Space Safety and Sustainability Momentum

Four considerations for future policy-making

ESPI European Space Policy Institute

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TABLE OF CONTENTS

1 INTRODUCTION

Space safety and sustainability - a prerequisite for societal and economic benefit of space

As human activity in space continues to increase, the challenges of ensuring the safety of space operations and long-term sustainability of the space operational environment are ever more crucial in view of humankind's future in space.

In this landscape, policymakers are increasingly called upon to take action to prevent further worsening of the status quo regarding space safety and sustainability, while private and public actors alike gradually engage in new commercial ventures across a variety of different activities and applications.

Space safety and sustainability are problems of today and tomorrow and if left unattended, severe risks will materialize, with implications going beyond the perimeter of the space sector. Space technologies, data and services create immense socio-economic benefit, in particular towards the achievement of policy-relevant objectives and in a variety of economic sectors. Inability of safely operating in the space environment would have grave consequences for developed economies in Europe and globally.

Future policy making in an evolving international landscape and a public-private ecosystem

Against this backdrop, a reliable evidence-based support to policy making is needed. This conviction has served as one of the underlying rationales for this study, in line with the mission of the European Space Policy Institute (ESPI).

ESPI has long supported decision-making with informed views, analyses and recommendations in domains related to space safety and sustainability, including but not limited to space situational awareness, space traffic management, international space diplomacy, global space governance, in-orbit services, and space weather.

Building on this foundation, **this report brings a targeted perspective on the future policy-making in the domain of space safety and sustainability, offering a suite of policy drivers and options for decision-makers and executives at national, European and international levels** (Chapter 3).

These considerations are built on the foundation of research results highlighting major awareness and policy momentum for space safety and sustainability, visible in national strategies, international agenda, as well as private sector engagement (Chapter 2).

The study does not aim at offering a comprehensive and exhaustive insight into a broad range of safety and sustainability issues. Instead, it takes a more focused approach, leveraging results of a specific research exercise into space safety and sustainability conducted by ESPI in the timeframe September 2022 – April 2023, further updated with developments unfolding since.

Context and support to the research

This report builds on research led by ESPI in support of a recurrent "Horizon Scanning" exercise within the EUSST Partnership, under the responsibility and coordination of the German Space Agency at DLR. Perspectives presented in this report are ESPI's viewpoints and not necessarily those of DLR or EUSST.

2 POLICY MOMENTUM FOR SPACE SAFETY & SUSTAINABILITY

2.1 A surging prioritisation of space safety and sustainability objectives in national space policies

Concerns related to the safety of space operations and sustainability of space activities in the long term have notably affected space-related policymaking in recent history.

Beyond the growing number of international efforts in pursuing space safety and sustainability (e.g., UN LTS Guidelines, industrial initiatives such as Space Safety Coalition), national policymakers have significantly increased their focus on the topics of safety and sustainability in developing national space policies and strategies.

This assessment is substantiated by tailored ESPI research in Q1 and Q2 2023, which focused on a quantitative analysis of the international policy landscape:

- Data analysis instruments and techniques have been run over a dataset covering a plethora of national strategies and policies released across the globe.
  - More than 50 national strategies and around 50 other policy documents have been selected and grouped along four batches based on the date of release.
- Along this line, the overarching objective of the research was to investigate the relevance of space safety and sustainability across national strategies and policies in a temporal dimension.
- The occurrence of a pre-defined set of words related to the topics of space safety and sustainability was counted in the text of each document; the rate of occurrence of words related to space safety and sustainability was calculated by dividing the absolute occurrence of the chosen words by the total number of words in each document.
- Finally, the harmonic mean for each batch was calculated to ensure the result was independent from the number of documents in the batch.

The results of the analysis of these instruments show a clear **increase in the relevance of the topics of space safety and sustainability throughout the years** (See Figure 1), quantitatively confirming the qualitative assumptions that initiated the research.

In addition to the **confirmation of the initial assumption**, the above-mentioned analysis provides several conclusions:

- During the last decades, some countries have released more than one strategy for their space activities. Therefore, a similar study to the one presented here could be conducted on this sole, national dimension.
- In these cases, the global trend outlined above can easily be confirmed at the national level, with further consideration that countries such as the U.S have even released a specific policy for STM.

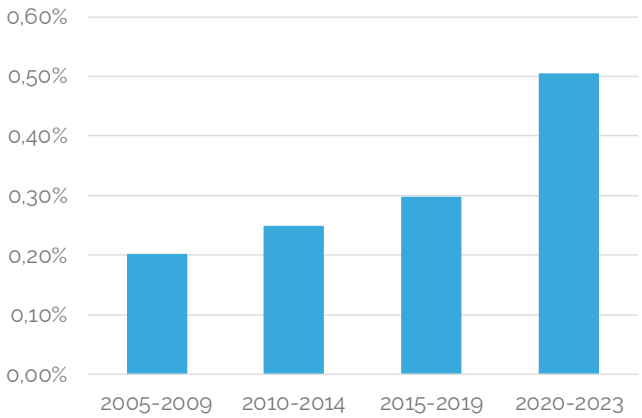

Figure 1: Frequency of keywords related to space safety & sustainability in national policy documents (Source: ESPI)

- The pre-defined set of words encompasses both general terms related to safety and sustainability and more specific concepts such as "collision avoidance" or "active debris removal (ADR)". Some of these more specific terms were found only in more recent documents, thus showing the **policy uptake of new or rather specific concepts** over the years.
- The last temporal batch of documents, despite covering only three years, counts a higher number of items than the previous batches which all covered five years. This exemplifies the **increased proliferation of space strategies and policies in the last few years**.

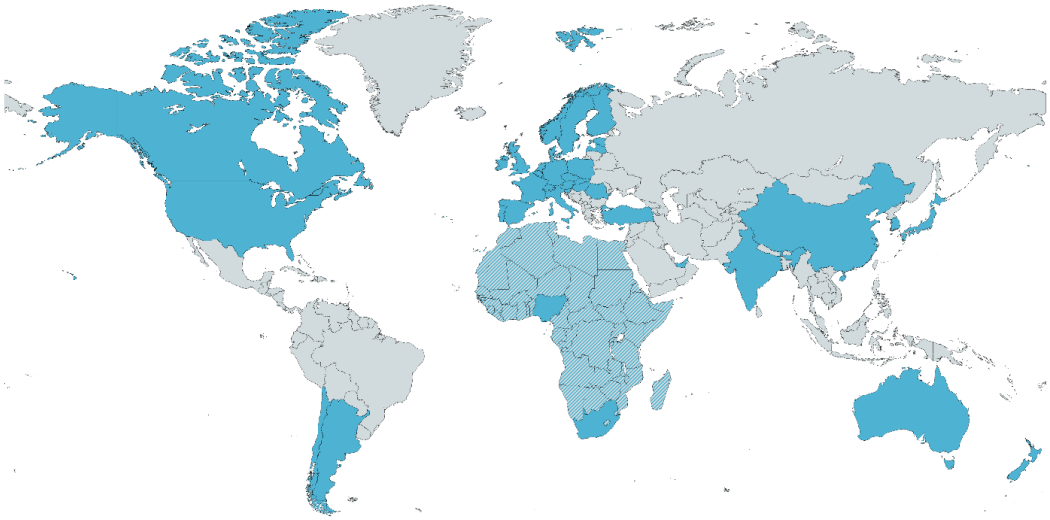

Figure 2: Countries included in ESPI's analysis of space policy documents (lighter blue denotes African Union members)

2.2 European countries leading the way with major focus on safety and sustainability topics next to programmatic priorities

When honing in on Europe, the aforementioned trend is noticeably present, with public actors taking policy, regulatory, programmatic and diplomatic action at both European and national levels.

ESPI research further focused on the national policy dimension. A first review of more than twenty national space strategies of European countries has significantly highlighted the trend of greater sensitivity to safety and sustainability topics. **More than half of the documents reviewed were released in the past three years**. Among them, half replaced previous strategies released in the 2010s, while the other half marked the first space strategy released by the respective countries.

Moreover, **some European states have just released or are in the process of soon publishing an update to their space policy**:

- Austria released a national space strategy in 2021, underlying sustainability as its central theme. The strategy also notes that "Space and sustainability" will be established as a core topic at the European Space Policy Institute (ESPI).[1]
- Switzerland adopted its 2023 Space Policy in April, following the Swiss Space Council decision to update the 2008 policy in parallel to drawing up a preliminary space law in the coming years.
- Slovenia published its Draft Space Strategy in April 2023, opening it up for public consultation,
- Malta is following a similar path, having opened for consultation its National Space Strategy in January 2022.

[1] The establishment of ESPI Centre of Excellence, is foreseen in 2024 in cooperation with the Austrian Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology

- Luxembourg is also updating their vision with a new policy for the period 2023-2027, released in December 2022, less than three years after the release of Luxembourg's previous strategy.
- In October 2022, Germany started work on a new space strategy to replace one dated back to 2010. Moreover, in June 2023 Germany released its National Security Strategy, "Robust. Resilient. Sustainable. Integrated Security for Germany". The strategy devotes a specific section to *Outer space*, where focus is brought to space situational awareness and ensuring safety and sustainability in space.
- Greece is also reported to be working on its national space strategy through its Hellenic Space Centre.
- Poland has announced its intention to release an implementation plan of its national space strategy, published in 2017.
- Finland has initiated the development of its new space strategy in 2023.

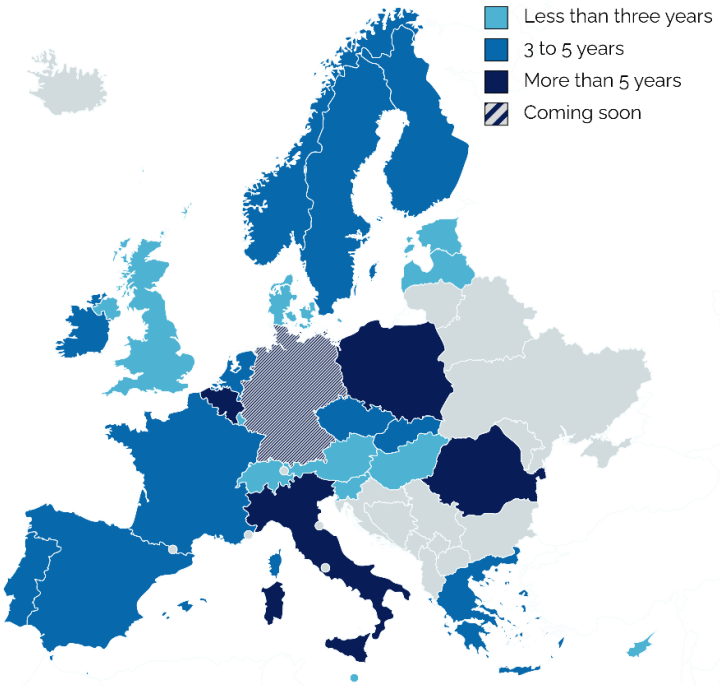

Figure 3: Wave of new national space strategies in EU and ESA member states (Source: ESPI Database)

A more detailed investigation of national space policies and strategies of European countries aimed to investigate the scope of their focus on space safety and sustainability topics. Indeed, most of the recent strategies draw specific attention to these matters, as shown by explicitly mentions of **safety and sustainability (as well as security) as national priorities in space**.

The following observations can be derived from the analysis of these strategies:

- **Space sustainability is seen as an urgent matter to be addressed.** Countries refer to the need to regulate private activities in pursuit of space sustainability. Furthermore, space sustainability is frequently linked with the urgency of sustainable development on Earth, which is itself served by many space applications.
- **Multilateral instruments are highlighted as a crucial tool.** UN guidelines and fora are also cited as the preferred framework for cooperation, with reference to UN diplomacy. Support for international norms also occurs in relation to multilateral instruments within Europe and beyond.
- **Space debris mitigation and removal stand out as national priorities in space.** This includes smaller countries or regions, as Scotland even aims to reach "debris neutrality". In-orbit servicing activities are also frequently mentioned in the strategies analysed, including ADR, with Italy dedicating a specific part of the 2020-2029 Strategic Vision for Space to this topic.
- **The protection of satellite systems is constantly presented as a key strategic objective**. To this extent, SSA services are seen as a vital tool. Notably, the nature of critical infrastructures of space assets is mentioned specifically by Norway, among others. Despite this fact mainly reflecting the trend of securitisation of space programmes, its impact on activities towards ensuring space safety and sustainability should also be considered.

New perspectives for space regulatory and legal competences at the EU level

The expansion of EU space engagement is increasingly taking other forms of action than just programmes, infrastructures and capability development. With the current MFF and initiatives under development, there is a **greater prominence of new regulatory considerations that could be developed at the EU level**, and crucially, doing so in compliance with the Treaty on the Functioning of the European Union (TFEU).

This is a significant trendline as regulation, authorisation, oversight, or licensing of space activities is a national competence and the TFEU clearly delineates that EU competence in space shall be understood as "excluding any harmonisation of the laws and regulations of Member States" (Art. 189, par.2, TFEU). Discussions on EU competence in these domains are not new. One of the key rationales behind such considerations is related to potentially diverging and insufficient national mechanisms for the regulation of space activities, which can produce a series of detrimental effects in the long-term (forum shopping, weaker international positioning).

The table below provides excerpts from some of the recent policy documents released by the major EU institutions which indicate continued reflection and an assertive approach of the EU in the domain of space safety & sustainability.

European Commission	• Positive incentive measures will be put in place to foster the use of the guidelines and standards by EU operators • The EU should make a legislative proposal covering STM rules (developing a level playing field at the EU level)
Council of the EU	• Recognises the role that the Commission could play in facilitating coordination between Member States' national efforts to address STM legislation and standardisation • Consideration be given to adopting appropriate national instruments, to be reinforced step by step
European Parliament	• A clear regulatory framework should serve as a basis for an EU-wide level playing field for space activities and a comprehensive framework for binding, European legislation on space

Table 1: EU institutional debate about the perimeter of EU competence in space,

The debate over a greater prominence of the regulatory dimension in EU space competence has been notably spurred on by the release of EC/EEAS Joint Communication on Space Traffic Management in early 2022. Particularly at the Commission level, the **evolution towards an EU role in European spaceflight safety rules** has continued ever since.

Moreover, the Commission has initiated the development of an EU space law, "to put in place common rules on safety, security & sustainability of our space operations". Member States will likely engage in in-depth discussions about their willingness to give the green light to the Commission's commitment to this ambition. It is reasonable to expect at least some kind of evolution towards an EU role in regulation or oversight of space activities.

Some of the latest publicly available reflections at the expert level have addressed topics such as EU acceptance of international space treaties, or development of EU soft law mechanisms, as well as the EU's increased role in public outreach and promotion.

2.3 Space safety and sustainability ever-high in international fora

In the past decade, concerns related to the safety and sustainability of space activities have been increasingly addressed in multilateral fora for space governance. A broader recognition of some of the growing problems, such as the proliferation of space debris, already emerged throughout the 2000s, with the adoption of the **UN Space Debris Mitigation Guidelines** (based on the previous work in the IADC and of a group of European space agencies, notably consisting of the European Code of Conduct for Space Debris Mitigation, 2006) and a few other initiatives, namely:

- Release of the EU Draft Code of Conduct for Outer Space Activities (2008),
- Development of the first iteration of the ISO space debris mitigation standard 24113 (2010), also superseding the European Code of Conduct for Space Debris Mitigation,
- Establishment of UN COPUOS Working Group on Long-term Sustainability of Outer Space Activities (2010),
- Release of the International Telecommunications Union (ITU) Recommendation ITU-R S.1003.2 Environmental protection of the geostationary-satellite orbit (2010).

In the following years, several major milestones occurred, particularly within the UN framework:

- **Approval of space traffic management as a standalone agenda item in the COPUOS Legal Subcommittee (2015).** This development has been a significant achievement, given that the topic of STM had not been widely and explicitly addressed in the political domain before.
- **Adoption of 21 Guidelines on the Long-term sustainability of outer space activities (2019)**, followed by a re-establishment of the LTS Working Group.
- **Adoption of a new requirement for large non-geostationary (NGSO) satellite constellations by the ITU (2019).** The new regulatory procedure for NGSO constellations requires operators to meet stricter deployment deadlines based on the size of the constellation.
- **Adoption of a Resolution of the UN General Assembly (UNGA) on Destructive direct-ascent anti-satellite missile testing (2022)** calling for a halt in ASAT missile testing, towards ensuring space sustainability and security (A/RES/77/41). The Resolution follows a process initiated by the U.S in April 2022, with a declared commitment to refrain from ASAT tests, followed by the endorsement of several other countries in the following months.

Important progress has similarly occurred in standardisation activities. The top-level industrial standard on space debris mitigation 24113 was last updated in May 2023, and the ISO has also adopted several new international standards with relevance for space safety and sustainability, e.g.,

- 19389 Space data and information transfer systems — Conjunction data message (2014),
- 23312 Space systems — Detailed space debris mitigation requirements for spacecraft (2022),
- 24330 Space systems — Rendezvous and Proximity Operations (RPO) and On Orbit Servicing (OOS) — Programmatic principles and practices (2022).

In addition, some other ISO work items have not yet reached the status of international standards, such as 16158 on "Avoiding collisions among orbiting objects" or 9490 on "Space Traffic Coordination" and 6434 on "Design, testing and operation of a spacecraft large constellation".

Furthermore, the crowding of orbits and related challenges have also begun to **appear in high-level diplomatic platforms (e.g., G7 or G20).** This indicates an increased willingness of public actors to engage in multilateral processes on space safety and sustainability.

At the 47th G7 Summit in 2021, **the Group of Seven recognised the growing hazard of space debris and increasing congestion in Earth orbit**, pledging support for "the safe and sustainable use of space to support humanity's ambitions now and in the future". The joint statement of G7 nations:

- Welcomed the adoption of the UN LTS Guidelines and called for their implementation,
- Welcomed and further encouraged institutional and industrial efforts in debris removal and on-orbit servicing activities,
- Recognised the importance of common standards, best practices and guidelines and the need for a collaborative approach for space traffic management and co-ordination.

Moreover, in May 2023, the G7 Science and Technology Ministers' Communique identified the promotion of a Safe and Sustainable Outer Space as one of the areas in which the G7 should demonstrate its leadership, and recognised the role of space in addressing global challenges.

Within the G20 Framework, the 2021 Report of the G20 Space Economy Leaders Meeting underscored the economic dimension of space sustainability, noting that "***ensuring the safety and long-term viability of space infrastructure improves ROI within the space sector, and increases investor confidence in the industry***" and encouraging the implementation of the UN LTS Guidelines.

Furthermore, the economic dimension of space sustainability has been recently addressed by the OECD through a specific policy paper published in April 2020 with the title "Space Sustainability: The Economics of Space Debris in Perspective".

The continuing work in the long-functioning IADC framework resulted recently in the release of updated versions of main IADC products: "IADC Space Debris Mitigation Guidelines", "Support to the IADC Space Debris Mitigation Guidelines" and "IADC Statement on Large Constellations of Satellites in Low Earth Orbit".

Looking ahead, the high-level agenda within the UN, particularly with the upcoming **Summit of the Future** in 2024, includes future work on ensuring space sustainability. In particular, the Summit comes after the publication of the UN's Secretary-General report 'Our Common Agenda' in September 2021, responding to an explicit request from the General Assembly for recommendations to "respond to current and future challenges" (UN75 declaration, A/RES/75/1). In 2023 the UN Secretary-General released a series of Policy Briefs providing additional details on the Our Common Agenda proposals and topics. In May, **Policy Brief 7 on 'the Future of Outer Space Governance'** was published: the brief lists space debris as one of the main challenges to be currently faced in space and provides a number of recommendations to member states towards ensuring the sustainability of outer space.

In parallel, **UNOOSA** and the **UKSA** are conducting a project on Promoting Space Sustainability following the adoption of the above-mentioned Long-Term Sustainability Guidelines. Started in January 2021, the project consists of a series of events and outreach efforts aimed at raising awareness and promoting multilateral activities and capacity building towards space sustainability.

Within platforms devoted primarily to space security, a UK-led effort to focus the discussion on ways of "reducing threats through norms, rules and principles of responsible behaviour" reached a widespread international recognition (UNGA Resolution in December 2020 (A/RES/75/36). Furthermore, the process led to the creation of a new open-ended Working Group (A/RES/76/231), scheduled to meet four times in the 2022-2023 timeframe. Perspectives for a new ground-breaking consensus remain, however, rather low, due to broader geopolitical developments. Despite the clearly security-related foundations of these initiatives, there are spill-over effects on safety and sustainability. For instance, efforts toward the prohibition of destructive ASAT tests naturally result in the reduction of space debris.

2.4 Private sector engagement with space safety and sustainability topics is accelerating through new bottom-up initiatives

The creation of Space Data Association in 2009 was one of the first signs of private-led initiatives aimed at ensuring the safety of operating in an increasingly congested space environment through fostering information exchange among its members and facilitating operational collision avoidance.

Following the Association's success, a few additional **initiatives led by industry, non-profit organisations and agencies have emerged recently** (memberships not mutually exclusive), targeting commitments to safe and sustainable space operations, and the sharing of best practices or new technological concepts developed hand-in-hand with regulations.

These different groupings, summarised below, have also released formal policy documents, indicating a high level of consensus among their members.

(February 2019) **"CONFERS Recommended Design and Operational Practices"**	CONFERS is an industry-driven initiative with initial seed funding provided by DARPA. The 2019-issued CONFERS Recommended Design and Operational Practices addressed commercial rendezvous, proximity operations, and in-orbit servicing. CONFERS' framework has since attracted new participants and the consortium has been notably active.
(September 2019) **"Best Practices for Sustainability of Space Operations" by Space Safety Coalition (SSC)**	*(Updated in April 2023)* SSC is a global ad-hoc coalition aimed at developing and updating a set of voluntary best practices, which were originally developed under the Global VSAT Forum framework. SSC's best practices are applicable to all spacecraft, regardless of physical size, orbital regime, and constellation size.
(October 2019) **Principles of Space Safety, released by Satellite Industry Association (SIA)**	The Satellite Industry Association (SIA), a U.S-based trade association, released a set of Principles of Space Safety with the goal to help protect freedom of use and long-term access to space by ensuring safe flight operations for satellites, human spacecraft, and other space missions.
(September 2021) **ESOA's White Paper, Space Sustainability: The Time to Act is Now**	Prior to transforming into GSOA, ESOA called in its report for 'prompt action' to prevent the risks of debris and collisions from growing worse. The report also highlighted the need to minimise the creation of space debris, maximise orbital resources through appropriate STM (including for launches), and enable the development of responsible solutions for existing and future orbital debris.
(November 2021) **Launch of the "Net Zero Space Initiative" by the Paris Peace Forum**	At the 4th edition of the Paris Peace Forum, a variety of public and private stakeholders joined forces in a platform of individual commitments towards achieving "sustainable use of outer space for the benefit of all humankind by 2030".

(June 2022) **Launch of Space Sustainability Rating (SSR)**	SSR has been developed by a collaboration of several organisations, including the European Space Agency, and is now shaped as a tool to provide a new, innovative way of addressing the orbital challenge by encouraging responsible behaviour in space through a compound rating, increasing the transparency of organisations' debris mitigation efforts.
(June 2023) **Launch of the Astra Carta by the Sustainable Markets Initiative**	The Astra Carta is a collective call aimed at serving as a roadmap for private stakeholders to make their activities in space compliant with and oriented towards space sustainability goals, in partnership with governments, international organisations and other actors.
(June 2023) **ESSI Memorandum of Principles for Space Sustainability**	On the occasion of the launch of the Earth&Space Sustainability Initiative, more than 100 stakeholders signed the Memorandum of Principles, as outlining the societal relevance of space and splitting the concept of space sustainability into a number of specific strands.

In late June 2023, another similar initiative has been kick-started: as part of its Zero Debris approach, ESA and other European and international space actors have initiated the co-development of the Zero Debris Charter, with the release of several jointly defined targets planned by the end of 2023.

In addition to these instruments, some of which include more than **50 signatories/endorsees of both public and private actors**, several private companies and/or their executives have been increasingly vocal about the issues of space safety and sustainability. For instance, OneWeb's commitments towards a Responsible Space, or Inmarsat's recently published Space Sustainability Report, can be mentioned.

The growing interest of private actors in fostering space safety and sustainability across various lines of action, including at the regulatory level, indicates a major international consensus of the urgency of the issues at stake and provides fertile ground for future developments at technological, commercial, regulatory, and diplomatic level.

3 FOUR POLICY CONSIDERATIONS FOR THE WAY AHEAD

3.1 The risk for Europe of widening the capability gap vis-à-vis other space powers: the case of SST/SSA

Recognising the need for the protection of space assets, Europe has undertaken major improvements of indigenous SST/SSA capabilities in the past decade, combining national ownership of assets with greatly increased action at the European level, in particular through R&D, operational coordination and service provision.

The assessment of the global landscape, however, also revealed a noticeable policy push towards capability development in SST/SSA-related strategies of public actors around the globe. A review of the global SSA landscape in terms of governmental strategies has revealed highly developed sovereign capabilities, particularly in the U.S, Russia, and China. Arguably, the **disparity of available resources for the development of SST/SSA capabilities and Europe's desire for greater autonomy calls into question the European ambition**.

While the national approaches are naturally unique in terms of organisational elements and the technical features of systems involved, the analysis identified some common themes in U.S, Chinese and Russian SSA-related strategies and actions:

- The publicly available information indicates a continued effort towards a **significant improvement of domestic SST/SSA capabilities**, through modernisation of existing assets and build-up of new capable sensor stations (both terrestrial and in-orbit).
- In each country, the **military dimension of SSA/SDA is highly prominent**, suggesting a close link with their broader military doctrine, either specifically for space awareness purposes (including as an enabler of other activities in space, such as RPOS) or through a connection to missile defence and early warning.
- There are indications of **importance associated to international partnership frameworks**, e.g.:
    - U.S – SSA sharing agreements at SPACECOM level with a variety of international and commercial partners and expansion of collaboration to joint exercises with allies,
    - China – leadership in the Asia-Pacific Ground-Based Optical Space Object Observation System (APOSOS), including through provision of sensor infrastructure to partner nations,
    - Russia – heritage sensors in former Soviet countries operated by Russia and growing governmental footprint in the scientific ISON initiative of ground-based SSA sensors in almost 20 countries (i.e., services provided to Russian government).

Figure 4: International footprints of SSA activities by Russia - ISON (left) and China – APOSOS (right)

A few particularities could also be observed in the U.S approach. The government has been **expanding the role of commercial actors in the overall SSA ecosystem**, putting emphasis on the emergence of a commercial marketplace, data fusion and value-added integration of various tools.

Internationally, acceleration of governmental SSA efforts is visible in several other countries, in particular **Japan, Australia, Canada, South Korea, South Africa and India**. The expansion of national activities in these countries also indicates a major push towards greater autonomy and security.

At the same time, the recent developments in Australia and India, with the increasing emergence of private ventures coupled with governmental efforts towards growth of the SST/SSA ecosystem, indicate the growing significance of the commercial dimension of SSA beyond the U.S and Europe.

The increasing efforts include both civil and military initiatives and, similarly to the aforementioned examples, underline a continuous, major role of international engagement in enhancing national SSA capacities. To some extent, this is driven by an extremely challenging objective to reach desired levels of autonomy through proprietary means.

Looking ahead, foreign governments will most likely continue to invest heavily in SSA capabilities and/or improve various elements of their SSA value chain - data collection, data processing, data sharing, SSA analysis and services, and commercial partnerships.

3.2 Greater Opportunities & Appetite to leverage commercial solutions & services

In addition to the development of public capabilities, commercially available services play an increasingly prominent role in the global SST/SSA ecosystem. There is a growing availability and increasing versatility of SST services.[2]

This trend has emerged particularly in the past several years (Figure 5), which correlates with the magnification of space safety, sustainability, and security concerns. It also indicates the maturation of a broad range of hardware and software solutions and a growing confidence in the commercial viability of SST activities in the future.

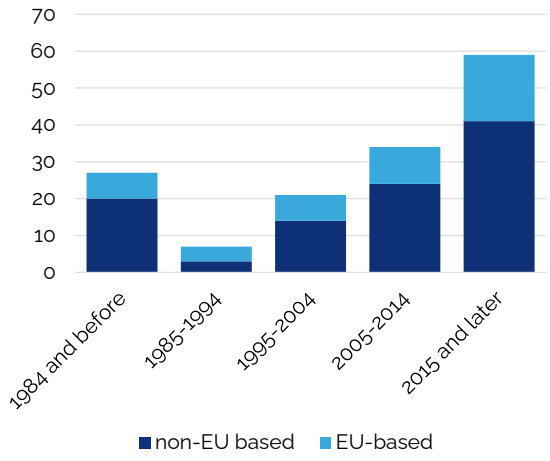

Figure 5: Establishment of companies offering private SST-services

ESPI analysis identified more than 150 active players in the domain of SST services. More detailed observations resulting from the research on actors and solutions in the global SST ecosystem are:

- **Prominence of U.S actors underpinned by military support in light of national security SSA/SDA**. More than 40% of the active commercial actors in SST services are based in the United States, which makes the U.S by far the most represented country in the analysed dataset. U.S companies appear to have largely benefitted from their national security space business, which drove the build-up of capabilities which later spilled-over to the commercial sector. A non-negligible portion of U.S commercial actors continue to only prioritise military contracts.

[2] For the purpose of this research, SST services entailed commercially available products (hardware or software), specifically equipping the customer with tools, data or information related to orbital dynamics of space objects and debris

But more recently, numerous smaller companies (e.g., Saber Astronautics, Bluestaq, Atlast Space Operations, Scout) have taken advantage of the Small Business Innovation Research (SBIR) programme, which has been providing support measures (including funds) to their R&D efforts.

- **Growing presence of SMEs and start-ups**: In addition to long-established aerospace companies with various capabilities, the analysis identified a considerable presence of recently established SMEs and start-ups in the ecosystem. These actors often come with a niche software-driven focus and are occasionally set up as consultancy companies consisting of few people, which has an impact on defining business strategies of these actors compared to larger (often hardware-driven) companies.
- **Spill-over into the SST market** in terms of:
  - recent entries in the SST domain by companies established in other sub-domains of the space sector (e.g., Maxar, Swedish Space Corporation or Spire)
  - gradual move of companies established in other related sectors, such as ICT or defence manufacturing (e.g., GlobVision, Fujitsu, or Terma)
- **Evolving European landscape**. Since 2015, more than 20 different companies have been established in the provision of SST services in Europe. The highest number of these new companies (6) are based in the UK. Among EU member states, companies from countries who are members of the EU SST Partnership represent the majority of SST/SSA providers.
- **Recent emergence of commercial solutions beyond the U.S and Europe**: The analysis identified new SST ventures particularly in the Asia-Pacific region, e.g., India (Digantara), Australia (Silentium Defence, Astrosite, Clearbox Systems), and South Korea (SpaceMap).

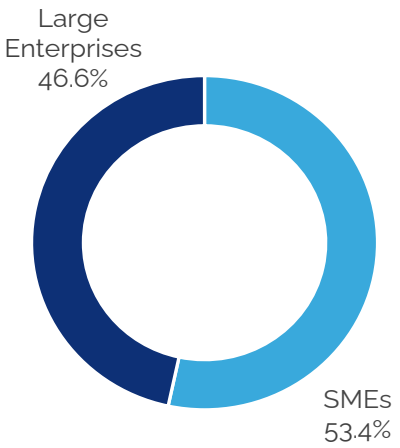

Figure 6: SME status of the identified SST/SSA/STM

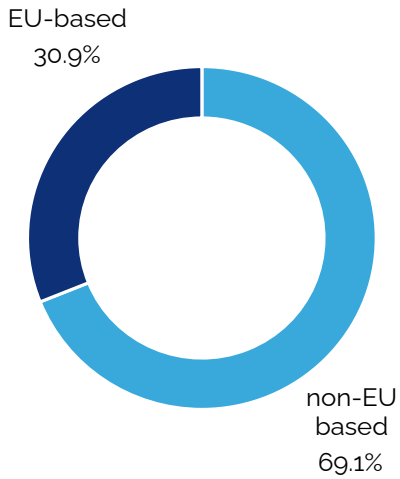

Figure 7: Overview of private SST/SSA ecosystem

- **Market growth**: The available market forecasts, while differing on definitional aspects related to SST and SSA, tend to converge on estimating 5-7% CAGR. Euroconsult predicts the SSA market to exhibit an "S-curve" dynamic (prevalent in nascent high-technology areas entering the mainstream commercial market) with strong expansion in the short to mid-term. An optimistic look towards SST has also spurred a recent wave of private investment deals (e.g., for Look Up Space, Kayhan Space, Privateer, Okapi Orbits or Vyoma).
- **Risks for the way forward**. Currently, SST/SSA revenues are generated primarily by governmental actors and a greater uptake by private customers could be subject to new regulatory developments. The market perspectives for commercial SST and SSA solutions will also depend on the availability and scope of publicly available services free of charge (e.g., SpaceTrack or free basic services by commercial actors).

Besides SSA, market growth is increasingly projected for related domains, such as in-orbit servicing and active debris removal, indicating interconnections in the value chain.

The analysis also discovered an increasing emergence of commercially available services in the space weather domain. However, this segment appears to still be in its infancy, with major challenges ahead in terms of technical issues, demand and market issues, as well as international cooperation.[3]

Towards a new perimeter of public action in space safety & sustainability?

Greater commercial dynamics in activities related to space safety and sustainability also lead to the debate on how the scope of public policy should adapt to this new landscape.

A few specific considerations can be further introduced, building on developments that are not unique to space safety and sustainability or also manifest in other parts of the space sector.

Overall, there is an **evolution of the dynamics between attainment of public goals and success of commercial ventures** with an increasingly significant role played by the private sector in the support of public policy goals. This can be seen across the space sector, in areas such as access to space, space applications, or space exploration. One of the common signs can be recognized in **procurement schemes increasingly exploring commercial service-provision models**, thus gradually replacing traditional procurement forms based on direct ownership of the infrastructure and relying on innovation-financing through private investment.

This trend results in a significant commercial push towards a global dimension, at times contrasting with political aspirations, geopolitical tensions, and regionalisation dynamics.

While the issues tackled in the safety and sustainability dimension differ from dynamics in space security, the **delineation between the two domains in some key technology areas remains blurred**, accompanied by a changing notion of dual use, due to:

- actors that act on, both, the safety and the security front due to the nature of their mission (e.g., military actors providing SSA for public services)
- activities which underpin both safety and security objectives (SSA supports collision avoidance with debris as well as protection of space infrastructures against intentional threats)

As a result, military actors continue to play a prominent role in the safety and sustainability discussions, with activities underpinning the production and dissemination of SSA data. In this context, **greater reliance of military actors on commercial capabilities is also witnessed**, including the use of commercially available solutions for day-to-day operations and the military hosting their payloads on non-military spacecraft.

3.3 The challenge of translating political awareness into funding

Increased media attention, NGO engagement, or statements by a variety of high-level politicians, including heads of states, contribute to a broader public awareness about issues related to space safety and sustainability. Nevertheless, **for now this increased awareness does not translate into effective and meaningful public action**.

Considering current budgetary arrangements for space and related activities in Europe (i.e., national civil and military funding, EU MFF 2021-2027, ESA CMs 2019 and 2022), public funding for activities

[3] ESPI (2019) 'European Space Weather Services: Status and Prospects', available online [Hyperlink]

in space safety and sustainability remains a minor component of the overall spending on space. Nevertheless, signs of new funding opportunities are seen in the recent introduction of ESA's Space Safety Programme. The Programme has witnessed an overall budget growth in 2022, despite a need to increase the share devoted to its core activities compared to the resources allocated to individual missions, conducted under its umbrella, remains to be addressed.

Given that the EU engagement in space safety and sustainability has notably grown and that the next EU MFF is soon to be initiated, EU Member States and parliamentarians will be faced with the question of expanding the existing EU-level of action. In particular, attention will be drawn to funding structures and mechanisms, to meet the goals of European leadership in these domains.

The argument on relevance and rationale of such investments can increasingly be built around the fact that **space technologies, data, and services are in fact a critical infrastructure and are being gradually recognised as such in policy documents.** As space applications mature and improve, the number of sectors served by space data and services increases. In parallel, several **sectors unanimously considered as critical domains are increasingly relying on space** – finance, transportation, security and defence, energy, connectivity or food and agriculture.

The telecommunications sector is a significant example of a **paradigm shift from space seen as a back-up solution in case of damages to terrestrial infrastructure, to satellite data and services as vitally integrated with the terrestrial assets**, or even replacing them. The critical role played by the satellite industry in this domain is also demonstrated by the recent inclusion of non-terrestrial networks in standardisation documents, such as, for instance, the 3rd Generation Partnership Project (3GPP) Release 17, "5G for space: the NR NTN standard" published in March 2022, and further complemented with the ITU Working Party 4B's developing standards for the satellite component of International Mobile Telecommunications (IMT).

Overall, the value of space towards the achievement of societal objectives has been increasingly recognised. Above all, the recent UN Secretary-General's Policy Brief 7 on 'the Future of Outer Space Governance' compiles a list of the contributions of space to the SDGs.[4]

Figure 8: Examples of critical sectors relying on space-based data and services

In this context, addressing the **need to formally define space as a critical domain is part of an ongoing debate, especially in the U.S**. Some countries such as Norway or the UK are already including satellites in the list of critical infrastructures, building on the argument that space data and services are currently enabling other critical domains and therefore deserve similar protection. In the same vein, two recent Directives at the EU level (NIS2 and CER) have notably moved towards the recognition of space assets, and the space sector at large, among essential infrastructures and priority sectors. Namely, it calls for the enhancement of resilience and paving the way for new measures towards the safety and security of space assets, particularly the ground segments.

[4] UN Secreatary-General (2023) 'For All Humanity – the Future of Outer Space Governance', available online [Hyperlink]

3.4 Need to re-consider risk assessments in light of emerging concepts and activities

Several trends related to the increasing dynamism of the outer space environment are posing significant challenges to space safety and sustainability. Appropriate mitigation measures should therefore be conceptualised and implemented, starting from a revised prioritization of risks faced when conducting space activities, including beyond Earth's orbits.

Skyrocketing LEO population mostly due to the development of satellite constellations for broadband connectivity

The most significant challenge to ensuring safety and sustainability in outer space is posed by the striking increase in the number of objects populating Earth orbits, with the potential (especially of some of these objects) to put at serious risk the future development of space activities

The number of spacecraft launched per year has grown from around 100 to almost 2,500 since the 2000s; the last three years have shown a regular +30% increase on an annual basis. These numbers, further visualised in Figure 9, confirm the necessity to address the issue of the skyrocketing space objects population with urgency, especially in the absence of a "control system" for space traffic.

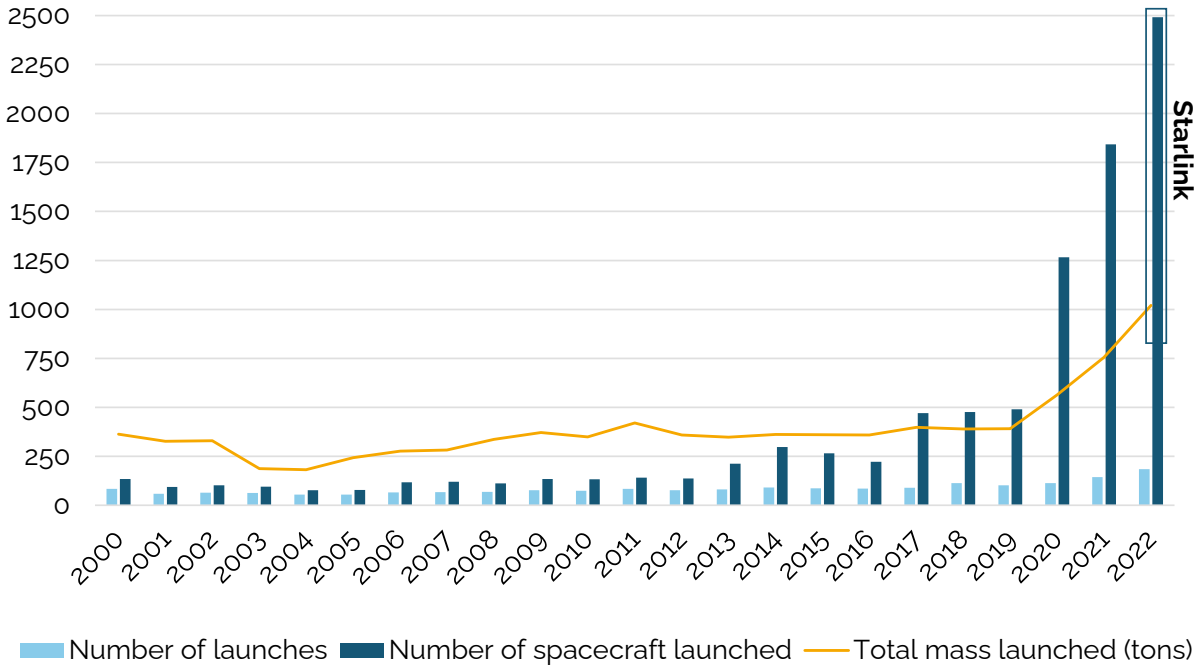

Figure 9: Increase of activity in the orbital environment (Source: ESPI)

Potential additional complexity in keeping track of each space object since its launch comes into play when observing that the number of launches has only tripled across the years, necessarily accompanied by a **growth in the number of rideshare launches** that have led to an increase of spacecraft launched by a factor of 20.

Low Earth Orbits clearly constitute the principal destination of the satellites launched in recent years. The growth of the LEO population is mainly a **result of the broad deployment of satellite constellations**, with SpaceX, OneWeb, Planet, Swarm Technologies and Sire in pole position.

This specific tendency is expected to be confirmed in the short- to medium-term due to the plethora of constellations planned with the aim to **provide broadband connectivity and enable IoT applications**. In particular, data from the ITU filings accounts for more than 1.7 million NGSO satellites to be launched (in theory) before 2030.[5]

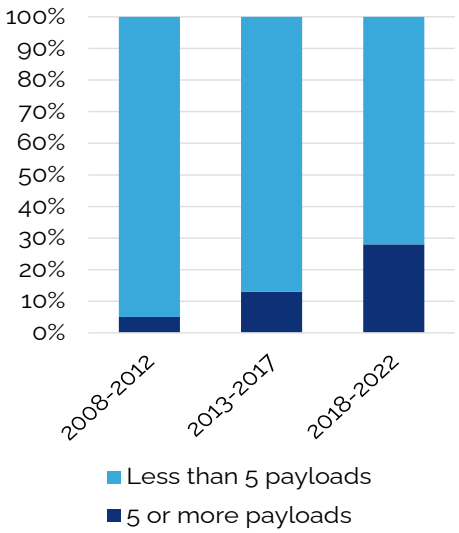

Figure 10: Growth of rideshare arrangements in orbital launches (Source: ESPI Database)

The significant challenges to space safety and sustainability posed by abandoned rocket bodies and derelict satellites are also part of the overall picture. Indeed, accidental breakups or collisions of these objects with other unidentifiable pieces of debris or active satellites result in accelerated debris generation.

Finally, the increase of the object population in the orbital environment has effects on the congestion of another limited (and scarce) resource, notably the radiofrequency spectrum.[6] In this regard, the 2022 ITU Plenipotentiary released a specific Resolution (219) on the "sustainability of the radio-frequency spectrum and associated satellite orbit resources used by space services."

Rising necessity of cis-lunar situational awareness resulting from reinvigoration of missions to the Moon

While the Earth's orbital space is witnessing significant changes, posing new challenges to the actors responsible for ensuring space safety and sustainability, cis-lunar space has become once again the destination of a wealth of ongoing and planned space missions.[7] These are now frequently aimed at ensuring a sustained long-term presence in the Moon's orbit and on lunar soil, including crewed missions and the construction of new infrastructures.

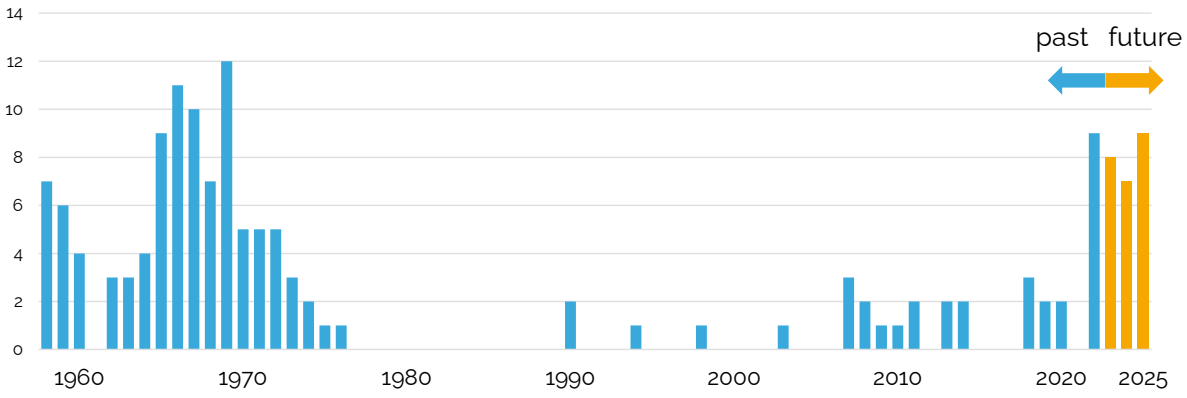

Figure 11: Timeline of past and projected missions to cis-lunar space

[5] *Ibid.*
[6] See Art. 44 of the ITU Constitution for a definition of both space and spectrum as limited natural resources.
[7] Following the lines of the study conducted by the Center for Strategic International Studies (CSIS), the cis-lunar space can be considered as including the region of space beyond GEO orbits and delimited by the L4, L5 and L2 Lagrange point (included).

According to CSIS, more than 100 missions have already been planned by 19 nations in the forthcoming years, with forecasts by other organisations going far beyond (e.g., 400+ missions to the moon by 2032 according to NSR); **one fourth of these missions are led by private actors. Science, transportation, and rover missions constitute a significant part of the total, proving the change of paradigm towards a longer-term sustainable presence in cis-lunar space**. Development of various types of infrastructures in lunar orbit also represent a major portion of the planned missions – proposals for new systems enabling communication or navigation services are increasingly presented by multiple actors, including Europe, the U.S, China, Japan, and Australia.

Calls for an extension of situational awareness capabilities towards the lunar surface and around the Moon have also emerged. As evidenced by the U.S example, this need has been openly recognised and translated into policy action. Indeed, a significant U.S push for cis-lunar SSA development, both at civil and military level, is signalling long-term interest of U.S national security actors in cis-lunar space as a new domain of operations.

Increasing cadence and changing nature of human spaceflight

Safety and risk management in space significantly changes with the inclusion of human lives in the equation. Recent developments in the field of human spaceflight have become an important factor for the evolution of space safety. These developments, underpinning the reinvigoration of the human spaceflight sector also resulting in more frequent launches, include:

- **New generations of publicly funded crewed missions with various destinations and formats** (e.g., Gateway, human presence on the Moon, Chinese space station, Indian human spaceflight ambitions), putting an end to the idea of the ISS as the sole permanent human outpost in space.
- **Growth in the number of countries, companies, and individuals interested or already pursuing human presence in space**.
- **Commercial human spaceflight initiatives and space tourism.** The different examples and concepts include:
    - Privately operated short-duration spaceflights, increasingly capable of a variety of destinations and mission profiles (suborbital, orbital, lunar)
    - Commercial utilisation of space station infrastructures (e.g., NASA's 2019 Plan for Commercial LEO Development) and new commercial space stations (See for instance NASA's 2021 Commercial LEO Development Programme)

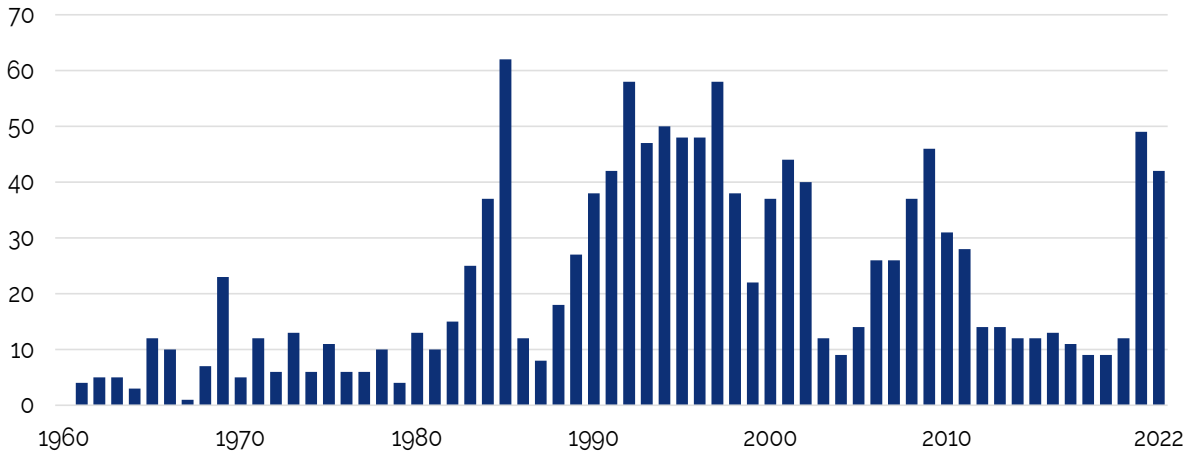

Figure 12: Surging human spaceflight missions (Source: ESPI)

Proliferation of small satellites boosted by miniaturisation of digital and space technologies

Technological advances related to the miniaturisation of space systems and their components have notably contributed to the **availability of spaceflight to a broader community**, decreasing the cost of access to space. Over the past decade, the utilisation of small satellites (<500 kg) has significantly increased and, since 2013, surpassed the number of large satellites launched in each consecutive year. In the past few years, the deployment of LEO constellations has boosted the trend.[8]

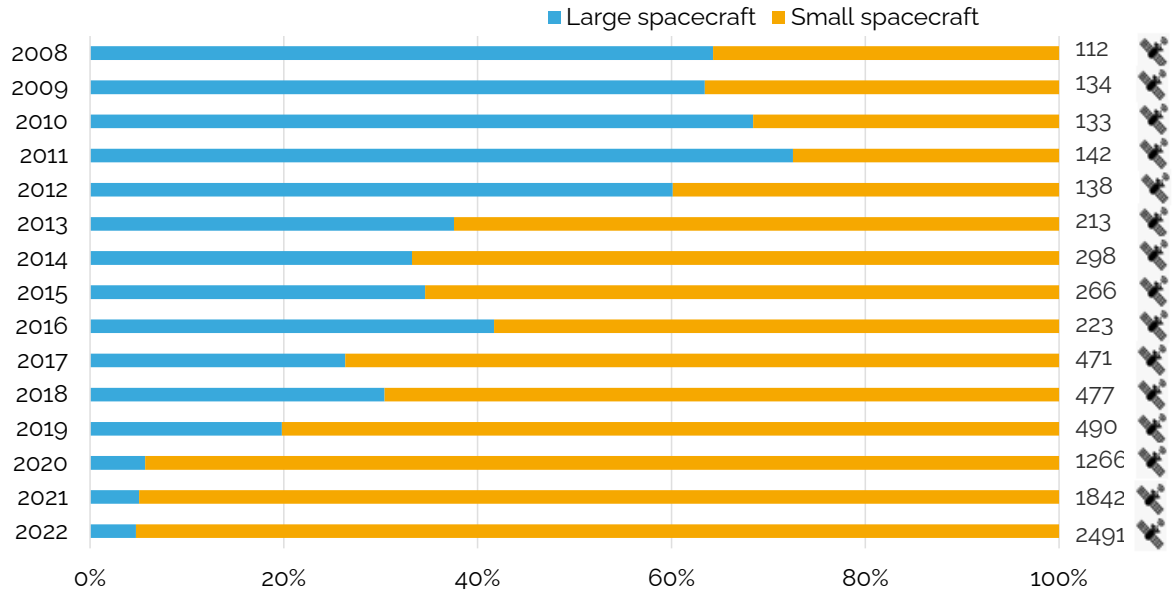

Figure 13: Proliferation of small satellites in the past 15 years (Source: ESPI database)

Beyond the conducive impact on the accessibility of spaceflight to a wider spectrum of actors, the proliferation of small satellites missions, specifically those relying on very small CubeSats, have brought about **major implications for space safety and sustainability**, such as:

- Limited or no orbital control (manoeuvrability) capabilities,
- Shorter lifetimes in-orbit,
- Problematic trackability and orbit determination from the ground,

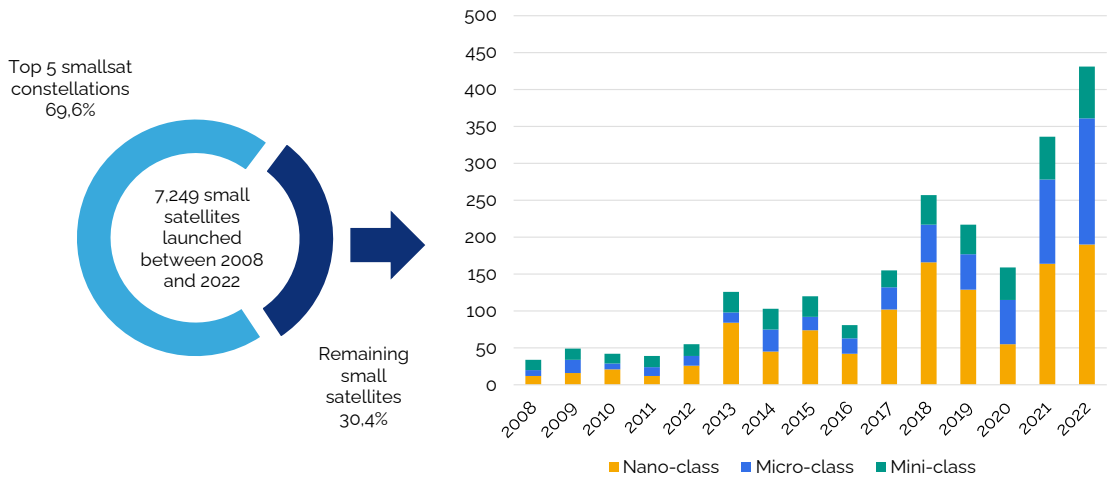

Figure 14: Growth of small satellites excluding Starlink, OneWeb, Planet, Swarm, Spire (Source: ESPI Database)

[8] Thresholds defined in ESPI Database: Mini-class (100-500 kg), Micro-class (10-100 kg), Nano-class (<10 kg)

- Risks of lower reliability of electronics and lesser redundancy.

One additional element particularly relevant in the utilisation of CubeSat platforms is the growth of less experienced spacecraft owners/operators, raising the issue of best practices for space operations management.

Looking ahead, **market forecasts focused on the utilisation of small satellite missions tend to project a growing business trend for the upcoming decade** with CAGR values above 10%.

Nevertheless, according to Euroconsult and other analysts the **small satellite market is facing a number of challenges**, from limited market addressability and low profitability, to oversupply, accompanied by the concentration of several established players. Therefore, the total number of small satellites will likely peak in the next few years, followed by an **opposite trend of more sizeable satellites being manufactured and deployed into orbit**. Evidence of it is already provided by the mass increments of Starlink satellites: first generation spacecraft had a mass between 227 and 260 kg, then increased to 295 kg for generation 1.5, and now raised to 800 kg for the first Mini satellites released in orbit in early 2023. OneWeb is also planning to increase the mass of its spacecraft from 147 kg of the first-generation satellites to about 500 kg for the second generation. Amazon Project Kuiper will follow a similar path, as also reflected in strategies of companies specialised in small satellites manufacturing, such as LeoStella, Terran Orbital and NanoAvionics.

Such a trend, also driven by a decrease of launch costs and by the large financial resources of some of the above-mentioned companies, is then coupled with the continuing miniaturisation of technology. This combination results in the possibility to integrate additional design features and components to the payload, potentially increasing its flexibility and design life, as well as allowing higher throughput of communication signals and enabling inter-satellite communication.

In this context, **design solutions in compliance with sustainability requirements could become more viable and acceptable** for satellite manufacturers and operators, despite the incurred additional weight and therefore higher cost for spacecraft manufacturing and launch.

Growing diversification and complexity of space-mission life cycle profiles from launch through in-orbit operations to re-entry

The challenge of fostering space safety and sustainability in the long-term is magnified by an increasing complexity of space traffic. **Greater manoeuvrability of spacecraft as well as more agile launch and orbital trajectories increase the difficultly of understanding and predicting the space operational environment**, thus intensifying safety risks and raising sustainability concerns.

New technologies and concepts of operation that contribute to this trend (either operational or entering operational use in the forthcoming period) are visible across different segments of the space-mission life cycle. Numerous new (and reusable) launch vehicles and spaceports are developed around the world and at least some of these are anticipated to become operational in the future (vertical and horizontal launch, incl. mobile and seaborne platforms). Beyond orbital launch activity, sub-orbital spaceflight is witnessing a boost, spurred on by commercial human spaceflight. Additionally, **rideshare launch arrangements,** with up to several dozens of spacecrafts launched by a single launch vehicle, are more common.

In-orbit transportation solutions are poised to grow in maturity and versatility to meet operators' demands for increased mobility and precise orbital insertions. There are currently more than 10 different companies actively operating or developing so-called space tugs for last-mile delivery purposes (e.g., D-Orbit, Gauss, Northrop Grumman, Momentus, Atomos, Exotrail, Firefly Aerospace, Launcher, Space Machines, Exolaunch, Impulse Space, Skyrora, RocketLab)

With regard to end-of-life measures at large, beyond more technical considerations, new **regulatory developments will presumably shape these practices in a significant manner** (See for instance the recent U.S case with the FCC introducing a 5-year de-orbiting requirement to satellite operators).

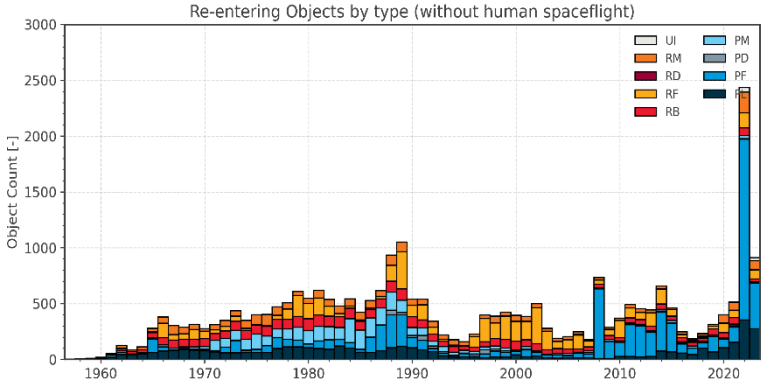

Figure 15: Growing number of re-entering objects (Source: ESA)

Among the variety of In-orbit Servicing, Assembly and Manufacturing (ISAM) technologies, **active debris removal** concepts stand out, despite currently still in development. Expert views on the space debris issue underline the need for such ADR capabilities to effectively reverse the growing curve of space debris population in the longer term. Along the same line, noteworthy recognition is given to these technologies also at the level of recent policy documents. For instance, the 2022 ISAM U.S National Strategy orients governmental action towards the development of cost-effective debris removal concepts in collaboration with commercial partners; New Zealand released a policy document in May 2023, specifically dedicated to ADR and on-orbit servicing missions.[9]

Overall, be it natural or assisted de-orbiting, the number of objects re-entering Earth's atmosphere will grow, challenging and putting further pressure on a reliable management of space traffic.

Emergence of new actors in space operations

The community of operators of space systems has changed, especially with a higher number of different actors manufacturing and/or owning spacecraft. In parallel to private stakeholders continuing to enter the space domain, the **number of institutional stakeholders operating their own satellites has also grown** rapidly, with more than half of current spacefaring nations having entered the sector in the last 15 years.

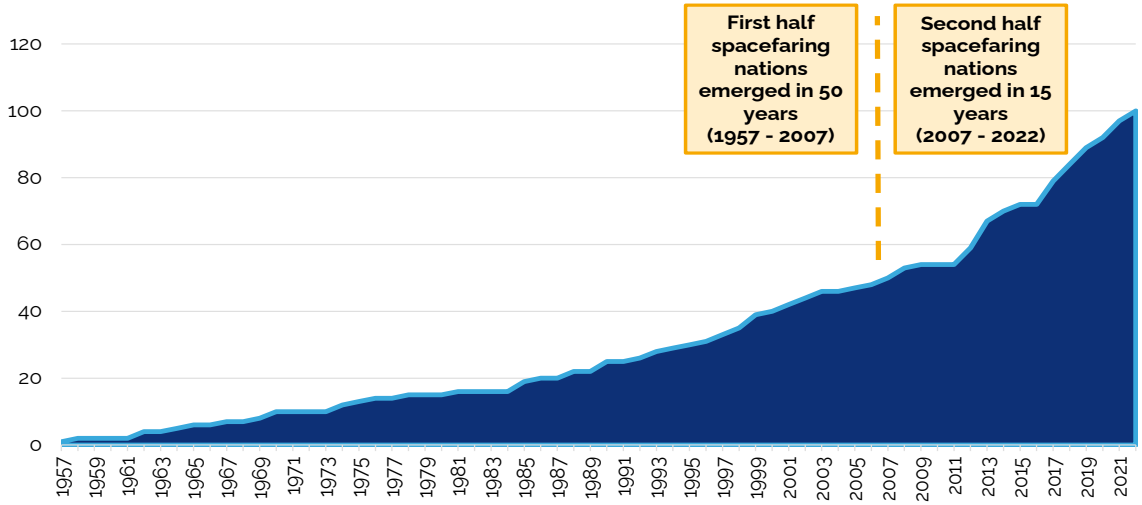

Figure 16: Division showcasing the emergence of the last 50% of spacefaring nations (Source: ESPI Database)

[9] New Zealand Space Agency (2023) 'Active Debris Removal and On-Orbit Servicing Missions', available online (Hyperlink)

Moreover, the role played by minor players such as universities and research institutes has also become significant, especially driven by the drastically increased affordability of small and standardised satellites such as CubeSats. As shown in Figure 17, **the number of CubeSats launched every year has grown in the past fifteen years**, currently stabilising at around 300 being sent to orbit annually. An important percentage of these satellites (approx. 25%-30%) are in fact **owned and operated by universities and research institutes for educational, scientific or technology demonstration purposes**.

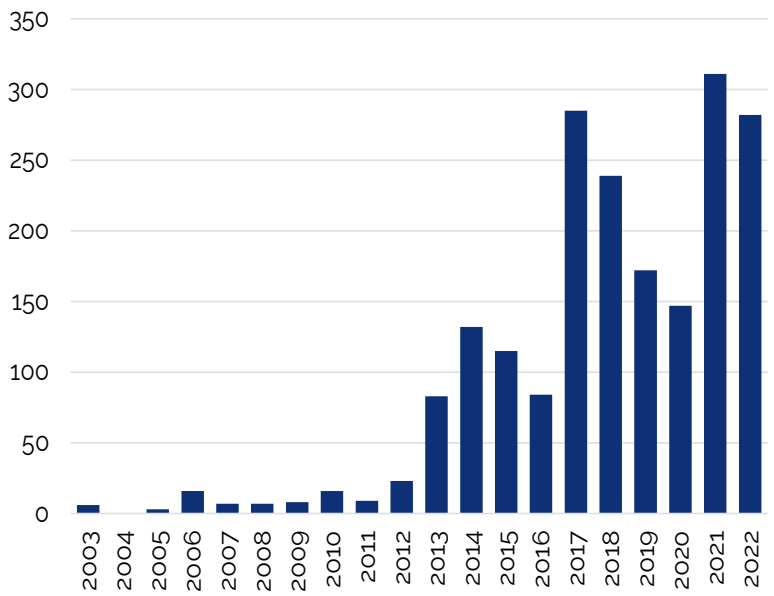

Figure 17: Number of CubeSats launched per year (Source: ESPI)

Additionally, several **enterprises primarily active in other industrial domains are increasingly exploring engagement in space** to improve their flagship solutions. For instance, the automobile manufacturer Geely has recently announced the plan to deploy a constellation of approximately 240 satellites to serve autonomous driving – nine of which were launched in June 2022. In the past two years, European OEMs in the automotive field (e.g., BMW, Porsche/Volkswagen) have also shown their interest in providing space-based satellite connectivity to their cars, potentially through the deployment of an *ad hoc* constellation.

4 CONCLUSION

Space safety and sustainability concerns have become widely recognised issues in policy-making and the available evidence signals a continuation of this trend in the foreseeable future. Without a safe and sustainable space operational environment, Europe (and international community at large) cannot fully develop and utilise the immense value of space for the broader society and economy.

While multiple concurrent developments and trends are magnifying the concerns related to safety of space operations and sustainability of the space environment, new opportunities arise for more impactful policy making, leveraging technological innovation, emerging commercial and investment dynamics, and a growing global awareness.

The identification of a **broad policy momentum for space safety and sustainability**, addressed in Chapter 2 of this study, was built around 4 underlying research findings:

1. There is a **surging prioritisation of space safety and sustainability objectives in national space policies**, which is noticeable around the world and paving the way for a targeted public action backed by dedicated budgetary considerations.
2. **European countries are leading the way with major focus on safety and sustainability topics next to programmatic priorities** and policy, regulatory, programmatic and diplomatic actions at both European and national levels.
3. **Space safety and sustainability are ever-high in international fora**, which underlines the urgency of the issues at stake and creates fertile ground towards a shared willingness of nations for international collaborative solutions
4. **Private sector engagement with space safety and sustainability topics is accelerating through new bottom-up initiatives**, indicating the perspectives for a greater commercial and investment dynamics in the ecosystem.

With the objective to support future policy making, the Chapter 3 of this report outlined several **policy drivers and options for decision-makers and executives at national, European and international levels.**

Policy Consideration #1: The risk for Europe of widening the capability gap vis-à-vis other space powers: the case of SST/SSA - There is a major push towards capability development in SST/SSA-related strategies of public actors around the globe, putting into question the level of European ambition, and policies and frameworks in place.

Policy Consideration #2: Greater opportunities & appetite to leverage commercial solutions and services - As commercially available services and emerging ventures play an increasingly prominent role in the global space safety and sustainability ecosystem, public actors are called to develop measures to leverage, facilitate and nurture the emerging commercialisation.

Policy Consideration #3: The challenge of translating political awareness into funding – The increasing recognition of safety and sustainability issues appear to not automatically translate to commensurate budgetary allocations required to foster the development of adequate solutions and hence require further targeted effort by the space community in formulation of public budgets.

Policy Consideration #4: Need to re-consider risk assessments in light of emerging concepts and activities – The dynamism and complexity of various types of activities in space, incl. beyond GEO, notably increases. This calls for forward-looking approaches in risk management strategies, identifying future impact of some of the emerging trends (e.g.. expanding human spaceflight, cis-lunar presence or growing complexity of space-mission life cycle profiles).

ANNEX A: METHODOLOGY FOR QUANTITATIVE POLICY ANALYSIS

The methodology used to substantiate the characterisation of the surging prioritisation of space safety and sustainability objectives in national space policies (§ 2.1) can be separated into two distinct steps: the collection of a corpus of space policy documents and their analysis using a topic model. The individual steps for the corpus creation involved selection, collection, translation, and due diligence:

- Firstly, for the sake of consistency, only national policies and strategies were used for the data analysis. These documents were carefully selected out of a database also encompassing national space acts, executive orders, decrees, sets of guidelines and implementation plans. Most of the documents used for the study are national space policies, covering all of the countries' priorities in space. Nevertheless, some countries have not yet released a comprehensive strategy for their space activities. Consequently, in these cases and if deemed appropriate throughout a more detailed inspection, defence space strategies or research strategies were selected.
- The documents were collected with the aim of ensuring a global coverage. Therefore, space strategies of more than 30 countries were collected across all continents. Nonetheless, the European countries find a larger representation in the database due to various reasons, starting from the overall objective of the study and finishing with their easier availability.
- An analysis of documents from a large variety of countries, which rarely provide official English versions of their policies and strategies, implicitly gives birth to some translation issues. In order to solve them, an advanced machine learning translation tool was deployed, corroborated by a manual random check.

The second step was devising a topic model to analyse the development of the safety and sustainability topic within the corpus documents. Topic modelling is a method of natural language processing – a subdomain of data science concerned with generating meaning from text. Specifically, a topic model seeks to detect and quantify (latent) topics in a set of documents.

In this case, the team opted for a rules-based method rather than one supported by machine learning. In rules-based topic modelling, researchers use statistical methods and domain expertise to devise a set of topics along with topic representations. These representations are words or phrases that reference the topic. Computing the aggregate frequency of representations in a document yields the frequency of the topic.

- As a first step, the documents underwent pre-processing to prepare them for topic modelling.
- The researchers studied individual documents picked at random from the corpus to devise a first set of topic representations. Thereafter, an algorithm was developed to compute the frequencies of topic representations. The results were compared with random checks of the documents to further refine the model. This included adjusting representations and adding logical rules to the model for enhanced accuracy. This process was repeated several times, with the goal of removing errors and to ensure that the representations only measure the desired topic. The final model contained more than 50 topic representations. This extensive set of words, abbreviations, and phrases enabled the model to perform well across a wide range of documents from variable origin in both space and time, which may have an impact on the specific words used to describe the topic.

- Using the final version of the topic model, the frequency of the topic was computed. However, since the documents differed greatly in length, the aggregate document-level topic frequency was normalised by the number of words. This rate was then standardized by computing the harmonic mean for each batch of documents. This specific mean was chosen based on its peculiar pertinence to the calculation of rates.

ANNEX B: LIST OF ABBREVIATIONS

ADR	Active Debris Removal	**OEM**	Original Equipment Manufacturer
APOSOS	Asia-Pacific Ground-Based Optical Space Object Observation System	**OOS**	On Orbit Servicing
ASAT	Anti-Satellite	**PD**	Payload Debris
CAGR	Compound Annual Growth Rate	**PF**	Payload Fragmentation Debris
CER	Critical Entities Resilience (Directive)	**PL**	Payload
CSIS	Centre for Strategic International Studies	**PM**	Payload Mission Related Object
DARPA	Defense Advanced Research Projects Agency	**R&D**	Research and Development
EC	European Commission	**RB**	Rocket Body
EEAS	European External Action Service	**RD**	Rocket Debris
ESA	European Space Agency	**RF**	Rocket Fragmentation Debris
ESA CM	ESA Council Meeting at Ministerial Level	**RM**	Rocket Mission Related Object
ESOA	European Satellite Operators Association	**ROI**	Return on Investment
EU MFF	EU Multiannual Financial Frameworks	**RPO**	Rendezvous and Proximity Operations
GSOA	Global Satellite Operator's Association	**SDA**	Space Domain Awareness
IADC	Inter-Agency Space Debris Coordination Committee	**SIA**	Satellite Industry Association
ICT	Information and Communications Technology	**SME**	Small and Medium-Sized Enterprises
IMT	International Mobile Telecommunications	**SSA**	Space Situational Awareness
ISAM	In-orbit Servicing, Assembly and Manufacturing	**SSC**	Space Safety Coalition
ISO	International Organisation for Standardisation	**SSR**	Space Sustainability Rating
ISON	International Scientific Optical Network	**SST**	Space Surveillance and Tracking
ITU	International Telecommunication Union	**STM**	Space Traffic Management
ITU-R	ITU Radiocommunication Sector	**TFEU**	Treaty on the Functioning of the EU
LEO	Low Earth Orbit	**UI**	Unidentified
LTS	Long-Term Sustainability	**UKSA**	UK Space Agency
NGO	Non-Governmental Organisation	**UN COPUOS**	United Nations Committee on the Peaceful Uses of Other Space
NGSO	Non-Geostationary	**UNGA**	UN General Assembly
NR NTN	New Radio Non-Terrestrial Networks	**UNOOSA**	United Nations Office for Outer Space Affairs
OECD	Organisation for Economic Cooperation and Development	**VSAT**	Very Small Aperture Terminal

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