mail distribution of conjunction data messages and ad-hoc e-mails or phone calls between operators in case of high-risk warnings. There are actually no shared protocols for collision avoidance procedures, in particular when two active spacecraft are subject to alert.

Current capabilities to manage collision risks are therefore already limited. These limits will become increasingly problematic with the growth of the number of objects in orbit and resulting collision alerts. The current best practices for space traffic coordination, involving mainly manual work and ad-hoc processes, will no longer be suitable.

Mounting pressures on orbital slots and spectrum

The international community is witnessing growing pressures for access and utilisation of the electromagnetic spectrum for various means of telecommunications, including those enabled by space systems. The demand for access to spectrum is rapidly growing, reflecting the emergence of new spectrum-hungry connectivity concepts, such as the awaited 5G mobile networks. This is leading to spectrum shortage and is creating profound competition, despite increasing optimisation of the spectrum usage (frequency sharing, usage of higher bands, satellite payload digitalisation…).

The increasing demand for spectrum brings about new competitors (i.e. large tech companies, start-ups) and expects to squeeze various novel types of services (high altitude platforms, intelligent transport systems…) into the existing regulation. This leads to multiple competing candidates for the same spectrum rights and contributes to serious concerns of interferences, even among very different types of applications.

With specific respect to the space sector, the commercial deployment of new generations of satellites also impacts spectrum allocation. GEO networks are increasingly complemented by large non-GEO constellations, some of which are already in the operational phase. Interestingly, GEO satellite operators are also exploring these new non-GEO avenues. Some examples include:

- SES, which already operates and is currently upgrading its O3b MEO network, or
- Eutelsat, which has started a nanosat LEO constellation project (ELO) aiming at the IOT market

The reduced availability of spectrum could potentially lead to unavailability of this precious resource for European space activities. Given the ever-increasing importance of the availability of services provided by space infrastructures, issues related to spectrum put at risk the overall European objective to access and use space in safe and secure manner.

Concerns of the meteorology community regarding latest spectrum allocations

The ITU with 193 member states has the international mandate to set up and oversee the rules of spectrum utilisation for telecommunications. In late 2019, the ITU's quadrennial World Radio Conference (WRC-19) took place in Egypt, to adjust the rules of global coordination of spectrum utilisation and accommodate them to new global realities. The WRC-19 agenda extensively addressed the anticipated rollout of 5G mobile networks and in this sense, allocated more than 17GHz of new spectrum for cellular 5G.

One of WRC-19 outcomes disturbed meteorologists, who expressed grave concerns about new 5G spectrum allocations in the 26GHz band, arguing they may lead to unwished-for interference to space sensors operating in an adjacent band (and hence also to degradation of weather forecasting precision). The ECMWF statement on the WRC-19 outcomes[69] is very clear: *"The agreement reached (at* WRC-19) falls far short of ensuring 5G applications do not interfere with weather observations at 24 GHz... It is worrying and disheartening to watch history repeat itself and science losing to other societal pressures".

This struggle shows that global coordination might not always bring outcomes welcomed by everyone in the space community and calls for adequate processes for assessing the value of spectrum in situations requiring arbitrations, which will most likely increase in the future.

In similar fashion to the problem of spectrum, the physical availability of orbits and near-Earth space environment is also an essential space resource. Reduced availability of certain orbits and uncertainties about potential collision risks jeopardize the long-term sustainability of European investments in the space sector.

4.2.2 Security and stability challenges

Just like safety and sustainability, so too security and stability challenges are closely interconnected, with security (or lack thereof) impacting stability and vice-versa.

More muscular posture of major space powers and unclear governance prospects

As seen in Chapter 3, space activities are taking place in an increasingly complex and unpredictable environment. Two main factors contribute to this trend:

- A political factor, with growing tensions between states and shifts in the balance of power leading to a new stance towards space;
- A capability factor, with new threats appearing due to the progress of technologies and the readiness of states to use them for unfriendly purposes.

[69] Available at https://www.ecmwf.int/en/about/media-centre/news/2019/ecmwf-statement-outcomes-itu-wrc-2019-conference

These factors have been leading major governments to reconsider their doctrines and to adopt more muscular postures in the space domain (see Focus Box). The major space powers are:

- Starting to address space as an operational warfighting domain alongside land, air and sea. Many nations are now seeking to improve and demonstrate their capacity and readiness to treat outer space as a theatre of military operations. As a consequence, space increasingly appears as a field of rivalry that could become an arena of conflict.
- Reorganizing their armed forces to better address and integrate the space domain: Overall, it is the whole spectrum of space defence activities, from research, development and acquisition, to operation and command that is concerned, following new national doctrines and objectives.
- Developing offensive and defensive capabilities as part of space security and deterrence strategies: Major space powers are advancing technologies to disrupt space systems (e.g. kinetic or energy weapons, RPO, electronic and cyber) but also exploring new approaches to reinforce the resilience of their critical space infrastructure (e.g. distributed architectures, responsive capabilities).

The development of these weapons contributes to the destabilization of the global space environment because of their duality, which makes it difficult to decipher the ultimate intent behind their development. Indeed, even if all of them justify their work on this kind of armament by the desire to protect their assets and interests in space, the sheer nature of this domain makes differentiation between technologies developed for defensive or civil goals and those that serve offensive purposes almost impossible.

Major developments in space powers

China

Creation of the Strategic Support Force (PLASSF) to deal with cyber, space and electronic warfare issues. Several RPO experiments between 2010 and 2016.

India

Creation of an Integrated Space Cell within the HQ of the Integrated Defence Staff and creation of a Defence Space Agency. Test of an ASAT missile in March 2019.

Japan

Assignment of 100 people to the Space Domain Mission Unit, which performs SSA missions (for instance to collect intelligence on foreign capabilities) and conducts satellite-based navigation and communications. A first version will be set up in 2020.

Russia

At least six tests of Nudol, an anti-satellite missile, between 2015 and 2018 (according to U.S. sources). Clandestine recent RPO experiments (allegations of spying on Intelsat satellites, Athena-Fidus, or U.S. KH-11 satellite.

United States

Reactivation of the U.S. Space Command in August 2019 and Creation of the Space Force in December 2019. Several test campaigns of the X37-B, a classified space plane programme and RPO experiments.

A clear case in point are rendezvous and proximity operation (RPOs) technologies. Such technologies could be used in the future for in-orbit servicing, as well as active debris removal, which would increase the security of space assets by eliminating the most important unintentional threat facing space systems. On the one hand, RPO technologies thus appear essential to the future of space by making it sustainable, are a reason for states to invest in them. However, on the other hand, RPO devices can be quickly repurposed to be used as a weapon against adversary satellites in case of conflict.

Therefore, some tests have created concern, be it China with its 2010, 2013-2014 and 2016 experiments, which were publicized as maintenance or active debris removal tests, or the United States with the X37-B project, whose classified missions could range from the repair of satellites in orbit, to the gathering of intelligence, to an attack on other space systems. More recently, Russian and U.S. satellites have performed unusual moves close to satellites of other nations, sometimes deliberately avoiding being spotted (e.g. by moving in the shadow of Earth). Dual-use technologies are thus ambivalent, and, because of their "dormant" military potential, blur the boundaries between a peaceful and a potential hostile activity, thus contributing to misperceptions and mistrust between already suspicious states.

All these uncertainties and the broader identification of space as a warfighting domain, are in turn, progressively leading to an escalation of confrontational behaviour, inevitably producing a "security dilemma" - to defend itself from a perceived threat, each state is improving its armaments, thus increasing the fear of other states and leading them to increase even more their own arsenals.

For most space policy experts, the potential for even stronger escalation is inevitable and, sooner or later, the prisoner´s dilemma in which major space powers look trapped will trigger a space arms race.[70] The lack of consensus reached by the Group of Governmental Experts on the PAROS, which convened in March 2019, is but one indication of these worrisome prospects. It is just a matter of time, and according to many, the inevitably of a space war most strongly stem from being a self-fulfilling prophecy. [71]

In this increasingly tense environment, Europe is one of the only major spacefaring actors that does not display the same degree of political interest in development and deployment of counterspace capabilities as that of other major space powers. This in part stems from the European stance vis-à-vis the need to ensure responsible behaviour in space and, in part, from the fact that the military dimension of European space activities has not yet been properly established. However, it is clear that the increasing escalations on the international stage will have major repercussions on Europe´s ability to use space in a safe and secure manner. Actions to prevent the most negative scenarios are needed.

Rising threats to European space infrastructure security

Besides the growing challenges to the overall stability of the outer space environment, current developments pose undeniable threats to Europe´s space infrastructure security (SIS).

As seen in Chapter 2, because of the substantial, continuous and long-term investment in space infrastructure, the European space strategy attaches importance to the capacity to protect assets against threats in space. This need is amplified by the deepening integration of space systems and the services provided by them in other sectors. As the use of space applications becomes more pervasive, brings more benefits, and becomes part of the business-as-usual routine, dependence on them creates new vulnerabilities for the economy and society at large.

This criticality becomes even more evident when looking at the adoption rate of space-based applications and the amount of dependent Gross Value Added on these applications (see Table 11 below). there is a severe economic dependency on space assets in the majority of European economic sectors, and a particularly critical one in sectors such as agriculture and finance, with potential disruptive effects in case of space assets loss, not only in economic terms, but also social and environmental.[72]

Indeed, financial assessments of the downstream sector and economic benefits to end-users assess that more than 10% of the EU GDP is linked to the space infrastructure and that the total economic benefit is

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[70] See for instance: Laura Delgado Lopez. "Predicting an Arms Race in Space: Problematic Assumptions for Space Arms Control". *Astropolitics* vol. 10, issue 1 (March 2012), p. 49-67. See also: Michael Krepon and Julia Thompson (eds). *Anti-satellite Weapons, Deterrence and Sino-American Space Relations*. Stimson Center, Washington DC. 2013.

[71] Based on a new concept of technological development, S.M. Pavelec of the Air Command and Staff College has for instance strongly argued that "as technology advances, space weaponisation not only is likely, but indeed is inevitable in the near future". Interestingly, his core argument is that "the development of these weapons is inevitable and should therefore be accelerated in the United States, given the country's position as the lone superpower, to command and control the space commons. Source: Pavelec in Michael Sterling. "The Inevitability of the Weaponisation of Space: Technological Constructivism Versus Determinism". *Astropolitics* vol. 10, issue 1 (March 2012), p. 39-48.

[72] PwC. (2017). Dependence of the European Economy on Space Infrastructures – Potential Impacts of Space Assets Loss. European Union.

around € 53.5 billion per year in Gross Value Added, supporting 1 million workers directly or indirectly.[73] Thus, even a partial incapacitation of these assets could lead to a substantial economic loss of many billions per year, and would put many jobs at risk.

European economic sectors	Adoption rate (% of GVA)	Dependent GVA (EUR billion)
Agriculture	25,5%	42,0
Forestry and logging	70,0%	18,3
Fishing	41,3%	2,6
Mining and quarrying	80,0%	69,6
Energy	8,2%	19,0
Construction	27,1%	173,5
Land transport	54%	172,5
Air transport	75,0%	33,2
Water transport	71,5%	25,9
Information and communication	13,3%	67,8
Finance and insurance	24,5%	167,6
Total sectors	28,6%	792,0

Table 11: Adoption rate of space-based solutions in the European economic sectors (source: PwC, 2017

Three types of threats to the security of space infrastructure and its services can be identified: natural threats (especially space weather, e.g. solar flares); unintentional man-made threats (i.e. space debris); and intentional man-made threats (i.e. space weapons). As this section focuses on the security aspect of space, it deals only with intentional man-made threats. Man-made threats are driven by endogenous and exogenous trends including:

- New concepts, technologies and capabilities;
- An ever more connected space infrastructure, including with other ground networks and systems;
- The increasing importance of space infrastructure, which makes it a key target for a variety of actors pursuing different objectives;
- The rehabilitation of a 'space warfare' doctrine encompassing activities to develop 'space control' capabilities.

This last trend in particular and, more broadly, the evolving and more aggressive postures of foreign actors, directly or indirectly creates threats to European SIS. Various typologies of threats can be identified. These threats can be characterized by two dimensions: their nature, and their potential consequences.

The nature of threats to Europe´s SIS relates to the means used to reach their goal:

- Kinetic devices are objects that use the energy produced by their speed to destroy their target. This kind of weapon can be Earth-to-space (i.e. a missile launched from the ground and reaching a satellite in orbit) or space-to-space (i.e. using a co-orbital space object that is thrown at the target). Thus, the

[73] PwC. (2016). Socio-Economic impacts from Space activities in the EU in 2015 and beyond. European Union.

development of manoeuvrable satellites creates some concern because of their potential use as kinetic weapons. Earth-to-space kinetic threats are similar to the technology used in ballistic missile defence programmes, developed by several countries (e.g. the March 2019 Indian ASAT test used a missile developed for such a programme).

- Electronic warfare refers mainly to jamming and spoofing, which aim at disabling the service provided by the space asset by interfering with its signal so that it is not understandable or gives erroneous information.
- Directed-energy weapons are mostly developed in lasers able to blind a satellite by attacking its sensors (e.g. to make imagery satellites inefficient). High-powered microwaves are another kind of directed-energy weapon, which damage the electronic components of the system.
- Cyber threats can attack data and systems that use these data in space and ground segments through command intrusion, denial of service, malware, hacking or hijacking[74]. The overall objective of cyber-attacks is to enter the network of the infrastructure. The consequences of threats describe the effects an attack would have on space assets:
- Physical destruction: Although four countries officially possess this capability (the United States, Russia, China and India), the extensive use of such kind of threat is very unlikely. Indeed, the destruction of a satellite would produce a major amount of debris, which would constitute a danger for the assets of all countries, including the attacker, and risk making the affected orbit unusable.
- Degradation, interruption: In this case, the service provided by space systems is not accessible anymore, that is, the effect is irreversible. Thus, degradation is "the permanent impairment of some or all of a space system's capability to produce results, usually with physical damage"[75].
- Denial, disruption, interference: In this case, services temporarily malfunction (they become non-working or erroneous), meaning that the effect is reversible. Disruption is consequently "the temporary impairment of some or all of a space system's capability to produce effects, usually without physical damage" whereas denial is the temporary "elimination" of this capability to produce effects, also without physical damage[76].
- Interception: this kind of attack is mostly related to spying and can include the interception of communications or data thanks to cyber-attacks or the use of an eavesdropping satellite. With the development of manoeuvrable technologies, in future it could also include the physical interception of satellites.

Overall, European space infrastructure may become the target of deliberate attacks to physically harm the system, to permanently degrade or temporarily disrupt its capabilities, or to intercept confidential information. Whereas kinetic attacks to European systems still seem an unlikely scenario, cyber-attacks are perceived as a clear and present threat.

Indeed, in recent years, cyber-attacks on both terrestrial and space systems have become ever more frequent, with an increasing number of targets and motivations, and perpetrated by a growing number of actors. From classic stealing of personal and financial (big) data to corporate espionage, from state-sponsored cyberwarfare activities to indiscriminate destructive attacks (or just a mix of all this), this decade has witnessed a blossoming number of increasingly bold offensive manoeuvres in cyber space– a trend poised only to continue.

[74] National Air and Space Intelligence Center. *Competing in Space* (December 2018). Retrieved from: https://media.defense.gov/2019/Jan/16/2002080386/-1/-1/1/190115-F-NV711-0002.PDF
[75] U.S. Air Force. *Air Force Doctrine Document 2-2.1: Counterspace Operations* (August 2004). Retrieved from: https://fas.org/irp/doddir/usaf/afdd2_2-1.pdf
[76] *Ibid.*

Cyber threats to space systems and services provided by space infrastructures

Cybersecurity concerns are becoming more prominent in the context of space security. Indeed, increasingly explored software-defined satellites, while more responsive to shifts in customer demand, need more security features to keep nefarious actors from exploiting their new capabilities. Similarly, the multiplication of small satellites using COTS components increase their vulnerability to cyber-attacks. Also, the possibility to operate space mission payloads across networks through public Internet connectivity (or through VPNs) opens up many threats against space-based assets and services, threats that did not previously exist. Access to a satellite's controls is a mounting issue that could allow an attacker to damage or destroy the satellite. The attacker could also deny or degrade as well as manipulate the satellite's transmission. The newer generation of cyber threats does not go after information, but rather after physical infrastructure. In the space domain, these attacks could exploit weakness/"back doors" in the mission industrial supply chain.[77]

Cases of GNSS signal jamming or spoofing are also well-known. As GNSS services are increasingly ubiquitous, more cases of service disruption are emerging, particularly in locations in close proximity to geopolitical hotspots. In Cyprus, GNSS signal has been unreliable for much of the past two years, significantly deteriorating the safety of maritime operations in coastal waters, Such disruptions are also on the rise elsewhere, often in conjunction with crime or armed conflict. Cyberthreats to space systems can be generally categorized as follows:

Space segment	User
Command intrusion Payload control Denial of service Malware	Spoofing Denial of Service Malware
Link	**Ground segment**
Command intrusion Spoofing Replay	Hacking Hijacking Malware

Table 12: Categorisation of cyberthreats to space systems [78]

As a result of increasing reliance of Europe on space-infrastructure, the socio-economic consequences of even a partial disruption of the availability or integrity of space data and signals could be dramatic.

Overall, the development of counterspace capabilities and more assertive stances with regards to military space operations creates uncertainties when it comes to Europe´s space infrastructure security and potentially could mean an increased hazard to the long-term availability of services provided by space.

Even if the (full) capacity of these systems is not exploited, international involvement in counterspace activities contributes particularly to the shared impression of a growing vulnerability of critical space systems and affects the environment in which space operations take place, possibly increasing the risks and costs of space operations, hampering commercial development and even discouraging future investments in space activities.

[77] Luca del Monte. *Towards a Cyber-Security Policy for a Sustainable, Secure and Safe Space Environment* (September 2013). Retrieved from: http://www.schrogl.com/02Telekommunikationspolitik/Dokumente/13a_LUCA_DEL_MONTE_CYBER_SECURITY_POLICY.pdf

[78] National Air and Space Intelligence Center. *Competing in Space* (December 2018). Retrieved from: https://media.defense.gov/2019/Jan/16/200208038 6/-1/-1/1/190115-F-NV711-0002.PDF

For Europe, these concerns are even more profound due to limited space defence capabilities and limited appetite for organizational changes compared to the other space powers, which provide no support from a deterrence perspective. This situation is expected to further deteriorate with the uptake of space-based solutions for various sectorial policies and the cross-fertilization of space technologies with ground technologies for promising future concepts. From this standpoint, the pervasive dependence on space systems suggests that rising threats to space infrastructure mean, ultimately, potential risks for the modern economy, society, security and, more generally, geopolitical change.

4.2.3 Autonomy and freedom of action challenges:

Together with safety and security challenges, another set of major challenges relates to Europe´s autonomy and freedom of action in the international space arena.

Technological dependence

These challenges primarily stem from Europe´s high level of technological dependency. While Europe possesses the broad majority of the technologies, processes and industrial capabilities needed to develop space programmes, European stakeholders still need to externally source certain components, and raw and advanced materials as well as some basic technologies and building blocks that are not available within European boundaries.

The most glaring example of European technological dependence is the number of foreign EEE components utilized in European satellites: the European Space Technology Master Plan (ESTMP) reports that "on a typical ESA satellite programme more than half of the EEE component procurement costs are still associated to components procured from outside Europe"[79]. Remarkably, this is in stark contrast to the policies of "[t]he governments of the major space nations outside of the EU [which] are investing considerable amounts of money on EEE technologies to maintain access to key capabilities"[80]

In addition to EEE components, there are many other technical domains where Europe relies on foreign sources for meeting critical needs, including, for instance, advanced materials, equipment, processes, and modelling tools. In short, European technical/technological dependence is a wide-ranging issue, with the extent of this dependence spanning from specific satellite technological subsystems to the more generic components that can be integrated transversally in multiple systems and architectures.

All this clearly places Europe in a position of strong dependence. It is important to highlight, however, that the most worrisome aspect is not Europe's reliance on final products, but rather on basic technologies, since the lower the level of technology on which a country or region is dependent, the greater the weakness of the country or region. [81]

To this, one needs to add eventual lack or low level of capacities that are nevertheless necessary for the conduct of space activities (e.g. SSA or manned space), the reliance on some critical items (such as the Ukrainian-built upper stage for the Vega launcher), or entire systems (such as the Russian-made Soyuz launcher), as well as critical data (such as, most notably, Europe's reliance on U.S. data for SSA and intelligence, surveillance and reconnaissance - ISR), which in itself creates a situation of dependence in coping with space safety and security issues.

Europeans are fully aware that situations of critical dependency create evident constraints; however "these constraints have not been deemed sufficient to justify the investment, because of the limited size of the markets to be potentially addressed with such technologies" This *de facto* acceptance of strong

[79] European Space Agency and European Commission. *European Space Technology Master Plan* (2018)
[80] *Ibid.*
[81] Letizia Caito. *European Technological Non-Dependence in Space.* ESPI Public Report n°51 (September 2015). Available at: https://espi.or.at/publications/espi-public-reports/category/2-public-espi-reports

European reliance on non-domestic sources (mostly on U.S. suppliers) is a European particularity. This is most likely deeply rooted in European culture, which is much more prone to international cooperation than to international competition. [82]

In the context of improved availability and affordability of technologies and services described in Chapter 3, the risk is that future decision makers in Europe could feel tempted to discontinue the financial support to foster European non-dependence and instead rely on commercially available options. While potentially favourable on price considerations, such a decision would create undeniable threats to Europe´s autonomy and freedom of action.

Accepting a state of technological dependence inevitably leads to several considerable negative impacts, including incomplete traceability and visibility of the supply chain, a weak bargaining position and unavoidable dependence on the will of those who procure the technology/capacity. An illustrative list of these ramifications is provided in the Figure 25 below.

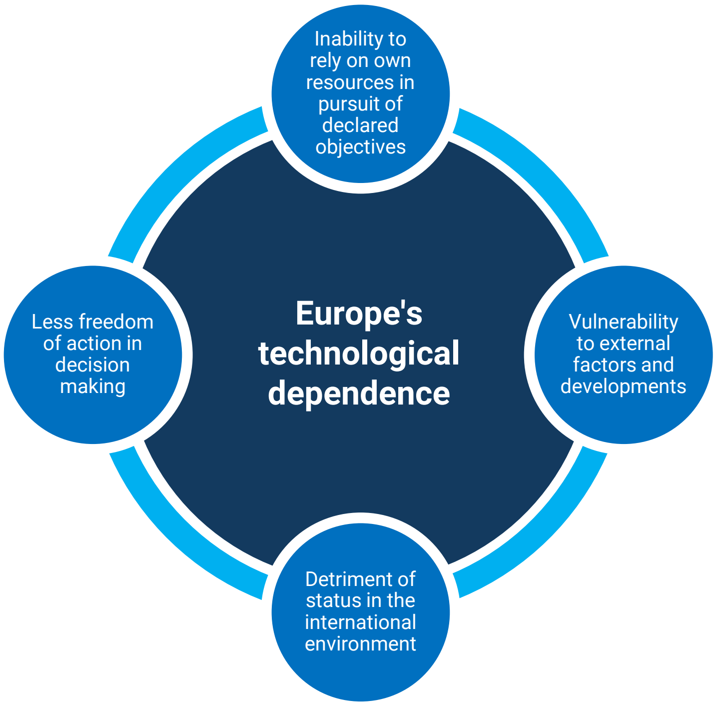

Figure 25: Impacts stemming from Europe´s technological dependence

One of the most evident threats that Europe has to face is supply insecurity. In fact, even with possible political agreements with foreign suppliers, Europe's condition of dependency will continue to expose it to many different risks and potential uncertainties. Europe, for instance, may be vulnerable to political instability, changing economic conditions or even a natural disaster in a supplier country (the issues raised by the COVID-19 in terms of security of supply offer a clear example of these risks). Security of supply may be threatened not only by political crisis and natural calamity, but also by the ever-changing regulatory barriers of export controls.

Because the dual-use and highly sensitive nature of most space technologies implies their subjection to export restrictions as strategic and defence-related items, the risk is that some of them may in future become completely unavailable from exporters, or subject to even more burdensome procurement delays that can have serious effects on European space programmes.

[82] Jean-Jacques Tortora. "European Autonomy in Space: The Technological Dependence". In Cenan Al-Ekabi, *European Autonomy in Space*. Vienna: Springer, 2015, p. 165-172.

In this respect, a major inherent risk is that a foreign supplier could impose unacceptable conditions on providing technologies – particularly military ones – or even refuse to provide them on the basis of political considerations. The American initial opposition to the Galileo programme because of its military implications offers a clear case in point. This well-known episode also shows how Europe's lack of autonomy constantly risks being translated into programmatic insecurity and eventually impair policy implementation. In fact, should a supplier country raise objections to the final aim of a given European space programme, decision-makers would be forced to either implement a given programme without using the specific (would-be-optimal) technologies or to discontinue the programme altogether. From a security standpoint, this is not acceptable.[83]

Another inherent risk associated with Europe's present condition lies in the difficulty of upholding security requirements throughout the value chain. This risk is well evidenced by "the rights awarded to suppliers' national authorities through the implementation of export control regulations. In fact, in order to achieve full visibility and transparency on the final use of the critical components at stake, European companies are required to fully open their books and to grant unlimited access to their facilities to foreign authorities. This is fair and acceptable in a number of cases but clearly unacceptable in some others [since this situation de facto allows foreign entities to gather useful intelligence …] In this respect, European military users are first and foremost affected by this issue of technological dependence and should primarily define their needs, concerns and objectives".[84]

Security Dependence

Space surveillance and tracking capabilities are an indispensable tool supporting the safety of spaceflight and providing strategic capability that transcends space activities. The USA possesses world-leading capabilities in this domain, with Russia and China being considered as autonomous players in this domain. In Europe, the development and enhancement of national and European SST capabilities is also progressing, contributing to the goal of improved protection of European space assets. More European countries are starting to engage in SST, and the European Union is stepping forward in addressing SST/SSA in the area of action it is provided by its member states[85]. Despite significant progress that includes operational service provision [86], European capabilities in the field of SST are still not fully able to autonomously meet the safety and security requirements of its space programme. Europe hence relies on SSA sharing agreements and other cooperative arrangements to fill its capability gap. While the need to build up Europe's own capabilities is clear, the current state of affairs continues to make Europe reliant on the United States to meet its safety and security needs.

Similarly, Europe is not engaged to the same degree as other major space powers in capacity building in the domain of counterspace capabilities, both with respect to relatively easily attributed activities (e.g. direct-ascent missiles) and to less transparent, covert dual-use actions, such as co-orbital RPOs, cyber intrusion or electronic intelligence. While several European countries as well as the European Union have recently been updating their space defence doctrines and the EU is increasingly exploring synergies between space and defence, these changes are not sufficient to deter potentially hostile actions against the European space infrastructure; a condition that can, to date, be temporarily side-stepped through sustained transatlantic cooperation.

[83] Marco Aliberti, Matteo Capella & Tomas Hrozensky. *Measuring Space Power: A Theoretical and Empirical Investigation on Europe*. Springer, 2019.
[84] Jean-Jacques Tortora. "European Autonomy in Space: The Technological Dependence". In Cenan Al-Ekabi, *European Autonomy in Space*. Vienna: Springer, 2015, p. 165-172.
[85] Tomas Hrozensky and Marek Dvoracek. "European SST landscape: Current status and challenges on the way ahead". In *Journal of Space Safety Engineering*, vol. 6, n°2 (June 2019), p. 122-129.
[86] The EU SST Support Framework now includes 8 EU member states (Germany, France, Italy, Spain, UK, Poland, Portugal and Romania) and is expected to further evolve as part of the SSA component of the EU Space Programme 2021 onwards.

Ultimately, the current situation for Europe means remaining at the mercy of external forces and accepting a higher level of vulnerability with regard to both security of supply (unrestricted access to required technologies, products, services or information) and supply chain security (control of security throughout the programme lifecycle).

From a political perspective, what is first and foremost at risk is European political sovereignty over the conduct of its space activities. As getting critical technologies from non-European suppliers requires European stakeholders to obtain a green light from foreign authorities, it is clear that Europe faces significant political risks.

For example, it should be noted that Europe's lack of autonomy may impact its freedom of action and ultimately restrict its capability to decide when and under what conditions to develop and deploy its space programme. In addition, by maintaining the *status quo* Europe may not enjoy the autonomy to freely choose its partners, due to possible external pressures. The issue, however, is not limited to cooperation activities for highly sensitive projects such as Galileo. Civil and scientific cooperation may be also impacted, as already demonstrated by the case of past cooperation activities (e.g. between India and France, ESA and Russia, Italy and China, etc.)

By the same token, continued reliance on third party assets could deter third partners from proposing joint initiatives with Europe, because of Europe's need beforehand to secure a green light from foreign authorities, most notably the United States. All this could result in a sub-optimal implementation of policies and programmes that do not necessarily align with Europe's interests. Therefore, technological dependency inevitably limits Europe´s freedom of action and political autonomy.

Equally important, dependence on the political will of external actors harms Europe's prestige and bargaining power on the international stage, making European diplomatic efforts, its potential to influence others, and the exercise of soft power, less effective. This, ultimately, may preclude the continent from being a convincing agenda-setter in the international space community, a limitation that is already evident in those domains (such as human spaceflight and space security) where Europe lacks the ability to rely on its own resources in pursuit of declared objectives. Taking this into account, positioning Europe as a credible interlocutor in international dialogue and negotiations requires equipping the continent with independent capabilities to safeguard its interests and strengthen its role as a global actor. This particularly applies to capabilities that would directly support the objective of keeping space safe, secure and accessible for European stakeholders (including the development of SSA capabilities and, according to some member states, also counterspace).

4.3 Assessment of risks stemming from the challenges

The previously described challenges pose a number of specific risks for Europe. These are summarised and evaluated in Table 13. The assessment of each risk is based on evaluating its likelihood and severity.

	Challenge	Related Risk(s)	Risk Assessment
Competitiveness	Growth in the number of competitors	Reduction of revenues and market share	Critical (Likelihood: High, Severity: Moderate)
	Changing competition dynamics	Competitive disadvantage of European companies in commercial bidding	Critical (Likelihood: High, Severity: High)
	Uncertain market evolutions	Reduced importance of European traditional space companies	Significant (Likelihood: High, Severity: Moderate)
	Growth in the size of captive markets	Inability to access foreign markets and penetration of foreign firms into European markets	Critical (Likelihood: High, Severity: High)
	Procurement policies: asymmetries in market access	Inability to export products or access foreign institutional markets	Significant (Likelihood: Moderate, Severity: Moderate)
	Use of economic diplomacy	Foreign actors penetrating markets relevant to European providers	Significant (Likelihood: Low, Severity: High)
	Export control measures and regulatory reforms	Restricted freedom of action in export, longer lead times and non-availability of technologies	Significant (Likelihood: Low, Severity: High)
	Government support to the consolidation of New Space	Faster innovation in adoption of New Space outside Europe	Limited (Likelihood: Moderate, Severity: Moderate)
Safety, Security, Autonomy	Low compliance with int. space safety and sustainability guidelines and best practices	Growing risks of collisions posing unintentional, hard to predict, threats to European space infrastructures	Significant (Likelihood: Low, Severity: Moderate)
	Inadequate international solutions for SSA/STM	Inadequate transparency in behaviour of space actors during launch, in-orbit and post-mission disposal	Critical (Likelihood: High, Severity: Moderate)
	Mounting pressures on orbital slots and spectrum	Reduced availability or unavailability of spectrum for European space operations	Limited (Likelihood: High, Severity: Moderate)
	More muscular posture of major space powers and unclear governance prospects	Security dilemma possibly leading to a space arms race	Significant (Likelihood: Moderate, Severity: Low)
	Rising threats to European space infrastructure security	Attacks disrupting services provided by space systems or damage to European space infrastructures	Limited (Likelihood: Low, Severity: Moderate)
	Technological dependence	Programmatic insecurity impairing policy implementation	Significant (Likelihood: Moderate, Severity: Moderate)
	Dependence of safety and security	Inability to autonomously safeguard and protect critical European space systems	Critical (Likelihood: High, Severity: High)

Table 13: Risks and challenges to the fulfilment of strategic European objectives in space

5 Addressing the Challenges: The Role of Diplomacy

The review of the challenges and risks faced by the European space sector underlines that these challenges, while being the most diverse in nature, are also highly interrelated, progressively intensifying, and have a strong, sometimes dominant, international dimension.

Representatives of European industry and institutional stakeholders alike are increasingly cognisant of these challenges and share serious concerns about current and expected developments. Consistently, they are taking a number of important efforts to circumvent the risks associated with them. These efforts are reflected in the very consolidation of the European space programme, and more specifically in the increasing budgets decided by the ESA Ministerial Council in 2019 and by the EC´s budget for the next MFF.

In this challenging international context, the request of the European space sector is that European institutions implement all necessary measures to protect the industrial, commercial and strategic interests of Europe, in the same way other space powers do. After all, recent and expected developments on the global scene, as well as the resulting geopolitical, programmatic and commercial challenges for Europe, are the direct or indirect result of a determined will-to-power of major space-faring states that gave rise to ambitious policies in the space sector.

Among the policy responses to these challenges, coherent and assertive action to promote Europe´s interests and defend its positions on the international arena proves of paramount importance. Indeed, given the impact that international trends and undertakings of other actors have on European space strategy, European efforts to cope with the identified challenges necessitate actions in the international arena. As also recognised by the EC in its Space Strategy for Europe[87], Europe's efforts to meet the three goals of its space strategy will be undermined unless the continent achieves a fourth goal, that of "taking a much stronger role on the world stage".

Diplomacy, generally understood as the dialogue and conduct of negotiations between sovereign nations, is a major instrument to meet this goal. Importantly, when applied to the space context, the term can assume a variety of forms, as briefly summarised in Table 14.

Space for diplomacy	Diplomacy for space	Diplomacy of space
The utilisation of space cooperation to support foreign policy goals (e.g. strengthen political and economic ties with third countries)	The conduct of diplomatic initiatives to support the fulfilment of public space objectives (e.g. space industry exports, programmatic synergies, etc.)	The formulation, negotiation and implementation of initiatives to manage strategic interaction in space and ensure convergence of behaviours

Table 14: Space and Diplomacy: a conceptualisation

Given the scope of this report, only the last two dimensions (*diplomacy for space* and *diplomacy of space*) are taken into specific account.

While the tools of diplomacy and international cooperation are certainly not a substitute for domestic policy actions and programmatic measures, they play important complementary roles to what Europe is already doing in the fields of competitiveness, safety and security of its space sector. While diplomatic

[87] Available at: https://ec.europa.eu/docsroom/documents/19442

efforts are typically time-consuming procedures that require intensive manpower and have no guarantee of success, their necessity arises from the fact that for many of the challenges related to competitiveness, safety, security and sustainability, only international solutions can provide effective countermeasures. In addition, leveraging the role of diplomats can also prove a very effective way to gain political attention and support at the highest level; an aspect of great importance for the stakeholders of the European space community, which have often lamented a perceived lack of high-level political backing.

From this standpoint, it seems increasingly pressing to make external actions an integral part of the European space strategy in order to address the mounting industrial concerns over the lack of a level playing field on commercial markets, while promoting international solutions that ensure the safe and responsible sharing of the outer space.

Based on the areas of concern identified in the previous assessment, this chapter will provide a set of reflections on how to overcome the identified challenges through more assertive diplomatic actions on the international stage. The considerations set out hereafter are not specific recommendations but rather open points of reflection for possible implementation in order to ensure the future competitiveness of Europe's space industry as well as the safe and secure use of the space environment.

5.1 Diplomatic actions to support competitiveness of European industry

Fully aware that nurturing a globally competitive European space industry is of paramount importance for the future of the whole European space sector, European actors have already embarked on several activities aimed at fulfilling this objective. These efforts are being pursued at different levels of decision-making and across more distinctive fields of action.

However, no concrete actions have been taken to address the recent growth of competition amidst market asymmetries and to restore a level-playing field on the international stage. As a result, Europe is not fully equipped to address the challenges stemming from both the growth in volume asymmetries (given the limited size of the European governmental market) and from access asymmetries. In fact, Europe is the only major power in which a broad and clearly stated preference for the procurement of space-based systems or services from European industry in the context of public and institutional programmes is still lacking.

In addition, European public institutions have been comparatively making less use of economic diplomacy to promote access to foreign markets as European space activities and industrial efforts are not fully connected to the broader foreign policy efforts at European level.

While the European industry has been able to deal with such asymmetries so far, as discussed in Chapter 4, the conditions are getting tougher. Representatives of the industry, manufacturers, operators and launch service providers alike share serious concerns about current and expected developments. In this context, the uncertain market evolutions (as most evident, for instance, in the satcom sector) with the more active involvement of governments in trade and regulatory affairs (including the use of economic diplomacy by emerging competitors) create risks that are now starting to cast doubt about the long-established maxims of the so-called "European way".

In many respects, the so-far successful "European way" is progressively turning into a **"European paradox"**. While Europe is, by far, the most reliant and exposed to the fluctuations of commercial markets, it is also the least well equipped to safeguard its interests in those markets and, in particular, to protect its industry from unfair competition practices and ensure conditions of reciprocity in a level playing field, also in terms of market access. Sound policy actions are therefore demanded by the European industry

Even if the growing role of the private sector in space is often praised as a promising lever, it would be a mistake to conclude that a logical corollary to this trend is a decline of the role of public actors. The current change of paradigm is not calling for a progressive withdrawal of governments from space affairs but for a change in the way space activities are supported. Recent and expected developments on the global scene, as well as resulting geopolitical, programmatic and commercial challenges for Europe, are the direct or indirect result of a determined will-to-power of major space-faring states that have given rise to ambitious policies in the space sector.

Today, the request of the European space industry is that governments and European institutions implement all necessary measures to protect the industrial, commercial and strategic interests of Europe, in the same way other space powers do.[88]

From this standpoint, actions are first required on the "domestic front". Public entities in Europe are, in particular, invited to further develop European public demand, based on a service-oriented procurement approach that is in line with the evolving role of space agencies.[89]

In the second instance, public entities are requested to build up the confidence of private investors by securing long term commitments and envisaging safeguarding measures such as anchor tenancy arrangements and the utilization of preference clauses for all European institutional missions (see Focus Box).

However, it also clear that these actions, while necessary, will not per se suffice to ensure international competitiveness for European industry. In fact, the adaptation of procurement policies or the introduction of a European preference clause would not automatically entail the expansion of demand for institutional missions in Europe.

Tacking stock of this, it is clear that Europe´s quest to restore a level-playing field with other spacefaring nations also needs to go be accompanied by complementary measures on the international scene. Therefore, alongside these and other important domestic measures, it is necessary to fully exploit the role that space diplomacy can fulfil.

Considering the status quo, trends at play and actions pursued by other actors, there seem to be three areas of action European actors should seek to further pursue:

- Promote the adoption of internationally agreed norms and rules for commercial competition on global markets
- Support export market access for European industry
- Promote industrial participation in international cooperation/ventures

Towards a European Preference Clause?

In the European context, an agreement between all major institutional entities on a broad and clearly stated preference for the procurement of space-based systems or services from European industry may become a necessity to further support the strengthening of the whole sector vis-à-vis increasingly competitive international markets, to ensure critical mass to European industry, and to support technological autonomy. Indeed, the emergence of strong(er) public demand in the European context is a condition for building up domestic demand, which in turn is a necessary condition for the stability and predictability of the whole sector. *(continued on next page)*

[88] This point was widely voiced by speakers and panellists of the 13th ESPI Autumn Conference. See ESPI. "Toward a more Strategic, Assertive and United Europe in Space". ESPI Executive Brief n°34 (September 2019). Available at: https://espi.or.at/publications/espi-executive-briefs From ESPI Brief 34

[89] Matteo Tugnoli & Leyton Wells. *Evolution of the Role of Space Agencies*. ESPI Public Report n°70 (October 2019). Available at: https://espi.or.at/publications/espi-public-reports

(continued from previous page) The enactment of a preference clause for all European institutional missions has been advocated by several representatives of industry[90] as a way to ensure – and ideally expand – a solid business base for European industries and generate economies of scale that would in turn enable competitive prices for European products and services. This is particularly the case for launch services in Europe.

Europe is noticeably the only space actor in the institutional field that simultaneously finances the development of an autonomous fleet of launchers, and yet often purchases launch vehicles from foreign providers. Thus, the enforcement of a "buy European" clause for all European institutional satellites could ultimately provide European launchers with the institutional support they need to maintain their competitive edge across the worldwide market without direct financial subsidies.

On both the EU and ESA sides these measures have been already contemplated. In principle, ESA has already been applying such a clause, as stated in its Convention, but in many instances some national space agencies, or the European Commission, have not comprehensively adopted this approach.

The preference clause – which has been under discussion among European stakeholders for at least two decades – has both merits and limits, and obviously requires that European stakeholders converge on its relevance and utility, and also set up the appropriate legal instruments to implement it. However, a comprehensive and binding agreement might prove hard to reach:

- For one thing, there are legal constraints at play, especially in the framework of the EU competition law, which does not allow preference to be given to European providers. A "Buy European Act" ,as borrowed from the United States (Buy American Act), is currently not compatible with the EU regulatory and legal corpus, and no exception or dedicated regime will be made for such a small economic sector as space. Therefore, any reflection in this direction should question the fundamentals of the construction of the EU. The conditions for that might be met in the aftermath of the COVID crisis.
- In addition, the adoption of a more stringent regime for the procurement of European satellite and launch services may cause undesired fallouts at international level such as the wrath of the United States. In October 2019, for instance, the executive director of the National Space Council subtly warned the EU about possible negative consequences for Transatlantic cooperation should it set up space development and procurement projects that would block non-EU allies from participating[91].It is clear that any movement in this direction will trigger hostile reactions from other major players (USA, China, Russia, Japan, India). A strong and unanimous position of all European member states is therefore a pre-requisite, but this might be difficult to achieve.

Finally, it should be noted that the introduction of a European preference clause may not necessarily expand the current level of institutional demand at European level, but just ensured that demand is served by European solutions.

[90] See various statements at the 11th European Space Policy Conference in 2019, in ESPI. *Official Proceedings of the 11th European Space Policy Conference – Space for Europe, European Space in the World (22-23 Janaury 2019)*. Retrieved from: https://espi.or.at/news/official-proceedings-of-the-11th-conference-on-european-space-policy

[91] Theresa Hitchens. "EU Plan to boost space industry draws White House ire". Breaking Defense (October 2019). Retrieved from: https://breakingdefense.com/2019/10/eu-plan-to-boost-space-industry-draws-white-house-ire/?_ga=2.129335177.401846571.1570015183-2002103815.1563352904

5.1.1 Promote rule-based global competition

A first important way space diplomacy can help to address market asymmetries and the obstacles for European industries in exporting space products and services is by seeking international consensus on trade rules. Considering that Europe has (thus far) no anchor tenancy arrangements comparable to those put in place by other major space nations and that a major driver in future public-private interaction at European level is to overcome the need for direct public subsidies, European stakeholders clearly have an interest in encouraging a transition of the commercial space markets from an era of discretionary government support structures toward a *free and fair trade* environment.

The concept of "free and fair trade" should not necessarily be intended as trade free from substantial government support in the development/exploitation of space infrastructures. Neither should it necessarily be intended as including space under the competences of the WTO. Rather, the concept should be thought of as achieving mutually agreed upon trading rules (such as the absence of market access restrictions, distorting grants or subsidies, inducements to international customers, offering of additional services, or providing unregulated government funding) as a way to ensure that market practices are under convergent expectations and behaviours by all players.

These efforts could be pursued through both bilateral engagement – as part of the trade dialogues and trade agreement negotiations between the EU and third countries – and through multilateral negotiations with relevant actors.

An effort in this direction is envisaged by the ongoing German EU Council Presidency (July-December 2020), with the initiative "Establishing key principles for the global space economy".

As anticipated by German Ministry of Economic Affairs at the 13th ESPI Autumn Conference, the initiative is based on the consolidation of European (ESA and EU) space programmes and responds to the growing importance of space infrastructures, services and products as an export good for the European space industries (Large System Integrators, SMEs, Service Providers, Start-Ups). The initiative aims to foster Europe´s role in the global space economy with rules-based global competition on a level-playing field, by setting out, together with other important actors and partners, rules of the road for the global space economy, benefitting the further development of exchanges and growth for all countries.

A concrete result expected from this initiative includes the adoption of a Resolution of the ESA-EU Space Council of 2020, containing:

- Europe's elaborated positions on key principles for the global space economy, as:
  - fair conditions for competition,
  - restrictions on the exterritorial application of national regulations,
  - protection of IPR and setting of appropriate standards,
  - basic European standards for space operations and activities,
  - framework conditions for investment and financing of space activities.
- Agreement on the procurement of European launch services for governmental payloads.

Based on this, the initiative will lead to the elaboration of concrete measures derived from the principles to be negotiated with international actors/partners. These measures may include:

- Rules of the road for the global space economy,
- Joint approach to Space Traffic Management, in particular for standardisation and regulatory issues. [92]

[92] A major risk in this respect is that foreign regulations may be used to restrict market access through the extraterritorial application of rules if third parties.

- Financing for space activities (including strengthening of the UNIDROIT Space Assets Protocol)
- Intellectual Property Rights, standardisation, cyber security and resilience for space operations/activities.[93]

In terms of implementation, the initiative will be developed by the member states in close cooperation with the relevant EU institutions and services as well as ESA, industry and other relevant actors. It will be presented to the Space Council (ESA-EU) in November 2020 as a contribution to further developing Europe's space policy. Following this, consultations and then negotiations with the international partners shall be conducted to achieve joint understandings and arrangements.

It must be emphasised that the implementation of this initiative in the international context will prove extremely challenging, given the need for the convergence of interests of many different and heterogeneous space powers with different economic systems and different governance mechanisms for space (e.g. China or Russia). Therefore, it will need not only a strong intra-European consensus but also a solid and coordinated political backing (by all European stakeholders) during the negotiation phase with international partner countries.

Compared to multilateral negotiations, bilateral engagement with likeminded partners would prove relatively more effective to define common approaches while also addressing export obstacles and ensuring Europe´s ability to achieve reciprocity in market access. However, it needs to be highlighted that any successful definition and enactment of key principles for the global space economy will not necessarily remove asymmetries or indirect distortions, but most simply clarify the rules of the game. These principles, norms and rules, in addition, will not be self-enforcing and other issues will inevitably emerge with regard to monitoring their compliance. Hence, while going in the right direction, this type of diplomatic effort will not per se be sufficient to properly address all obstacles for the European industry and ensure a level playing field. Therefore, other complementary diplomatic initiatives should be envisaged in parallel to the promotion of principles and norms for international trade.

5.1.2 Support European industry accessing foreign markets

Because of the historical and still growing strategic importance that space assets, services and products have as an export good for the European space industries, a second major measure to favour a level-playing field is to appropriately support export market access through trade policy and economic diplomacy instruments.

These instruments can play an important role in addressing access asymmetries, maximising market access, and promoting penetration of European companies in emerging space markets. Indeed, with the demand for satellites set to increase fourfold over the next decade and with 20+ countries launching their first ever satellite, economic diplomacy can provide, European manufacturers and launch providers with crucial support indispensable to stabilize or penetrate new institutional markets.

However, as opposed to its competitors, Europe has thus far made relatively less use of economic diplomacy to assist European companies active in global export markets. Several European member states have been supporting national industries through the mobilization of their diplomatic network and by acting as an interface between national industries and foreign governments. These efforts, however, remain piecemeal and somehow limited by their national character.[94]

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[93] Kai-Uwe Schrogl. "Establishing key principles for the global space economy". Presentation at the 13th ESPI Autumn Conference (September 2019)

[94] For an example in the case of France: "Support for companies in the space sector". Ministry of Foreign Affairs (last updated: February 2018). Retrieved from: https://www.diplomatie.gouv.fr/en/french-foreign-policy/economic-diplomacy-foreign-trade/supporting-french-businesses-abroad/strategic-sector-support/support-for-companies-in-the-space-sector/

At pan-European level, some orientations started to emerge in the 2016 European Space Strategy. In this document, the European Commission underscored the importance of politically backing European companies on international markets and more specifically highlighted that "through its trade policy instruments and economic diplomacy, the Commission will seek to establish a level playing field for European industry by addressing market access barriers and promoting convergence of dual use export controls, and actively promote European space technologies, solutions and know-how in non-EU countries. This could open up new business opportunities for European industry and promote the EU as an attractive place and partner for research and investment. The Commission will further support space business internationalisation by mobilising existing instruments [95] to help European companies, particularly clusters and networks of SMEs, access external market" [96].

Building on this, reflections have continued within the EEAS, the European Council and the Parliament, which have positively welcomed the idea of economic diplomacy. Significantly, the European Space Agency ESA has also seen the need to figure out a toolbox to help the European industry to compete internationally and help it penetrate foreign markets (this is in particular the case of mid-caps and SMEs that are often not present in these markets). The contemplated tools include:

- Access to finance (in the form of cooperation with the European Investment Bank by setting up a guarantee fund to facilitate the access of SMEs to banks when they want to access export markets),
- Awareness-raising initiatives on the opportunities for business in foreign countries, B2B meetings both in Europe and the foreign country, and
- Promotion of space-related offsets for large infrastructure development projects.

Other forms of support could be envisaged trough the creation a "label" for European products or services used and validated by ESA programmes. Even though ESA is not a political actor, it can be instrumental in strengthening Europe's actions on the international arena. Actually, ESA is willing to contribute to improve the overall competitive environment and create a level playing field for the European space industry at the international level. In addition, ESA is undertaking international cooperation activities in the frame for instance of its science and exploration programmes, and could use this opportunity to "open doors" to the European industry (see next section).

By the same token, the increasing interest of EU institutions to further promote the deployment of concrete economic diplomacy initiatives in coordination with national efforts should also be seen as an opportunity to support export of European space industry's products and services. As also stressed in an industry position paper on this matter, "the industry would need the EU to exert its leadership and deploy its diplomatic efforts in providing advocacy for European solutions, opening doors and providing support with the local decision-making bodies. With a more systematic involvement of local EU delegations and offices around the world, this support should also include commercial awareness considerations and aim at monitoring/ensuring that a fair treatment is in place with respect to competitors from third space powers". [97]

Institutional support on foreign markets could be first provided through the promotion of European capabilities at summits and conferences with third countries and organisations as a way to raise awareness among potential partners about the capabilities of the European space industry and the use of space data and services in the fulfilment of their national policies. This support could also be accompanied by other dedicated measures such as the expansion of the "EU Space Prizes" to targeted

[95] For example, the COSME cluster internationalisation instrument, EIB loans or export credits. See: "A vibrant platform at the service of cluster organisations". European Cluster Collaboration Platform. Retrieved from: https://www.clustercollaboration.eu/vibrant-platform-service-cluster-organisations

[96] European Commission. *A space strategy for Europe*. COM(2016) 705 final. (2016)

[97] ASD-Eurospace. *Towards a "Space Economic Diplomacy" – Contribution of the European Space Industry*. Position Paper (2017)

countries, to encourage Galileo/EGNOS and Copernicus-based innovation and market uptake, namely by fostering cooperation on European space technology, the development of applications, and new business opportunities.

Institutional support on foreign markets could be also provided through cross-fertilization with other EU policies, such as development policy and trade policy. Towards this, coordination between the different EU stakeholders (the EEAS, DG DEFIS, DG TRADE, DG DEVCO, etc.) is necessary to identify possible export opportunities through the exploitation of the synergies between various EU directorates and respective policies.

Among these policies, important opportunities may be offered by the EU development policy. The Commission's DG for International Cooperation and Development (DG DEVCO), which is responsible for designing European development policy and delivering aid throughout the world[98], is one of the most active development actors worldwide and has a wide toolbox at its disposal to reinforce synergies between space and development. Among these tools, the practice of providing Official Development Assistance (ODA) funds to developing countries to support the procurement of European service packages (satellite, launch service and ground support) could be an effective mechanism. The practice has been already implemented by Japan with some positive results and provides Europe with an interesting model for implementation.

Utilising this tool would enable Europe to tackle the need to increase strategic presence with developing countries, particularly those interested in establishing their own space infrastructure. At the same time, it would support the EU development policy with concrete tools. Industrial stakeholders have also highlighted that as part of its action, DG DEVCO could explore synergies with DG DEFIS and the EEAS in providing training in space-related activities to emerging countries and enable them to capitalise on the European legacy with respect to the development of national policies, operational standards, etc.

Another important type of support for European companies in global space markets is offered by trade policy. As also stressed by ASD-Eurospace, the EU trade policy can provide an important "leverage to ensure reciprocity in market access conditions and foster accordingly the level playing field for industry. For this purpose, the Commission should integrate the objectives of a "European space economic diplomacy" to revise its trade agreement elaboration guidelines to make sure that the specificities of the space sector and the European space industry are taken into account when trade agreements impacting the space sector are being negotiated"[99].

Taking stock of other space powers' export financing strategy, another possible measure to support the internationalisation of European companies is to reinforce the role of Export Credit Agencies (ECAs) in a more effective manner. While the importance of ECAs is often overlooked, in fact they play a crucial, strategic role for the satellite and space launch industry. In Europe the French-based Coface already plays an important role in supporting European satellite exports and the commercialization of Ariane launch services. Yet, its effect is somewhat limited by its national character. European stakeholders could thus contemplate the creation of a pan-European ECA in which the resources of all actors involved are pooled to more strongly support the export activities of all European space industry. As an alternative, the European Investment Bank (EIB) could be mandated to support the activities of European manufacturing primes, SMEs and mid-caps e.g. by providing loans, guarantees and credit insurance in order to reduce investments uncertainty and risks related to business development strategies, and thus encouraging EU businesses to get a foothold in new markets.

[98] European Commission. *DG DEVCO – DG for International Cooperation and Development.* Retrieved from: https://ec.europa.eu/knowledge4policy/node/6664_it
[99] ASD-Eurospace. *Towards a "Space Economic Diplomacy" – Contribution of the European Space Industry*. Position Paper (2017)

In both cases, the European External Action Service (EEAS) could play an enabling role, so as to link the provision of European space-related services to the foreign policy objectives of the European Union in a more structured manner.

By the same token, industry would also welcome the EEAS and DG TRADE to promote (as part of their external and trade policy) agreements with foreign partners to ensure the security and sustainability of space-related supply chains, thus contributing to secure Europe's autonomous access to state of the art space technologies.

A specific instrument that could be used to support these activities would be the establishment of a Task Force on space industry exports composed of representatives of ESA, the EU and private industry. With a clear nod to the recently established Task Force on Space System Overseas Development in Japan[100], this task force could be entrusted with a number of responsibilities, including:

- The analysis of targeted markets all over the world and the assessment of the potential market uptake of EU space programme components (i.e. Galileo/EGNOS and Copernicus) in those markets
- The identification of specific export measures through the examination of the actual needs of partner countries in terms of equipment, ground infrastructure, services and human resources as a way to propose tailored solutions.
- The organization of meetings, seminars and round-tables with third countries to provide advocacy of European capabilities and support the EU space dialogues with targeted third countries, facilitating institutional and industrial cooperation and promoting regulatory convergence.

5.1.3 Secure industrial activities in international cooperative ventures

A third way diplomacy could be used to support Europe's competitiveness on the international scene is to promote the active participation of European industries in international cooperation ventures.

Space cooperation is often intended as a means to optimise resources in the pursuit of programmatic objectives and avoid duplication of redundant efforts – thereby including industrial ones. However, international cooperation can also greatly contribute to advancing industrial interests, in addition to achieving programmatic objectives or yielding political objectives.

These include enabling national industry to address a broader range of activities with the same institutional budget, ensuring sustained industry activities if public funding for institutional programmes get scarcer, foster technological progress in new areas as well as the development of new skills, methodologies and operational standards. While this is particularly the case in cooperative ventures among advanced spacefaring countries, also cooperative ventures envisaged to contribute to capacity-building in emerging space countries can help to sustain industrial activities in the donor´s country or support its industrial leadership through regulatory convergence and standardization practices (i.e. by defining standards which newcomers may then apply in future space efforts).

In Europe, cooperation can thus be seen as a key tool for compensating the plateauing institutional budgets and maintaining a high level of business, which is a main requirement to sustain the current excellence of industry in all major domains of activities and hence ensure that European industry is equipped to remain competitive on the global stage.

In this regard, there are important national cooperation experiences (e.g. the strategic partnership several European countries have built with the United States, or the cooperation agreements with Russia, China and India) that showcase the benefits of such an approach for the broader European space programme.

[100] Marco Aliberti and Sara Hadley. *Securing Japan. An Assessment of Tokyo strategy for space.* ESPI, Vienna (July 2020)

Europe is already in a strong position to secure adequate industrial participation in a broad range of international ventures thanks to the wide and robust network of cooperative relations ESA has built up with all the other space actors worldwide as well as the long-standing experience European industry has in implementing international cooperation projects. In many instances, European companies have then leveraged these projects for developing products that are sizeable for the export market (e.g. EO satellite systems) or for developing specific capabilities that can make them a partner of choice for future international cooperation.

The implementation of international programmes in the field of exploration, for instance, has also enabled major European companies to build long-lasting relations and synergies with foreign companies and institutions; synergies that now place them in a good position to participate in future programmes (e.g. the Lunar Gateway). A prominent cooperation model in this regard is already offered by the European Service module built by Airbus for the U.S. Orion capsule.

From an industrial standpoint, strengthening cooperation would prove particularly important in such demanding areas as human space exploration where Europe has no ambition (so far) to push forward an autonomous initiative but where it wants to play an active role given the variety of benefits to be harvested, including the opportunity – not to say the necessity – to maintain the state-of-the-art technological level and solid set of critical capabilities acquired in this domain by its industry.

The 2019 Ministerial Council has already secured European participation in the LOP-Gateway programme. Ideally, this cooperation could be strengthened and extended to secure additional industrial activities beyond the European service module. For instance, efforts could be devoted to securing the use of Ariane 6 as part of Europe's contribution to the cooperation on lunar exploration. Arianespace has already made clear its resolve to be the launch service provider for European robotic missions to the Moon.

Promoting the use of Ariane 6 may be a good example to ensure more industry activities in cooperative ventures. In a similar vein, diplomatic efforts could be devoted to ensure that European preferences are taken into due account in the negotiations to define the standard interfaces between the systems of the major space nations that will participate in future lunar exploration (be it within the LOP programme or in other frameworks) and with which Europe plans to cooperate.

Besides these specific examples, using cooperation as an industrial policy tool means that, whenever possible, European diplomacy should extensively take into account European industry expectations alongside traditional foreign policy or programmatic objectives in the negotiation of future cooperative undertakings. This is for instance the case of future cooperative missions between ESA and international partners in the field of space science and, ideally, also for the joint missions between national space agencies and third countries.

5.2 Diplomatic actions to address safety, security and sustainability challenges

Beyond the concerns put forward by industry, space diplomacy will play a major role in the multilateral governance of the space environment and in particular in ensuring that space remains safe, secure and accessible for European stakeholders.

Considering the impact that international trends and undertakings of other actors have on Europe´s ability to continue accessing and utilising space in a safe and secure manner, European efforts towards meeting this objective inevitably require actions in the international arena. Diplomacy and tools of international cooperation indeed offer a complementary way of addressing the identified challenges and do not necessarily reflect the same rationales as the programmatic tools or legal instruments measures put in place on the domestic front.

At the same time, their growing importance rises from the fact that profound transformations of the global space environment no longer allow the permissive situation that characterised the first space age.

Indeed, it must be underlined that for almost five decades, strategic interaction in space has remained rather limited and that for many activities related to space individual states could basically do what they wanted without damaging the interests of others. Unsurprisingly, the institutional arrangements that have been agreed in the basic space treaties have sanctioned freedom of use and access to the space environment for civil, commercial and even military activities. In those limited cases where individual decision-making could cause collective issues, relatively simple coordination regimes have been established to ensure stability (such as for instance the ITU regime for managing the allocation of the radio-spectrum, whose acceptance prevents signal interference that would leave all parties worse off). But even where more specific restrictions were accepted, these did not, at least to date, impose much constraint upon the actors (for instance, the denial of sovereignty claims over celestial bodies or the ban on placing WMD have arguably been costless concessions given the previous state of technologies).[101]

This permissive situation is, however, no longer maintainable today, because of the consequences generated by such trends as:

- the proliferation of many new actors with ambitious projects, such as mega-constellations
- the emergence of new enabling technologies and new uses of space (e.g. RPO operations)
- the increasing – and often critical – dependence on space assets for both civil and military purposes
- the advent of a new political context characterized by power transitions and "the unravelling" of the post-cold war order.

These rapidly unfolding trends have contributed to turning space into a limited commodity and sensibly increasing strategic interaction (with possible clashes of strategic interests) among states. In turn, this has inevitably challenged the current space governance, creating a clear progression towards problems of cooperation, i.e. situations where actors need to eschew unilateral decision making and agree on specific behaviours to prevent the collective sub-optimality stemming from unrestrained actions. In such situations, the role of diplomacy as a tool to ensure that actors´ expectations and behaviours are convergent on specific issue-areas of their interaction, has obviously become more critical.

The orbital congestion problem (both in terms of debris and utilization of radio frequencies and orbital slots) offers a clear example in which the role of diplomacy is bound to substantially increase in order to manage the likely emergence of the typical "dilemma of the commons". And so do most of the issues

[101] Marco Aliberti, Stephan D. Krasner. Governance in Space. In: Al-Ekabi, C. et al. *ESPI Yearbook on Space Policy 2014*. Vienna. Springer, 2015.

related to the safe and secure sharing of outer space, for which only internationally-agreed solutions can provide effective solutions.

Because of the very nature of space as a shared resource, any negative development on safety, security and sustainability of space operations will have a widespread impact across the entire space community. Individual efforts to tackle these challenges are certainly needed, but these will not suffice alone to properly ensure continued ability to access and use space safely and securely in the future. Space safety, security and sustainability can be effectively pursued only by ensuring the adoption of internationally agreed principles, norms and rules that clarify behavioural standards and reduce the risk of mistrust, misunderstandings, and mishaps.

This is even more so for Europe. Given its limited appetite for power competition, the comparably lower support towards a muscular military doctrine based on the maxims of space control and the development of counterspace capabilities, as well as the complex multi-layered governance framework allowing for potentially diverging policies, Europe does not favour hard force and deterrence to safeguard the strategic objective of ensuring the safety and security of its space infrastructure. The preferred way Europe can square the circle is to leverage its diplomatic channels to push forward practical initiatives aimed at achieving convergence of interests among states and other entities conducting space activities.

With respect to the actions conducted in the international environment, European stakeholders are already engaged in a number of diplomatic and cooperation activities. Considering the status quo (including for instance the political challenges in advancing legally binding instruments for space activities), trends at play and actions pursued by other actors, there seem to be three areas of action European diplomacy should seek to further pursue:

- Promote the elaboration and implementation of norms of responsible and sustainable space behaviour with a harmonized European approach
- Advance security partnerships with like-minded partners to protect Europe's interests in the utilisation of space resources
- Enhance existing cooperative arrangements and foster back-up agreements guaranteeing service delivery or security of supply

5.2.1 Advance multilateral norms creation with a harmonised European approach

A first line of action to address the identified challenges entails using diplomacy to re-ignite European efforts to promote the elaboration and – even more important – the practical implementation of norms of responsible and sustainable space behaviour. In this respect, it should be first reiterated that European actors have already long contributed to the elaboration of norms and rules in a variety of technical and diplomatic-forums, including:

- the Inter-Agency Space Debris Coordination Committee (IADC) Responsible for production of Space Debris Mitigation guidelines, it grew out of the NASA-ESA coordination meetings and was set up as a formal organisation in 1993. Besides ESA, space agencies of major European spacefaring countries are members of the IADC (Italy, France, Germany, UK).
- the UN framework. Traditionally, European countries have shaped discussions at multiple space-related platforms, such as the Committee on the Peaceful Uses of Outer Space (COPUOS), the Conference of Disarmament (CD), the General Assembly (GA) and its committees and two Groups of Governmental Experts on Space (GGEs). In 2018, the EU obtained observer status in the COPUOS, enabling it to take a more significant role in UN space diplomacy.
- the ITU's World Radio Conferences. Dealing with spectrum allocation for space activities, Europe's views and positions on the different agenda items and issues are prepared by the European

Conference of Postal and Telecommunications Administrations (CEPT) through the work of the Electronics Communications Committee (ECC) Conference Preparatory Group (CPG).

- the International Organisation for Standardisation (ISO). Within the ISO, two subcommittees of Technical Committee 20, both with major European membership, deal specifically with space topics: TC20/SC13 deals with Space Data, and Information Transfer TC20/SC14 deals with Space Systems and Operations.

Europe was also the initiator of the International Code of Conduct for Outer Space Activities (ICOC), the major diplomatic initiative on space undertaken in the last decade. As also stressed by IISL president Kai-Uwe Schrogl, the ICOC "challenged not only the existing institutions (it was deliberately conducted outside UNCOPUOS), experimenting with various forms of interactions (regional conferences), but also setting out to elaborate a new element to space law (behaviour in outer space) with numerous additional features. At the final negotiation conference held in July 2015, it drew the participation of more States than the OST has signatory Parties, showing the importance of the initiative, despite its failure to reach a final consensus".[102]

Irrespective of the negative outcome of this ill-fated initiative, all these contributions have already demonstrated European leadership and actual willingness to advance multilateral norms creation contributing to the objective of using space in a safe and secure manner.

Moreover, Europe is the only major space actor not actively supporting a doctrine based on the maxim of space superiority (with the corollary development of counterspace) and for which the advancement of and compliance with norms and rules of behaviour proves to be consistent with the objectives set forth in its space strategy.

This posture has been arguably providing Europe with a level of credibility and capital trust on the international scene, which could be more aptly leveraged to position Europe as purveyor of behavioural standards in space that protect its underlying interests and objectives.[103] In principle, different approaches could be explored in this respect. European diplomatic efforts could be focused on promoting the practical application of already existing recommendations, guidelines, technical standards and legally binding documents or on the elaboration of new norms and rules (through bilateral, plurilateral or multilateral consultations); efforts could be conducted within existing international platforms or through new, ad-hoc European-led initiatives; and Europe could pursue a set of holistic or specific norms having a broader or narrower scope (e.g. the promotion of measures related to *due regard* for the environment, or other actors, or transparency and disclosure measures of national space activities and capabilities).

In concrete terms, diplomacy could be leveraged to encourage a widespread commitment to the effective implementation and review of the internationally agreed LTS guidelines as well as to promote political support to the efforts of the new working group established within the Scientific and Technical Subcommittee to consider the adoption of new guidelines for long-term sustainability (the so-called LTS 2.0 process).[104]

[102] Kai-Uwe Schrogl. Space Law and Diplomacy. 59th International Institute of Space Law (IISL) Colloquium on the Law of Outer Space, 2016.

[103] This has often not been the case, as for instance evidenced by Europe´s silence vis-à-vis the 2019 Indian ASAT test. As already noted by ESPI, after the Indian test "there has been a lack of official statement from European institutions, apart from a generic remark by the European Union on the EU's commitment to safeguarding the long-term use of outer space for peaceful purposes at the occasion of a general exchange of views on space debris mitigation during the 58th session of the Legal Subcommittee of UNCOPUOS. Given Europe's past stance on debris mitigation and the use of weapons in outer space, an official statement could have been expected. In fact, given its projected role of purveyor of behavioural standards in space, expressed through the EU proposition of the International Code of Conduct (ICoC), the silence seems particularly inconsistent with Europe's purported posture". ESPI. India´s ASAT Test Amidst Global Ambiguity". ESPI Brief No. 31 (April 2019).

[104] Peter Martinez. "The UN COPUOS Guidelines for the Long-Term Sustainability of Outer Space Activities". Secure World Foundation factsheet (last updated: November 2019). Retrieved from: https://swfound.org/media/206891/swf_un_copuos_lts_guidelines_fact_sheet_november-2019-1.pdf

In the meantime, complementary, Europe-led diplomatic initiatives could be pursued or reinforced to address emerging issues and source of tensions (e.g. non-consensual RPOs, ASAT testing and resource extractions, to name the most pressing). While, since the failure of the ICOC, the EEAS has been reorienting its diplomacy towards a UN-focused approach, this does not mean that new, non-traditional diplomatic approaches should be seen as having failed. Initiatives such as the ICOC and the two Groups of Governmental Experts (GGE) on Transparency and Confidence-Building Measures (TCBMs) in Outer Space "show that different approaches in dealing with the issue of peaceful uses are necessary and that they have to be accompanied by respective diplomatic approaches in establishing a consensus on peaceful uses and on how to enforce, or at least to encourage, application of the rules and ensure compliance".

As also stressed by the EU during the 2017 meetings of the CD Working Group established to discuss the "Way Ahead" for PAROS:

Efforts to pursue political commitments, such as a multilateral code of conduct to encourage responsible actions in, and the peaceful use of, outer space, are still relevant. It should be recalled that they were also endorsed by the Group of Governmental Experts (GGE) on TCBMs in outer space, which the UN Secretary General set up in 2010 in accordance with UN General Assembly Resolution 65/80.

In this context, we would like to encourage all States to work together to elaborate common guidelines such as principles of responsible behaviour in outer space, which could complement existing initiatives. Such principles should be designed in a way that they are agreeable by a vast majority of spacefaring nations.[105]

Whereas the existing platforms provide an established and proven framework for continued institutionalised dialogues, specific European initiatives on top of the contribution to common platforms allow for development of additional ideas, promotion of a common understanding, demonstration of the European interest in preserving a safe and secure space operational environment and enhancement of European leadership in activities fostering the safety, security and sustainability of space operations.

There are, of course, lessons to be drawn from past initiatives such as the ICOC. These most notably include the importance of seeking inclusive engagement as a way to prevent possible misconceptions over Europe´s vested interests[106] as well as the importance of favouring incremental steps focused on low-hanging fruits rather than comprehensive agreements.

An effort along these lines has been recently undertaken by the EEAS with the 3SOS (which stands for safety, security and sustainability of space operations), a new public diplomacy initiative launched in September 2019 aiming to reach a common understanding among all space actors on responsible and sustainable behaviour.

Interestingly, 3SOS has been opened to a variety of stakeholders, gauging inputs not only by states but also private industry, academia and civil society. In addition, the initiative has been primarily focused on raising awareness, promoting common understanding and attaining coordination of efforts, rather than the adoption of a new set of obligations for space actors by imposing new regulations.

[105] EU Statement on the Prevention of an Arms Race in Outer Space. Conference on Disarmament, Working Group on the "Way Ahead". EEAS (June 2017). Retrieved from: https://eeas.europa.eu/delegations/guatemala/28329/conference-disarmament-working-group-way-ahead-eu-statement-prevention-arms-race-outer-space_en

[106] As also underlined in this context by Rajeswari Pillai Rajagopalan, "the EU developed the ICoC by itself, neglecting an important opportunity to reach out to a larger number of states and so develop a globally viable instrument. Many countries, especially in the developing world, perceived the EU´s attempt to develop the code as the EU's determining what is good for the rest of the world. Although the EU eventually recognized some of its mistakes and attempted to rectify them, it was too late. Hence, future initiatives need to take into account that "including many countries, even if the measure being developed is not ideal, gives those states gives those states a sense of ownership that can have a far-reaching impact. Rajeswari Pillai Rajagopalan. "Achieving global cooperation in space security: settling for less than the ideal". *Space Security Index 2018*. Available at: http://spacesecurityindex.org/ssi_editions/space-security-2018/

This stepping-stone approach may prove conducive to producing progressive convergence towards *widely accepted solutions*. However, it is also clear that the more inclusive the engagement is, the harder it will be to reach a wide international consensus. It is likewise important to reiterate that to be successful, new European initiatives such as 3SOS should be more thoroughly supported – both politically and financially by member states. As a bottom line, it is critical that future EU diplomatic engagement in multilateral norms creation is based more extensively on common positions on critical issues (see 5.3). Currently, this is not the case across the initiatives in the space security domain, where potentially diverging national interests of EU member states continue to play out in some topics and keep primacy over the merits of collaboration towards joint positions. This implies finding ways to mend the fragmented landscape and skilfully craft an effective one-voice system capable of having weight in international negotiations that is commensurate with Europe´s capacity and interests.

5.2.2 Build coalitions of like-minded spacefaring nations

A different line of action could entail leveraging diplomacy to advance cooperation on safety and security matters with allies and like-minded partners. Diplomacy here would be used to bring other states that are willing to ally with European countries and institutions into a coalition that would protect European interests and be able to set rules and standards for activities in space.

These alliances could grow out of the bilateral policy dialogues Europe entertains with major partners such as the United States or Japan and could then be opened to additional partners willing to join or broader frameworks. Alternatively, these partnerships, could be used as a basis to pursue the development of coordinated space doctrines enabling the collaborative pooling of space capabilities to manage crisis and conflict situations.

In this respect, there are already several initiatives that provide a sound basis for future actions. For instance, some European countries have been pursuing advanced forms of partnerships with the United States, which include SSA experiments, liaison military officers in U.S. bases, joint Schriever War Games exercises and the Combined Space Operations (CSpO) initiative. These, and also potentially other forms of partnerships (for instance within the framework of NATO), may provide European institutions with a basis to extend safety and security cooperation beyond the exchange of SSA data and contribute to broader safety and security objectives.

Beyond meeting operational needs, an expanded level of cooperation on SSA would indeed prove highly beneficial to progress towards a common framework for Space Traffic Management (STM) and build verification regimes to monitor compliance or detect violations of rules of behaviour (e.g. the prohibition of the placement of weapons in space, the prohibition of co-orbital attacks or intentional destruction of space objects). Of course, to build such a regime, partners would need to converge on what represents compliance or a violation of behavioural standards; however reaching this convergence within a coalition of like-minded partners would actually prove less challenging compared to broad multilateral frameworks.[107] Through the construction of a verification regime, a further and closely related objective these coalitions could achieve is to disincentivise irresponsible behaviours and ensure a degree of deterrence against potentially hostile actions.[108]

[107] Daniel Porras. "Eyes on the Sky – Rethinking Verification in Space." Geneva, Switzerland: UNIDIR (2019). Retrieved from: https://unidir.org/publication/eyes-sky

[108] As also underlined by UNIDIR in its Handbook of Verification and Compliance, "the more effective a verification system, the more likely it is to deter parties from even contemplating a deliberate violation. Verification systems do not need to be one hundred per cent effective to provide a significant level of deterrence: just as parties to a treaty are unlikely to be absolutely certain that all other parties are complying fully, a non-compliant State can never be completely certain that its actions will go undetected. The Handbook adds that the more sources of data that exist—and the more layered a verification system can be—the more effective it will be in convincing possible offenders that they will be detected and caught before they can gain a meaningful advantage.

Ultimately, the construction of verification systems could overcome one of the main challenges in the development of legally binding normative solutions for space (i.e. the lack of effective means to monitor compliance with international agreements) and hence make it easier to successfully negotiate new legal measures to address space safety and security threats.

All in all, given the perennial challenges confronting the adoption of new norms and rules within the broader multilateral frameworks, rule-setting through coalitions of the willing may provide Europe with more tangible answers to its safety and security needs. However, it is again clear that the European way forward in advancing safety and security in the international arena should seek to strike a proper balance between this line of action and the above-discussed promotion of multilateral norms and rules of behaviour through inclusive diplomatic engagement. The tension between the two lines of action is indeed apparent and giving preference to this latter path may undermine the effectiveness of the former (as it would undercut the credibility of Europe and raise misconceptions about vested interests). Vice-versa, focusing only on multilateral diplomatic engagement may not be sufficient to ensure safety and security.

5.2.3 Foster agreements to guarantee security of supply and service delivery

Closely intertwined with the previous set of discussed actions, a third set of diplomatic actions to guarantee freedom of action and ensure continued availability of services provided by European space infrastructures entails the enactment/implementation of so-called back-up agreements with international partners. The objective of these agreements would be either to guarantee service delivery (launch, telecom, EO, GNSS…) or to ensure the security of supply (systems, technologies, components…).

In this context, European actors have established several cooperative arrangements fitting this purpose. For instance, in the field of GNSS, through transatlantic cooperation, the EU has been able to achieve, a higher level of resilience in GNSS capability, in which the negative consequences of service dropout of one's own system could be mitigated by reliance on continuous service provision from the other partner. Resilience is further supported through the different operational characteristics of each system, such as signal formats of frequencies, which make it impossible for a potential attacker to jam both with one single disruptive effort[109]. In the context of provision of Galileo PRS service, interestingly, no definitive arrangement has been made between the EU and the United States.

Again, in the field of meteorological service delivery guarantees a prominent example is offered by the long-lasting partnership between NOAA and EUMETSAT, while in the field of launch services, Arianespace and Mitsubishi Heavy Industries (MHI) and Boeing have signed a mutual backup agreement to guarantee launch dates for commercial satellite launches.

Tacking stock of the growing number of spacefaring nations, of the increasing capabilities of the private sector as well as of the favourable standing of Europe in terms of international cooperation (Europe is one of the few space actors cooperating with any international partner), European stakeholders should exploit the opportunity to capitalize on these favourable conditions and utilise international cooperation in the form of service delivery guarantees and security of supply arrangements so as to contribute to meeting the strategic objectives of accessing and using space in safe and secure manner.

Several types of cooperative arrangements could be envisioned in line with this reasoning, including launch service back-up agreements, supply chain diversification and reciprocal cooperative arrangements in applications (SatCom, EO, GNSS). Similarly, the scope of partnership can range from bilateral to multilateral partnerships.

[109] Marco Aliberti, Martin Sarret, Tomas Hrozensky & al. *Security in Outer Space: Perspectives on Transatlantic Relations*. ESPI Public Report n°66 (October 2018), p. 48

Regardless, in order to evaluate possible alternatives in this field of action, several criteria will have to be identified, primarily concerning:

- Reliability of the cooperative arrangement, addressing whether the type of guarantees and the partners themselves can be reliably trusted to ensure unrestricted access to the required technology or service
- Incurred costs and added value, in order to comprehensively evaluate necessary resource allocation and potentially identify alternative solutions,
- The factor of swiftness, to obtain precise estimations whether the delivery of service or supply of technologies could be expected in a timely manner.

5.3 The bottom line: a more assertive Europe and dedicated policies

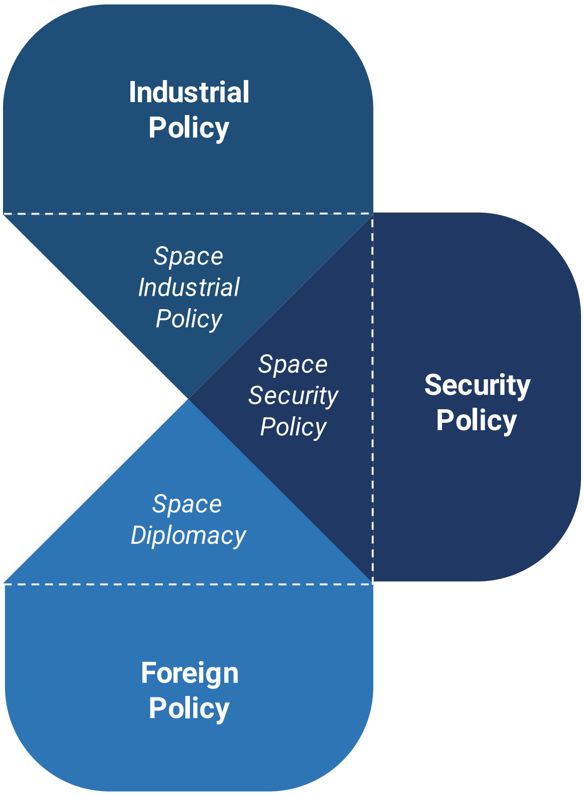

Figure 26: Nexus of the elements to take into account in future European actions

Irrespective of the actual implementation of the specific policy measures proposed in the previous sections, any coherent and effective action in the international context needs to rest on a number of enabling factors[110], including:

- Availability of proper know-how
- Presence of proper funds
- Clearly identified scope and policy
- Clear priorities
- Identification of implementing strategy

Taking stock of this, European actions on the international stage should be consistent with, and embedded within:

- the broader international agenda of the Union
- dedicated Europe-wide sectorial space policies to inform diplomatic action and, in particular,
    - a space industrial policy
    - a space security policy

5.3.1 Towards a more assertive Europe in the international arena

Historically the European approach to international space diplomacy has not been driven by a foreign policy agenda, but by programmatic opportunities, centred mostly in the framework of ESA. As a European research and development organisation, ESA is indeed a programmatically-driven organisation i.e. the international cooperation is informed by programmatic needs more than a general "foreign policy", as is the case for sovereign states. [111]

However, with the progressive involvement of the EU in space matters, a broader strategy for international space relations has been gradually emerging, driven by increasing synergy and complementarity among European constituencies. The development of a common European space diplomacy has been primarily led by the EC/EEAS which, since the entry into force of the Lisbon Treaty in 2009, has taken primary responsibility for defining and representing the external dimensions of the European space programme. This has been duly reflected, for instance, in the Space Dialogues the EC has set up with United States, Russia, China, Japan and South Africa to address a range of civilian (industrial) and security issues. In collaboration with its member states, the EU has also become actively involved in the work of international organisations and committees such as the International Telecommunication Union (ITU), the International Committee on Global Navigation Satellite Systems (ICG) and the UN COPUOS. Even more

[110] Giuseppe Viriglio. "Space Diplomacy for Business". Presentation at the 13th ESPI Autumn Conference (September 2019)
[111] Annabelle Fonseca. "ESA cooperation with Russia, China, Brazil, India and South Africa".Leiden: European Space Agency (May 2013)

noticeable is the leading role played by the EU since 2007 in the preparation, negotiation and tentative adoption of an International Code of Conduct for Outer Space Activities (ICoC).

Even though the original initiative ultimately failed to reach its objective, the EU and its member states demonstrated their willingness to move forward in the promotion of norms of responsible space behaviour to advance the safety, security, and sustainability of space activities.[112]

The European way of utilizing space for diplomatic purposes showcases Europe's interest in deepening political and economic ties, addressing global challenges, such as those stemming from climate changes, and safeguarding international security and stability (be it in space and on Earth). In these contexts, European diplomatic initiatives and cooperative undertakings with third countries have multiplied over the past years, making Europe a more credible interlocutor on the international stage.

What is, however, still missing in the promotion of a stronger and consistent 'European way' to space diplomacy is a higher degree of coordination with national governments and space agencies, which conduct many international cooperation activities under their own steam, and which are central to strengthening Europe's weight in the international arena and multiplying its effectiveness in pursuing foreign policy objectives.

In addition, more systematic support at the higher political level (i.e. the European Council) and a greater structured effort to efficiently gather the forces of the different institutional stakeholders (DG DEFIS, EEAS, DG TRADE, DG DEVCO) is required and would be highly beneficial for ensuring the implementation of diplomatic initiatives.

In short, in order to safeguard European positions and promote its interests in the international space community a more strategic, assertive and united Europe is required.[113]

This need was fully echoed in the mission letter of the 2019-elected President of the European Commission, Ursula von der Leyen, to Josep Borrell, High Representative of the Union for Foreign Affairs and Security Policy[114]. In this letter, the EC president called for a Geopolitical Commission able to make the European Union more strategic, more assertive and more united in its approach to external relations. Towards this, and with the objective of strengthening European leadership, Ms. von der Leyen underlined the need to:

- take decisions in a faster and more efficient way,
- better link the internal and external aspects of European policies,
- make the external action a systematic part of the decision-making process,
- take bold steps towards a genuine European Defence Union,
- ensure a strategic use of external financial instruments to contribute to wider political aims and enhance Europe's leadership and influence in the world.

In many ways, the challenges ahead of Mr. Borrell resonate particularly strongly in the space sector. As seen, the situation is indeed rapidly deteriorating and stakes are high to maintain a level playing field and fair competition, to ensure the safe and sustainable sharing of outer space, and to preserve Europe's place as a key actor and partner in space.

[112] The European External Action Service declared in 2018 continuing European interest in bringing once again to international discussion the idea of adoption of a voluntary international instrument setting the rules of the road for responsible behaviour in space for countries engaging in space and aspiring to become spacefaring nations. This announcement stated that the new approach would be more closely pursued through a UN framework.

[113] The reverse is to a large extent also true: by acquiring space capacities, the EU is, in fact, building its status as a political power having an influence on the international scene. It is undoubtedly a slow and painstaking process, but it has a long-term effect, which could actually explain the opposition of some member states to support more ambitious space capabilities at EU level.

[114] Ursula von der Leyen, "Mission Letter to Josep Borrell, High Representative of the Union for Foreign Policy and Security Policy/Vice-President-designate of the European Commission" (September 2019). Retrieved from: https://ec.europa.eu/commission/sites/beta-political/files/mission-letter-josep-borrell-2019_en.pdf

From this standpoint, and along the lines drawn by Mr. Borrell's mission letter, it seems more and more essential to make external actions an integral part of the European space strategy and to embed space affairs in the broader international agenda of Europe. Profoundly global and at the crossroads of many European Union policy challenges (security and defence, digital agenda, internal market, industrial policy, socio-economic development…), space may actually be an ideal test case to shape such a strategic, assertive and united approach to international relations.

Such action can, however, only be effective if it follows clear and shared European positions and objectives in the space sector. This again implies finding ways to mend the fragmented landscape and skilfully craft an effective one-voice system capable of drafting a common vision and action for Europe on crucial issues such as economic and industrial policy, space security and defence, and, in general, any topic that needs to be addressed at the highest political level to stimulate decision-making processes and ensure consistency of action.

5.3.2 Towards dedicated space policies

Besides embedding diplomatic initiatives within the broader international agenda of Europe, there is also a need to make these actions an integral part of dedicated policies serving the interests of the European space sector, in line with a clear and shared political vision for Europe in space and space in Europe.

More specifically, the international actions discussed in previous sections should be fully integrated into a European policy framework taking into account both "internal" and "external" aspects, thus including:

- Relevant external actions to promote European positions and protect European interests,
- Appropriate mechanisms to promote a coherent diplomatic engagement by:
  - enhancing the coordination between European stakeholders
  - ensuring consistency between internal and external actions
- Mandates to ensure appropriate representation in relevant fora

In light of the specific challenges faced by Europe, two dedicated sectorial policies are needed:

- Space industrial policy
- Space security policy

The need for these two policies is broadly recognized by institutional and industrial stakeholders alike.

Space industrial and commercial policy

With respect to the space industrial policy, its need has been recently brought to the fore within both ESA and the European Commission.[115] More specifically, in the "Resolution on ESA programmes: addressing the challenges ahead", the ESA Ministerial Council recognized the importance of a comprehensive European industrial policy for space, with a view to fostering the competitiveness of European industry and stressed the need for ESA's industrial policy to evolve, in view of the rapidly changing context for space activities in Europe and worldwide and of the different types of programme being conducted in the Agency. By the same token, discussions are ongoing in the Commission as part of the broader EU´s reflections on a new industrial strategy. As a step in this direction, the communication "A New Industrial Strategy for Europe" was issued in March 2020 by the Commission.[116]

[115] "Resolution on ESA programmes: addressing the challenges ahead" (Resolution 3), adopted by ESA Ministerial Council on 28 November 2019. Retrieved from: https://esamultimedia.esa.int/docs/corporate/Resolution_3_Space19+Final-28Nov-12h30.pdf
[116] European Commission, "Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions: A New Industrial Strategy for Europe" (March 2020). Retrieved from: https://ec.europa.eu/info/sites/info/files/communication-eu-industrial-strategy-march-2020_en.pdf

What is still missing, however, is a reflection on the ways to ensure convergence between the industrial policies and procurement approach of these two major stakeholders. This should not be taken to mean the need for a single interface at European level for institutional programmes or a broader evolution of the institutional governance.

As advocated also by representatives of the European space industry, this convergence rather means that "at least ESA and EC approaches should not be conflicting and their rules should be adapted to better cope with the specificities of the space sector and serve overarching political goals. Ideally, their respective roles should be clarified through clear regulations" and their respective industrial policies elaborated along joint principles and goals so as to ensure consistent procurement regulations".[117]

A dedicated European-wide industrial and commercial policy should more broadly contain:

- shared objectives between ESA and the EU, already identified as:
  - Strengthening the competitiveness, efficiency, reliability of the European space industry,
  - Enhancing the European technological non-dependence in the space sector,
  - Building on the existing European leading edge industrial and technological capabilities,
  - Contributing to balanced industrial development across EU member states.
- "Domestic" means to address challenges and meet the objectives, including dedicated procurement regulations
- "External" means to address the challenges and achieve the objectives, including the above-discussed efforts to level the playing field with international competitors

Space security and defence policy

Along the same lines, international action towards promoting a safe and secure space environment should be fully integrated in a European space security and defence policy. The need for a dedicated European-wide space security and defence policy has been amply discussed in previous ESPI studies.[118] Also in this case, it would be essential to integrate the competencies of the major stakeholders into a single, coherent policy framework clarifying the European approach to a number of pressing issues, including the governance framework (balance between the intergovernmental and supranational roles), exploitation of the developed systems, and the role of private industry as a user and provider of the developed systems and services.[119]

Just as with the industrial and commercial policy, a dedicated space security and defence policy should comprise:

- The objectives to be achieved in the short-medium and long-term
- "Domestic" measures to achieve the objectives
- "External" actions to achieve the objectives

Enacting the policies

It is beyond the scope of this report to go into the details of these policies and identify the modalities of enactment and implementation. However, just like Europe´s overarching strategic framework for space, an enabling role could be played by the EU-ESA Space Council which, at the moment, is the most appropriate venue to reach and express convergence of interests among the main actors in European

[117] ASD-Eurospace. *Towards a European space-specific procurement policy?*. ASD-Eurospace, 2018.
[118] See the following ESPI Public Reports: Sébastien Moranta, Serge Plattard, Martin Sarret & al. *Security in Outer Space: Rising Stakes for* Europe. ESPI Public Report n°64 (August 2018); Marco Aliberti, Martin Sarret, Tomas Hrozensky & al. *Security in Outer Space: Perspectives on Transatlantic Relations*. ESPI Public Report n°66 (October 2018); Sébastien Moranta, Tomas Hrozensky & Marek Dvoracek. *Towards a European Approach to Space Traffic Management*. ESPI Public Report n°71 (January 2020)
[119] Sébastien Moranta, Serge Plattard, Martin Sarret & al. *Security in Outer Space: Rising Stakes for* Europe. ESPI Public Report n°64 (August 2018), p. 66

space governance. Indeed, the development of a joint European policy framework clearly implies reaching a broad political consensus among member states, on:

- Shared goals and principles to be set for European efforts, be it on commercial markets or in bilateral and multilateral frameworks.
- Mechanisms to ensure productive and efficient coordination among stakeholders,
- An appropriate delineation of roles, sharing of responsibilities and distribution of activities.

More broadly, consensus must be reached on the recognition of the strategic nature of space activities. Only this recognition will **accelerate the emergence of a much more effective, independent and dedicated industrial as well as security space policy for Europe.** If this convergence and recognition does not materialise, European actions on the international stage are bound to remain ineffective.

6 Conclusion

The European space strategy cannot be attained in isolation from the broader international context in which Europe operates. With its profound transformations, this context is setting more challenging boundary conditions, which are increasingly testing Europe´s capacity to "promote its position as a leader in space, increase its share on the world space markets, and seize the benefits and opportunities offered by space". Many of the challenges ahead for the European space sector have a strong, sometimes dominant, international dimension. Recent and expected developments on the global scene, as well as the resulting strategic, programmatic and commercial stakes for Europe, are the direct or indirect result of a determined will-to-power of major space-faring states, which have given rise to ambitious space policies creating far reaching implications for Europe.

From a commercial perspective, Europe has extensively leveraged (and so far, quite successfully) commercial markets to support the development of its industrial base but now finds itself squeezed between intensifying competition and new business forces affecting core markets. In this context, the active involvement of foreign governments in trade and/or regulatory affairs plays an ever more prominent role in fostering the commercial performance of their domestic industry to the detriment of Europe´s. Much more significantly exposed to commercial "open" satellite and launch service markets than its competitors, the fluctuations and difficulties faced by the European industry today – and which could further deteriorate in the future – resonate in the European space sector at large, challenging the so far successful foundations of the so-called "European way".

In parallel, the expansion and acceleration of global space activities is also creating new challenges to the safety and sustainability of space activities while the more assertive stance of some foreign governments in the field of space defence and security is bringing forward new security dilemmas and strategic stability issues. European governments have long expressed their concerns about the peaceful, responsible and fair sharing of outer space but the recent acceleration of policy developments in these domains, in particular in the United States, is pressing Europe to step up its effort around a more determined and comprehensive approach to effectively weigh in on upcoming international frameworks and ensure a balanced cooperation with other actors.

In this challenging international context, it is the place of Europe as a competitor on commercial markets, as a partner in international endeavours, and even as an actor in outer space, that is put at stake. Today, the request to the EU institutions is that they implement all necessary measures to protect the industrial, commercial and strategic interests of Europe, in the same way other space powers do. After all, the full deployment of Galileo and Copernicus makes the EU the owner and operator of major space infrastructure. This comes along with additional concrete obligations and responsibilities to safeguard its interests on the international scene.

From this standpoint, an assertive and coordinated diplomatic action on the international stage can do a lot to cope with the challenges ahead and avoid that European singularities turn into European weaknesses. As the global space sector is rapidly shifting towards a scenario characterised by the growth of strategic competition in the commercial, political and security spheres, the need for sound diplomatic action is inevitably bound to increase to maintain stability and reach an adequate convergence of interests among the various nations and entities involved in space.

As amply discussed by the speakers at the 13th ESPI Autumn Conference in September 2019, diplomacy has some specific cards to play in this new context (including close proximity to decision-makers at the highest political level as well as its world-wide network of embassies, permanent representations and offices). Leveraging diplomats is thus of paramount importance in protecting European interests and positions on the international scene, be it on commercial markets or bilateral and multilateral frameworks.

Considering the status quo, trends at play and actions undertaken by other actors, a variety of diplomatic measures have been discussed to contribute to addressing the identified challenges and, in particular, to support the competitiveness of the European space sector while ensuring the safe, secure and sustainable sharing of the outer space environment. Specifically, for each of the two areas of concerns, three types of diplomatic actions have been discussed: broad, targeted and transversal measures, as summarised in Table 15.

	Diplomatic actions to address competitiveness challenges	Diplomatic actions to address safety, security and sustainability challenges
Broad	Promote the establishment of principles and rules for competition in the global space economy	Promote the elaboration and implementation of norms of responsible space behaviour with a harmonized European approach
Targeted	Support European industry´s access to foreign markets	Advance security partnerships with like-minded partners to disincentivise irresponsible behaviours
Transversal	Secure appropriate industrial activities in international cooperative ventures	Enhance existing cooperative arrangements and foster back-up agreements guaranteeing service delivery or security of supply

Table 15: Overview of diplomatic actions to support Europe´s strategic objectives

Irrespective of the actual implementation of the specific policy measures discussed in this report, any coherent and effective action in the international context needs to rest on a number of enabling factors, including the availability of proper know-how and funds, the presence of clearly identified priorities and scope for policy actions, as well as the identification of the appropriate implementing strategy.

Tacking stock of this, it is recommended that European actions on the international stage should be consistent with and embedded within:

- the broader agenda and action of the EU on the international stage, which should itself become more strategic, assertive and united
- dedicated European-wide sectorial policies informing both “internal” and “external” actions and serving the interests of the European space sector, in line with a clear and shared political vision for Europe in space and space in Europe. Two dedicated policies are specifically needed, i.e.:
  - a space industrial policy
  - a space security policy

Overall, securing Europe´s ability to effectively address the growing challenges on the international stage and hence fulfil the strategic objectives set forth in its space strategy would require moving towards:

- a coherent – if not unified – European space diplomacy that will be an integral part of the European space strategy and embedded in the broader international agenda
- a top-down approach to space policy, with key areas for common policies and diplomatic action such as space industry and commercial business as well as space security and defence
- a more strategic, assertive and united Europe in space, which itself would require
  - revisiting the concept of shared competence in space affairs,
  - addressing the reluctance of member states to agree on any additional transfer of sovereignty towards European institutions or to voluntarily align their national policies to contribute to and reinforce the objectives defined at EU level,
  - crafting an effective one-voice system to ensure that EU will be in a position to weigh in on space-related international negotiations

Meeting these requirements, and in particular progressing toward a more strategic, assertive and united Europe, is an essential condition to maintain a level playing field and fair competition, to ensure the safe and sustainable sharing of outer space, and to preserve Europe's place as a key actor and partner in space.

Acknowledgment

The authors would like to express their gratitude to the participants in the 13th ESPI Autumn Conference, which was held on 18-19 September 2019, whose interventions contributed to feed reflection in the report. The authors would like to especially thank ESPI Director, Jean-Jacques Tortora, for his guidance and continuous support to this research, as well as the whole ESPI team for constructive and fruitful exchanges. Additional interviews were conducted with panellists and keynote speakers at the Autumn conference, as reported below.

List of interviewees	
Lucas Buthion	Project manager – European and International Policy Affairs, French National Cybersecurity Agency
Carine Claeys	Special Envoy for Space, European External Action Service
Luca del Monte	Head of Industrial Policy and SME Division, European Space Agency
Pierre Delsaux	Deputy Director-General, DG DEFIS, European Commission
Sorin Ducaru	Director, European Union Satellite Centre
Luce Fabreguettes	Executive Vice-President, Missions, Operations and Purchasing, Arianespace
Augusto Gonzalez	Adviser for International Matters to the Development & Innovation Director, DG DEFIS, European Commission
Olivier Lemaître	Secretary General, Eurospace
Piero Messina	Senior Officer, Strategy Department, European Space Agency
Frederic Nordlund	Head of External Relations Department, European Space Agency
François Rivasseau	Ambassador, Permanent Representation of France to the United Nations Organisations in Geneva and International Organisations in Switzerland
Jana Robinson	Space Security Program Director, Prague Security Studies Institute
Wolfgang Röhrig	Head of Unit Information Superiority, European Defence Agency
Andre Rypl	Diplomat, Embassy of Brazil in Vienna
Giorgio Saccoccia	President, Italian Space Agency
Kai-Uwe Schrogl	Seconded to the German Federal Ministry for Economic Affairs and Employment, European Space Agency
Brig. Gen. Giuseppe Sgamba	Assistant Director, NATO's Joint Air Power Competence Centre
Jenni Tapio	Chief Specialist, Ministry of Economic Affairs and Employment of Finland
Graham Turnock	CEO, UK Space Agency
Giuseppe Viriglio	Former CEO, Alenia Space; Former Director of Telecommunications and Navigation, European Space Agency
Johann-Dietrich Wörner	Director General, European Space Agency

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