The Geopolitics of Space

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Contents

Preface

by Ettore Greco

This volume includes three papers drafted and discussed within the framework of the research project "The Geo-Finance of Space" conducted by the IAI in 2022–2023 in cooperation with and with the support of Intesa San Paolo. The authors offer different perspectives on the main developments in the outer space domain, the most recent positions and initiatives of the major space actors and the efforts to promote a more secure and stable space environment. They focus on three closely interconnected dimensions of outer space: its commercialisation and growing economic importance, the role and impact of the expanding and diversifying military activities, and the still embryonic and inadequate regulatory framework.

The chapter "A Star-spangled Screen for the Protection of Great Power Competition?" by Julian Suess describes the new configuration of the role that outer space plays in geopolitics, notably in the deepening rivalry between big powers. In an increasingly multipolar world space actors have multiplied. This trend seems set to continue in the coming decades complicating efforts to reach agreements and find common solutions to a large number of unsolved issues related to management and regulation of space activities. The military relevance of space has steadily grown. It has become a crucial domain for the deployment of some of the most advanced dual-use technologies. Leading space-faring countries are now heavily dependent on space-based assets that can become primary instruments or targets of warfighting. They have built new defence structures, including space commands, to make full use of outer space as a military platform and better integrate space capabilities into their military apparatuses. At the same time, Suess notes that space activities reflect and are closely interconnected with the dynamics on earth. In particular, the fight for hegemony between the US and China is likely to become the single most important factor that will shape the military dimension of the space environment. In this context the lack of regulation of space activities represents a major source of concern also because major powers are extremely reluctant to accept constraints that can erode their military advantages or prevent them from acquiring new capabilities based on the emerging technologies. And in fact they are rather focusing on developing new means to protect their assets. However, as Suess underlines, only agreements to regulate conduct in space can reduce the growing risks associated with the militarisation of space. The commercialisation of the space domain and the related economic interests could provide a powerful incentive for a convergent regulatory effort. However, the existing disparities and asymmetries in space capabilities remain a big stumbling block.

The chapter "The Regulation of outer space activities" by Giulia Pavesi provides a critical overview of the existing normative framework aimed a regulating space activities and of the ongoing efforts to introduce new rules to cope with the rapidly changing space environment which is characterised by a growing congestion of activities and heightening competition between major powers. The chapter illustrates the main legal developments in the different sectors of space evolution. It first discusses the legal problems posed by the use and appropriation of space resources, an issue that has recently assumed high prominence. Pavesi notes that some provisions of the 1967 Outer Space Treaty (OST) and the Moon Agreement (MA) are relevant for the utilisation of space resources, but there remains a considerable legal uncertainty that may favour activities that undermine the principle of non-appropriation. While there have been attempts in the UN framework to fill this legal gap, the adoption of an international agreement in the near future is, according to Pavesi, unlikely. The US has instead concentrated on promoting the "Artemis accords" between its space agency and those of partner countries, while China and Russia have, in turn, signed various agreements centred on space exploitation. This highlights the growing rivalry over leadership in space, which complicates any efforts to reach agreement in a multilateral, that is, UN setting. Another priority underlined by Pavesi is Space Traffic Management (STM) and responsible behaviour in outer space. This includes orbital debris mitigation and remediation. Existing legal instruments are clearly inadequate in the STM sector. So far, international cooperation has been of a regulatory and technical nature but what is needed, Pavesi stresses, is a comprehensive set of rules and clear obligations. She argues that efforts should concentrate on vital STM aspects such as establishing information-sharing and notification mechanisms, ensuring standardisation at the operational level, and developing uniform practices for debris management. In this regard she notes that states have shown a clear preference for flexible approaches that aim to ensure a responsible behaviour rather than prohibit or restrict the use of technology. This is what emerges also by her critical evaluation of the various attempts to regulate the interaction of states in outer space. Priority continues to be given to the freedoms of exploitation and use of outer space resources. According to Pavesi, soft and hard law instruments should not be seen as mutually exclusive but complementary and mutually reinforcing.

The chapter "The Global Space Economy: Definition, Evolution and Forecasts" by Jules Varma and Rodolfo Zontini discusses key structural questions related to the role of outer space in global economy. The authors emphasize the need to develop more effective and accurate models to assess the socio-economic impacts of space activities. Effective decision-making should be based, so his argument goes, on more accurate identification and understanding of the components of space economy. This can be achieved only through a greater transparency and access to international data and the development of a shared methodology. Professional research has a crucial role to play in this regard. After this methodological premise, Varma and Zontini look into the changing estimations of the global space economy, examining its various components, both public and private, and the related future scenarios. They compare the various forecasts regarding the future evolution of space economy and its potential contribution to global economic growth, warning against possible shortcomings of the most optimistic evaluations. However several drivers, including the steady growth of private space investment, the development of new business models, and technological advances will probably continue to enhance the role of space activities in global economy and its significance for everyday's life.

1. A Star-spangled Screen for the Projection of Great Power Competition?

by Juliana Suess

In 2022, it is a rarity not to find at least one headline per week that declares a new race for space over announcements of innovative technologies. The old space race, that between the Soviet Union and the United States during the days of the Cold War, has faded into the background and the way in which space plays a role in geopolitics has taken on a new shape. Where the Cold War once pitched two blocs against each other, great power competition is now joined by numerous other actors – some of whom are more or less closely aligned to particular sides but exert their own agency as well.

Within this multipolar dynamic, the term "great power competition" is often used to describe strategic and diplomatic moves. In this competition, space plays an important role and political dynamics can be observed quite clearly in this domain, whose unique characteristics need to be understood. In addition to the fact that space is considered an operational domain by states and therefore carries military importance, it is a platform through which capabilities and technological advances can be displayed. As such, it is also an ideal medium for soft power projection – the building and hosting of space stations being just one example of this process.

With space being the expensive business that it is, the domain further holds economic opportunities with the growth of states' private sectors and GDP. The increasing commercialisation of the domain, a development also referred to as "new space", prompts an additional demand for the overhaul of the legal framework that currently exists for it, which is thin on the ground and not suitable for the increasingly congested and contested environment. The current lack of rules is rendering space a riskier environment to operate in, and it also enables geopolitical competition as states are grappling to tip the inherent asymmetries in their favour – with the setting of rules having become a battleground in itself.

Why does space matter?

States' reliance on space for both civil and military uses is growing steadily. Space assets enable global navigation and assist with power delivery and banking, amongst other everyday uses.[1] The resulting dependence further means that states need to secure their interests and protect their assets in the domain. Military reliance on space points to the inclusion of space-enabled assets in future conflicts, and the ongoing Ukraine war has confirmed this trend to an extent. Owing to a reliance on military assets in space – whether it be for communications, navigation or reconnaissance – satellites, their data links and ground elements become viable targets. Space is considered an operational domain by many modern militaries – NATO declared it as such in November 2019 and the US Space Capstone Publication refers to space as one of the warfighting domains.[2]

Many states have undergone changes to their defence structures to carve out a nerve centre for space. As such, France changed the name of its Air Force to the Air and Space Force, with Space Command forming one of its *grands commandements*.[3] Russia similarly combined its air force, anti-air and anti-missile defences into the Aerospace Forces in 2015, reportedly in response to "a shift in the combat 'centre of gravity' toward the aerospace theater".[4] New space commands have been created by Germany, the UK and the US and Italy established its Comando delle Operazioni Spaziali in 2020.[5] Modern states are grappling with the challenge of integrating a capability universal to all services

1 White House, *United States Space Priorities Framework*, December 2021, https://www.whitehouse.gov/briefing-room/statements-releases/2021/12/01/united-states-space-priorities-framework.

2 NATO, *NATO's Overarching Space Policy*, 17 January 2022, https://www.nato.int/cps/en/natohq/official_texts_190862.htm; US Space Force, Spacepower. Doctrine for Space Forces, Space Capstone Publication, June 2020, https://www.spaceforce.mil/Portals/1/Space%20Capstone%20Publication_10%20Aug%202020.pdf.

3 Website of the French Ministry of Armed Forces: *Armée de l'air et de l'espace. Organisation*, http://air.defense.gouv.fr/node/108.

4 Matthew Bodner, "Russian Military Merges Air Force and Space Command", in *The Moscow Times*, 3 August 2015, https://www.themoscowtimes.com/2015/08/03/a48710.

5 Giacomo Cavanna, "The Italian Space Operations Command Is Getting Ready", in *Ares Osservatorio Difesa*, 27 February 2021, https://aresdifesa.it/the-italian-space-operations-command-is-getting-ready.

in a way that leaves it accessible across the board while, to differing extents, allowing it its own independence in budgetary terms.

Naturally, the use of space is not altogether new to militaries. This organisational shift comes on the back of thirty years of using space in active combat. The first Gulf War in 1990 is often considered the first "Space War" due to the use of satellite-based navigation that helped direct infantry and artillery.[6] Since then, militaries have never looked back in this regard: the use of space enables precise targeting of the enemy while simultaneously allowing for the dispersal of own troops and the maintenance of command and control.[7] The natural conclusion follows that space as a domain presents opportunities for power projection. That being said, there are differences in how space should be conceived of – while analogies to the sea can be helpful for strategy and policy alike, space power cannot truly be thought of in the same way as air, land or sea power.

1. Space – Not your usual domain

When outlining how power is projected into space, it is important to understand the domain in and of itself. That includes understanding how conduct in the domain influences terran politics – space power is ultimately geocentric, meaning that the Earth is of primary importance to it from a strategic perspective.[8] After all, the command of space matters only because of political objectives pursued on Earth – at least, as long as the planet is humanity's centre of life.[9]

Earth orbits can be seen as the natural borders of space and encompass the main realm in which satellites operate. While space assets can go deeper into the realms beyond this (the James Webb Telescope being one very prominent example of this), the Earth's orbits are where the majority of activity is taking place and we will therefore limit ourselves to them.

6 Larry Greenemeier, "GPS and the World's First 'Space War'", in *Scientific American*, 8 February 2016, https://www.scientificamerican.com/article/gps-and-the-world-s-first-space-war.
7 Bleddyn E. Bowen, *War in Space. Strategy, Spacepower, Geopolitics*, Edinburgh, Edinburgh University Press, 2020, p. 207.
8 Ibid., p. 158.
9 Ibid., p. 58, p. 158.

The three main orbits are Lower Earth Orbit (LEO), Medium Earth Orbit (MEO) and Geostationary orbit (GEO). The purpose of any satellite dictates which orbit it would be best placed in. Earth observation satellites are usually placed in LEO, as this provides the closest proximity to the planet and therefore the most detailed images of it. Its proximity also makes it a popular spot for communications satellites, as delay of the signal is much reduced. MEO, the orbit between LEO and GEO, is home to the European navigation system Galileo and is a preferred orbit for navigation assets.[10] Geostationary orbit circles the equator, and satellites in it travel around the Earth at almost exactly the same speed as the planet – this makes them seem "stationary".[11] This provides opportunities for satellites that need to observe the same spot for long periods of time, or those that need to cover a large surface area – such as weather-monitoring or telecommunications satellites. Unlike GEO, there are no specific paths that satellites need to take in either LEO or MEO.[12]

1.1 Not all space powers were created equal

Getting into space, then (at the appropriate orbit), is the first challenge for space operations – and not all space powers were created equal. A state's location on Earth is a determinant of how orbits can be reached. Proximity to the equator permits utilising the spin of the Earth itself to reach a higher velocity, which is much more fuel efficient than launching from a latitude further away.

A state's geography may also determine the direction of their launch – for example, Israel effectively launches against the Earth's spin by conducting an east–west retrograde launch. This prevents a launch trajectory over neighbouring states and guarantees flight over the Mediterranean Sea instead.[13] The location of launch sites comes with its own set of politics: currently, the International Space Station (ISS) is accessible for both NASA, the American space agency, and Roscosmos, its Russian counterpart. As the Ukraine

10 European Space Agency (ESA), *Types of Orbits: Medium Earth Orbit (MEO)*, 30 March 2020, https://www.esa.int/Enabling_Support/Space_Transportation/Types_of_orbits#MEO.

11 Ibid.

12 Ibid.

13 Bleddyn E. Bowen, *War in Space*, cit., p. 72.

war has seen threats from then-Roscosmos Director Dmitry Rogozin about the fate of the ISS, host to both cosmonauts (Russian-trained) and astronauts (American-trained), speculations surfaced about whether Russia might cut ties with the West and instead join the Chinese space station Tiangong.[14] This, however, comes with its own political and technological recalculations. On the technological side, given the inclination of Tiangong, a much more complicated orbital-insertion manoeuvre would be required for Russia to access the station from its own launch sites; it has been reported that Russia bilaterally requested an adjustment of the inclination to make launches from its sites possible.[15] From the political perspective, Russia would be joining China's space efforts as the junior party given the latter's headway in the domain.

1.2 Space is big, expensive and increasingly congested

There is a reason why the longest-manned and -operated space station in LEO is the product of the collaboration of several national space agencies – simply put, space is expensive and complicated. The engineering required to make a craft viable in space differs from terran engineering calculations in many ways with the distances of travel and the speeds involved being just the initial concerns. An additional quandary is that once in space, repairs and physical adjustments are near impossible and the subject of future spaceflight.[16] As a result, certain contingencies need to be built in pre-launch.

Currently, the lifetime of satellites is mostly defined by their fuel supply.[17] While those in stable orbits do not need to use fuel, they will require it to correct their orbit (for example, in the case of gravitational pull towards the Earth) and to avoid collisions or close encounters with space debris and other satellites.[18]

14 Elizabeth Howell, "Russian Space Program Chief Says US Sanctions Could 'Destroy' International Space Station Partnership", in *Space.com*, 25 February 2022, https://www.space.com/roscosmos-rogozin-russia-iss-space-sanctions.

15 Andrew Jones, "Russia Wants to Send Cosmonauts to China Space Station", in *Space.com*, 22 June 2021, https://www.space.com/russia-cosmonauts-may-visit-china-space-station.

16 Hannah Duke, "On-Orbit Servicing", in *Aerospace Security*, 16 September 2021, https://wp.me/p9qFfk-vC.

17 Richard Franklin, "Back to the Basics – What's in a Satellite?", in *War in Space Podcast*, 10 June 2022, RUSI, https://rusi.org/podcasts/war-in-space/episode-13-back-basics-whats-satellite.

18 UN Office Outer Space Affairs (UNOOSA) and ESA, *The Cost of Avoiding Collisions*, 10 February 2021, https://www.unoosa.org/oosa/en/informationfor/media/unoosa-and-esa-release-infographics-and-

Occurrences of close encounters and potential collisions will only become more frequent in the near future, given the increase of assets in orbit – the number of operational satellites approximately doubled between 2002 and 2017,[19] with estimates stating that if even just 10 per cent of future plans turn into reality we could potentially be looking at another 10,000 operational satellites by 2030.[20] At the moment, space traffic management (STM) is taking place on an ad hoc basis, meaning that space objects are observed but there are no clear rules on collision-avoidance manoeuvres. Instead, it is up to satellite operators to make a decision in each individual case.

The technology and the costs involved mean that international collaboration is a "baked-in" element of spaceflight. Sanctioned states will feel the reverberations in their space industries – as, most recently, has Russia, which has a rich history of spaceflight but is heavily reliant on the West for electronic components.[21] An isolated country will struggle to even build a reliable space programme, as is evidenced by North Korea. The country has placed two satellites in orbit, though neither is currently considered operational as both ceased to transmit signals shortly after their launch.[22] That should not, however, lead to the erroneous assumption that a non-spacefaring state is unable to do damage to satellites. With space capabilities experiencing similar cyber vulnerabilities to non-space systems, cyber attackers are able to transfer their knowledge and skills to the domain and potentially cause damage to a broad degree, ranging from information denial to physical destruction.[23]

Space is big – so big, in fact, that the command of space cannot translate into dominance of the domain. While this is sometimes inferred through analogies to the maritime, the command of space refers to the control of communications

podcasts-about-space-debris.html.

19 Bhavia Lal et al., "Global Trends in Space Situational Awareness (SSA) and Space Traffic Management (STM)", in *IDA Documents*, No. D-9074 (April 2018), https://apps.dtic.mil/sti/citations/AD1123106.

20 Carmen Pardini and Luciano Anselmo, "Evaluating the Impact of Space Activities in Low Earth Orbit", in *Acta Astronautica*, Vol. 184 (July 2021), p. 11-22, https://doi.org/10.1016/j.actaastro.2021.03.030.

21 Pavel Luzin, "Russia's Defense Industry and Its Influence on Policy: Stuck in a Redistributive Feedback Loop", in *Russia Matters*, 3 November 2021, https://www.russiamatters.org/node/24937.

22 Juliana Suess, "North Korea's Satellites: Smokescreen for Missile Tests or Just Propaganda?", in *RUSI Commentaries*, 29 July 2022, https://rusi.org/explore-our-research/publications/commentary/north-koreas-satellites-smokescreen-missile-tests-or-just-propaganda.

23 Brian Weeden and Victoria Samson (eds), G*lobal Counterspace Capabilities Report. An Open Source Assessment*, Secure World Foundation, April 2022, https://swfound.org/counterspace.

– which means that control and denial of space are the goals of opposing powers.[24]

2. Space is a blank canvas

While space is hailed as a "province of all mankind" in the Outer Space Treaty of 1967, this romanticised view differs from the reality:[25] not only was spaceflight initially possible due to the strides made in missile development,[26] but also space has been used to make a show of military power ever since the launch of the first satellite in 1957.[27] In short, space has been used as a realm into which to project terran politics ever since humankind began exploring it.

The advent of spaceflight occurred against the backdrop of the Cold War, and one might struggle to picture the space race between the United States and the Soviet Union without the political dynamics underlying it – not least, because what was posed as a space race was in fact much more of a "missile race".[28] However, the prestige and the global excitement of space exploration held out possibilities for political signalling – a tool, the power of which states were able to appreciate and use.

To what extent is that earlier space race mirrored in the events of today? While newspapers still enjoy the semantics of the "space race" – a term now often used to denote the new space efforts of billionaires – does it also hold true for the political dynamics of states? Is great power competition playing out in the domain too?

24 Bleddyn E. Bowen, *War in Space*, cit., p. 63.
25 *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies* (Outer Space Treaty), 1967, https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html.
26 Melissa Hanham, "Rocket Beginnings: What Links Missile Development and Spaceflight?", in *War in Space Podcast*, 7 July 2022, https://rusi.org/podcasts/war-in-space/episode-15-rocket-beginnings-what-links-missile-development-and-spaceflight.
27 Mark Shanahan, *Eisenhower at the Dawn of the Space Age. Sputnik, Rockets, and Helping Hands*, Lanham, Lexington Books, 2017, p. 73.
28 Melissa Hanham, "Rocket Beginnings", cit.

2.1 Great power competition in space

Earth orbits are inhabited by human-made and launched assets. Therefore, space is the extension "of Terran politics by other means" and the goings-on in orbits will naturally reflect the political dynamics on Earth.[29] This means that great power competition, as it is currently playing out on Earth, can be observed in space too.

Space plays host to critical assets – for national security but also for telecommunications, banking, etc. – and these assets will naturally become legitimate targets during wartime. In peacetime that is nonetheless shaped by a multipolar order, a show of power in this realm becomes extremely useful for diplomatic signalling. Therefore, we can observe an element of great power competition in multilateral forums through such diplomatic signalling.

2.2 The fight is in the courtroom now

Despite the fact that space is becoming increasingly congested and that a growing multitude and variety of actors are getting involved in it, there are hardly any set rules that govern conduct within the sphere. On the micro level, this means that the lack of STM could lead to a riskier operating environment; on the macro level, it gives states mostly free rein over what to place in orbit. The basis that everyone still relies on is the Outer Space Treaty (OST) of 1967, even though the playing field has changed dramatically since then. The OST dictates that there is freedom of scientific investigation in outer space, that space and its celestial bodies cannot be claimed by states. On weapons, it states that no nuclear arms or other weapons of mass destruction should be installed in space or on celestial bodies. The moon and other celestial bodies are further protected from the establishment of military bases and the testing of any weapons on them.[30] Twenty-first-century efforts to build on these rules by including some regulations on conventional weapons have not borne fruit. Recent space governance efforts have aimed to tease out more detail around space weapons, specifically direct-ascent anti-satellite weapons (DA-

29 Bleddyn E. Bowen, *War in Space*, cit., p. 3.

30 *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space*, cit.

ASATs), which are highly destructive and leave the affected orbit a high-risk environment for other spacecraft to operate in. Efforts often become stuck around such details – including the meaning of the word "space weapon". The lack of regulation is enabling competition in the domain while the setting of rules has become a diplomatic dimension in this competition.

The most recent shake-up over space rules was led by the United Kingdom, which tabled a United Nations General Assembly motion towards "responsible behaviours" in space – also referred to as Resolution 75/36.[31] Its ambition is nothing less than to begin to untie the Gordian knot that constitutes discussions around space governance by going back to states and asking them what constitutes responsible behaviour in space. The overarching goal of the resolution is to prevent an arms race in space. This bottom-up approach is intended to deconflict the existing deadlocks around these discussions. Meanwhile, China favours a top-down approach in the form of a space arms-control treaty.[32] Both Russia and China point towards their 2008 draft "Treaty on the Prevention of the Placement of Weapons in Outer Space, and the Threat or Use of Force in Outer Space" (PPWT) as a basis for future discussions.[33] China's response to 75/36 mentions the US several times – stating that some of its space operations have "aggravated tension in space and increased the risk of military miscalculation and conflict".[34] This act of signalling reflects the inherent asymmetry underlying global dynamics – China is challenging the United States' status as the biggest space power by accusing it of tilting the global balance towards a higher level of escalation.

This diplomatic wrangling amounts to an attempt to shape the rules of space while not curtailing one's own advantages there (whether these exist yet or

31 UN General Assembly, *Reducing Space Threats through Norms, Rules and Principles of Responsible Behaviours* (A/RES/75/36), 16 December 2020, https://undocs.org/A/RES/75/36.

32 UN Secretary-General, *Reducing Space Threats through Norms, Rules and Principles of Responsible Behaviours (2021)* (A/76/77), 13 July 2021, https://undocs.org/A/76/77.

33 Russia and China, *Letter dated 2008/02/12 from the Permanent Representative of the Russian Federation and the Permanent Representative of China to the Conference on Disarmament addressed to the Secretary-General of the Conference transmitting the Russian and Chinese Texts of the Draft "Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force against Outer Space Objects (PPWT)" introduced by the Russian Federation and China*, 29 February 2008, https://digitallibrary.un.org/record/633470.

34 UN Secretary-General, *Reducing Space Threats through Norms, Rules and Principles of Responsible Behaviours (2021)*, cit., p. 30.

not). One of the reasons why the US (and the West generally) have not been in favour of adopting the PPWT, and other top-down measures, is that it wants to retain its freedom of manoeuvre in developing capabilities, including "space-based missile defenses".[35] This is one of the factors that explain why so little headway has been made on space governance: neither China nor the US is willing to agree to a framework for discussion that threatens to constrain its developments and thereby limit its own advantage.

Nonetheless, the US has found a way of retaining its advantage while driving forward the development of space rules and signalling that it cares about international rules for space: in April 2022, it committed to not testing destructive DA-ASAT weapons.[36] This has allowed the US to send a signal of its red lines, specifically after the destructive ASAT test carried out by Russia in November 2021. The US possesses "the most advanced military space capabilities in the world" and does not need to rely on the testing of DA-ASATs to affirm that position.[37] This is partly because it has already demonstrated this capability successfully in 2008 during "Operation Burnt Frost".[38]

Today's political dynamics can be observed in space – a domain whose lack of regulations and rules is partly enabling great power competition. The struggle around space regulations in multilateral forums reflects these dynamics. The legal frameworks that guide behaviours in space are too scarce and too broad to be useful for the modern-day use of the environment. The domain therefore lends itself to this type of diplomatic wrangling. None of the players involved is willing to surrender its advantages, which makes sweeping agreements almost impossible. Perhaps the best way forward, as demonstrated by the United States, is to enter into initial commitments that other states can freely join. These do not rely on agreement by others and yet allow for advances in space governance.

35 Victoria Samson and Brian Weeden, "Enhancing Space Security: Time for Legally Binding Measures", in *Arms Control Today*, Vol. 50, No. 10 (December 2020), p. 6-13, https://www.armscontrol.org/node/12015.

36 White House, *Fact Sheet: Vice President Harris Advances National Security Norms in Space*, 18 April 2022, https://www.whitehouse.gov/briefing-room/statements-releases/2022/04/18/fact-sheet-vice-president-harris-advances-national-security-norms-in-space.

37 Brian Weeden and Victoria Samson (eds), *Global Counterspace Capabilities Report*, cit., p. 1.

38 Nicholas L. Johnson, "Operation Burnt Frost: A View from Inside", in *Space Policy*, Vol. 56 (May 2021), Article 101411, https://doi.org/10.1016/j.spacepol.2021.101411.

Conclusion

Space matters hugely for today's militaries and cements the foundations of many modern-day conveniences in civilian life. As space has become an integral part of both civil and military infrastructures, the requirement to protect the domain and the assets within it has emerged – while also rendering space a legitimate target in wartime. As a result, states are developing technology to protect those assets and space has subsequently become a domain of interest in itself. Power projection into space is evident, and is certainly not an invention of the 21st century.

The strategic calculations surrounding the involvement of space in international norms should consider how inherently unique the domain is, despite how useful analogies to more traditional domains might be. Furthermore, abiding asymmetries hinder individual space powers – a state's geography, for one, determines how effective its launch capability can be. And while space carries with it huge economic opportunities, space efforts are also costly and space ambitions must be tailored accordingly.

The asymmetry affecting space powers is an important element of the great power competition that we can observe in space. It is shaping political dynamics on the international stage around conduct in space and how to regulate it. Such regulation is vital for a number of reasons, ranging from the avoidance of military miscalculation to ensuring that space continues to be an environment that can be operated in without constant risks. The commercialisation of the realm, which has enabled private companies to venture into a domain previously only accessible to powerful states, brings with it increased demand for spots and has rendered the domain more congested. As a result, the need for Space Traffic Management – as well as for comprehensive rules around conduct within space – is becoming ever more urgent. In the meantime, geopolitical competition will continue to play out in and through space, when all the while more commercial entities enter the domain. Thus, the immediate need for rules and the asymmetry in capabilities have left an uneven playing field that makes compromise surrounding the rules of space complicated at best. Therefore, perhaps the best way to reach an agreement is to follow the lead of the US – by initiating commitments and leaving the door open for other states to join.

2. The Global Space Economy: Definition, Evolution and Forecasts

by Jules Varma and Rodolfo Zontini

The space economy has become a topic of increased focus in the past decade, notably due to renewed interest and ambition shown by both established and more recent spacefaring nations. A series of technological innovations coupled with the emergence of "New Space" (see Section 2.3 below) have enabled space companies to explore new markets and business models that many believe will constitute a factor of significant growth for the space sector in the coming decades. Furthermore, the development of the Internet of Things (IoT) and the growth of non-terrestrial networks – notably, in Low Earth Orbit (LEO) – is expected to drive the growth in demand for space-based data in the years to come.

The combination of these factors has led some to estimate that the space economy will be valued at 1 trillion US dollars in 2040. This figure, however, is debated among analysts in the industry, and many questions remain as to the current value of the space economy and how to begin to define it.

1. Defining the global space economy

1.1 Why defining the space economy has become a question of increased relevance

Prior to examining the question of how to define the space economy, it is important to ask why establishing such a definition has garnered more relevance today than hitherto. In recent years, specialised institutions as well as national statistical offices have put a significant effort into trying to reach a suitable definition.

Two primary reasons can be invoked for this increased effort:

- Firstly, *the development of robust models to better analyse the socioeconomic impacts of space activities has become a crucial tool for policymakers*. This has become more important considering the impact of recent socioeconomic crises, the fact that space activities are increasingly subject to public scrutiny and the increase in the number of countries pursing efforts to develop their own capabilities.
- Secondly, a better understanding of the space economy and its components will be a crucial step in *improving decision making* by both public institutions and representatives of industry, as well as determining the best policy options for intervention if necessary. Currently available definitions often differ from one another, making it difficult to establish appropriate benchmarks and accurately estimate the growth of the various markets encompassed within the space ecosystem.

1.2 Understanding the value of the space economy and services for public policy objectives

Taking into account the above-mentioned reasoning, it is also important to appreciate that many of the activities undertaken in space have more than just a pure economic value, as space-based systems are increasingly used by public and private institutions alike to achieve both public and commercial objectives.

In fact, due to the nature and the wide scope of the activities undertaken, the development of space infrastructures and services has historically been seen as a driver for tackling a wide range of policy goals in addition to commercial or economic objectives.

The link between space-based services and public policy objectives is still very much present today, as space services are increasingly regarded by policymakers as tools to meet a growing number of targets. An important and recent example of this is represented by one of the two overarching goals of the EU Space Policy: "increasingly harnessing space investments and services to address key EU political priorities such as the European Green Deal and the

Digital Decade".[1]

Many of the activities related to EU flagship programmes are in fact structured with this link, with Galileo[2] and GMES/Copernicus[3] having been created to support a wide range of EU policies and offer free and open signals and/or data that can be operated through applications as public goods.

The space activities that have been set up in this regard stem more from political than commercial demand, and are thus more difficult to quantify in purely economic terms. From a practical standpoint, the development of these space-based assets is undertaken by governments who set the policy requirements and lead procurement in order to set up infrastructures to meet their public policy objectives.[4]

Such activities would thus be more easily quantifiable in terms of their enabling nature for other services, their geopolitical effects or even more non-tangible criteria such as international "status".

1.3 Providing a definition for the space economy

A widely used and comprehensive definition provided by the Organization for Economic Cooperation and Development (OECD) describes the space economy as

> the full range of activities and the use of resources that create and provide value and benefits to human beings in the course of exploring, understanding, managing and utilising space. Hence,

1 Clément Evroux, "EU Space Policy: Boosting EU Competitiveness and Accelerating the Twin Ecological and Digital Transition", in *EPRS Briefings*, February 2022, p. 1, https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2022)698926.

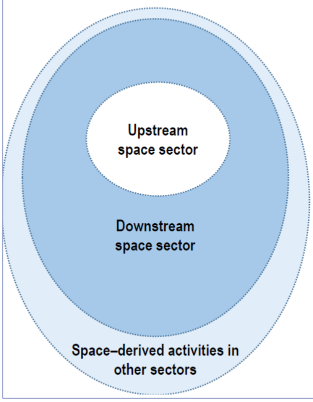
2 Council of the European Union, *Council Resolution of 13 December 1994 on the European Contribution to the Development of a Global Navigation Satellite System (GNSS)*, https://eur-lex.europa.eu/legal-content/en/TXT/?uri=celex:31994Y1231(03).

3 European Commission, *Global Monitoring for Environment and Security (GMES): From Concept to Reality* (COM/2005/565), 10 November 2005, https://eur-lex.europa.eu/legal-content/en/TXT/?uri=celex:52005DC0565.

4 Pierre Lionnet, *Space Economy Fundamentals. Discussion paper*, 2021, https://www.linkedin.com/posts/eurospacepierrelionnet_space-economy-fundamentals-activity-6835514574809137152-tGPI.

it includes all public and private actors involved in developing, providing and using space-related products and services, ranging from research and development, the manufacture and use of space infrastructure (ground stations, launch vehicles and satellites) to space enabled applications (navigation equipment, satellite phones, meteorological services, etc.) and the scientific knowledge generated by such activities.[5]

Figure 1 | Space value chain breakdown



Scope	Activities
Upstream space sector = Scientific and technological foundations of space programmes, manufacturing and production of space infrastructure	Fundamental and applied research; scientific and engineering support; dedicated ancillary services (e.g. insurance); supply of materials and components; design and manufacturing of space equipment and subsystems; integration and supply of full systems; space launch
Downstream space sector = Daily operations of space infrastructure and "down-to-earth" activities that directly rely on the provision of a space capacity (satellite technology, signals or data) to exist and function	Operations of space and ground systems; supply of devices and products supporting consumer markets (e.g. GPS-enabled devices, set-top boxes, selected GIS); supply of services supporting consumer markets (e.g. satellite television broadcast)
Space-derived activities in other sectors = New activities in various economic sectors that derive from or have relied on space technology transfers	Activities/products/services derived from space technology, but not dependent on it to function (e.g. ad-hoc space technology transfers in the automotive or medical sectors)

Source: OECD, *OECD Handbook on Measuring the Space Economy*, 2nd ed., cit., p. 31.

The OECD Space Forum has also played an important role in contributing to a shared definition of what can constitute the space value chain. To this effect, it provides definitions for three segments constituting that chain[6] – namely,

1. the upstream segment, which includes research, manufacturing, and ground systems;
2. the downstream segment, which includes space operations for terrestrial use, and products or services such as satellite broadcasting or Global Navigation Satellite System- (GNSS-) enabled devices that rely on satellite technology to function; and

5 OECD, *OECD Handbook on Measuring the Space Economy*, 2nd ed., Paris, OECD Publishing, 2022, p. 28, https://doi.org/10.1787/8bfef437-en.

6 European Space Agency (ESA), *Measuring the Space Economy*, October 2019, https://space-economy.esa.int/article/34/measuring-the-space-economy.

3. the space-related segment, which includes applications, products or services that are partly enabled by the space infrastructure but do not depend on it.

These products may stem from spin-offs or technology transfers coming from the space sector.

The OECD's definition has served as a robust basis for the development of further definitions developed for studies conducted at the national level, including in the United States and Australia.

Another definition of note due to its comprehensive nature is that established by the US Bureau of Economic Analysis (BEA). According to the BEA, "the space economy consists of space-related goods and services, both public and private. This includes goods and services that: (a) are used in space, or directly support those used in space; (b) require direct input from space to function, or directly support those that do; (c) are associated with studying space".[7]

The BEA's definition is part of a broader effort being undertaken in the United States to define the space economy and create a rigorous methodology to accurately estimate its size and growth. Another definition was recently provided by the Space Technology Policy Institute (STPI), which is part of the Institute for Defense Analyses (IDA). In 2020, the STPI published an influential paper on measuring the space economy in which they provided a definition with the objective of offering a more restrictive estimate of the space economy. Their definition considers past studies and methodologies in order to provide a redefined "perimeter" for space activities; according to it, the space economy "only includes the value of goods and services provided to governments, households, and businesses from space or used to support activities in space" and therefore excludes space-enabled activities that are primarily generated by terrestrial means.[8]

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7 Tina Highfill, Annabel Jouard and Connor Franks, "Preliminary Estimates of the U.S. Space Economy, 2012–2018", in *Survey of Current Business*, Vol. 100, No. 12 (December 2020), p. 2, https://apps.bea.gov/scb/2020/12-december/1220-space-economy.htm.

8 Keith W. Crane et al., "Measuring the Space Economy: Estimating the Value of Economic Activities in and for Space", in *IDA Documents*, No. D-10814 (March 2020), https://apps.dtic.mil/sti/citations/AD1122153.

Their definition is like many being produced in Europe that also have the objective of providing policymakers with a more accurate and, in some cases, more restrictive definition of the space economy based on a robust methodological approach.

Another instance of this approach is represented by an influential discussion paper published in 2021 by the Research and Managing Director of Eurospace, Pierre Lionnet. In the paper, the space economy is divided into three segments: the Upstream (the supply side), the Midstream (the demand side) and the Downstream (induced markets). As with the definitions adopted by the STPI and the BEA, Lionnet's downstream segment is considered within a stricter perimeter that includes only products or services that are "induced" by the midstream. A line is thus drawn between products and services that rely on space-derived data and infrastructure (e.g. the satellite terminal market) and those in which space-derived data and infrastructures are indeed integrated into a service but are not essential to that product's or service's existence (e.g. television delivered by satellites).[9]

1.4 Challenges in defining the global space economy and the way forward

Although an increasing number of studies and methodologically robust approaches attempt to give an accurate picture of the global space economy, there are still many challenges to arriving at a common definition.

One of the primary challenges is the *fragmentation of the national space-statistics landscape*. As space is not yet recognised as a category in international standards of industrial classification, national-level entities are left with the task of collecting and analysing data on the space economy. This leaves the landscape highly fragmented with no clear common methodology for collecting and reporting data about the space economy.

9 Pierre Lionnet, *Space Economy Fundamentals*, cit.

A related challenge is represented by the *relatively underdeveloped national classification systems* themselves. National statistical offices rely on robust classification systems to create comprehensive statistics for their countries, but space activities and products are not always found in the statistical classification systems that they use.

In addition, a challenge that is often highlighted is the *relative lack of transparency and access to international data*. Many countries, such as the United States, make available data that is useful for the valuation of the space economy, such as their national space budgets. However, some major players in the space economy – including Russia and China – are less transparent, making it difficult to estimate annual spending on the development of their space industries. Therefore, economists must rely on national budget estimates by comparing and scaling such activities to those of other countries.

Finally, as we will discuss in more detail in the upcoming sections, the *absence of a common methodology and differing perimeters* when defining the global space economy can also be considered a major challenge. This is particularly the case when considering definitions of the downstream segment or "space enabled" activities. As this part of the value chain often accounts for a large share of the overall value of the space economy as currently estimated, differently established perimeters can significantly affect overall valuations. Until recently, studies rarely disclosed their methodologies, which did not allow for verification and replicability. A common issue is that of double counting (counting both expenditures to buy goods and services and the revenue gleaned from the sale of those same goods and services), which can lead to an overvaluation of the sector.

Despite these hurdles, multiple factors have contributed to the progress made in recent years towards the establishment of a definition for the space economy. Among these, an important factor that should not be overlooked is the *increasing professionalised study of space economics*. In fact, multiple countries have invested heavily in professionalising their national capacity for the study of the space economy. To this end, many space agencies and administrations in G20 economies – including in the United States, Canada, Germany and the United Kingdom, for example – also employ chief economists and/or have invested significant resources in data collection and survey disbursement, often in collaboration with the countries' national statistical offices.[10]

In addition, significant progress has been made in statistical measurements for the space sector – notably, through the use of satellite accounts. In accordance with its own definition of the space economy, the BEA in the United States has estimated the gross domestic product (GDP) as well as the gross output of the space sector by industry (manufacturing, wholesale trade and information) as part of its Space Economy Satellite Account (SESA).[11] This account contains estimates of the US space economy consistent with a framework used to measure the US economy overall. Other countries are exploring the option of launching similar satellite accounts, and recent efforts by the European Space Agency (ESA), Eurostat and the Joint Research Centre (JRC) have been made towards a European Space Economy Satellite Account.[12]

Finally, the increased use of national industry surveys can also be considered an important factor contributing to the improvement seen in recent years. To this effect, countries such as Germany, Italy and Australia have recently launched national space-industry surveys and other studies aimed at quantifying and better understanding the space economy at the national level.[13] South Korea and the United Kingdom have long since surveyed their space industries, but are adapting the methodologies traditionally employed in order to encompass innovation and societal impacts as well as improving definitions to allow for international comparison.

10 OECD Space Forum, *Space Economy for People, Planet and Prosperity*, OECD Paper for the G20 Space Economy Leaders' Meeting, September 2021, https://www.oecd.org/sti/inno/space-forum/space-economy-for-people-planet-and-prosperity.pdf.

11 OECD, *OECD Handbook on Measuring the Space Economy*, 2nd ed., cit., p. 42.

12 European Space Agency, *ESA-Eurostat Workshop on a European Space Economy Satellite Account*, March 2022, https://space-economy.esa.int/article/127/esa-eurostat-workshop-on-a-european-space-economy-satellite-account.

13 OECD Space Forum, *Space Economy for People, Planet and Prosperity*, cit.

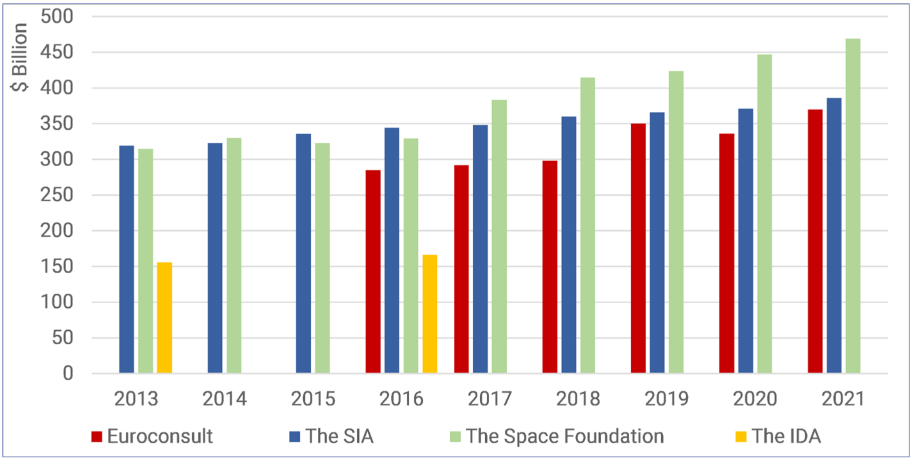
2. Evolution and estimations of the global space economy

2.1 Historical evolution of space economy estimations

Considering the challenges and ways forward presented in the previous section regarding definitions of the global space economy and its value, we can now take a closer look at how organisations have attempted to estimate its size in previous years.

Figure 2 presents a non-exhaustive picture of some of the most widely used figures for the size of the global space economy in the period 2013–21. As we can see, the two organisations that have historically been at the forefront of these analyses are the Space Foundation and the Satellite Industry Association (SIA). Other companies, such as Euroconsult, have more recently also started publishing regular estimations and reports using different valuations and methodologies.

Figure 2 | Global space economy evolution (consolidated), 2013–21



As discussed in the previous section, the primary reason behind differences in estimations stems from the diversity of methodological approaches across these organisations – and particularly from their approach to defining the perimeter of the space economy. In fact, different definitions of the perimeters, often due to different measurements of the value of the "Downstream" segment, can lead to significant variations in final estimations as can be noted in Figure 1.

In this regard, the estimations of the space economy presented by the IDA for 2013 and 2016 particularly stand out, as they represent approximately half of the other estimations. The IDA based their analysis ex-post on estimates provided by the SIA, the Space Foundation and the OECD (2013 estimates) and proposed a new methodological approach with the objective of providing a more targeted estimate of the global space economy. The primary reason behind the discrepancies with other estimations is the adoption of a more restrictive definition of the space economy that only includes the value of "goods and services provided […] from space or used to support activities in space" and excludes "activities that are enabled by space but are primarily generated terrestrially".[14]

Nonetheless, although significant differences in the total value may exist, we can also note that all organisations estimate that the global space economy has seen a growth trend over the last decade, with estimates of compound annual growth rates (CAGR) going from 2.41 per cent for the SIA and 5.1 per cent for the Space Foundation over the 2013–21 period. In this regard, however, it is interesting to note that Euroconsult estimates 2020 to be the only 12-month period in the past few years in which there has been an overall decrease in the value of the space economy – primarily due to the effects of the Covid-19 pandemic on the space industry. They nonetheless estimate a CAGR of approximately 5.3 per cent from 2016 to 2021.

2.2 Breakdown of the global space economy

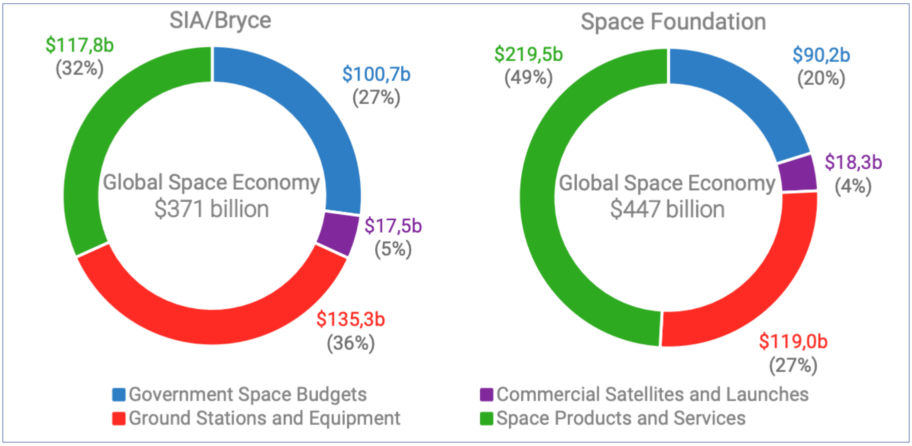
The value of the global space economy ranges between 350 billion and 450 billion US dollars on a yearly basis and depending on the organisation doing

14 Keith W. Crane et al., "Measuring the Space Economy", cit., p. 3.

the estimate. One of the most notable reasons behind such a large variation is the difficulty of settling on a homogeneous definition of what the space economy is.

The European Space Policy Institute (ESPI) annually break down data on the various segments of the space economy from two organisations that provide estimates on the global size of the space economy (SIA/Bryce and the Space Foundation).[15]

Figure 3 | Global space economy breakdown in 2020



Source: ESPI, *ESPI Yearbook 2021*, cit., p. 110.

The institute breaks down the space economy into four segments for better comparison between estimates that may themselves have many sub-segments: government space budgets; ground stations and equipment; commercial satellites and launches; and, finally, space products and services.

What can be seen is that while both Bryce and the Space Foundation have similar estimates with regard to government space budgets, commercial satellites and launches, and ground stations and equipment, the large difference in global estimates originates from space products and services. The

15 European Space Policy Institute (ESPI), *ESPI Yearbook 2021. Space Policies, Issues and Trends*, https://www.espi.or.at/?p=2770.

key differentiating factor here is the fact that the Space Foundation include positioning, navigation and timing (PNT) services within their estimate. This difference is worth 90 billion US dollars, which is close to the figure separating both total estimates (76 billion US dollars).

Over the span of six years (2014–20), breakdowns show that the global space economy has been relatively stable in terms of size per segment.[16] On average, the growth of all segments has been aligned with GDP growth.

2.3 Private space investments and their role in the global space economy

The global landscape of space activities has seen profound changes, with various cycles of innovation and commercialisation. The early twenty-first century saw the emergence of so-called New Space. New Space is defined by ESPI as a combination of six factors: new public schemes; new entrants; new solutions; new markets; new industrial set-ups; and, lastly, new private investments.[17]

The last factor, new private investments, has played a critical role in allowing and supporting the emergence of a global New Space ecosystem. The sheer volume of private investments earmarked for space start-ups has supported the development and establishment of thousands of start-ups worldwide since the turn of the century.

The best year thus far for private investment into New Space companies was 2021. Bryce highlights the fact that 15 billion US dollars were invested in 2021, spread over 241 deals.[18] This broke the previous record set in 2020, when global New Space start-ups raised 7.7 billion US dollars over a total of 140 deals. The cumulative total global volume of space investments from 2000 to 2021

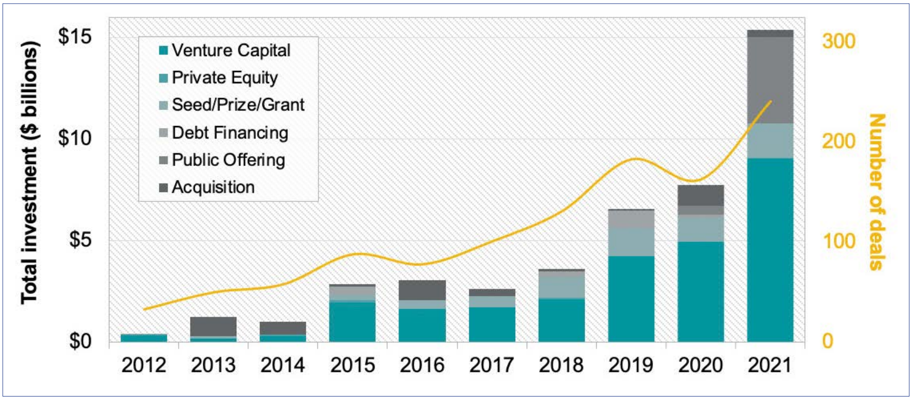
16 Ibid., p. 115.

17 Sebastien Moranta et al., "Space Venture Europe 2021. Entrepreneurship and Investment in the European Space Sector", in *ESPI Reports*, No. 83 (June 2022), https://www.espi.or.at/?p=2541.

18 Bryce Tech, *Start-up Space 2022. Update on Investment Commercial Space Ventures*, April 2022, p. 2, https://brycetech.com/reports/report-documents/Bryce_Start_Up_Space_2022.pdf.

reached a total of 52 billion US dollars.[19]

Figure 4 | Evolution of private space investments worldwide



Source: Bryce Tech, *Start-up Space 2022*, cit., p. 24.

The volume of private investments in space start-ups is relatively easy to assess;[20] however, it is important to look at the role that private funding has played in the growth of the global space economy. The ratio of private space investments to public space budgets has been continuously growing over the past three years, reaching 1:5 in the US and approximately 1:6 in Europe in 2021.[21] While space budgets are generally targeted towards the acquisition of goods and services, private investments play an entirely different role. They fuel technological development and alternatives to established products and services – which, in turn, supports the emergence of new business models and a more resilient global space sector. As such, it could be claimed that for future sustainable growth of the global space economy to occur the growth of private space investments is critical.

19 Ibid., p. 23.
20 See Ibid.; ESPI, *ESPI Yearbook 2021*, cit.
21 Sebastien Moranta et al., "Space Venture Europe 2021", cit., p. 28.

3. The future of the global space economy

3.1 Existing studies and forecasts

Estimating the size of the space sector is a critical undertaking, as it is one of the factors that motivates increases in public space budgets and the attraction of private capital. In line with this, a range of forecasts have been made by various actors, both public and private, to estimate the size of the future global space economy.

Table 1 | Forecasts of the space economy (consolidated)

Forecaster	Date	Space economy estimate ($)
Union Bank of Switzerland (UBS) [a]	2040	926 billion
Morgan Stanley [b]	2040	1.1 trillion
US Chamber of Commerce [c]	2040	1.5 trillion
Bank of America [d]	2045	2.7 trillion
Goldman Sachs [e]	2040	Multi-trillion
Satellite Industry Association (SIA) [f]	2040	580 billion
Space Foundation [f]	2040	1 trillion
Euroconsult [f]	2040	1.2 trillion

Sources: (a) Carl Berrisford, "Space", in *UBS Longer Term Investments*, 30 November 2018, p. 6, https://www.ubs.com/content/dam/WealthManagementAmericas/documents/space-p.pdf;
(b) Morgan Stanley website: *The New Space Economy*, https://www.morganstanley.com/Themes/global-space-economy;
(c) Brian Higginbotham, "The Space Economy: An Industry Takes Off", in *U.S. Chamber of Commerce*, 11 October 2018, https://www.uschamber.com/technology/the-space-economy-industry-takes;
(d) Nasdaq website: *The Future of the Space Economy*, https://www.nasdaq.com/space-economy;
(e) John Manning, "Space: Investing in the Final Frontier", in *International Banker*, 5 April 2022, https://internationalbanker.com/?p=13560;
(f) non-official; authors' calculation.

These forecasts range from 2.7 trillion US dollars by 2045, estimated by the Bank of America, to 926 billion US dollars by 2040, estimated by UBS. The Space Foundation have not provided any estimates for growth to 2040 – but, based on their calculated CAGR remaining steady, the space economy would reach 1 trillion US dollars by that year. However, extrapolating the Satellite Industry

Association's CAGR, a 1 trillion US dollars space economy would not occur before 2050.[22]

The Paris-based space-and-data analytics consultancy Euroconsult have published very similar numbers, estimating that the global space economy will reach 642 billion US dollars by 2030 on a yearly CAGR of 5.65 per cent. Extrapolating from Euroconsult's estimates and employing the same CAGR for the period from 2030 to 2040, the global space economy would be worth nearly 1.2 trillion US dollars by 2040.

3.2 Origins of growth and difference in assessment

UBS estimate that 30 per cent of the space economy's growth will originate from the sale of satellite broadband and internet services, and that another 30 per cent will originate from sales of ground equipment. The rest of the economy is expected to remain relatively stable.

Morgan Stanley, on the other hand see most of the growth originating from second-order impacts from the increase in broadband internet demand (almost 75 per cent of the growth) along with the ground-equipment increase. UBS and Morgan Stanley are the only organisations that have provided detailed assessments of the source of the space economy's growth: based on these two appraisals, most of it will originate from growing access to internet in currently under- and unserved parts of the world. Beyond the applications and revenue streams linked to increased access to the internet worldwide, there will also be a gradual increase in demand for bandwidth from the downstream economy – with notable use cases being autonomous cars, IoT, artificial intelligence- (AI-) related products, virtual reality (VR) and forms of video usage.[23]

Organisations such as the US Department of Commerce, Goldman Sachs and the Bank of America have not provided a breakdown of where they believe growth will occur, but have rather highlighted trends through which they believe it will happen. Some of these trends include lunar habitats, a commercial LEO and

22 ESPI, *ESPI Yearbook 2021*, cit.
23 Morgan Stanley website: *The New Space Economy*, cit.

space-based solar power.

3.3 Limits to assessments of future growth

As discussed above, there are several challenges to producing accurate estimations of the current global space economy. In addition to the more methodological aspects that have been previously highlighted, there are a series of structural evolutions currently ongoing that render the development of accurate future estimations more challenging.

Among these we can count the lowered cost of access to space, which has become an important factor leading to an increase in the number of both public and private stakeholders taking part in space activities. Furthermore, the increased digitalisation of space and the participation of new actors from the data economy is further blurring the divide between what is considered space and non-space.[24]

The increased focus on digital assets is an important factor contributing to this blurring of the line in many estimations of the size of the future space economy, as it factors in estimation of the downstream segment.

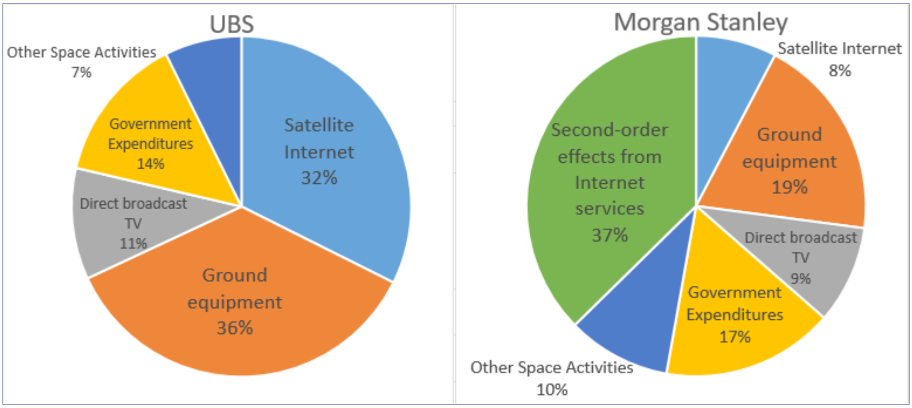
Beyond issues of definition, the IDA have highlighted many of the possible shortcomings of optimistic future valuations.[25] For instance, they stress the fact that some potential future drivers of growth that are often singled out (lunar habitats, LEO tourism and space-based solar power) are still very far from generating revenue, sometimes have dubious business models and will require a range of conditions that do not yet exist (cheap and readily available launches, and stable demand for such products and services).

With regard to large growth estimations based on the increased demand for space-based broadband services (such as in the analyses of Morgan Stanley and UBS), the IDA also underlines the fact that many potential future broadband internet customers reside in developing countries that have limited capacity to

24 OECD, *OECD Handbook on Measuring the Space Economy*, 2nd ed., cit.
25 Keith W. Crane et al., "Measuring the Space Economy", cit.

access these services. Furthermore, developing countries often have expanding phone coverage – meaning that future providers of space-based connectivity will be faced with strong competition from terrestrial operators.

Figure 5 | Breakdown UBS/Morgan Stanley projection: space economy 2040



Source: Keith W. Crane et al., "Measuring the Space Economy", cit., p. 36.

Overall, there are still many limitations – and challenges can be raised regarding the idea of a trillion-dollar space economy. However, it is important to remember that these estimates are based on growth from second-order effects of internet services by bridging the connectivity divide and the associated ground-segment equipment.

3.4 The future space economy: enabling future space architecture and digital solutions

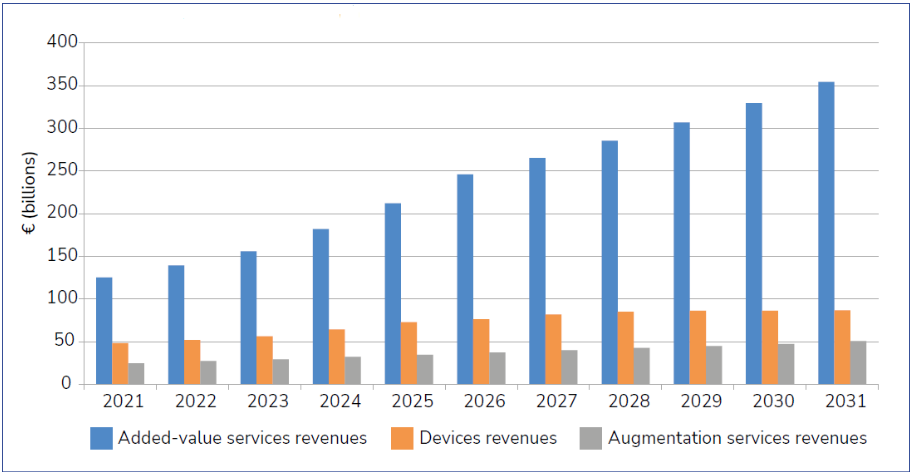
The downstream economy represents the largest share of the space economy. In 2020, the Space Foundation assessed that the downstream economy (including PNT services) was worth almost 220 billion US dollars, which was approximately 50 per cent of the total size of the space economy at the time.[26] Beyond PNT products and services, the downstream segment also includes

26 Space Foundation, *The Space Report 2021 Q3*, 26 October 2021, https://www.spacefoundation.org/?p=32127.

direct-to-home television, satellite communications, remote sensing and satellite radio.

Research by the European Union Agency for the Space Programme (EUSPA) indicates that the global market for GNSS-enabled systems and devices is expected to reach 492 billion euro by 2031 with a CAGR of 9.2 per cent.[27] This growth is understood to be primarily generated through the revenue from added-value services over the next decade.

Figure 6 | Revenues from GNSS sales, devices and services



Source: EUSPA, *EO and GNSS Market Report*, cit., p. 21.

Morgan Stanley's estimate of the size of second-order effects from internet services in 2016 is difficult to verify based on existing and shared information; however, it is expected to grow to 412 billion US dollars in 2040. While this growth and size is considered optimistic by the IDA, it becomes more realistic when thinking about the digital economy of tomorrow. Outside of the "direct" idea of simply bridging the connectivity divide and developing new targeted applications for specific markets, space-based data is bound to become an enabler of future business applications and strategies.

27 European Union Agency for the Space Programme (EUSPA), *EO and GNSS Market Report*, 2022, https://www.euspa.europa.eu/node/2923.

In addition, and as highlighted by Sebastien Moranta in his paper on the downstream space sector,

> Analysts seem confident that future market developments, coupled with an intense innovation dynamic in the space sector, will translate into considerable commercial opportunities for space-based solutions. Prospects in the areas of the Internet of Things, Ubiquitous Connectivity, Mobility, Smart Everything, Digital Twins, and Metaverse and augmented reality (among many others) have motivated some analysts to talk about space as a future trillion-dollar industry.[28]

Furthermore, access to "space" and space data is bound to become increasingly seamless. The merging of upstream and downstream services, as well as the creation of new business models like ground segments-as-a-service or space-as-a-service, will lower the entry barrier for both public and private actors who had previously considered access to private space resources and data to be financially unattainable.

3.5 The great upstream potential and the rise of "space-for-space"

While the downstream economy represents the largest share of the of space economy according to many of the estimations previously presented, the development of new markets and marketplaces in the upstream segment of the space value chain should not be overlooked.

When assessing future estimates, the IDA considers the feasibility and business cases of revenues originating from space tourism, space-based solar power and space mining.[29] While all three of these future sources of growth may fall short of contributing to the space economy in a meaningful way (unrealistic economic incentives, cheaper alternatives and little demand), there are other sources of growth – notably regarding future LEO and lunar markets.

28 Sebastien Moranta, "The Space Downstream Sector. Challenges for the Emergence of a European Space Economy", in *Etudes de l'Ifri*, March 2022, p. 21, https://www.ifri.org/en/node/22947.

29 Keith W. Crane et al., "Measuring the Space Economy", cit.

Some of these new and upcoming markets include space situational awareness (SSA), on-orbit servicing (OOS) which includes end-of-life active debris removal, in situ space situational awareness and life-extension services. Furthermore, there are markets in on-orbit manufacturing research and assembly, as well as those related to the future LEO economy and the potential future cis-lunar economy.[30]

The development of commercial space stations represents an additional future driver of growth. More than four firms have received 100 million US dollars from the US National Aeronautics and Space Administration (NASA) to develop the commercial space stations of tomorrow. These stations, which should be completed by the end of the 2020s, are design to attract a new form of demand through research and development (R&D) and manufacturing in space (from pharmaceuticals to new materials), space tourism and potential new market uptakes that have not yet been foreseen.[31]

Advancing a step further, it is even possible to begin to look at the utilisation of space assets for future space activities – or the market of "space-for-space". As the expansion and footprint of humankind in space can be predicted, some commercial actors are already taking steps to provide services for these future markets. Companies like Orbit Fab[32] are building an in-space propellant supply chain that would source water on the moon in order to create its product. Others, like Astro Forge,[33] are raising capital to make asteroid mining a reality.

For the time being, many of these future commercial ecosystems have a potential economic size that remains difficult to estimate. However, initial assessments of the market value of on-orbit servicing point to 10.1 billion US dollars with a CAGR of 17 per cent between 2020 and 2030. Euroconsult estimate that the SSA market will reach revenues of 300 million US dollars by

30 European Space Agency (ESA), *Moonlight - Navigation and Telecommunications for the Moon*, 20 May 2021, https://www.esa.int/ESA_Multimedia/Images/2021/05/Moonlight_-_Navigation_and_Telecommunications_for_the_Moon.

31 Matthew Weinzierl et al., "Your Company Needs a Space Strategy. Now", in *Harvard Business Review*, November/December 2022, https://hbr.org/2022/11/your-company-needs-a-space-strategy-now.

32 Orbit Fab website: https://www.orbitfab.com.

33 Astro Forge website: https://www.astroforge.io.

2030. Axiom Space have previously assessed that the total addressable market (TAM) for a commercial space station is 37 billion US dollars for the 2020–30 period. Space tourism has also been assessed to have a TAM of 400 million US dollars in the coming decade.[34]

Conclusion

The space sector is increasingly intertwined with other sectors, which constitutes one of many reasons why the space economy as an entity has proven so difficult to define. While there are still many challenges to defining the space economy, recent efforts have yielded significant progress.

Many entities have undertaken analyses to define an estimate of the space economy's size, with most current estimations varying from 200 to 400 billion US dollars. The question of whether the space economy will reach 1 trillion US dollars by 2040 is still uncertain, with the primary cause of such growth stemming from the effects of satellite broadband expansion and the lower cost of access to space placing a higher emphasis on digital services and products. Nonetheless, it is important to view this 1 trillion US dollars-by-2040 goal not as a measure of success but as a reminder of the necessity of a forward-looking mindset.

Regardless of whether the space economy reaches 1 trillion US dollars by 2040, it is important to remember the fact that space infrastructure and space-based services are enablers and drivers for achieving a wide range of policy objectives, with the true impact of the space economy ranging far beyond its mere commercial value.[35] Furthermore, 2040 is still almost two decades away – and, as such, we should not forget the popular saying: we always overestimate the change that will occur in the next two years and underestimate the change that will occur in the next ten.

34 Matthew Weinzierl et al., "Your Company Needs a Space Strategy. Now", cit.
35 Sebastien Moranta, "The Space Downstream Sector", cit.

3. The Regulation of Outer Space Activities

by Giulia Pavesi

1. A changing environment: Competitive, congested and contested space

In policy statements, space strategies and recent military doctrines, space has been described as competitive, congested and contested. Space is no longer the prerogative of a few major nations, through their national space agencies or large national industries, but has opened up to a variety of different actors and dynamics. In this sense, the ecosystem of space activities has been profoundly transformed in just a few years.

The so-called New Space phenomenon has brought increased use of venture capital, reduced costs of space access and higher production rates, diversification of actors and products, new business models and new production methods, as well as the emergence of new services and the increased commercialisation of outer space.[1]

As a direct consequence of increased competition and commercialisation, space has become congested – with the number of launches of space objects increasing sharply compared with the last century. This development has also been a direct result of the deployment of small satellites in mega or large constellations, particularly in Low Earth Orbit (LEO), and, as space technology becomes more accessible, a consumer trend has also emerged in the space

1 Ingo Baumann, Hussaine El Bajjati and Erik Pellander, "NewSpace: A Wave of Private Investment in Commercial Space Activities and Potential Issues under International Investment Law", in *Journal of World Investment & Trade*, Vol. 19, No. 5-6 (October 2018), p. 930-950 at p. 933, DOI 10.1163/22119000-12340115.

sector.

An additional and interconnected element of complexity in space congestion has arisen with the proliferation of space debris and non-functional but not yet de-orbited objects in the atmosphere. These objects represent potential "loose cannons" for the safety of space assets in orbit and make the risk of generating chain collisions, the so-called Kessler syndrome, increasingly real and the preservation of continuity of ground-dependent services problematic.

Finally, because of its strategic and commercial value, space has grown contested, as evidenced by the development of defence space strategies aimed at protecting national and commercial interests. Nowadays, space has been fully recognised as an integrator and enabler of modern civil society and national security, with an increasing number of countries researching and developing new systems to protect their space capabilities and institutionalising military space entities – indirectly increasing instability in this domain of exploration.

All these levels of complexity constantly interact with each other, requiring a holistic approach to preserve the security, sustainability and safety of this domain – including through the implementation of updated regulatory and governance solutions.

2. Global space governance at a crossroads

Global governance in relation to outer space has been referred to by some scholars as the "collection of international, regional, or national laws as well as regulatory institutions and actions/manners/processes of governing or regulating space-related affairs or activities".[2] In the case of international space law, the specific area in which international relations between actors unravel is outer space.

2 Ram S. Jakhu and Joseph N. Pelton, "Introduction to the Study on Global Space Governance", in Ram S. Jakhu and Joseph N. Pelton (eds), *Global Space Governance. An International Study*, Cham, Springer, 2017, p. 3-13 at p. 7.

Since the launch of the first satellites and the creation of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS, 1958), space has been a priority in the global governance agenda.

In the first phase of space exploration, states initially decided to adopt a realist approach and to regulate their interactions through a multi-step process laid down by a combination of so-called soft law instruments. These were then transposed in the hard law instruments that still constitute the backbone of international space law today.[3]

Throughout the evolution of the Space Age until the present time, this framework has been enlarged and enriched by a set of soft law instruments in the form of guidelines or proposals for codes of conducts, addressing space safety, security and sustainability issues.

However, in the light of recent technological and geopolitical developments, an urgent question needs to be addressed. Are old space law instruments and governance mechanisms still fit to address pressing issues such as the appropriation of space resources; the identification of space traffic management; or, at least, the coordination rules, as well as agreement on what constitutes responsible behaviour in outer space?

This chapter provides a synthetic overview of the main complexities linked to each of these areas of development, illustrating the principal legal trends in each field of space evolution.

3 Paul B. Stares, *The Militarization of Space. U.S. Policy, 1945-1984*, Ithaca, Cornell University Press, 1985, p. 30. At present, the cornerstone of international space law is still represented by the 1963 Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space, the 1986 Principles Relating to Remote Sensing of the Earth from Outer Space, the 1992 Principles Relevant to the Use of Nuclear Power Sources in Outer Space and the five space treaties adopted in the first two decades of space exploration (in chronological order, the 1967 Outer Space Treaty, the 1968 Rescue Agreement, the 1972 Liability Convention, the 1975 Registration Convention and the 1979 Moon Agreement).

3. The utilisation and appropriation of resources in space

Over the past decade, the issue of the utilisation and appropriation of space resources has been gaining. In 2012 and 2013, two US companies first announced plans to mine asteroids.[4] This announcement was followed by a legislative framework first in the United States,[5] then in Luxembourg,[6] followed more recently by the United Arab Emirates[7] and Japan.[8]

In 2020, the United States also launched the Artemis Accords,[9] a series of non-binding statements, signed by the national space agencies of 23 countries supporting the Artemis Program – an exploration programme led by NASA, ESA, JAXA and the CSA.[10]

Despite initial commercial interest, however, no domestic activities on space mining have been authorised to date,[11] ruling out the possibility of having potential case law on the subject for the time being.

4 Rod Pyle, "Deep Space Industries: A New Asteroid-Mining Company Is Born", in *Space.com*, 28 January 2013, https://www.space.com/19462-asteroid-mining-deep-space-industries-birth.html; Mike Wall, "Asteroid Mining Venture Backed by Google Execs, James Cameron Unveiled", in *Space.com*, 24 April 2012, https://www.space.com/15395-asteroid-mining-planetary-resources.html.

5 United States, Public Law 114-90: *U.S. Commercial Space Launch Competitiveness Act*, 25 November 2015, https://www.govinfo.gov/app/details/PLAW-114publ90.

6 Luxembourg, *Law of July 20th 2017 on the Exploration and Use of Space Resources*, https://legilux.public.lu/eli/etat/leg/loi/2017/07/20/a674/jo/en.

7 United Arab Emirates, *Federal Law No. 12 of 2019 on the Regulation of the Space Sector*, 19 December 2019, https://www.moj.gov.ae/assets/2020/Federal%20Law%20No%2012%20of%202019%20on%20THE%20REGULATION%20OF%20THE%20SPACE%20SECTOR.pdf.aspx.

8 *Act on Promotion of Business Activities Related to the Exploration and Development of Space Resources* (Act No. 83 of 2021) (Space Resources Act).

9 *The Artemis Accords. Principles for Cooperation in the Civil Exploration and Use of the Moon, Mars, Comets, and Asteroids for Peaceful Purposes*, 13 October 2020, https://www.nasa.gov/specials/artemis-accords.

10 Respectively, the US National Aeronautics and Space Administration, the European Space Agency, the Japan Aerospace Exploration Agency and the Canadian Space Agency.

11 Jeff Foust, "Deep Space Industries Acquired by Bradford Space", in *SpaceNews*, 2 January 2019, https://wp.me/p5sx4f-lZK; Jeff Foust, "Asteroid Mining Company Planetary Resources Acquired by Blockchain Firm", in *SpaceNews*, 31 October 2018, https://wp.me/p5sx4f-lzk.

Yet, the question of the legality of and conditions for the use and appropriation of space resources under existing international space law has remained – especially in the light of new legislative initiatives, as well as the question of the potential need for a specific international framework on the subject.

3.1 The relationship between the principle of non-appropriation and the utilisation and appropriation of space resources

The legality of such activities has been tested particularly in light of the so-called Magna Carta of space activities, the 1967 Outer Space Treaty (OST).

Although the OST was not designed primarily to regulate the commercial exploitation of asteroids by private actors, three of its main provisions are particularly relevant for the utilisation of space resources: Articles I, II and IX.

Article I ensures the indiscriminate freedom of exploration and use of outer space, the moon and other celestial bodies by all states in accordance with international law, as well as free access to all areas of celestial bodies. Article II prevents outer space, including the moon and other celestial bodies, from being subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means. Article IX further limits the ways in which states should behave as part of any activity in outer space, so as to avoid "harmful interference" with other states' activities and "harmful contamination" of the moon and other celestial bodies.

The *corpus juris spatialis* consists, then, of other four conventions subsequent to the OST that specified or detailed the vague and broad provisions contained in the "constitutional charter" of space activities.

Among these, the most relevant for the purposes of space-resource utilisation is the Moon Agreement (MA), in which Article 11 Section 3 further specifies the protection of the moon and its natural resources against appropriation. However, the OST fails to clearly address limitations to the extraction and appropriation of resources from the moon and other celestial bodies, and the reluctance to adopt and ratify the Moon Agreement by major space countries has led practice and doctrine to doubt the ability of the MA to effectively fill this gap.

Uncertainty therefore remains – particularly on the legality of the use of space resources for profit and the lawfulness of national space laws in granting possession or ownership of asteroids or space resources. One of the main criticisms in this regard is that by granting property rights on such resources through municipal law, the authorising state could claim jurisdiction over space resources and, by extension, the celestial bodies from which the resources were extracted, *de facto* breaching the non-appropriation principle.[12]

The issue may nevertheless be more theoretical than real. A functional interpretation of the text of the OST leaves no doubt that the treaty's negotiators did not want to exclude the use of space resources, since humanity's progress in the exploration and use of outer space depends also and precisely on such use.[13]

Consistently, doctrine has called on states not to underestimate the interpretive value of the Moon Agreement and the internal coherence of the *corpus juris spatialis*,[14] viewing the MA as a concretisation of the OST principles on the exploitation of the resources of celestial bodies.[15]

Additionally, in practice, commentators and sometimes even policymakers and legislators often tend to use "exploitation" and "appropriation" of space resources interchangeably, misreading the fact that only the latter is prohibited.

Therefore, to clarify this dichotomy and the issue of property rights over space resources, it has been suggested that the International Telecommunication Union (ITU) regime governing the management of frequencies and related

12 Thomas Cheney, "There's No Rush: Developing a Legal Framework for Space Resource Activities", in *Journal of Space Law*, Vol. 43, No. 1 (2019), p. 106-150 at p. 112, https://airandspacelaw.olemiss.edu/wp-content/uploads/2020/09/full-issue-43.1.pdf.

13 Ibid.

14 Philip De Man, "Interpreting the UN Space Treaties as the Basis for a Sustainable Regime of Space Resource Exploitation", in George D. Kyriakopoulos and Maria Manoli (eds), *The Space Treaties at Crossroads. Considerations de Lege Ferenda*, Cham, Springer, 2019, p. 15-33 at p. 20.

15 Ibid, p. 24.

orbital slots might provide useful insights.

In fact, as demonstrated by authoritative scholarship, a comparison with the ITU regime shows that unlawfulness arises only when a state claims certain resources in space for its *exclusive use* but then does not use those resources, thus violating Article II and I of the OST.[16]

Consistently with property-rights theory, exclusive exploitation will be "only lawful when justified by actual and continued use". Conversely, only when exclusion occurs on the basis of mere claims or physical possession not followed by actual exploitation of the resource is the situation revealing of property rights.[17]

3.1.1 An international framework for the utilisation of space resources?

A second question concerns the extent to which space activities are permitted and regulated by national laws and whether an international framework should be preferred instead, in which the prospect of excessive use of the resource could violate the duty of states to share the benefits of carrying out space activities.

As noted in the previous section, the Outer Space Treaty and the Moon Agreement are both sources of international space law. As such, they create obligations for the states that accept their terms[18] and, without necessarily venturing into the dualism–monism debate, it is a fact that most international rules are operationalised through national implementation.[19]

International (space) law itself has been formulated to leave ample room for interpretation and it remains a flexible and evolving tool. However, space technology and industry move at a faster pace than international (space)

16 Ibid, p. 29.
17 Ibid, p. 31.
18 Although some doctrine holds that certain provisions of the OST and the above mentioned declarations can now safely be considered international customary norms or even principles of jus cogens.
19 Antonino Salmeri, "The Integration between National and International Regulation of Space Resource Activities under Public International Law", in *Journal of Space Law*, Vol. 43, No. 1 (2019), p. 60-84 at p. 66, https://airandspacelaw.olemiss.edu/wp-content/uploads/2020/09/full-issue-43.1.pdf.

law, and domestic law becomes not only a way of transposing or integrating (depending on the doctrinal approach taken) the obligations of states but also an economic policy tool to support a specific sector while preserving the public interest.[20]

In this way, national legislations do not necessarily address or interpret the same provision in the same way,[21] exacerbating the risk of forum shopping and jeopardising the implementation of a state's treaty obligations.

For this reason, in 2016 a new agenda item on the matter[22] was established within the UN COPUOS Legal Sub-Committee, and a dedicated high-level working group was tasked with first assessing the need for a framework on space-resource activities and then with producing "building blocks" for a governance framework meant to encourage discussion among states.[23]

The 19 building blocks on substantive and non-substantive matters serve as a baseline for further multi-stakeholder discussion, providing an authoritative interpretation of international space law, proposing adaptive governance mechanisms to conduct such activities, and identifying best practices for greater consistency across national legislation.[24] However, the current geopolitical context and developments in space law over the past three decades suggest that the adoption of an international framework in the near future is unlikely.[25]

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20 Ibid., p. 61.

21 As shown, for example, by the legislation of Luxembourg and the US in authorising and regulating through national legislation the conduct of this type of activity and fulfilling their duties of ongoing control and supervision over the activities of their nationals in accordance with Article VI of the OST: the US seems to have a more restrictive approach than the broader interpretation of the term "appropriation" suggested, for instance, by Luxembourg. See: para 51303: "Asteroid resource and space resource rights", in United States, *Public Law 114-90*, cit. See also Article 4 of Luxembourg, *Law of July 20th 2017*, cit.

22 Working Group on Legal Aspects of Space Resource Activities named "General exchange of views on potential legal models for activities in the exploration, exploitation and utilization of space resources", https://www.unoosa.org/oosa/oosadoc/data/documents/2021/aac.105c.2l/aac.105c.2l.314add.8_0.html.

23 Webpage of the Hague International Space Resources Governance Working Group: https://www.universiteitleiden.nl/en/law/institute-of-public-law/institute-of-air-space-law/the-hague-space-resources-governance-working-group.

24 The Hague International Space Resources Governance Working Group, "Reflections on the Building Blocks for an International Framework", in *Journal of Space Law*, Vol. 43, No. 1 (2019), p. 151-170 at p. 158, https://airandspacelaw.olemiss.edu/wp-content/uploads/2020/09/full-issue-43.1.pdf.

25 Philip De Man, "Interpreting the UN Space Treaties as the Basis for a Sustainable Regime of Space Resource Exploitation", cit., p. 32.

3.1.2 The Artemis Accords: Constructive legal ambiguity as a political choice

Another recent example of unilateral interpretation of treaty provisions that could create divergence in the implementation of international space law, and even conflicts between laws, is to be found in the Artemis Accords.

"Artemis" indicates both a programme to explore the moon – the Artemis Program – and a political initiative on space law from the US – the Artemis Accords – i.e. the Principles for Cooperation in the Civil Exploration and Use of the Moon, Mars, Comets, and Asteroids for Peaceful Purposes. The latter are a series of unilateral statements signed by the US and the national space agencies of 23 countries that constitute "a political commitment to the principles described herein, many of which provide for operational implementation of important obligations contained in the Outer Space Treaty and other instruments".[26]

These accords reaffirm and reinforce the principles already included in the United Nations space treaties, and recognise the benefits of coordination through multilateral forums – including COPUOS. The principles also call on states to contribute to the development of shared international practices and rules at the level of efforts around the Artemis Accords, addressing the preservation of outer space, the extraction and utilisation of space resources and the definition and determination of safety zones and harmful interference.[27]

This policy and legal instrument is the result of a US position on space policy and law at the time they were promoted, as evidenced by the Executive Order on Encouraging International Support for the Recovery and Use of Space Resources, indicating the United States' non-intention to make the MA an international customary practice.[28]

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26 *The Artemis Accords*, cit., Section 1.

27 Ibid.

28 In fact, the document reads: "Outer space is a legally and physically unique domain of human activity, and the United States does not view it as a global commons. […] The Secretary of State shall object to any attempt by any other state or international organization to treat the Moon Agreement as reflecting or otherwise expressing customary international law". White House, *Executive Order on Encouraging International Support for the Recovery and Use of Space Resources*, 6 April 2020, https://trumpwhitehouse.archives.gov/presidential-actions/executive-order-encouraging-international-

In this sense, the accords represent a clear political choice to develop international law on the moon through specific partnerships structured around the Artemis Accords, and a clear indication that the United States, which is not a signatory to the MA, does not want the 1979 agreement to become binding customary international law.

Among the countries that ratified the Outer Space Treaty but did not enter the MA[29] or sign the Artemis Accords are China and Russia, the former not being allowed to collaborate with NASA on dual-use space applications, including space travel, following the 2011 Wolf Amendment.

Both countries have criticised the accords in relation to their conceptualisation of safety zones (China) and for their US-centric approach (Russia).

In parallel, they started collaborating in the field of space exploration and moon missions through a series of agreements, including a Memorandum of Understanding Regarding Cooperation for the Construction of the International Lunar Research Station signed in 2021 and supported by a similar set of principles agreed by the two space powers.[30]

Russia–China cooperation reiterated the fact that leadership in space remains contested,[31] offering an alternative in space exploration to the US-led initiative and testing the legitimacy of the Artemis Accords in relation to the interpretation of international space law.[32]

However, both initiatives are structured on the basis of bilateralism in the lunar regime and underline the risk inherent in undermining the consensus-based,

support-recovery-use-space-resources.

29 For the status of the Moon Agreement, see the United Nations Treaty Collection: https://treaties.un.org/Pages/ViewDetails.aspx?src=IND&mtdsg_no=XXIV-2&chapter=24&clang=_en.

30 China National Space Administration, *China and Russia Sign a Memorandum of Understanding Regarding Cooperation for the Construction of the International Lunar Research Station*, 9 March 2021, http://www.cnsa.gov.cn/english/n6465652/n6465653/c6811380/content.html.

31 See Namrata Goswami, "The Strategic Implications of the China-Russia Lunar Base Cooperation Agreement", in *The Diplomat*, 19 March 2021, https://thediplomat.com/2021/03/the-strategic-implications-of-the-china-russia-lunar-base-cooperation-agreement.

32 In this regard Saudi Arabia, which withdrew from the Moon Agreement in January 2023, and Turkey already showed interest in joining this Sino-Russian cooperative framework.

UN-centred multilateralism within COPUOS. At the same time, they disregard the intention of the MA to introduce certain concepts into space law such as that of the "common heritage of mankind" in relation to the moon and its natural resources, as well as jeopardising the proper application of the principle of non-appropriation outlined in the OST.

Ultimately, the real test will come when the principles of the Artemis Accords are put into practice and the Russian–China cooperation initiative is implemented.

In fact, while establishing common practices in relation to the descent to the moon, operations on the lunar surface and the creation of lunar bases or safety zones,[33] it will be the states that signed various agreements and, at the same time, must abide by the principle of non-appropriation enshrined in the OST and, eventually, in the MA who will constantly have to determine whether their implementation of the different agreements complies with their obligations in international space law.

4. The codification of the "rules of the road": STM and responsible behaviours in orbit

The increased diffusion of space technology and market opening have also resulted in increased congestion in space orbits. While this development has certainly resulted in a democratisation of access to space and a greater diversity of services and products, the urgency of some "rules of the road" has emerged and, with them, the need to establish and/or coordinate existing international practices to manage space traffic.

Although space traffic management (STM) has become a political priority at the international level, there is currently no consensus on a clear and internationally agreed definition of STM. Nevertheless, several definitions have

33 *The Artemis Accords*, cit., Section 11, para 7.

been proposed since 2006 by national,[34] regional[35] and international actors,[36] as well as academics and experts, fuelling the debate on the need to establish an international approach to the issue.

STM is based on several sub-components, whereby each component is to some extent already regulated by existing hard or soft law instruments and frameworks that directly or indirectly affect space traffic. Yet, current best practices appear to be slow or ineffective in addressing the various components, and data sharing (space situational awareness, SSA), the real backbone of STM, is still unilaterally regulated.[37]

The OST, for its part, does not seem to help determine a rigid obligation to share data, although a rudimentary framework can be sought in Articles III, IX, X and XI of the treaty.

From a combined reading of Articles III and IX, states are required to respect international law when conducting activities in space, cooperating and not interfering with one another, and to conduct such activities with due regard to the corresponding interests of other treaty parties. Article X then establishes a specific, albeit very weak, right of access to information, while Article XI links cooperation with information on the nature, conduct and location of space activities.[38] In this sense, without focusing explicitly on SSA, the treaty establishes a set of technology-neutral principles based on cooperation between states and mild information-sharing obligations, but mostly based on best efforts.[39]

34 White House, *Space Policy Directive-3, National Space Traffic Management Policy*, 18 June 2018, https://trumpwhitehouse.archives.gov/presidential-actions/space-policy-directive-3-national-space-traffic-management-policy.

35 European Commission, *An EU Approach for Space Traffic Management. An EU Contribution Addressing a Global Challenge* (JOIN/2022/4), 15 February 2022, https://eur-lex.europa.eu/legal-content/en/TXT/?uri=celex:52022JC0004.

36 Kai-Uwe Schrogl et al. (eds), *Space Traffic Management. Towards a Roadmap for Implementation*, Paris, International Academy of Astronautics, 2018.

37 Giulia Pavesi, "Reconciling SSA Data Sharing Legal Practices through a Comparative Approach", in P.J. Blount et al. (eds), *Proceedings of the International Institute of Space Law 2021*, Eleven International Publishing, 2021, p. 201-217 at p. 202.

38 Ibid.

39 P.J. Blount, "Space Traffic Coordination: Developing a Framework for Safety and Security in Satellite Operations", in *Space: Science & Technology*, Vol. 2021, Article 9830379, p. 4, https://doi.org/10.34133/2021/9830379.

When looking at other instruments of space law and seeking more stringent information-sharing obligations in Articles II, III and IV of the Registration Convention (RC), this gap is not filled.

The RC provides for a registration system based on an open data registry managed by the United Nations Office for Outer Space Affairs (UNOOSA) but, again, practice has shown that there are shortcomings in the implementation of the convention in terms of delays or general deficiency in the registration and notification system on the status of the object.[40]

Another component of STM is orbital debris mitigation and remediation. Once again, while through interpretive work some provisions preventing space pollution *per se* can be found in Articles I and IX of the OST, their practical applicability is not borne out.[41]

For this reason, space debris mitigation has been mostly based on non-binding and voluntary technical instruments, such as the Inter-Agency Space Debris Coordination Committee (IADC) and UN Space Debris Mitigation Guidelines, implemented by well-established national and international space organisations and meant to limit the creation of new debris and the number of objects with which the current and future space objects' population will need to interact. However, here too the system is flawed – especially in relation to registration and SSA sharing practices.[42]

The same is true for another set of non-binding, voluntary technical guidelines, the United Nations COPUOS Voluntary Guidelines for the Long-Term Sustainability of Outer Space Activities. Here, despite openness to the integration of commercial data, the use of nations' liability waivers could jeopardise the liability system linked to potential inaccuracy of such data.[43]

40 Ibid.
41 Giulia Pavesi, "Legal Consequences of Environmental Pollution in Outer Space", in Annette Froehlich (ed.), *A Fresh View on the Outer Space Treaty*, Cham, Springer, 2019, p. 15-30.
42 P.J. Blount, "Space Traffic Coordination", cit., p. 4.
43 Giulia Pavesi, "Reconciling SSA Data Sharing Legal Practices through a Comparative Approach", cit., p. 216.

Finally, a sort of STM system limited to geostationary orbit is available in the International Telecommunication Union regime, which manages the allocation of international frequency through a notice-and-registration system, whereby the ITU ensures coordination by setting procedures for information sharing. However, once again, this is limited to a selected orbit and not necessarily adaptive to the features of LEO.[44]

Ultimately, STM to date has been coordinated to a great extent at the regulatory or technical stage at domestic, supranational or international levels, but a holistic approach to the overall management of space traffic is still lacking – together with a comprehensive set of rules of the road and clear legal obligations in this respect.

4.1 From regional to international management: A multi-step approach to STM design

In terms of the scale of such an approach, it is clear that any model of STM must be treated as a global governance mechanism and therefore requires to be addressed at the international level.

This consideration is even more compelling when one considers that the very operational core of STM is based on SSA – which, in turn, depends on the geographical distribution of sensors and thus necessarily requires a global approach and cooperation also at the operational level.[45]

Based on current developments, on a mostly domestic (as in the case of the US) or regional (as in the case of the EU) basis, it is likely that such STM mechanisms will develop through a bottom-up approach. In that case, the challenge will be to create interoperability among systems at the technical level, standardise data distribution and integrate commercial data with state-based sources.

A multi-step approach also shows the way in which national and regional/ supranational conceptualisations could create divergent approaches in

44 P.J. Blount, "Space Traffic Coordination", cit., p. 5.
45 Ibid., p. 6.

national space law requirements for the authorisation of space activities or, in the case of a lack of national legislation, different national requirements for space missions dictated by national space agencies.

Therefore, since, in the area of space safety and sustainability, cooperation is especially efficient at the technical level, it is suggested that an international approach based on framing such management (or coordination) as a technical rather than a political issue (or a mixture of the two) would also be beneficial in reaching a common definition of an STM regime – or, at least, space traffic coordination, regardless of the international forum in which such a dialogue will take place.[46]

To summarise, rules of the road should be established in terms of increased information-sharing and notification mechanisms, enhanced international cooperation, standardisation at the operational level, the development of right-of-way rules, increased transparency between states and the development of uniform practices for space debris management.

This also seems to be the path suggested by the work of the UN COPUOS Legal Sub-Committee, in which STM has become an agenda item since 2015 and delegations have noted the importance of a programmatic approach to it. This is based on the gradual adoption of guidelines or standards and exchange mechanisms at the international level, without necessarily developing them immediately into binding regulations, as well as the need to possibly consider joint treatment of the topic by both the Legal and the Scientific and Technical Sub-Committees.

5. Responsible behaviour in outer space

With increased dependence on outer space, the need to preserve access to this domain has become a national security priority for states.

46 Ibid., p. 6-8.

Since 2010, more powers have moved towards a "securitarian" approach to space exploration and cooperation, developing an internal reorganisation of their space policies and administrations. They include the United States, France, Germany, the United Kingdom, Italy, India, China, Russia, NATO and the European Union.[47]

This has resulted in the formalisation of military space structures within national Ministries of Defence; the adoption of dedicated (defensive) space strategies; and, in some cases, the development of defensive counterspace capabilities and the testing of anti-satellite weapons.[48]

The development of such capabilities has involved not only "traditional" kinetic anti-satellite capabilities (kinetic ASATs)[49] but also non-kinetic ones.[50]

Another source of complexity in the current picture is the fact that space technologies are by nature dual use, an issue further complicated by the increasing involvement of commercial operators in military operations.

From a legal perspective, the *corpus juris spatialis*, and the OST in particular, does not seem to provide much help in dealing with space instability. Certainly, the OST can be rightly understood as one of the most effective disarmament treaties.[51] It imposes important limits on the weaponisation and militarisation of space, prohibiting the placement and stationing in orbit of any nuclear weapon or any other type of weapon of mass destruction (WMD) carrier in Article IV – albeit not their transit – and mandates the total demilitarisation of certain areas of outer space.

47 Giulia Pavesi, "NATO versus Non-kinetic Threats: Implications and Opportunities", in *CIGI Cybersecurity and Outer Space series*, 29 January 2023, https://www.cigionline.org/articles/nato-versus-non-kinetic-threats-implications-and-opportunities.

48 Alessandro Marrone and Michele Nones (eds), "The Expanding Nexus between Space and Defence", in *Documenti IAI*, No. 22|01 (February 2022), https://www.iai.it/en/node/14669.

49 The most recent such tests, in chronological order, are those conducted by India in 2019 and Russia in 2021.

50 The most recent, in chronological order, have been against the Viasat company's KA-SAT network in February 2022 and against the SpaceX company's Starlink internet communication systems in May 2022.

51 James Clay Moltz, *The Politics of Space Security. Strategic Restraint and the Pursuit of National Interests*, 3rd ed., Stanford, Stanford University Press, 2019, p. 17.

However, the treaty prevents neither the phenomenon of direct testing of kinetic ASATs or conventional weapons in the atmosphere nor the ambiguity brought about by the potential use of non-kinetic means – allowing states to exploit this vacuum to the detriment of space stability, including with regard to commercial activities. In fact, companies often experience jamming or spoofing against their satellites, but may sometimes be reluctant to immediately disclose or denounce such interference because of the potential impact on their market reputation.

Article III of the OST requires that the activities of states in space must be conducted in accordance with the norms of international law, including the United Nations Charter. Therefore, norms on the threat or use of force also apply in space, but again it is difficult to determine when force is used in space and even more difficult to determine when the threshold of an armed attack is reached – especially in the light of non-kinetic operations.

In this sense, UN diplomacy and multilateralism have also had mixed results. Discussion on preventing an arms race in space (PAROS) has been on the agenda of the Conference on Disarmament[52] in various capacities since the late 1970s[53] and transposed into a series of UN resolutions since the early 1980s,[54] now adopted on an annual basis. These instruments constitute policy statements and more or less authoritative interpretations of certain treaty provisions, but they do not prevent or restrict the operations mentioned above.

Since 2008, Russia and China have inked a draft treaty to ban weapons in outer space, the PPWT,[55] and several UN resolutions have been promoted, including one on the Non-first placement of weapons in outer space,[56] together with draft resolutions on "Transparency and confidence-building measures in outer

52 The Nuclear Threat Initiative (NTI) website: *PAROS Treaty*, https://www.nti.org/?p=24591.

53 UN General Assembly, *Resolution and Decisions adopted by the General Assembly during its Tenth Special Session, 23 May-30 June 1978*, New York, United Nations, https://undocs.org/A/S-10/4.

54 UN General Assembly, *Resolution 36/97: Prevention of an Arms Race in Outer Space* (A/RES/36/97), 9 December 1981, https://digitallibrary.un.org/record/610780.

55 Russia and China, *Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects (Draft)*, 16 June 2014, https://www.fmprc.gov.cn/mfa_eng/wjb_663304/zzjg_663340/jks_665232/kjfywj_665252/201406/t20140616_599726.html.

56 UN General Assembly, *Resolution 70/27: No First Placement of Weapons in Outer Space* (A/RES/70/27), 11 December 2015, https://digitallibrary.un.org/record/814872.

space activities"[57] and on "Further practical measures for the prevention of an arms race".[58] However, once again, the lack of verification mechanisms or gaps in the definition of the concept of "space weapons", or even limitations on the use of ground-based ASATs have hindered the success of international negotiations.

Moreover, without the leverage of the typical nuclear security dynamics that characterised most negotiations during the Cold War era, states are no longer willing to approach cooperation in these areas or space security management through hard law instruments.[59]

The latest example of this trend comes, specifically, from the failure of the Group of Governmental Experts (GGE) on PAROS.[60] Here, although in 2017 the UN General Assembly established a GGE to discuss and make recommendations for a legally binding instrument on PAROS and the placement of weapons in space (in a similar fashion to the successful 2013 GGE on transparency and confidence-building measures, or TCBMs),[61] the group failed to reach consensus on a substantive report.[62]

In the current international environment, states are no longer ready and willing to regulate their interactions in space security through binding instruments such as treaties, which are perceived as rigid and limiting to the exercise of the freedoms of exploration and use of outer space enshrined in Article I of the 1967 treaty.[63]

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57 Armenia et al., *Draft Resolution: Transparency and Confidence-building Measures in Outer Space Activities* (A/C.1/77/L.71/Rev.1), 24 October 2022, https://digitallibrary.un.org/record/3992092.

58 Algeria et al., *Draft Resolution: Further Practical Measures for the Prevention of an Arms Race* (A/C.1/77/L.70), 13 October 2022, https://digitallibrary.un.org/record/3991730.

59 Setsuko Aoki, "The Function of 'Soft Law' in the Development of International Space Law", in Irmgard Marboe (ed.), *Soft Law in Outer Space. The Function of Non-binding Norms in International Space Law*, Wien, Böhlau, 2012, p. 57-86.

60 Group of Governmental Exerts on further effective measures for the prevention of an arms race in outer space, https://www.un.org/disarmament/topics/outerspace/paros-gge.

61 UN Secretary General, *Group of Governmental Experts on Transparency and Confidence-Building Measures in Outer Space Activities* (A/68/189), 29 July 2013, https://digitallibrary.un.org/record/755155.

62 Although some countries, led by Russia and China, advocated for the re-establishment of a GGE on PAROS following the end of the Open-Ended Working Group (OEWG) on Space. See: Algeria et al., *Draft Resolution: Further Practical Measures for the Prevention of an Arms Race*, cit.

63 Marco Ferrazzani, "Soft Law in Space Activities – An Updated View", in Irmgard Marboe (ed.), *Soft Law in Outer Space. The Function of Non-binding Norms in International Space Law*, Wien, Böhlau, 2012, p. 99-118.

Rather, states have begun to adopt a more flexible and evolutionary approach, focusing not on the prohibition of the technology itself but instead on the responsible or irresponsible nature of the behaviour. The idea is that by focusing not on the nature of the space object but the behaviour of an actor in space, some obstacles typical of securitisation processes initiated in past decades could be more easily overcome.

5.1 From a technology ban to responsible behaviour in outer space

The first initiative in this regard was the International Code of Conduct, initially launched as the EU's reaction to a "call to arms" launched by the UN General Assembly between 2006[64] and 2007.[65] This was shaped around open consultations involving 95 UN member states in various rounds of consultations from 2008 to 2015.[66]

Although this instrument was a solid tool to increase TCBMs in space and sketched some rules for responsible behaviour in space, the proposal stalled in 2015 and was perceived as not inclusive from the start, non-legally binding and not impacting on space debris mitigation and remediation – as well as being controversial in some aspects referring to self-defence in outer space.[67]

The Union did not give up and in 2019 launched the 3SOS approach, a public diplomacy initiative promoting "ethical conduct" in space. It involved discussions with stakeholders beyond traditional state-based actors such as industry, space agencies and think tanks in order to build a common

64 UN General Assembly, *Resolution 61/75: Transparency and Confidence-building Measures in Outer Space Activities* (A/RES/61/75), 18 December 2006, https://digitallibrary.un.org/record/588287.

65 UN General Assembly, *Resolution 62/43: Transparency and Confidence-building Measures in Outer Space Activities* (A/RES/62/43), 8 January 2008, https://digitallibrary.un.org/record/613138.

66 *International Code of Conduct for Outer Space Activities. Draft*, 31 March 2014, https://eeas.europa.eu/archives/docs/non-proliferation-and-disarmament/pdf/space_code_conduct_draft_vers_31-march-2014_en.pdf.

67 Jana Robinson, "Europe's Space Diplomacy Initiative: The International Code of Conduct", in Ajey Lele (ed.), *Decoding the International Code of Conduct for Outer Space Activities*, New Delhi, Pentagon Security International, 2012, p. 27-29 at p. 27, https://idsa.in/node/10440.

understanding of the issue and develop potential solutions to address safety, security and sustainability in space.[68]

Responsible behaviour was also addressed at the unilateral level with the politically binding voluntary commitment first made in April 2021 by the United States[69] regarding the self-imposed ban on testing destructive direct-ascent anti-satellite missiles. The US was followed by Australia; Canada; Germany; Japan; New Zealand; South Korea; Switzerland; the United Kingdom; and, more recently, by France – although operations based on the use of non-kinetic means were not included within the purview of the ban.

Later, in September 2022, this unilateral initiative was translated into a multilateral effort: the US proposed a UN General Assembly Resolution on the same topic, which was approved by a large majority in December 2022,[70] and a nearly identical draft resolution on "Destructive direct-ascent anti-satellite-missile testing" was presented within the UN First Committee,[71] supporting the establishment of this commitment as an international norm in space.

Finally, at the multilateral level, among the most interesting and promising initiatives is the Open-Ended Working Group (OEWG) on Reducing Space Threats through Norms, Rules and Principles of Responsible Behaviour. This was convened by General Assembly Resolution 76/231,[72] following the General Assembly's request to the Secretary-General (Resolution 75/36) to gather the views of member states on the further development and implementation of norms, rules and principles of responsible behaviour and on reducing the risks of misunderstanding and miscalculation in relation to outer space.[73]

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68 European External Action Service (EEAS), *SOS SOS SOS: EU Calls for Ethical Conduct in Space to Avoid Collision and Orbital Debris*, 19 September 2019, https://www.eeas.europa.eu/node/67538_en.

69 Theresa Hitchens, "US Pushes ASAT Missile Ban as UN Norms Group Reconvenes", in *Breaking Defense*, 9 September 2022, https://breakingdefense.com/?p=242899.

70 A total of 155 nations voted in favour; 9 against, including Russia and China; and 9 abstained, including India.

71 A total of 154 in favour, 8 against and 10 abstaining. UN General Assembly, *Resolution 77/41: Destructive Direct-Ascent Anti-Satellite Missile Testing* (A/RES/77/41), 7 December 2022, https://digitallibrary.un.org/record/3996915; Brazil et al., *Draft Resolution: Destructive Direct-Ascent Anti-Satellite Missile Testing* (A/C.1/77/L.62), 13 October 2022, https://digitallibrary.un.org/record/3991887.

72 UN General Assembly, *Resolution 76/231: Reducing Space Threats through Norms, Rules and Principles of Responsible Behaviours* (A/RES/76/231), 30 December 2021, https://digitallibrary.un.org/record/3952870.

73 UN General Assembly, *Resolution 75/36: Reducing Space Threats through Norms, Rules and Principles of*

Although the findings of the OEWG will not be legally binding, the very purpose of the group[74] is to create a shared understanding of responsible and irresponsible behaviour in space and to build consensus around rules and principles in this regard.

To this end, and similarly to the EU with its 3SOS initiative, the discussion, which will be concluded in the autumn of 2023, will not only be based on the positions of state delegates but will also have an open composition. This means that in addition to UN member states and international organisations (participating as permanent observers), the group will also be open to input from civil society – specifically gathering the expertise of various stakeholders including experts and those from academia.[75]

The work of the OEWG could also be used as a bridge between hard and soft law processes in future discussions on space security matters. Particularly, soft and hard law processes should not be seen as mutually exclusive legal instruments but rather as complementary and mutually reinforcing ones. This is evident from the fact that while many states have proven reluctant to engage in hard law processes related to space security, a number of them have also begun to see legally binding instruments as the ultimate goal of international diplomacy. This development has promoted the establishment of a new group of government experts advancing the PAROS process and legally binding instruments, which will also be fuelled by the work performed within the OEWG.

Finally, two other initiatives creating an authoritative interpretation of what constitutes responsible behaviour in outer space are the Woomera[76] and the MILAMOS[77] projects. These comprise manuals led by independent groups of legal experts, civil servants and technicians meant to identify existing rules in

Responsible Behaviours (A/RES/75/36), 16 December 2020, https://digitallibrary.un.org/record/3895440.

74 Similarly to that already existing in the context of cyber security but also to the above-mentioned 2013 successful GGE Report on TCBMs in space.

75 The group is expected to deliver its report in the autumn of 2023.

76 University of Adelaide website: *The Woomera Manual*, https://law.adelaide.edu.au/woomera.

77 Ram S. Jakhu and Steven Freeland (eds), *The McGill Manual on International Law Applicable to Military Uses of Outer Space, Vol. I: Rules*, Montreal, McGill University, 2022, https://www.mcgill.ca/milamos.

the *corpus juris spatialis* and instruments of international law with regard to military conduct in space, in wartime (Woomera) and in peacetime (MILAMOS).

Concluding remarks

This contribution has shown that complexity in space has grown significantly. The entry of new actors, new dynamics in space exploration and utilisation, and the rethinking of traditional security dynamics in this domain are challenging the existing regulatory framework and exposing vulnerabilities in the system.

The "sky" is no longer "the limit" – and human evolution in space, along with technological development, will not stop.

The "club" of space countries has grown, and with it the need for some emerging space countries to challenge traditional space law systems. These were developed by a handful of states in a bipolar dynamic and are not necessarily responsive to the needs and interests of newcomers.

Interests in space have also expanded, no longer limited to those of state actors but extending also to those of private actors – sometimes with transnational identities, and interests that do not necessarily coincide with those of their authorising states.

The use of national space legislation to address these developments has also developed in complex ways.

This contribution has shown, first, that although national approaches to the use of space resources do not necessarily violate the principle of non-appropriation guaranteed by the OST, the time is not yet ripe to opt for an international framework on the subject.

Second, the lack of a holistic and international definition of STM or coordination certainly hinders the safety and sustainability of space activities. However, there are soft and hard law instruments in the space law system on which the international community has already built consensus. The challenge will be to condense these provisions to a shared set of technical and uniformly enforceable "rules of the road", once a common understanding is built internationally – albeit for now based on regional and national contributions.

Third, space activities and evolving trends in their commercialisation must take into account the growing instability of this sector, in which principles of responsible behaviour have yet to be agreed upon by the international community.

Finally, it should be noted that while an international approach remains the preferred avenue to address space governance, practice shows that national legislation is increasingly addressing international issues. National legislation plays a crucial role by translating and integrating international obligations for private operators and by relieving the state of its control and supervision obligations under Article VI of the OST. Nonetheless, in discharging themselves of their international obligations, states still maintain freedom for manoeuvre.

National legislation establishes the licensing conditions and procedures for conducting activities in outer space and, as space activities become more complex, national legislation should be expected to become more sophisticated.

However, it should be remembered that the law also functions as an economic policy tool, whereby national space legislation is usually tailored to the national state of the space industry and the market size/capacity of non-governmental commercial activities or used as a tool to attract investors or to specialise in specific areas of space exploration and use.[78]

New models to approaching space exploration and use could result in a revision of existing space policies and (legal) strategies to better attract investment or respond to the needs of this new market.

While until now national space laws have tended to be fairly similar in terms of registration, authorisation and liability, with the rise of spacefaring emerging

78 Peter Malanczuk, "Investment Protection of Commercial Activities in Space: Treaties, Contracts, Licenses, Insurances, Arbitration", in *Journal of World Investment & Trade*, Vol. 19, No. 5-6 (October 2018), p. 951-1000 at p. 960, DOI 10.1163/22119000-12340116.

countries this could change. Legal complexity is also expected to increase due to the globalisation of the industry and the industrial flexibility that companies can now enjoy.

Instead of being driven by the protection of national interests in creating national regulatory frameworks, national legislators could take other factors into account – pursuing investment stimulation and growth, innovation, job creation, etc. In this way, ultimately different interests could in the future result in different legislative approaches, creating a risk of forum shopping[79] or the distortion of competition.

To this end, the international dynamics that have hitherto characterised space governance must adapt to the new challenges brought about by the enlargement of the actors and the population of space systems that tends to increasingly falter, while ensuring consistency at the international level if sustainability, safety and security in space are to be achieved.

79 Ibid., p. 969.

Abbreviations

AI	Artificial intelligence
ASAT	Anti-satellite weapon
BEA	US Bureau of Economic Analysis
CAGR	Compound Annual Growth Rate
CSA	Canadian Space Agency
COPUOS	United Nations Committee on the Peaceful Uses of Outer Space
DA-ASAT	Direct-ascent anti-satellite weapon
ESA	European Space Agency
ESPI	European Space Policy Institute
EU	European Union
EUSPA	European Union Agency for the Space Programme
GDP	Gross domestic product
GEO	Geostationary orbit
GGE	Group of Governmental Experts
GMES	Global Monitoring for Environment and Security
GNSS	Global Navigation Satellite System
IADC	Inter-Agency Space Debris Coordination Committee
IDA	Institute for Defense Analyses
IoT	Internet of Things
ISS	International Space Station
ITU	International Telecommunication Union
JAXA	Japan Aerospace Exploration Agency
JRC	Joint Research Centre
LEO	Low Earth Orbit
MA	Moon Agreement
MEO	Medium Earth Orbit
MILAMOS	Manual on International Law Applicable to Military Uses of Outer Space
NASA	US National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization

OECD	Organisation for Economic Cooperation and Development
OEWG	Open-Ended Working Group
OST	Outer Space Treaty
PAROS	Prevention of an Arms Race in Outer Space
PNT	Positioning, navigation and timing
PPWT	Prevention of the Placement of Weapons in Outer Space, and the Threat or Use of Force in Outer Space
R&D	Research and development
RC	Registration Convention
SESA	Space Economy Satellite Account
SIA	Satellite Industry Association
SSA	Space situational awareness
STPI	Space Technology Policy Institute
STM	Space traffic management
TAM	Total addressable market
TCBM	Transparency and Confidence-Building Measure
UBS	Union Bank of Switzerland
UK	United Kingdom
UN	Unite Nations
UNOOSA	United Nations Office for Outer Space Affairs
US	United States
VR	Virtual reality
WMD	Weapon of mass destruction

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The Geopolitics of Space

IAI, in collaboration with Intesa Sanpaolo, organised a series of three workshops titled "The Geo-Finance of Space" with the goal of investigating how the space race is impacting geopolitics, the world economy and the international legal regime. In a multipolar world, the international dynamics of "great power competition" on Earth has far-reaching reverberations in outer space. As space has become an integral part of the civil and military infrastructure, the need to protect the space domain and the assets within it has come to the fore. There has also been a marked trend towards commercialisation of the space realm. Companies have ventured into a domain previously only accessible to powerful states. This has contributed to making outer space increasingly competitive and congested. A series of technological innovations coupled with the emergence of "New Space" have enabled space companies to explore new markets and business models. Furthermore, the development of the Internet of Things (IoT) and the growth of non-terrestrial networks – notably, in Low-Earth Orbit – is expected to drive the growth in demand for space-based data in the years to come. To frame the legal regime for the management of space beyond the aerial zone, several treaties, pacts, secondary legislation, and soft laws have been developed. Despite those efforts, important grey areas of space regulation exist. In the next future, global actors are likely to increasingly compete over key aspects of space regulation, such as utilisation and appropriation of resources in space and the codification of rules of the road and responsible behaviour in orbit.

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