REPORT — SUMMER 2022

Running out of space

European security in space

friends of europe

European Ariane 5 rocket launches NASA's James Webb Space Telescope

This report is part of Friends of Europe's Peace, Security and Defence programme. Written by Paul Taylor, it brings together the views of scholars, policymakers and senior defence and security stakeholders.

Unless otherwise indicated, this report reflects the writer's understanding of the views expressed by the interviewees and participants of survey. The author and the participants contributed in their personal capacities, and their views do not necessarily reflect those of the institutions they represent, or of Friends of Europe and its board of trustees, members or partners. Reproduction in whole or in part is permitted, provided that full credit is given to Friends of Europe and that any such reproduction, whether in whole or in part, is not sold unless incorporated in other works.

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Author: Paul Taylor
Publication Director: Dharmendra Kanani
Programme Manager: Elena Saenz-Feehan
Programme Executive: Alejandro Esteso
Programme Officer: Rayan Vugdalic
Editors: Anna Muizniece, Seán Flynn and Clotilde Besson
Design: Lucien Leyh and Matjaž Krmelj

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List of abbreviations

3SAS:	Strategic Space Situational Awareness System
AI:	artificial intelligence
ASAT:	direct-ascent anti-satellite rockets
ASD:	AeroSpace and Defence Industries Association
AWACS:	Airborne Warning and Control System
CD:	UN Committee on Disarmament
COPUOS:	UN Committee on the Peaceful Uses of Outer Space
DARPA:	US Defense Advanced Research Projects Agency
DG DEFIS:	Directorate-General for Defence Industry and Space
EGNOS:	European Geostationary Navigation Overlay Service
ESA:	European Space Agency
EUMETSAT:	European meteorological satellite
EUSPA:	EU Space Programme
FRS:	Foundation for Strategic Research
GDPR:	General Data Protection Regulation
GEO:	geosynchronous earth orbit
GovSatCom:	Governmental Satellite Communication
GSP:	Global Positioning System
IPCC:	UN Intergovernmental Panel on Climate Change
ISS:	International Space Station
ITU:	International Telecommunications Union
JEDI:	Joint European Disruptive Initiative
LEO:	low earth orbit
MAD:	Mutual Assured Destruction
NASA:	National Aeronautics and Space Administration
NATO:	North Atlantic Treaty Organization
PESCO:	Permanent Structured Cooperation
PLASSF:	People's Liberation Army Strategic Support Force
R&D:	research and development
SSA:	space situational awareness
SSR:	Space Sustainability Rating
STM:	space traffic management
UAE:	United Arab Emirates
WEF:	World Economic Forum

Methodology and acknowledgments

Paul Taylor
Senior Fellow at
Friends of Europe

This is the tenth in a series of reports I have written for Friends of Europe on European defence issues. It follows country studies on France and Germany in 2017, the United Kingdom and Poland in 2018, Italy and Mediterranean security in 2019, as well as reports on transatlantic defence cooperation in the Trump era, the Arctic and European security in 2020, Europe and the Sahel in 2021, and the Black Sea and European security in 2022.

My research spanned the period of Russia's invasion of Ukraine, which has upended European security and international relations, and in which both sides sought to use space for military advantage.

The tail-end of the COVID-19 pandemic limited my travel, but I was able to interview 40 current and former officials in governments, space agencies, international organisations, the military, parliaments, diplomacy, the commercial space sector, universities, think tanks and civil society in Europe, the United States and Asia. The interviews were conducted between February and April 2022.

Many of the serving officials, soldiers and diplomats whom I interviewed were able to talk only on condition they were not identified, due to the nature of their positions. Others, notably the Director General of the European Space Agency, Josef Aschbacher, and Steven Freeland, Co-Chair of the UN Committee on the Peaceful Uses of Outer Space (COPUOS) Working Group on Space Resources, agreed to on-the-record interviews, for which I am most grateful.

In addition to the many interlocutors named in the report, I would like to thank the following for their kind assistance and insights: Jerome Barbier, Justin Vaisse, Jerome Bequignon, Eleni Paliouras, Olivier Lemaitre, Laura Grego, Juliana Suess, Jean-Jacques Tortora, Paul Weissenberg, Sergei Gugkaev, Anna Rathsman, Guillem Anglada-Escudé, Senator Helene Conway-Mouret, James Bergeron, Florent Mazurelle, Karine Claeys, Masami Onoda, Saki Hirami, Christoph Kautz, Angus Lapsley, Alessandro

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In addition to my own research, I derived great benefit from the Space Café podcast series hosted by Markus Mooslechner of spacewatch.global, the War in Space podcast series hosted by Juliana Suess of the Royal United Services Institute and the encyclopaedic online coverage of two US-based websites, SpaceNews and space.com.

At Friends of Europe, I am grateful to Dharmendra Kanani for his support, encouragement and deep interest in space matters, and to Elena Saenz Feehan, Alejandro Esteso and Rayan Vugdalic in the Peace, Security and Defence programme for their tireless, cheerful assistance, efficiency and constructive ideas.

Alejandro Esteso and Rayan Vugdalic wrote the analysis of major countries' and international organisations' space strategies annexed to this report.

I am especially grateful to my fellow senior fellows, Jamie Shea and Chris Kremidas-Courtney, and to Elizabeth Wiltshire of Friends of Europe's Space programme for agreeing to read the first draft of my study and offering incisive comments and suggestions. Needless to say, the views expressed here, and any errors, are entirely mine.

My wife Catherine has supported me lovingly through ten reports, putting up with my all-too-frequent "I've got to run to a Zoom interview" excuses, and tolerating my midnight writing sessions in the panicky deadline week. I couldn't have done this without her.

Foreword

Jamie Shea
Senior Fellow at
Friends of Europe

Over the past three years, Paul Taylor, Senior Fellow for Peace, Security and Defence at Friends of Europe, has explored many new frontiers of Europe's security: from the Arctic to the Sahel and to the Eastern Mediterranean. His many reports for Friends of Europe have given readers a comprehensive and well-researched overview of the nexus of geography and politics in all the regions of vital strategic interest to Europe, either within the European Union itself or on its periphery.

In recent times, **a non-geographical and extra-terrestrial frontier has become as important to that security as the more traditional domains on land, at sea and in the air that Paul has explored hitherto.** It is the domain of space and its rapidly growing significance for global geopolitics as the world's major powers compete for control, influence and even resources in both lower and upper orbits of the atmosphere, while reaching out to the planets beyond. Whoever controls space in the 21st century will also control much of what happens on earth as well.

Space is seen as ungoverned territory. Some have even called it the 'Wild West' in that few internationally agreed norms govern space activity, and those that do exist are barely enforceable. As more states launch satellites and as the private sector and 'New Space' companies overtake governments in the number of satellites launched, space has become ever more contested and congested. This lack of space governance increases the risk of incidents and friction. Norms, rules and standards have always been the hallmark of the EU.

One issue that Paul rightly focuses on in his report is the extent to which the EU can lead in this area and its ability to carry the United States and the other Western democracies along with it.

Getting other space powers, such as Russia, China, India, Brazil or the United Arab Emirates (UAE), on board for at least a minimal code of conduct will test the EU's global diplomacy even further.

Moreover, space has become ever more important for vital economic and societal activities, such as navigation, meteorological forecasting, banking transactions, climate monitoring and even our daily Zoom calls via the internet. Europe's ability to stay in the game and preserve its vital economic and commercial interests by developing its own capabilities and expertise has risen to the top of the EU agenda. **Space has become a priority component of the EU's quest for strategic autonomy.** The EU's leadership is proposing a European secure connectivity constellation and a dedicated space situational awareness and tracking system as part of the EU Commission's new Space Package. These capabilities would build on the European satellite programmes, such as Galileo and Copernicus, or the collaborative space ventures of the European Space Agency, that have already proved successful.

Are these ambitious and costly projects really needed? Do they represent the best value for money compared to investing in other technologies and projects? Does the EU need to go it alone when it can rely on allies like the US or share the costs and burdens alongside other like-minded partners, such as Japan? What should be the balance between government and private sector investments in promoting space innovation? What can the EU do to create a more open and competitive internal market in space, allowing start-ups and New Space innovators to thrive alongside the larger, established companies, such as Thales or Arianespace?

If the EU is to keep up with its major space competitors, these key questions need answers, and this is exactly what Paul provides the reader in this report.

Finally, as space becomes more important for our economic growth, ability to communicate and capacity to exploit new resources, as those on our planet become more and more depleted, this domain is inevitably being militarised as well. The EU has a clear interest in avoiding an arms race in space, given its growing dependency on space-based assets but lag in offensive and defensive space capabilities, such as anti-satellite (ASAT) weapons, lasers, jammers, spoofers and directed energy weapons.

The cyber vulnerabilities of satellite links are also a growing concern, as has been demonstrated by the cyber-attack on the Viasat constellation at the beginning of Russia's invasion of Ukraine. Yet whatever hopes are placed in future space arms control agreements, such as a ban on ASAT weapons and tests, or the modernisation of the 1967 Outer Space Treaty, **the militarisation of space now seems irreversible.**

What are the challenges to Europe's security from the military activities of the EU's competitors? How can the EU better leverage the considerable efforts of some of its major powers, particularly France, which has its own space launch rockets, space command and satellite protection capabilities, and also conducts military space exercises? How can the EU's military space activities be better coordinated with those of NATO, which in 2019 declared space as a domain of operations, covered by the alliance's collective defence clause, and has subsequently established a space operations centre at Ramstein? Can the EU also work productively with the United Kingdom, another potential partner with important space assets in both the public and private sectors, notwithstanding the frictions and tensions caused by Brexit? **These are sensitive and inescapable issues**, and ones where Paul proves in this report that he is more than capable of rising to the challenge.

Getting space policy right is central to the EU's ability to remain a leading global actor in the 21st century, as well as provide for the prosperity, freedom and security of its citizens. Space opens many doors into our contemporary geopolitics and raises many issues and challenges for political leaders and policymakers. It is easy to become lost in the maze of threats, treaties, legal issues, technologies, programmes and missions as space is truly a global concern with multiple players vying for power and influence. **The merit of Paul's study is to guide us skilfully and reliably through all the key areas where space impacts directly on our daily lives.**

The talent for explanation and synthetic summary that Paul displayed in his previous security reports for Friends of Europe is once again in evidence here. The writing is concise and accessible. Paul's long experience as a seasoned journalist and political analyst, together with the many interviews he has conducted with senior officials and experts at the heart of EU space policy, enables him to give us **a clear roadmap into the critical stakes and choices for Europe.** I am therefore confident that readers wanting to get to grips with the challenges of space quickly and comprehensively will find Paul's latest study just as valuable as all his previous ones.

As Paul usefully points out in his conclusion, space is a fast-moving domain. The EU has a good track record to date, but it can quickly fall behind if it fails to invest in line with its competitors and in the right capabilities. Space may be infinite; but **if Europe doesn't take it seriously enough, it may well indeed, as Paul warns us, find itself running out of space.**


Europe from Space

Executive summary

Europe is falling behind in many key areas regarding the race to utilise space for the benefit of its population and of mankind, and to protect its interests. Yet **it is a vital domain for developing European strategic autonomy** and reducing dependence on other actors for access to space, situational awareness and strategic intelligence.

As the number of actors – states, corporations and international organisations – vying for strategic and commercial advantage multiplies, **space is increasingly congested and contested.** Europe is handicapped by complex institutional structures, a relative dearth of public investment in space technologies and individual states' secretive national security culture.

This report examines what Europeans need to do to protect their common security interests and derive maximum benefit from space.

Europe can point to major collective achievements: the European Union's Galileo satellite navigation system, which provides the

world's most accurate positioning service; the Copernicus earth observation programme, which delivers a wealth of data on climate change, the atmosphere, meteorology, and the land and sea environment; and the EU Satellite Centre, which delivers rapid analysis of earth observation imagery data for governments. **These common assets serve as a strong foundation for building European security in space**, provided there is a step change in public investment and strategic culture.

However, in recent years, European countries have been losing ground to both the United States and China in technologies that are essential for future prosperity and security. These include satellite constellations, reusable launchers, micro-launchers, space transport for humans, encrypted connectivity, quantum computing, artificial intelligence (AI) and military space capabilities.

Public investment – military and civilian – in space technologies is roughly six times higher in the US than in Europe. EU High Representative for Foreign and Security Policy Josep Borrell recently put the gap as high as 10 times. China too is investing heavily in space research and development (R&D) and quantum computing in its growing rivalry with Washington. While the major powers' commercial space sectors remain propelled by defence contracts, the European space sector is overwhelmingly civilian.

Europe is the world's fourth space power, far behind the US and China, but also well behind Russia. It also trails Japan in some metrics.

The EU space sector had a turnover of €7.7bn in 2020 and employs about 50,000 workers directly. However, the number of European launches has declined every year since 2016, as has the tonnage of satellites produced in Europe since 2017, according to ASD-Eurospace, the space industry association.

The US private sector, cushioned financially by Pentagon and National Aeronautics and Space Administration (NASA) orders, is becoming increasingly dominant in the commercial utilisation of space. United Kingdom-based OneWeb is the only European competitor in space-based broadband internet so far. Due to Brexit, the UK is not considered by Brussels as part of the European space technological ecosystem, leaving EU member states and agencies trailing in comparison, with about 500 satellites in space.

The scramble for space began as a strategic contest between the US and the Soviet Union in the 1950s and 1960s. The public spotlight was mostly on the heroic narrative of scientific exploration and human space travel. The first commercial uses were for telecommunications and broadcasting.

The security uses of space widened from rocket technology to intelligence, surveillance and reconnaissance, communications, navigation, positioning and timing, and precision guidance. The

US has increasingly relied on space-based assets to project its power on earth. US troops used the Global Positioning System (GPS) for the first time to navigate and direct fire in the 1991 Gulf War, when 6% of US munitions used in the conflict were space-guided. By the time of the US-led invasion of Iraq in 2003, 65% were space-guided.

Increasing great power rivalry in the last 15 years has accelerated the militarisation of space and the development of counter-space capabilities.

The US, Russia, China and India have all demonstrated earth-launched, direct-ascent anti-satellite rockets (ASAT) and other capabilities to shadow, disable or blind an adversary's space assets. No European power has officially conducted an ASAT or counter-space weapon test. Germany, France, the UK and Italy have all created national military space commands, but Paris alone among European powers has said it plans to develop an earth-based counter-space laser weapon.

No state has yet admitted to deploying orbital space weapons, although the US believes both Russia and China have tested the ability to manoeuvre space vehicles close to an adversary's satellites with a view to spying on them, or jamming or disabling them.

There are three main thrusts to European security policy in space:

- **regulatory and arms control initiatives** aimed at managing fast-growing space traffic, curbing proliferating space debris and codifying responsible behaviour in space;
- a European Commission-led drive to boost EU **space power for commercial, scientific and security benefit** with a proposed new satellite constellation for quantum-encrypted, secure connectivity and autonomous European space situational awareness (SSA) tools to reduce dependence on the US; and
- moves by individual major European powers to build **national space defence capabilities.**

Europe's space and defence communities long lived in different orbits and barely communicated with each other. They have only lately begun docking manoeuvres. Astonishingly, EU defence ministers held their first-ever discussion of space as a strategic domain as recently as January 2022. Two months later, EU leaders agreed to adopt a common space strategy for security and defence by the end of 2023.

The North Atlantic Treaty Organization (NATO), which unlike the EU has no space

assets of its own and does not plan to develop them, declared space a fifth operational domain in 2019 along with land, sea, air and cyberspace. The alliance issued its first overarching space policy in January 2022, assigning itself a modest coordinating role to the extent that allies are willing to share satellite data. The EU and NATO have yet to start cooperating in this field, which would be beneficial for both organisations.

Russia's invasion of Ukraine has accelerated a geopolitical awakening in Europe and **broken down mental and institutional barriers between defence and space.** It has also raised new political and security barriers to international space cooperation with countries such as Russia and China.

The Ukraine conflict has seen **widespread use of both public and private space assets.** The unprecedented availability of high-definition commercial satellite imagery enabled Western governments and media to expose Russia's military build-up in the months and days before the invasion. That denied Moscow the element of surprise, although many in Europe doubted President Vladimir Putin's intentions until the last minute.

War will never be the same again, and Europeans need to adapt fast to the new realities.

In this study, the word 'Europe' is used to denote the collective efforts of the EU, the European Space Agency (ESA) and individual European states, plus the European commercial space sector.

Under the prevailing informal division of labour, the 22-member ESA is an intergovernmental organisation that designs and manages exclusively civilian, scientific space projects. The EU provides jointly financed collective space enablers for both civilian and security needs, run by the recently established EU Agency for the Space Programme, while a handful of larger member states have hitherto handled space defence assets nationally, or not at all.

The UK's departure from the EU compounded these divisions. The country, which has one of Europe's leading space industries and science bases, was ejected acrimoniously from the Galileo programme and suspended from Copernicus. The rupture dealt a blow to the European space sector that would only be partially mitigated if there was some agreement between the EU and the UK.

Under the leadership of Thierry Breton, EU Commissioner for the Internal Market, and High Representative Josep Borrell, **the Commission is driving an ambitious EU space defence agenda**. But how far and how fast the Union progresses down the

path of developing common space defence capabilities depends on the willingness of the biggest members to increase investment and to rethink some of the secrecy surrounding national military space assets and data.

This study explores how Europe can **build resilience in space and make the best use of its assets** for communication, earth and climate observation, and surveillance. It analyses the strengths and weaknesses of **Europe's commercial space industry** and suggests ways to enhance its competitiveness.

It considers how Europe can best **advance realistic international governance to preserve space as a global common** for the benefit of mankind by promoting space traffic management, arms control and sustainability. It examines what forms of **international cooperation** remain possible in space given heightened great power rivalry.

This study also offers recommendations on how Europe can **develop a common strategic culture to protect its own interests in the geopolitics of space**, including through deterrence and the development of some counter-space capabilities.

The EU needs to change gear rapidly to remain a major player in an increasingly contested and competitive commercial and security space environment. Otherwise, it risks running out of space.

A European Vega satellite carrying ESA's experimental space plane lifts off from the European spaceport in Kourou, French Guiana, in 2015

Very Large Array, Socorro, United States

CHAPTER 1

Strategic overview – **civilian space**

Filling space

In the 65 years since the Soviet Union alarmed Washington by launching the first Sputnik satellite into orbit, the uses of outer space have grown exponentially.

Beyond the original scientific exploration, telecommunications and spy satellites, space is used today for everything from positioning, navigation and timing, to weather forecasting and monitoring climate change, crops and oceans, to managing electricity grids, sewage systems, maritime traffic and financial transactions, as well as broadcasting and video conferencing. Just as importantly, as we shall see in Chapter 2, space is constantly used for strategic signalling – a euphemism for national and military muscle-flexing.

Western economies are far more dependent on space for everyday transactions, communications and public services than most citizens imagine. "**Our daily life really depends on satellites**," said Josef Aschbacher, Director General of ESA.[1]

The number of objects in orbit has dramatically risen with the emergence of a fast-growing commercial sector, often collectively known as 'New Space', which has far outstripped the number of government players in space. This has raised growing issues of congestion, pollution and traffic management that lack an up-to-date international regulatory framework.

Highlighting the extraordinary pace of change, Aschbacher said **as many satellites were placed in orbit between 2020 and 2021 as in the entire period from the first Sputnik launch in 1957 until the end of 2019.** The growth rate is set to accelerate further as constellations of thousands of satellites are proliferated in low earth orbit (LEO), between 400km and 2,000km above earth, to provide connectivity and broadband internet access to users in every corner of the globe.

The original rulebook for space activities has been overtaken by the multiple users and players. In this respect, it is in urgent need of an update. "**The increase of activity by non-state actors was not envisaged**," said Tanja Masson-Zwaan of Leiden University and President Emerita of the International Institute of Space Law. "There is no clear duty to clean up your mess in space. There are no space traffic rules and no duty to de-orbit retired satellites."[2]

However, progress in United Nations negotiations is excruciatingly slow and outstripped both by technological innovation and by unilateral legislation and plurilateral agreements that are already shaping how future space activities will be conducted.

(1) Interview with the author, March 2022
(2) Interview with the author, February 2022

Legal backbone

The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, otherwise commonly known as the Outer Space Treaty, signed in 1967 and ratified by 110 states, forms the legal backbone for all human activity in the cosmos.

Four more treaties were adopted between 1972 and 1979, which cover the rescue of astronauts, legal liability for objects placed into space, the establishment of an international registry for space objects, and the activities of states on the Moon and other planets. **No further treaty has been concluded in the last four decades, during which time the uses of space have expanded beyond recognition.** The authors of the original charter assumed that most space activity would be conducted by states, not companies. The treaty regime provides only a flimsy framework for fast-advancing commercial exploitation.

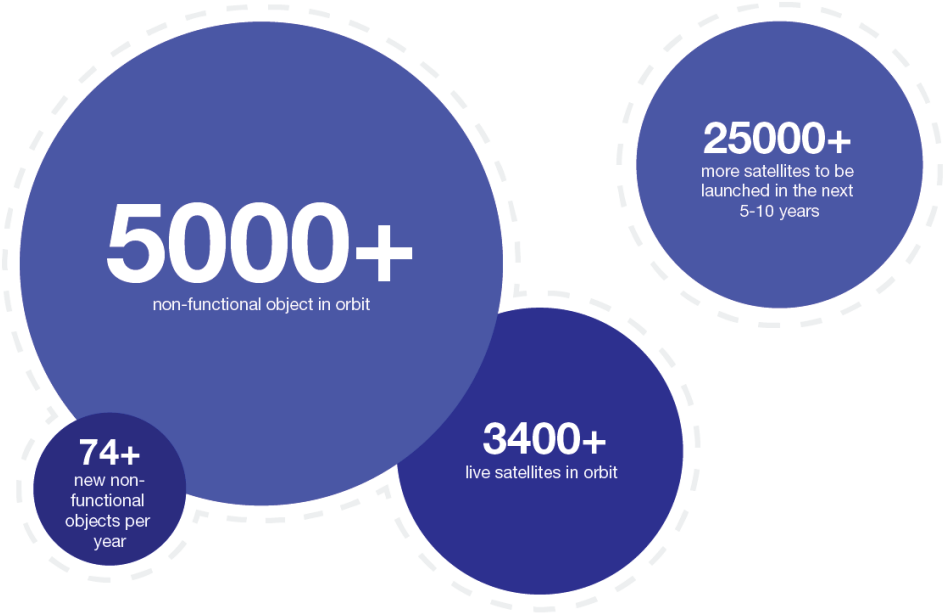
Two UN forums work on separate aspects of space regulation – the Committee on the Peaceful Uses of Outer Space (COPUOS) in Vienna and the Committee on Disarmament (CD) in Geneva – even though many of the issues that require international action are intertwined and overlapping. Both bodies are effectively paralysed by heightened great power rivalry.

The Outer Space Treaty defines space as "the province of all mankind", free for all to explore and use for the benefit of humanity, and "not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means". It leaves responsibility in the hands of individual states to license, regulate and supervise the activities of their own public and non-governmental space operators, and to notify them to the UN.[3]

"In aviation, states are sovereign in the airspace above their territory. **The big difference in space is that no one is sovereign,**" said Masson-Zwaan.

There is no Highway Code for spacecraft, no international space traffic police to fine litter louts, restrain road hogs or issue parking tickets, and no space road sweeper to remove accumulating debris. Diplomatic realists say that there is next to no prospect of binding, enforceable global rules being agreed to regulate these issues. However, there are somewhat higher hopes for so-called soft law attempts to agree on best practice among like-minded nations. Such attempts have the potential to reduce some hazards.

(3) https://www.unoosa.org/pdf/publications/STSPACE11E.pdf



Wild West?

"At the moment, it's the Wild West and cowboys are populating outer space," Aschbacher said. "What happened in the United States [in the mid-19th century] is now happening in space. Territories are being conquered, new orbits are being conquered and satellites are being placed there. This creates a completely new problem of regulation."

Not everyone sees the situation as such a free-for-all. On the contrary, **international space law experts contend that activities in the cosmos are already quite highly regulated**, with launching states legally liable for the activities of their public and private operators, while satellite communication frequencies and geosynchronous earth orbit (GEO) slots are allocated by the International Telecommunications Union (ITU), a UN agency.

The number of satellites that can be stationed in a ring in GEO, 35,786km above the equator,

(2) Pham speech to Center for Strategic and International Studies Sahel Summit, Washington DC, Oct 16, 2020, https://www.csis.org/events/online-event-2nd-annual-sahel-summit

is calculated to be 1,800. **There is fierce competition among telecoms operators for those slots, which are allocated by the ITU via national authorities.**[4]

"Space is far less anarchic than people imagine," said Research Fellow Jill Stuart, specialised in international space law, at the London School of Economics. "Companies have to register with their launch state. Most governments demand to see insurance and a plan to de-orbit the satellite after 10 years. There is a really high-cost barrier to entry. There may be no technical enforcement of international law, but most countries do adhere to the pre-existing governance infrastructure."[5]

However, since there is no limit on the number of satellites that any state may register, **one country – the US – may effectively begin to monopolise LEO by issuing thousands, or tens of thousands, of licences to its space companies.** It can also hog the radio frequency spectrum by applying for thousands of licences and then sitting on them. The ITU has tried to curb such practices by limiting the duration of unused licences to seven years.

Of the roughly 4,500 active satellites currently in all orbits, a single company – Starlink, a unit of Elon Musk's privately owned SpaceX – already operates more than 2,000; the internet satellite constellation has regulatory permission to launch 10,000 more this decade and applied to launch another 30,000. Musk's arch-rival and Founder of Amazon, Jeff Bezos, has licences to launch a constellation of more than 3,000 LEO satellites as part of his Project Kuiper to compete in the broadband internet market.

UK-based OneWeb, rescued from bankruptcy by the British government and Indian investors in 2020, is the only European competitor in space-based broadband internet so far with nearly 400 satellites in space as part of a planned broadband constellation. China also has plans for a 13,000-satellite mega-constellation run by private companies and overseen by a state-owned enterprise.

Starlink is subject only to US regulation. Its first mover advantage in 'occupying' space real estate, with the approval of US government agencies, is not constrained by any international limits or supervision. ESA's Aschbacher says **this is effectively a land-grab that could shut out European competitors seeking frequencies in LEO.**

"You have one person owning half of the active satellites in the world. That's quite amazing. De facto, he is making the rules. The rest of the world including Europe…is just not responding quick enough," he said.[6]

(4) https://theconversation.com/theres-a-parking-crisis-in-space-and-you-should-be-worried-about-it-83479
(5) Interview with the author, February 2022
(6) Interview with the author, February 2022

SWISSto12 Agile micro-geostationary satellite

Ownership in space

SpaceX, which also launches payloads for the US military and NASA, **has so far shown no inclination to engage with international efforts to develop regulation of space**, whether on curbing space debris, limiting light pollution or ownership of space resources. On the contrary, Musk has begun to outline his own vision of Mars, where he plans to create a permanent human colony, as a legal vacuum.

A paragraph in the Starlink's terms of service issued in 2020 states: "Services provided to, on, or in orbit around the planet Earth or the Moon…will be governed by and construed in accordance with the laws of the State of California in the United States. For Services provided on Mars, or in transit to Mars via Starship or other colonization spacecraft, the parties recognize Mars as a free planet and that no Earth-based government has authority or sovereignty over Martian activities. Accordingly, Disputes will be settled through self-governing principles, established in good faith, at the time of Martian settlement." [7]

Space lawyers challenge that claim and note that **the Outer Space Treaty stipulates that international law applies to all celestial bodies.** The debate may seem esoteric since a colony on Mars is still a distant vision. But permanent bases on the Moon, as well as commercial mining activities there or on asteroids, are a much more plausible prospect within the coming decade, with legal and security implications for all spacefaring nations. For example, Helium 3, an isotope seen as a potentially crucial energy source in nuclear fusion, exists in larger concentrations on the Moon than on earth. China, Russia and the US are all exploring the possibility of mining it on the Moon.

As the world's leading space power, **the US has unsurprisingly got out ahead of other nations in preparing the legal ground for the commercial exploitation of space resources**. The Commercial Space Launch Competitiveness Act of 2015 allows US industries to "engage in the commercial exploration and exploitation of space resources", effectively declaring that American space miners may keep whatever they find. While saying that the US does not claim sovereignty or ownership of any celestial body, the law mandates the president to "facilitate commercial exploration for and commercial recovery of space resources by United States citizens".[8]

(7) https://www.reddit.com/r/Starlink/comments/jjti2k/starlink_beta_terms_of_service/
(8) https://www.congress.gov/114/plaws/publ90/PLAW-114publ90.pdf

Spacex Dragon in orbit

Many international lawyers contend that this breaches Article 2 of the Outer Space Treaty, which stipulates that "[o]uter space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means."

This controversy is mirrored in Europe, where Luxembourg, home to a thriving New Space sector clustered around its historic communications satellite giant SES, became the first EU state and only the second country worldwide to adopt a similar Space Resources Act in 2017. **The law declares unambiguously in Article 1 that "space resources are capable of being owned". That runs counter to a strong current of European thinking**, present notably in the European Parliament, which opposes outright or seeks prior international regulation of the commercial appropriation and exploitation of space resources for profit.

Practice trumps theory

At the UN, a sub-committee of COPUOS has been debating the permissibility and legal framework for use and commercialisation of space resources since 2017. There is no legal or political consensus among the committee's 87 member nations, although **most agree on the desirability of some international understanding before space mining becomes a reality**. However, these issues may well be settled in practice before they are resolved in theory.

The US Trump administration announced an initiative in 2020 to create a framework with like-minded nations for cooperation in exploration and mining on the Moon. **The NASA Artemis Accords**, named after the US-led programme to return astronauts to the Moon from 2024, **are a series of bilateral agreements with partner countries to establish a unified set of guidelines for the civil exploration and peaceful use of the Moon, Mars, comets and asteroids.**

The text contains many provisions consistent with the Outer Space Treaty and in line with the COPUOS guidelines for sustainable practices in space adopted in 2019. However, it also asserts two controversial notions – the right to extract and keep space resources, and the right to declare "safety zones" around bases or mining areas on the Moon and other celestial bodies, to avoid "harmful interference" by other actors within that perimeter. [9]

"The Signatories affirm that the extraction of space resources does not inherently constitute national appropriation under Article II of the Outer Space Treaty, and that contracts and other legal instruments relating to space resources should be consistent with that Treaty," the document says.

The accords were signed initially by the space agencies of eight countries: the US, the UK, Canada, Australia, Japan, Italy, Luxembourg and the United Arab Emirates (UAE). They have since been joined by Poland, Romania, Ukraine, South Korea, New Zealand, Brazil, Mexico, Israel, Bahrain and Singapore. The US is hoping to draw key European countries into its orbit, and France has expressed interest in joining the Artemis Moon probe, but has stopped short of signing so far.

The initiative is controversial within the EU, where some countries and Brussels officials view it as an attempt by Washington to impose a legal *fait accompli* and cherry-pick preferred allies rather than engaging in a multilateral negotiation about common rules.

(9) https://www.nasa.gov/specials/artemis-accords/img/Artemis-Accords-signed-13Oct2020.pdf

"We have one big space actor which is going unilateral and having adopted a national approach is trying to sell it to the rest of the world," a senior EU official said. "To speak to that big space actor, we need a regional European approach." (10)

However, a common European position on the Artemis Accords seems difficult since four member states have already signed them. (11)

Mathias Link, Director for International Affairs and SpaceResources.lu at the Luxembourg Space Agency, said there had been a real negotiation between Washington and its initial Artemis partners about the text of the accords. "Between the first version and the one signed, there is a big difference. This was truly a multilateral initiative," he said. "These accords are definitely better than nothing. Discussions at the UN will take a long time. We support them but it's much better to be in the same boat." (12)

(10) Interview with the author, March 2022
(11) https://www.politico.eu/article/space-rules-us-france-germany-europe-moon/
(12) Interview with the author, April 2022

Littering space

The same legal quandary applies to the fast-growing problem of space debris, which unless remedied could render LEO hazardous and eventually inaccessible to all nations and companies.

Satellites and launchers are supposed to fall back towards earth and eventually burn up on re-entering the atmosphere, which most do. However, **LEO is cluttered with tens of thousands of pieces of scrap metal left over from past launches, defunct satellites, the results of collisions, break-ups, explosions, electromagnetic space storms and other events.**

In early April 2022, ESA said Space Surveillance Networks were tracking some 30,820 debris objects in their catalogues. But not all pieces of space debris are tracked. ESA estimated on the basis of statistical models that there were 36,500 pieces of space debris larger than 10cm in orbit, some 1mn objects between 1cm and 10cm, and 130mn items between 1mm one 1cm large. **Even tiny specks can wreak significant damage on a satellite if they collide with it when travelling at speeds of between 4km and 6km** per second.[13]

In theory, countries are responsible for the debris that they and their licensed operators create in space. Ownership of tiny space debris is often hard to establish, making issues of liability difficult – if not impossible – to pin down. In practice, there is no enforcement.

Most debris is not created intentionally but some is caused deliberately. Russia's 2021 ASAT test destroyed one of its own satellites that had been in orbit since 1982 and caused a massive field of debris with at least 1,500 trackable objects. It forced Russia's own cosmonauts in the International Space Station (ISS) to take evasive action and shelter for a time in detachable re-entry capsules. The Russian government said the test, which drew widespread Western condemnation, was successful and harmless to orbital stations and spacecraft.

A Chinese ASAT test in 2007 caused the biggest creation of space debris in history, with more than 2,000 trackable items the size of a golf ball or larger and an estimated 150,000 smaller shards. Many of these are still in orbit 15 years later.

(13) https://www.esa.int/Safety_Security/Space_Debris/Space_debris_by_the_numbers

ESA Artist's impression of satellites and space debris in earth's orbit

A US space scientist, Donald Kessler, warned as early as 1978 that space pollution could cascade, causing chain collisions that might render space activities and the use of satellites in some orbital ranges impossible for generations. The phenomenon known as **the Kessler Syndrome has become more menacing as the number of objects in LEO has multiplied in the last two decades**. Kessler wrote in 2009 that the debris environment was already unstable and any attempt to clean up LEO by removing legacy debris was likely to fail because “fragments from future collisions will be generated faster than atmospheric drag will remove them”.

Another form of space pollution, which has alarmed the scientific community, is light reflection from the growing number of LEO satellites. An increasingly bright night sky is interfering with ground-based observation of the galaxy. In theory, licensing states are supposed to take the interests of all stakeholders, including astronomers, into account. The US has given priority to commercial ventures over the protests of its scientists. However, Musk has shown some sensitivity to the criticism, working with the astronomy community to darken the appearance of Starlink satellites.

Sustainable space

Space debris presents a classic collective action challenge. All nations and companies that use space have an interest in preventing the highway from being rendered unusable, but there is insufficient trust, especially in the current geopolitical environment, to build a common solution.

"If we screw up space, the large countries, the major spacefaring nations, would suffer most. They are the most vulnerable," said Steven Freeland, the Australian Co-Chair of the COPUOS Working Group on Space Resources.[14]

The European, UK and Japanese **space agencies have contracted companies to develop and demonstrate capabilities to capture and remove space debris. If successful, these could offer private sector solutions to governments and space companies.** However, given the high costs, it would probably require public support and other incentives to make such a system effective.

Apart from the cost, another concern is that all of the technologies that would be used to retire debris could also have military uses to capture other countries' satellites.

An initiative called Zero Net Space, launched by the Paris Peace Forum – an annual event created by French President Emmanuel Macron to promote global governance – has brought together space agencies and companies from the US, Europe, Japan and China to establish norms for the sustainable use of space to prevent the creation of additional pollution.

A declaration issued in 2021 set the objective of making all space activity sustainable by 2030. "To do so, we seek to adopt appropriate mitigation and remediation measures in all space operations from the outset, taking into account the distinctive features of the different orbits used for space operations," said the signatories.[15]

Such soft-law initiatives could be given teeth by **a market-based sustainability rating system akin to credit ratings that would provide financial incentives for best practice** in the form of lower insurance premiums, as conceived by the World Economic Forum's (WEF) Global Future Council on Space.

Participation in the Space Sustainability Rating (SSR) system would be voluntary. Spacecraft operators, launch service providers and satellite manufacturers would be given four levels of certification, based on factors including data sharing, choice of orbit,

(14) Interview with the author, February 2022

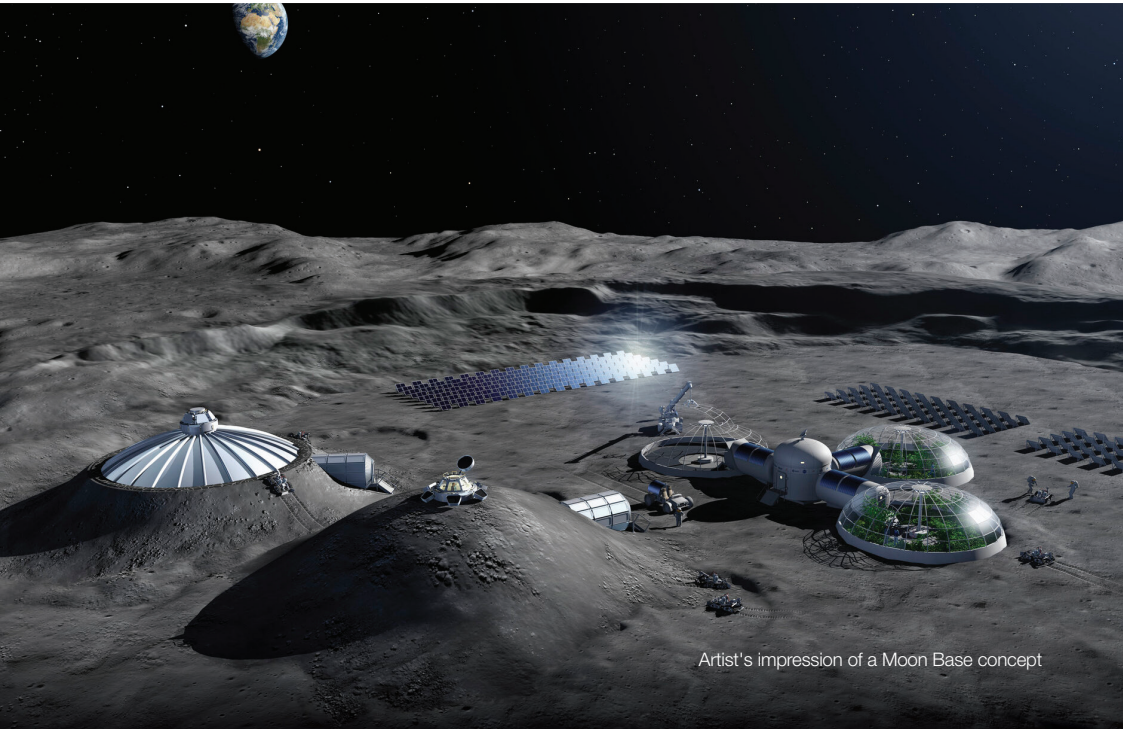
(15) https://parispeaceforum.org/en/initiatives/net-zero-space/, interview with Justin Vaïsse, director-general of the Paris Peace Forum, February 2022

measures taken to avoid collisions, plans to de-orbit satellites on completion of missions, and even how well they can be detected and identified from earth.

Importantly, several big space companies, including Airbus/Arianespace, Lockheed Martin, SpaceX and Planet Labs, as well as insurer AXA, have supported the initiative and expressed interest in participating when the SSR, designed by the École Polytechnique de Lausanne, is launched in 2022, according to the WEF. [16]

Given the difficulties of agreeing internationally on regulation, "these sorts of bottom-up industry initiatives may be the way forward," said Masson-Zwaan.

(16) https://www.weforum.org/impact/world-s-first-space-sustainability-rating-launched



Artist's impression of a Moon Base concept

US Vice President Kamala Harris announces on a visit to Vandenburg Space Force Base in California in April 2022 that the United States will no longer conduct direct-ascent ASAT tests.

CHAPTER 2

Military overview

War in space?

For some, war in space has already begun.

"The threats are really growing and expanding every single day," General David Thompson, the US Space Force's Vice Chief of Space Operations, said at the Halifax International Security Forum in November 2021. "We're at a point now where there is a whole host of ways that our space systems can be threatened." [1]

The Space Force was dealing daily with 'reversible attacks' on US government satellites, through cyber-attacks, radio frequency jamming or laser dazzling by Russia and China. Although the US was technologically still ahead of Moscow and Beijing in space, Thompson voiced concern that China was catching up fast. He added that the Chinese were fielding new technology twice as fast as the US and were likely to overtake Washington in terms of capabilities if they maintained the current pace of development. [2]

European commanders are slightly more relaxed about the state of the military space race. However, there is no doubt that **space will be central to strategic competition among advanced nations in the coming decades.**

Western societies' reliance on space for the everyday functioning of their globalised economies brings enormous benefits in terms of productivity and efficiency but creates major vulnerabilities. Our financial transactions, telecommunications, internet connectivity, navigation on land and at sea, weather forecasting and monitoring of climate change all depend on space. As a result, they can be disrupted by interfering with satellites, the radio frequencies they use to transmit data or the systems that receive and manage that data on earth.

For the armed forces, **space has become an indispensable strategic enabler**. It is vital for intelligence, surveillance and reconnaissance, positioning, navigation and timing, command and control of forces and weapons systems, weather forecasting for operations, secure communications and intercepts of other nations' signals, as well as early warning of rocket launches and interception of ballistic

(1) https://m.youtube.com/watch?v=n_Knnsagcm8
(2) ibid.

missiles. Without access to space data, Western forces would be blind, deaf and lame.

Logically, **the ability to deny the use of space to an adversary, whether temporarily or permanently, has become a key element of warfare.** Russia's war in Ukraine has provided examples both of the military utility of space and of efforts to disrupt an enemy's use of space.

US companies, such as Maxar Technologies and Planet Labs, as well as Alphabet's Google Earth, have democratised satellite intelligence. Even if the US had not shared classified satellite intelligence with the Ukrainian government, the availability of high-resolution commercial space imagery of specific zones, such as areas of Russia bordering Ukraine or the surroundings of Kyiv, largely robbed Moscow of the element of surprise in its invasion. Satellite pictures of concentrations of tanks, artillery and aircraft were plastered all over the internet and the media.

That enabled the defenders to target and disrupt tank columns advancing on Ukrainian cities. With more satellites at their disposal than the military, **commercial providers are able to pass over a requested location more frequently than national intelligence satellites,** according to NATO officials.

On the other hand, suspected Russian cyber warriors conducted a "multifaceted and deliberate cyber-attack" on US internet provider Viasat's KA-SAT network on 24 February 2022, the day Moscow launched its invasion of Ukraine. The attack on the ground-based system that manages customer terminals knocked out tens of thousands of terminals across Europe, particularly in Ukraine, where the military used this single commercial provider to network its communications.[3]

Ukraine was able to replace that service rapidly with another commercial provider, Starlink, illustrating states' **widened room for manoeuvre between public and private enablers.**

(3) https://www.viasat.com/about/newsroom/blog/ka-sat-network-cyber-attack-overview/

Strength and vulnerability

As the country with the most advanced military technology, **the US is the most reliant on space and hence the most vulnerable to adversaries' counter-space capabilities.** The Viasat attack illustrated the vulnerability of commercial satellite communications on which the US military increasingly relies.

The first Space Command was created in 1985 as part of former US president Ronald Reagan's 'Star Wars' missile defence programme. After the end of the Cold War, it was wound down and merged into the Strategic Command, as the weaponisation of space was put on the back burner in the absence of a peer competitor to US power. **This competition has been revived and amplified in the last 15 years** with the return of Russian military power and, above all, the rise of China as a strategic rival.

The militarisation of space is now out in the open. **US doctrine makes clear that maintaining 'space superiority' is a key objective in any conflict.** That was the reason for the establishment of the Space Force as a separate branch of the armed forces in 2019 with an explicit focus on space as a 'warfighting domain'.

Its mission is defined as: "To conduct operations in, from, and through space to deter conflict, and if necessary, defeat aggression, deliver space combat power for the Joint/Combined force, and defend US vital interests with allies and partners."[4]

The US is keen to highlight Russian and Chinese efforts in counter-space technologies but coyer about its own capabilities. **The US tested an air-launched ASAT weapon in 1984 and 1985** as part of its Star Wars programme. The programme was cancelled in 1988. Then in 2008, the US Navy destroyed a malfunctioning spy satellite with a sea-launched missile, officially to prevent possible danger from a toxic hazarding fuel tank. The hit produced 74 pieces of orbital debris, which burned out on re-entering the Earth's atmosphere within a year.

China first tested a vertical launch ASAT weapon successfully in 2007, destroying a defunct weather satellite, but creating a massive field of debris.

India tested an ASAT weapon against one of its own live satellites in LEO in 2019, creating only a small number of space debris,

(4) https://www.spaceforce.mil/About-Us/About-Space-Force/Mission/#:~:text=USSF%20Mission,options%20to%20achieve%20national%20objectives.

most of which rapidly burned up on re-entry. Indian space scientist Ajay Lele of the Institute for Defence Studies and Analyses in New Delhi, said the successful test "put India in its rightful place at the top table and sent a message of deterrence to adversaries that India's LEO satellites have security cover". [5]

"This forces the 'Big Three' – the US, China and Russia – to talk to India and not exclude it as they did from the official nuclear club with the Nuclear Non-Proliferation Treaty," Lele said. However, he stressed that most of India's effort in space was in the civilian scientific area and the promotion of economic development through meteorology, natural resources management and technological innovation.

The Soviet Union, which had an anti-ballistic missile defence system around Moscow, conducted a range of unsuccessful ASAT programmes in the 1980s. **Russia revived the defunct effort under Putin and successfully tested its first ground-launched ASAT missile in 2015.** Several more tests followed until 2018, and in November 2021, Moscow destroyed a defunct Cosmos satellite with a direct-ascent weapon, causing a large field of 1,400 pieces of debris and threatening the ISS. [6]

(5) Interview with the author, February 2022

(6) https://www.dia.mil/Portals/110/Documents/News/Military_Power_Publications/Challenges_Security_Space_2022.pdf

Space arms control

The 1967 Outer Space Treaty committed signatories "not to place in orbit around the earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner".

It also prohibited the establishment of military bases and the testing of weapons on the Moon or asteroids. However, **it left a large margin for the use of ballistic missiles, interceptors and other yet-to-be-invented weapons in space.**

Trying to prevent an arms race in space has been on the UN agenda since the 1970s and throughout the 1980s in reaction to Reagan's controversial 'Star Wars' missile defence programme. The dynamics at the time were about the placement of weapons in space by two clearly identified superpowers: the US and the Soviet Union.

However, the return of great power competition and the emergence of China and India, but also Iran, North Korea, Israel, the UAE and Brazil, among others, as space powers has complicated the security dynamics. Moreover, **many space technologies are capable of both civilian and military uses, making them harder to control.** Most counter-space capabilities are electronic and hence difficult to attribute or define.

"North Korea has developed and demonstrated ground-based counter-space electronic warfare capabilities to disrupt, deny, deceive or degrade" US space communications, according to a US Defense Intelligence Agency report published in April 2022. Iran has also demonstrated interference with commercial satellite signals, it noted.[7]

While pressing ahead with their own ASAT weapons development, **Russia and China jointly put forward a draft treaty at the UN in 2008** "on the prevention of placement of weapons in outer space". [8] Western countries declined to engage in the proposal, arguing that **it did not address the real threat**

(7) https://www.armscontrol.org/act/2021-12/news/russian-asat-test-creates-massive-debris
(8) https://www.reuters.com/world/us/us-will-not-conduct-direct-ascent-anti-satellite-missile-tests-harris-says-2022-04-19/

from earth-launched ASAT weapons but sought to constrain other systems yet to be deployed, which would be difficult to verify. Privately, Western officials say the treaty was transparently aimed at tying US hands and countering its technological lead in space.

For its part, **the US indicated in December 2021 its support for a ban on ASAT weapons tests.** Washington went a step further in April 2022 by announcing unilaterally that it would not conduct ASAT missile tests. The announcement by Vice President Kamala Harris came in the midst of the war in Ukraine, perhaps intended to exert political pressure on Russia not to try to shoot down US satellites providing intelligence to Kyiv. [9]

This public jousting with rival arms control initiatives suggests a contest in the court of public opinion rather than a serious attempt to negotiate greater strategic stability in space. However, since **all sides would be losers from an uncontrolled proliferation of space weapons and a growing spread of debris from ASAT tests**, there may be some common ground to explore at least a moratorium on such tests.

Rather than trying to ban specific weapons systems, the EU proposed in 2008 a voluntary, non-binding International Code of Conduct for Outer Space Activities. Despite going through four iterations up to 2014, **the EU initiative failed** because it ran counter to the Sino-Russian treaty proposal but also **because of a widespread perception that Brussels was trying to force its own norms on others**, rather than engaging in a process of consultation and bottom-up consensus-building with other nations. [10]

More recently, **the UK sought to revive efforts for a set of principles** with a 2020 resolution in the UN General Assembly, adopted by 150 states, with 12 against and 8 abstentions, seeking to focus the global discussion about space security on ways of "reducing threats through norms, rules and principles of responsible behaviour". The objective is **to build consensus on what it means to be a 'responsible' actor in outer space.** [11]

UK diplomats say they are agnostic about the form of an eventual agreement or agreements, which could eventually include a binding treaty. But their approach is to start by **getting the broadest possible buy-in to define the problems that need to be addressed** and to work through transparency and confidence-building measures.

The resolution led to a report by the UN Secretary-General and the creation of two working groups at the Conference on Disarmament in Geneva to identify responsible space behaviours. Although Russia and China voted against the resolution, along with anti-Western countries such as Syria, Iran, Venezuela and Cuba, they have since participated in the working groups. 'Unofficial' nuclear powers India, Pakistan and Israel were among notable abstainers.

(9) Interviews with the author, February-March 2022

(10) https://ploughshares.ca/pl_publications/the-uk-process-on-norms-and-space-security/, Interviews with the author, March 2022

(11) Interview with the author, February 2022

The US favours behaviour-based guidelines rather than binding treaties on space arms control, both to preserve its own freedom of action and because of the difficulties and pitfalls of defining categories of weapons that could be verifiably banned. "The US doesn't want to give away anything they might need later," said Laura Grego, a space arms control expert and Nuclear Security Fellow at the Massachusetts Institute of Technology.[12]

US Defense Secretary Lloyd Austin issued a memorandum to the Joint Chiefs of Staff and the US defence establishment in July 2021 outlining **five broad tenets of responsible behaviour in space**: "operate in, from, to, and through space with due regard to others and in a professional manner; limit the generation of long-lived debris; avoid the creation of harmful interference; maintain safe separation and safe trajectory; communicate and make notifications to enhance the safety and stability of the domain." [13]

Whether the UK-led effort can lead to any international agreement in the current fraught state of great power relations seems highly doubtful. But it at least **creates a forum for discussing space behaviour**, which in itself may serve as a modest transparency and confidence-building measure.

With the two UN committees hamstrung by geopolitics, an alternative might be to develop a non-binding, declaratory process along the lines of the 2002 Hague Code of Conduct against Ballistic Missile Proliferation, which now has 143 signatories, including Russia but not China. Members commit voluntarily to **provide pre-launch notifications of ballistic missile and space-launch vehicle launches and test flights.** Subscribing states also commit themselves to submit an **annual declaration of their country's policies on ballistic missiles and space-launch vehicles** and allow visits to launch sites on a voluntary basis. There is no enforcement mechanism. [14]

"The Hague Code is one of the few forums where there are still exchanges of information. It can be used for Track Two dialogue. That's what's missing in space," said Xavier Pasco, Director of the Foundation for Strategic Research (FRS) in Paris and an expert on space capabilities. The FRS is the implementing agency of the code on behalf of the EU. "We need such an informal platform that is flexible for multilateral discussion at a time when space is moving very fast." [15]

(12) https://media.defense.gov/2021/Jul/23/2002809598/-1/-1/0/TENETS-OF-RESPONSIBLE-BEHAVIOR-IN-SPACE.PDF
(13) https://www.hcoc.at/
(14) Interview with the author, March 2022
(15) Interview with the author, March 2022

Space spoilers

Building a broad international consensus around the definition of responsible space behaviour would **make it easier to identify and call out hostile actions and rogue actors.**

While much public attention has focused on vertical-launch ASAT missile tests, not least because of the debris they engender and the threat to other space users, **the more disruptive weapons and tactics in space are usually less visible, harder to attribute and easier to use** below the threshold of armed conflict. Prime among them are cyber-attacks that target the downlinks from space systems, either to steal or corrupt data, temporarily or permanently deny service to ground users, or seize control. These connections are vulnerable partly because many satellites were designed before cybersecurity was considered such a high priority, but also because they rely on ground nodes that can be attacked or diverted.

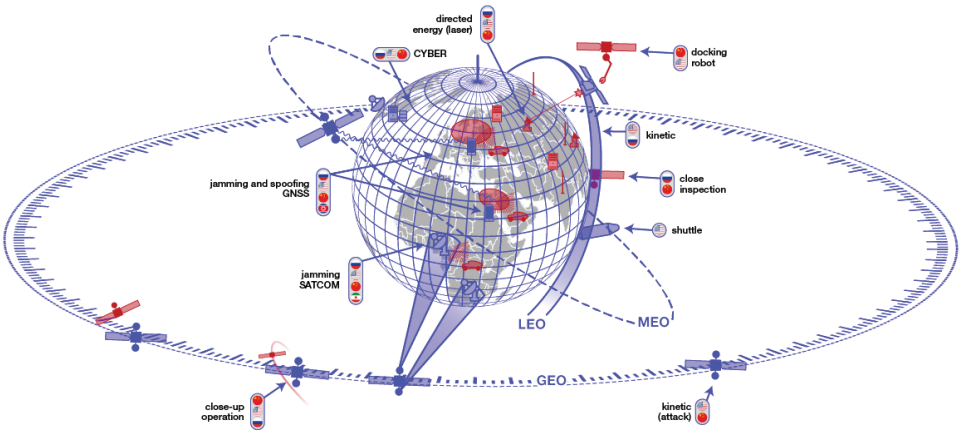
Satellites are susceptible to jamming as they either collect information or provide connectivity, using the radio frequency spectrum to link with ground stations. **NATO has encountered frequent instances of electronic interference with GPS signals** to disrupt its exercises and movements. GPS jamming – temporarily cutting the signal between a navigation satellite system and a ground or sea-based military user – has been used frequently to spook NATO troops on manoeuvres. There were widespread instances, for example, during NATO's 2018 Trident Juncture exercise in Norway, the largest reinforcement drill ever staged inside the Arctic Circle. Forces can work around the problem by switching to another navigation service, such as the EU's Galileo, or using pre-digital map-reading techniques. Western armed forces have long used jamming as part of their own electronic warfare arsenal.

"Everyone jams," said Victoria Samson, Washington Office Director of the Secure World Foundation, a US-based think tank, which promotes sustainable and peaceful uses of outer space. "Jamming and cyber are perceived as being much more usable. Using direct-ascent ASAT in a conflict has never been done. Countries have only tested it on their own satellites. It would be perceived as hugely escalatory. It is easy to attribute a launch, whereas cyber-attacks have deniability and can be reversible." [16]

More sophisticated, and potentially more dangerous, is GPS spoofing – sending a false signal to give the user erroneous positioning data. During Trident Juncture, a NATO warship

(16) Interview with the author, March 2022

Space defence threats identified by French AsterX exercise



Source: French Ministry of Defence.

was lured towards the rocks off the northern Norwegian coast by suspected Russian spoofing, a NATO admiral said. The error was detected in time, but the potential loss of life and capability alarmed alliance commanders and prompted refreshers on using traditional navigation instruments as an essential back-up. (17)

NATO commanders reported increased use of both jamming and spoofing against allied vessels in the Eastern Mediterranean between Syria and Cyprus since 2018, in the Black Sea in 2021 during the run-up to Russia's invasion of Ukraine and against aircraft flying from the UK's sovereign bases in Cyprus.

Other techniques, which both Russia and China have developed, involve using ground-based lasers to dazzle Western intelligence satellites, blinding them with an intense directed-energy beam. Satellites can also be temporarily or permanently disabled by electro-magnetic pulses or high-powered microwaves.

In addition to these forms of attack, **Western satellites have been subject to hostile approaches by Russian and Chinese spacecraft for inspection, suspected espionage and potential close-range attack or diversion.** Some of these approaches may be intended to test the reflexes and manoeuvrability of Western space probes.

French Armed Forces Minister Florence Parly disclosed in 2018 that a Russian Louch-Olympus "spy satellite" had "come a bit too close" to a Franco-Italian Athena-Fidus military communications satellite in 2017 in an apparent attempt to eavesdrop on communications and

(17) https://www.dw.com/en/france-details-military-command-of-space-plans-to-protect-satellites/a-49747318

had subsequently "left its business card" on several other satellites. [18]

Ironically, the techniques being experimented with to track and capture space debris could also be used to capture an adversary's satellite in a sort of flying 'butterfly net' and precipitate it back towards earth to burn up on re-entering the atmosphere.

The Secure World Foundation publishes an annual report, which acts as an open-source bible on counter-space capabilities. The 2022 edition highlights the **growing incentive for states to develop and potentially use offensive counter-space capabilities.** "The evidence shows significant research and development of a broad range of destructive and non-destructive counter-space capabilities in multiple countries. However, only non-destructive capabilities are actively being used in current military operations," it states.

Russia has the widest arsenal of offensive counter-space weapons, but China is catching up fast, the report shows. Among European states, only France has so far conducted research and development of directed-energy and electronic warfare counter-space capabilities. The report also pinpoints the vulnerability of commercial space satellites to cyber-attacks from both states and non-state actors including hackers. [19]

2022 Global Assessment

	U.S.	Russia	China	India	Aus.	France	Iran	Japan	North Korea	South Korea	U.K.
LEO Co-orbital	■	▲	■	●	●	●	●	●	●	●	●
Meo/GEO Co-orbital	■	▲	■	●	●	●	●	●	●	●	●
Leo Direct ascent	■	▲	▲	■	●	●	●	●	●	●	●
MEO/GEO Direct ascent	■	▲	■	●	●	●	●	●	●	●	●
Directed energy	■	▲	■	●	●	■	●	●	●	●	●
Electronic warfare	▲	▲	▲	■	●	■	■	●	■	●	●
Space situational awareness	▲	▲	▲	■	■	■	■	■	●	■	■

Legend: none ● some ■ significant ▲

(18) https://swfound.org/media/207346/swf_global_counterspace_capabilities_es_2022_en.pdf

(19) https://www.csis.org/analysis/defense-against-dark-arts-space-protecting-space-systems-counterspace-weapons

Active and passive defence

Defending space assets involves a wide range of techniques, including avoidance manoeuvres, equipping more satellites with sensors to detect and identify hostile activity, and surrounding key intelligence or communications assets with a cloud of micro-satellites to make hostile approaches more difficult.

"One of the key takeaways is that distributed, diversified, and proliferated **constellations can all be used in various combinations to complicate the targeting calculus of an adversary and reduce the benefits of attacking** any single satellite," the Center for Strategic and International Studies said in a 2021 report, outlining techniques that the US government could use to protect its space systems against the 'dark arts' of adversaries.

Passive defences such as jam-resistant waveforms, antenna nulling and electromagnetic shielding can make platforms harder to attack, while satellite manoeuvring, stealth, deception, decoys and other operational passive defences can make satellites difficult to detect, monitor and target. [20]

The US is working on ways of refuelling satellites in orbit and using micronuclear plants and other innovative techniques to generate energy aboard its strategic space systems. It is also developing ways of hardening or concealing its space assets from adversaries, akin to the radar-evading coating and materials used on 'stealth' warplanes, according to US officials and published accounts in specialised US media. [21]

Thompson said **preventing attacks on satellites through such protective measures and design features was far preferable to having to fight a war in space**, both because key US space assets were so few and strategically important, and due to disastrous consequences for all space users of kinetic conflict in orbit.

US policy stresses the importance of working with an enlarged group of like-minded allies in space security to improve resilience and maximise the capabilities of government and commercial actors. That thinking led to the creation of an informal Combined Space Operations alliance grouping the US, the UK, Canada, Australia, New Zealand, France and Germany. This adds Paris and Berlin – but notably not yet Italy, a significant European space player – to the Five Eyes group of nations that closely share intelligence.

The group issued a vision statement for 2031 that outlined the objectives of developing interoperability in space and collaborating "to protect and defend against hostile space activity".

"We share a desire to accelerate and improve our ability to conduct combined military space operations, as responsible space actors, in order to maintain security and prevent escalation in space and on earth," the joint statement said. [22]

(20) https://spacenews.com/space-force-looking-at-what-it-will-take-to-refuel-satellites-in-orbit/

(21) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1055940/Combined_Space_Operations_Vision_2031.pdf

(22) Interview with the author, March 2022

Space deterrence

One factor that may determine how far Western powers go down the road of the weaponisation of the cosmos is the perception of **what forms of deterrence are possible in space.**

We know from experience that nuclear deterrence, sometimes described as the balance of terror or Mutual Assured Destruction (MAD), has functioned for the last seven decades to prevent the use of atomic weapons on earth since their initial use by the US in 1945. We also now know that the world came uncomfortably close to a nuclear exchange by accident or due to heightened superpower tensions on several occasions during the Cold War.

Even though both Washington and Moscow developed tactical nuclear weapons and toyed with the idea of a limited nuclear war, **deterrence is based on the certainty that a strategic nuclear exchange between great powers would annihilate tens of millions of people and potentially render the planet uninhabitable.** On a more local level, a country like Israel, Pakistan or North Korea can feel reasonably confident that possession of a devastating weapon of last resort protects it from being totally overrun by a hostile neighbour or a great power.

The same assumptions do not apply to attacks on space assets, which might cause no casualties on earth, and the most severe consequence of which might be to render certain earth orbits unusable for all. Countries that are technologically or militarily less capable than the US may see an asymmetric advantage in attacking its military or civilian space assets to throw sand in its eyes or try to disable the positioning, navigation and timing services on which its weapons systems depend.

"Some nations may have an offensive capability in space but be less reliant on space [than Western countries are]. That may entice some adversaries," a senior NATO military policymaker said. "It's just too tempting not to develop capabilities with another nation's space capabilities. So the deterrent can't just be 'you take out my satellite and I'll take out yours'." [23]

Seeking to deter any such temptation, former president Donald Trump declared in December 2020: "Any purposeful interference with or an attack upon the space systems of the United States or its allies that directly affects national rights will be met with a deliberate response at a time, place, manner, and domain of our

(23) https://trumpwhitehouse.archives.gov/presidential-actions/memorandum-national-space-policy/

choosing." In other words: **you hit us in space, we may hit you on earth.** [24]

Fear of assured retaliation may well restrain a massive offensive in space or the use of easily attributable capabilities such as a vertical-launch ASAT weapon. However, **much military activity nowadays takes place in the grey zone between war and peace where attacks are often hard to attribute.** Since there are no direct human casualties from acts of sabotage in space, the threshold for responding to such a strike is blurred. The possession of a full range of offensive counter-space capabilities may thus not be a deterrent against such attacks.

"There are a lot of indeterminate objects in space. **It will often be hard to distinguish attacks from accidents**," said Pasco. [25]

In 21st century warfare, space is becoming just another infrastructure – an enabler that is part of the wider information technology ecosystem and involves some of the same players. **The cost barrier to entry is falling rapidly with the emergence of big commercial operators**, driven by the same advances in digitalisation, miniaturisation and automation that have revolutionised aviation, automobiles, computers and distribution.

The **availability of cheap satellite imagery is already changing the balance of power** and the way war is fought on the ground, as the Russia-Ukraine conflict has illustrated. It made Russia's massive armoured forces highly vulnerable to more nimble Ukrainian defenders.

"The beneficiaries of spacepower can disperse whilst retaining an effect previously gained only by massing forces into large concentration," British space power theorist Bleddyn Bowen of Leicester University has pointed out. "The opponents of such a force must disperse, counter spacepower, intercept precision munitions in response, or face annihilation." (26)

States do not need to be spacefaring powers to reap some of the benefits of space intelligence, surveillance and reconnaissance, nor to be able to deny or inhibit control of space by a major power, whether by cyber-attacks, jamming and spoofing or ground-based effects.

From an exclusive bespoke military-led domain open only to a handful of advanced powers, **space is becoming industrialised, privatised and democratised**, for better and for worse.

(24) Interview with the author, March 2022

(25) Bleddyn E. Bowen, War in Space: Strategy, Spacepower, Geopolitics; Edinburgh University Press 2020

NATO Space Command

CHAPTER 3

NATO in space

Joining the dots

NATO had come a long way in a short time in integrating space into its strategic thinking.

At its London summit in 2019, **the alliance declared space its fifth operational domain** after land, sea, air and cyberspace. Defence ministers decided in 2020 to open a NATO Space Centre. At their 2021 Brussels summit, allied leaders declared that "attacks to, from or within space present a clear challenge to the security of the Alliance, the impact of which could threaten national and Euro-Atlantic prosperity, security, and stability, and could be as harmful to modern societies as a conventional attack. Such attacks could lead to the invocation of Article 5 [NATO's mutual defence pledge]."

NATO also welcomed a French proposal to host a space centre of excellence in Toulouse, home of the French and European aerospace industry, which highlighted both Paris' more constructive engagement in the alliance and its wish to leverage its national space expertise. The centre started work in 2021 and should be up to full strength by the middle of the decade. [1]

However, the alliance has taken a cautious approach to developing its own role in space defence, making clear in an overarching Space Policy, published in January 2022, that **it does not plan to develop its own space capabilities, but will rely on national assets and join the dots by acting as a venue for consultations and a clearing house, when desired, for member nations.**

"Considering that the alliance is not aiming to develop space capabilities of its own, allies will undertake to provide, on a voluntary basis and in accordance with national laws, regulations and policies, the space data, products, services or effects that could be required for the alliance's operations, missions and other activities," the policy said.

As if that were not modest enough, it added: "NATO is not aiming to become an autonomous space actor. NATO will seek to complement and add value to the work of allies and to engage with other relevant international organisations, as appropriate, avoiding unnecessary duplication of effort." [2]

Officials say these humble beginnings may lead to **a fundamental change of approach towards space over time because of a**

(1) https://www.nato.int/cps/en/natohq/news_185000.htm

(2) https://www.nato.int/cps/en/natohq/official_texts_190862.htm?utm_source=linkedin&utm_medium=nato&utm_campaign=20220117_space (author's italics)

shared sense of the growing challenge from China and Russia. "This is 'Year One' of developing a real space defence policy," a senior NATO official said. [3]

"This serves as a policy unlock for several other policy layers," a leading military policymaker added. "It allows the NATO system to start to grind on staffing and thought processes, to create a big body of expertise and to work space into our doctrine and our change management."

The first stage was to make political leaders and commanders more aware of the opportunities and threats in space, and to try to maintain Western technological superiority by exchanging information and best practice, and drawing on private sector expertise. One area in which NATO may need its own space capabilities is when it comes to replacing its commonly-funded 1980s-era Airborne Warning and Control System (AWACS) aircraft with a more modern multi-layered surveillance infrastructure.

NATO is studying a range of new technologies and different options to replace the 'eyes in the sky' AWACS aircraft, which are Boeing jumbo jets with a mushroom-shaped radar on top. The replacement could entail a combination of systems in the air, on land, at sea, in space and in cyberspace. That might eventually involve a commonly funded space element, some officials say.

Sharing or shielding?

Both the US, which has the overwhelming preponderance of Western military space assets and is highly protective of its classified programmes and projects, and France, the second space power in the alliance, were reluctant to give NATO a higher-profile role in this sensitive area or to commit to sharing sensitive space-based intelligence with all 30 allies through NATO.

To protect the secrecy of sources and methods, **intelligence is usually shared in much smaller circles**, such as the Five Eyes Treaty grouping of the US, the UK, Canada, Australia and New Zealand, or bilaterally. The alliance only created a joint intelligence division in 2016, recognising the need to increase the amount of classified information analysed and exchanged via its headquarters.

"US space imagery is not even Five Eyes but NOFORN [not releasable to foreign nationals], with case-by-case releasability,"

(3) Interview with the author, March 2022

said the senior NATO official. In the run-up to the Russia-Ukraine war, Washington shared more satellite intelligence than usual with a slightly wider group of allies, including France and Germany alongside the Five Eyes, but it is not clear whether those ad hoc arrangements will last beyond the conflict.

The embryonic NATO Space Centre received some high-quality commercial space imagery on Ukraine as part of a pilot project to enhance open-source satellite data using advanced software and AI, the official said. "We're working with allies on space data sharing. We've got to move from a need-to-know basis to a need-to-share mentality."

"The war may be setting a precedent. **We are moving gradually from case-by-case releasability to releasability in principle** [unless otherwise decided]," the official said. The pervasiveness of the ability to use high-quality commercial satellite pictures that can be shared quickly because they do not need to be declassified is likely to change mentalities.

It may also change the nature of warfare. "It's becoming increasingly difficult for any nation to manoeuvre clandestinely, especially with the availability of electro-optical commercial imagery to not only the belligerents," the senior military policymaker said. In some cases, the US administration had made commercial satellite companies with government contracts agree "to block out national security areas" in the imagery they sell. That may explain why no space images of the disposition of Ukrainian forces or weapons supply routes from NATO countries have been published so far during the war.

A senior military officer noted that US Space Force Chief of Space Operations General Jay Raymond had underlined the need to classify information appropriately so that it isn't withheld from the end user. "We've become better at disseminating information. We do see that nations are more willing to share. But there are always going to be crown jewels that each nation will keep to itself." (4)

NATO's role will be to ensure that space is integrated into the delivery of the alliance's core tasks of collective defence, crisis management and cooperative security. This includes serving as a forum for political-military consultations and information sharing on space developments to help the alliance's situational awareness, decision-making and readiness, ensuring that alliance operations receive effective space support, and promoting interoperability of allies' space services.

NATO has had its own commonly funded satellite communications programme since 2005, based on services provided by France, Italy and the UK, which was upgraded in 2020 when the US joined as an additional provider. Moreover, the 2021 Brussels summit backed plans to develop a Strategic Space Situational Awareness System (3SAS) at NATO Headquarters to better understand the space environment and space events, and their effects across all operational domains.

(4) https://transforming-classification.blogs.archives.gov/2021/03/08/space-operations-chief-decries-over-classification-and-its-effect-on-operations/

Slow build-up

The NATO Space Centre, occupying a small, dedicated area inside Allied Air Command in Ramstein, Germany, is a monument to the modest, incremental nature of the alliance's ambitions in space. It began with three staff officers in 2020 and has grown to eight in mid-2022. Finding qualified, available staff in this highly technical field has been hard. "They are a little team. It will take a number of years," a NATO official said. "NATO is competing with countries for specialists." [5]

Their main task is processing requests daily from NATO commanders for assistance from allies with space data. The number of requests increased after the start of the war in Ukraine, not only from NATO entities on the eastern flank but also for commanders in NATO's Cold Response exercise off the Norwegian coast.

"Right now, we're facilitating and collecting information, fusing information delivered from a variety of sources – government and commercial – and delivering it to commanders to facilitate their decisions," a senior officer said. [6]

Ensuring commanders and NATO officials are accustomed to how space systems function and increasing awareness of threats in space can only be achieved gradually. "We started from scratch," the officer said. "This is still a small journey."

Staff from the centre have attended space defence simulations, such as the US Schriever Wargames at Nellis Air Force Base in Nevada and France's AsterX space exercises in 2020 and 2022 in Toulouse. But asked whether NATO might run its own space exercise, the officer said: "I'm not sure we're there yet to do our own exercise."

NATO's lumbering defence planning process makes it difficult to adapt to a fast-moving field like space, increasingly dominated by the commercial sector. "It will be uncomfortable for allies who wrap ourselves up in security classifications and bureaucratic process. We're going to have to do better in the future," a defence planner said. [7]

The alliance works on a four-year planning cycle, with ministers giving political guidance that serves as the basis for setting force goals for member nations. The last political guidance in 2019 did not say much about space, and the next round, due in 2023, may not either. "It will be interesting to see if allies enshrine more space capabilities. I suspect not. It will take time to set space force goals. Before 2027, it's likely to be on

(5) Interview with the author, March 2022
(6) Interview with the author, March 2022
(7) Interview with the author, March 2022

an ad hoc basis, with allies approached by the command structure and not part of any obligation," the defence planner said.

NATO is highly unlikely to take a collective position on developing counter-space systems, which is seen as a "super-sensitive" national prerogative that allies are reluctant to discuss. "The only counter-space capabilities we can talk about are the capabilities of the other side," the defence planner said. "We talk in terms of reducing vulnerabilities, building resilience and having so many systems that if one went down, there would be a failover."

Officials say they are using tabletop exercises and scenario-based discussions to make clear where key weaknesses lie at the political and senior commander levels, and also integrating the notion of multi-domain warfare, in which armed forces will need to be much more joined-up than ever before. "People in senior leadership positions don't understand what those vulnerabilities are," the defence planner said.

Blurred threshold

There has been some initial discussion among NATO officials and ambassadors about what kind of attack on an ally's space assets might trigger an Article 5 response, but **most allies are keen to retain a degree of strategic ambiguity to discourage any testing of the frontiers.** Besides, vexed questions of attribution and decision-making processes make it hard to give pre-formatted answers. NATO officials have tried to tease out some of this ambiguity in tabletop exercises.

The only time NATO has invoked Article 5, which requires a unanimous decision by the 30 allies, was after the 11 September 2001 terrorist attacks on the US. It did not lead directly to military action, although it was a clear physical attack on a NATO country by an identifiable non-state actor that caused more than 3,000 casualties.

By contrast, it is hard to imagine NATO triggering Article 5 following an incident involving the destruction of a privately-owned civilian satellite, or even several, with no human casualties. Such an attack might be passed off as a debris collision. "**Imagine the difficulty of taking an Article 5 decision on something that by all appearance is the legal equivalent of an automobile accident**," said an expert who has worked on such hybrid exercise scenarios.

The wording of **the 2021 Brussels summit communiqué was deliberately vague about the nature or level of hostile activity in space that might draw a NATO response.** "A decision as to when such attacks would lead to the invocation of Article 5 would be taken by the North Atlantic Council on a case-by-case basis," it said. The first challenge would be to identify beyond doubt the origin and intention of such an attack – easy enough if it involved a vertical-ascent ASAT weapon, but much harder if it involved a collision in space or an electro-magnetic pulse that disabled a Western satellite.

"Leaders agreed that an attack on a space system could be considered under Article 5. Not every such attack. **We hope that will be interpreted by adversaries as a deterrent**," the defence planner said. "We are trying to discourage that sort of behaviour to ensure we can continue to do what we need in space."

A British official said there were possible analogies with incidents at sea. "We don't like it if a ship cuts across our bows, but that is classified as unfriendly, not hostile. But if it opens fire, that is a hostile act," the official said. "If Russia or China dazzle one of our satellites, is it an act of war or just an unfriendly act? Those are the sorts of policy debates we're starting to have." [8]

(8) Interview with the author, March 2022

Working with the EU

Without its own space capabilities or a big common budget, NATO is dependent on a handful of members or outside providers of space services and data. But there may now be an opportunity to work with the EU in this field.

The two organisations signed an agreement in Warsaw in 2016 on increased cooperation in a range of fields, including countering hybrid threats, enhancing resilience, defence capacity building, cyber-defence, maritime security and exercises. Two years later, they agreed to focus on swift progress in the areas of military mobility, counter-terrorism and strengthening resilience to chemical, biological, radiological and nuclear-related risks. However, **space has so far been excluded from the areas of cooperation**, not least because the EU did not formally recognise the military utility of its space programmes. That may be about to change.

The two organisations look at space with very different eyes. NATO's approach is operational, whereas the EU's primary focus is promoting economic growth, scientific achievement and security, notably at its borders. Political sensitivities aside, **there is a natural complementarity between NATO's analytical emphasis on space-based intelligence on regions outside Europe, and the EU's focus on Europe and its immediate neighbourhood.**

Space is one of the rare security areas in the relationship where the EU would not be a junior partner. With large existing dual-use capabilities, including the Galileo satellite navigation network, the Copernicus earth observation system, the EU Satellite Centre in Spain and the Governmental Satellite Communication (GovSatCom) programme, in addition to a sizable space budget, **the EU has key assets of its own that are of interest to NATO.**

"It won't be an easy discussion because the EU has seniority in this field and know-how, while NATO is a supplicant and doesn't bring a lot to the table. NATO could be a customer for EU services," the senior NATO official said. However, the fact that **the EU has now openly recognised that its space systems have a defence utility** and are not purely for civilian or scientific purposes was an important change in mentality and a good starting point, he said.

"Working with the EU in space is on our to-do list," the military policymaker said.

Since most EU member states are also members of NATO, there ought to be room for cooperation. But there will also be hurdles, not least the complex position of the UK, which exited the EU in 2021 amid political acrimony and has rebuffed all calls so far to negotiate even a minimal security and defence relationship with the Union.

Earth from space with a focus on Europe

CHAPTER 4

Europe in space

Ahead and behind

Europe is both ahead and behind in space. Its satellite navigation and earth observation systems are world-leading, its 25-year-old Ariane 5 rocket remains the most accurate and reliable launcher, and it has undisputed expertise in space science. But worryingly, the **Europeans are far behind other major powers in space security** and they need to catch up fast.

To speak of Europe in the context of space is complicated in itself. The main civilian and scientific programmes are conceived and developed by the inter-governmental ESA, based in Paris, whose 22 members include some but not all EU member states, as well as non-EU members Norway, Switzerland and the UK. **ESA is a major player in space exploration** on its own and in partnership notably with NASA and its Russian counterpart, Roscosmos, until the Ukraine war severed cooperation.

The EU has its own space capabilities: the 22-satellite Galileo global navigation system and the related European Geostationary Navigation Overlay Service (EGNOS), the Copernicus earth observation satellite system, and the GovSatCom network. All of these have, or will eventually have, dedicated secure channels for government uses. The EU created its own operational agency for the EU Space Programme (EUSPA) in 2021 to manage the four programmes, and to implement and monitor the security of the EUSPA.

"**Space is one of Europe's great underrated successes**," said Claude-France Arnould, a former head of the European Defence Agency, EU space envoy and space policy advisor to the French government. "**Space shows the relevance and value of the scale of the EU.** It's the only way we can compete with the US or China." [1]

The EU contributes 26% of ESA's €6.9bn annual budget, giving it a big say in the agency's activities, but not the sole say. Member states contribute 67% and the rest comes from income from the European meteorological satellite (EUMETSAT) and other services.

The relationship between the European Commission and ESA has long suffered from political tensions and power struggles, but **it has improved since the two institutions concluded a Financial Framework Partnership Agreement** – a sort of peace accord – in June 2021, unlocking €9bn in EU investments in the 2021-2027 period.

(1) Interview with the author, March 2022

ESA's Director General Aschbacher made strengthening EU-ESA relations, as well as security and safety in space, two of his Agenda 2025 programme's five key priorities in April 2021.

The EU earmarked altogether €13.4bn in its 2021-2027 long-term budget for space – a 36% increase from the previous budget period, but still small change compared to US military and civilian public investment in space of some $55bn per year.

"Europe has an economy of a size similar to the United States and China, but in space, it has much lower capability," Aschbacher said in an interview. "Europe risks being thrown out of the race, as in IT [information technology]. **We risk the same in space if we are not investing.** Private investment in space is one-fifteenth in Europe of what it is in the US." [2]

As another veteran European space official put it: "We are neither as entrepreneurial as the US nor as dictatorial as the Chinese."

Wake-up call

Defence was long a taboo subject for the EU, partly because the Union treaties explicitly bar spending from the community budget on military operations and the production of military capabilities. However, EU lawyers found ways around that restriction, and **since 2017, the EU has embraced the goal of a defence union**, creating a modest European Defence Fund to finance joint military research and development projects, and embarking on so-called Permanent Structured Cooperation (PESCO) on defence capability projects.

Institutionally, the Commission took a step towards becoming a player in the defence aspects of space by creating a new Directorate-General for Defence Industry and Space (DG DEFIS) in 2019, which comes under the powerful industrial and regulatory portfolio of Commissioner Thierry Breton.

In partnership with High Representative Josep Borrell, **Breton has championed the goal of European strategic autonomy in defence and space.** That objective received a boost in February 2022 when Russia invaded Ukraine, triggering the first major war on the European continent since 1945 and catapulting stronger European defence up the agenda of the EU and NATO.

A week before the Russian assault, Breton had presented a package of proposals for a space-based secure connectivity system

(2) Interview with the author, March 2022

and a European approach to space traffic management, including space surveillance and tracking capabilities. He also suggested that **the EU could develop its own space command in the medium-to-long term.** [3]

"On 24 February, the situation changed 180 degrees. It was an eye-opener for many of us as to how vulnerable we are. It's clear we cannot continue as is. We have to take this as a wake-up call," Aschbacher said. Member states are now clamouring for more autonomy and resilience.

President Macron addressed a space summit in Toulouse a few days before the invasion and pinpointed how **Europe had missed out on strategic turning points in recent years**, notably in reusable launchers, the New Space sector and the space arms race. "Europe is very largely absent from this new deal," he told ministers from EU and ESA countries.

Macron said Europe needed to defend its own sovereignty in space by developing "the means to protect our own space assets and to respond with all our allies to attacks on our capabilities". He also called for a "European preference" when launching public satellites, an approach with which some free-trading European partners disagree.

"There can be no industrial and research policy if Europe is the only naive power which doesn't apply the principle of giving priority to itself," he said. "The Chinese do it, the Americans do it. But we don't do it systematically." [4]

The debate about a "European preference" in space launches hits Europe at a particularly vulnerable time when new Ariane 6 and Vega C launchers have yet to make their maiden flights. This leaves most satellite operators without a European launch option in 2022 after Roscosmos' withdrawal of its Soyuz rockets. Those in a hurry are looking for a ride with SpaceX or other US or Indian launchers.

Most defence-related European space activities are conducted by a handful of states with space capabilities – France, Germany, Italy, Spain and the UK – either nationally or in partnerships, such as the Franco-Italian Athena-Focus military communications satellite and the MUSIS optical image-sharing alliance of France, Italy, Germany, Belgium, Greece and Spain. "**Few European member states have capabilities and they are reluctant to share or even to cooperate**, for example, on remote sensing high-resolution satellites," a veteran European space official said. [5]

There is an informal division of labour under which the EU and ESA provide enablers, but member states handle military space requirements by themselves.

However, the times may be changing. Four of the PESCO projects launched since 2017 involve developing military space capabilities: ballistic missile early warning and interception, military use of Galileo, military space situation awareness and defence of space assets.

(3) https://nove.eu/wp-content/uploads/2022/02/NOVE-Summary-of-the-EU-Space-Package-February-2022.pdf

(4) https://www.elysee.fr/emmanuel-macron/2022/02/16/strategie-spatiale-europeenne-le-discours-du-president-emmanuel-macron-toulouse

(5) Interview with the author, February 2022

Different strategic cultures

The birth of European countries' space programmes highlights longstanding differences in strategic culture and the approach to space in Europe. European scientists – some of them refugees from fascism in 1930s Europe and others who had worked on Nazi Germany's V2 rocket programme – **helped the US and the Soviet Union launch their first satellites** into space.

Italy became the third country to enter space, launching its civilian San Marco space probe atop a US rocket in 1964. The following year, France was the first European country to launch a military satellite using its own rocket. The communications satellite was nicknamed AsterX after the plucky little Gaul, Astérix, resisting Roman rule in the eponymous cartoon books. It was a propaganda coup for General de Gaulle's French exceptionalism during the Cold War. From the outset, **France was determined to establish an independent national space industry not reliant on other powers.**

The UK followed with its first Skynet military communications satellite in 1969, but it was launched by a US rocket. The UK never developed its own launchers and was agnostic about whether its military probes were transported by US or European rockets – whichever was cheaper. **To this day, the UK relies entirely on the US for military satellite imagery** and many British politicians think that is not a problem or a vulnerability.

West Germany launched a first scientific space satellite in 1969, using a US rocket. Its space programme long remained exclusively civilian, due to historic restraint in military matters and a strong pacifist strain in public opinion. When united Germany finally launched its first military reconnaissance satellite, SAR-Lupe in 2006, it was aboard a Russian Soyuz rocket from a launchpad in Plesetsk, Russia.

The same year, Spain became the only other European country to have put a military satellite in space so far. It was launched by a European Ariane rocket from the French/European spaceport in Kourou, French Guyana. Poland plans to launch its first military satellites by 2024.

French President Emmanuel Macron

French agenda?

Fault lines in political outlook and strategic culture, as well as industrial rivalry, continue to hamper European cooperation in space. While **France, the EU's biggest space power, insists on achieving European strategic autonomy** and making Europe less dependent on the US for launches, satellite intelligence, SSA and space debris alerts, other European countries are happy to rely on the US or the commercial sector.

When Breton announced his proposals for the EU to build its own constellation for secure connectivity and universal broadband access, some member states grumbled that this was just a 'French commissioner pushing a French agenda'. German, Dutch, Austrian and Luxembourg officials **questioned whether the EU really needed a publicly funded constellation when many member states already share secure satellite communications** and broadband internet is commercially available from the private sector.

"We are aware of the need, but it's too early to say whether the Commission proposal is the

right approach. There are still a lot of unknowns. Our most important concern of course is that we have to absolutely make sure we do not distort the market," said Link of the Luxembourg Space Agency.[6]

The German government's space coordinator and Greens lawmaker, Anna Christmann, questioned whether the real need was for secure communications, when the GovSatCom programme was already providing pooling and sharing of national capacities, or to extend broadband coverage to remote rural or Arctic areas. She stressed the need to involve the New Space sector and to ensure there was private money backing the plan, as opposed to "only a public initiative where we get another public-paid satellite into orbit every few years and we're not having a clear demand for the services. That would be the negative scenario."[7]

EU diplomats suggested Berlin's reticence was partly driven by a concern to secure business for its own dynamic New Space companies, such as Isar Aerospace, Rocket Factory Augsburg or Exolaunch, and to obtain assurances that the tenders would not be skewed towards big incumbents, notably Arianespace.

"Macron's speech in Toulouse was right, but from a German point of view, it raises alarm bells about the French national interest to keep French industry still on top of the European space sector. There's always that suspicion," said Andrea Rotter, an expert on German space policy at the conservative Hanns Seidel Foundation.[8]

An EU official said the Commission was holding an intensive bilateral dialogue to convince Berlin that both German "old space" incumbent, OHB System, and New Space companies would have **plenty of opportunities in the secure connectivity constellation.** The war in Ukraine has made it far more likely that the plan will go ahead, although there are still question marks about the funding, with member states and the private sector expected to contribute €2bn each.[9]

An initial attempt to fund the Galileo satellite navigation system by public-private partnership collapsed in the early 2000s, forcing the EU to take over the whole cost, which burgeoned from the initially planned €3bn to an eventual €10bn, and was completed 13 years behind schedule. The US initially opposed Galileo as an unnecessary duplication of its own GPS system and wrote warning letters demanding to limit the radio frequencies the EU system would use. Now, **Washington embraces Galileo as a valuable contribution to Western resilience** in an increasingly hostile environment.

The Commission estimates the secure connectivity system will cost €6.4bn, of which €2.4bn will come from the EU budget. EU officials say the difference with Galileo is the large commercial markets that a European broadband constellation will open for European companies, giving them a clear interest in investing. **Industry executives are less sure that the market will be attractive enough for the private sector to invest** in the infrastructure.[10]

(6) Interview with the author, April 2022
(7) https://m.youtube.com/watch?v=p_DLSAPpkUo
(8) Interview with the author, February 2022
(9) Interview with the author, April 2022
(10) Interview with the author, February 2022

Space policy divide

France, Italy and the UK have published space defence policies in the last few years **recognising the vital importance of access to space and of space communications for military operations**, and the growing threat to space systems. Germany has adopted space defence guidelines, which remain classified, probably because of public sensitivities about any military role in outer space.

France, which has Europe's most advanced military space programme, is the only European state that has **openly announced plans to develop so-called 'active defence' measures.** Armed Forces Minister Florence Parly said in 2019 that Paris planned to field a fleet of nano-satellites equipped with cameras to shield and watch over its strategic space assets, and to use laser dazzlers to repel attempted hostile approaches.(11)

However, France draws the line at kinetic space weapons, such as ASAT rockets, which cause space debris.

France's Space Command is the pioneer in Europe of space defence exercises simulating a comprehensive range of space accidents and potential hostile or ambiguous acts against space assets. Officers and observers from the US, Germany, Italy, Belgium and more than a dozen other nations, NATO, the EU and ESA, as well as commercial space sector executives, took part in the second AsterX exercise in Toulouse in March 2022. "Space is evolving very fast, but we are moving very fast too," said General Michel Friedling, Commander of the French Space Command. "**We don't have much time to face up to the challenges**, which keep growing."(12)

Germany has military communications and earth observation satellites but remains coy in talking about space defence. In a keynote speech at the 2022 European Space Summit, Christmann stressed **the importance of space in fighting climate change and developing a vibrant commercial space sector** but said nothing about its security role.(13)

She has poured cold water on proposals to create an offshore spaceport in the North Sea for micro-launchers sought by German New Space companies. She questioned the utility

(11) https://www.vie-publique.fr/discours/268578-florence-parly-25072019-strategie-spatiale-de-defense
(12) https://m.youtube.com/watch?time_continue=3299&v=zAmfuydWqXU&feature=emb_logo
(13) https://spaceconference.eu/programme/

on environmental grounds and suggested that remote existing launch sites in Norway or northern Sweden could be used instead. [14]

"The problem we in Germany have is that we don't think of space as a strategic or military domain," Rotter said. "The public discourse is focused on exploration and the new space industry."

The war in Ukraine may yet change that, as it has already led to a substantial increase in German defence investment and an easing of longstanding arms export restrictions. However, **it may entrench other divisions among EU member states, with central European countries even more determined to keep the US engaged in European security**, including by buying weapons systems and satellite services from US companies.

Those divisions emerged over the US-proposed Artemis Accords on space resources, which Poland, Italy and Luxembourg have signed, while other EU countries have stayed out so far.

A similar European divide may occur over Commission proposals for guidelines and standards to regulate space traffic management (STM). Some advocates, such as German MEP Nicklas Nienass, argue that the EU needs its own legislation making entry to space contingent on a commitment to remove satellites from space at their end of life, and to remove all debris. Others contend it would be better to negotiate such rules at the multilateral or UN level to avoid putting European industry at a disadvantage.

The Commission argues it is essential for the EU to develop its own space surveillance and tracking tools to avoid being totally or mostly dependent on the US for any vision of the risks in space. Some member states see this as a national competence.

Others are relaxed about trusting the US to continue providing data and collision warnings as a global public service because it is in Washington's interest as the world's biggest user of space to avoid accidents and debris.

Some Brussels officials noted that the US had in the past downgraded the GPS signal it shared with allies and been selective in the satellite intelligence it shared with them, notably in the run-up to the 2003 Iraq War. But French warnings that the EU needs to prepare for a possible return of Donald Trump or the election of another president hostile to Europe do not convince everyone of the need for big spending to duplicate US capabilities.

(14) https://www.zeit.de/wissen/2022-01/anna-christmann-gruene-raumfahrt-weltraumbahnhof-klimakrise?utm_referrer=https%3A%2F%2Fwww.google.com%2F

Brexit cost

The loss of the UK as a member state amid political acrimony has been a blow to the EU's space capabilities, if not to its ambitions.

While **the UK has a thriving New Space sector** and is planning its first domestic micro-launch by the end of 2022, it has chosen to rely entirely on the US, its closest ally, for satellite intelligence and SSA in return for hosting a major US space radar station. The UK has its own Skynet military communications satellites but since Brexit, it is wholly dependent on the US GPS system for positioning, navigation and timing.

Following the 2016 referendum decision to withdraw from the EU, **the UK was ejected from the secure parts of the Galileo and EGNOS programmes.** British companies had supplied the most sensitive encryption technology for the planned Public Regulated Service. The Commission's view, backed by member states, was that a 'third country' could not be allowed in the most sensitive areas of a sovereign EU satellite navigation, positioning and timing capability. The UK government decided it would not be 'value for money' to stay in the rest of the programme.

The UK agreed to pay to participate in several other EU programmes, including Copernicus, however, the EU has not yet implemented that agreement in principle due to disputes over other aspects of their Trade and Cooperation Agreement, especially the trade arrangements for Northern Ireland. The EU also says the UK must first sign a protocol on its participation in Union programmes as a legal basis for cooperation. As a result, **the UK is withholding its contribution to the Copernicus budget**, leaving a €750mn hole in the funding of the EU's flagship earth observation programme over the 2021-2027 period. This is delaying some contract decisions.

Many European space officials and entrepreneurs lament the break-up with the UK, wishing its vibrant New Space sector and security expertise could be retained in the European space industrial base, but political realities suggest that is unlikely to happen, at least until the UK has a government willing to engage with the EU on foreign policy and defence cooperation. Prime Minister Boris Johnson ruled out any institutional agreement with Brussels on those issues.

"I am convinced **we have an interest in continuing to cooperate in the military and space domain with the UK**. But the current climate doesn't even enable us to sit down and

discuss this," said Arnould, the former EU space envoy and defence agency chief.

Another veteran European space official said he could not see how the EU could build its proposed secure connectivity constellation and space surveillance and tracking tools without UK know-how. "A sensible successor to Boris Johnson could see the common sense in doing things together with their closest neighbours," he said. [15]

Seen from the other side of the Channel, **Breton's emphasis on EU strategic autonomy narrows any possibility for UK engagement on equitable terms.**

One theoretical possibility would be to link the planned EU constellation to OneWeb's growing network of broadband internet satellites, especially since Airbus, an EU company, has a satellite joint venture with OneWeb and is partnering with it to offer communication services to some European and British armed forces, security and civil protection services. In addition, Paris-based satellite communications company Eutelsat has a 23% stake in OneWeb.

However, an EU official said **cooperation was very unlikely** both because the UK sought its own sovereign capability and because the EU wanted a single architecture for the entire secure connectivity structure.

For now, the EU and the UK appear to be in divergent orbits and unlikely to be able to extract mutual benefit from their space sectors.

(15) Interview with the author, March 2022

Timothy Peake, Astronaut

Inherent obstacles

Brexit was not the only blow to the EU's space capabilities. It is often said that **lack of access to venture capital is the biggest handicap for European innovators.** To try to counter this problem, the Commission has earmarked a €1bn space investment fund as part of its CASSINI initiative to seed and grow New Space innovation. [16]

But tech entrepreneurs say **a number of other inherent obstacles slow down progress in space** and handicap its companies. They include the tendering system and contract allocation, bureaucracy, risk-aversion, 'old space' bias and the time it takes to receive a patent for innovation in Europe.

"The biggest hurdle is our way of public procurement. We're still stuck in the 20th century," said André Loesekrug-Pietri, Chairman of the Joint European Disruptive Initiative (JEDI), a funding agency aimed at promoting disruptive technologies along the lines of the US Defense Advanced Research Projects Agency (DARPA). For example, the Commission had indicated that the initial constellation tender would be open to companies with at least a €100mn turnover, which would effectively shut out New Space entrepreneurs and favour large incumbents such as Thales and OHB. After outcry, the Commission reopened the call for proposals. However, most small companies do not have the dedicated teams it takes to respond to an EU public tender.

Since the Commission's DG DEFIS is so recent, there is very limited in-house competence, compared to national defence ministries, in evaluating proposals for complex technological projects that require expertise in antennae propulsion, uplink and downlink systems. **The prevailing culture is to go with trusted large providers** with a track record.

"There's only one Elon Musk, but if you're depriving yourself of new entrants or, like the French Direction Générale de l'Armement, making new start-ups work as subcontractors to old prime contractors, then **there's no incentive for the smaller companies to bother tendering**," Loesekrug-Pietri said. [17]

He also suggested **the EU should be trying to leapfrog US competition rather than seeking to catch up** when competitors have moved on one or two generations – as it is still doing with a European drone project two decades after the US Reaper was first fielded, or by pressing to develop a European reusable launcher when Musk has already captured the market.

(16) https://ec.europa.eu/defence-industry-space/eu-space-further-cooperation-support-space-entrepreneurship-europe-2022-01-25_en
(17) Interview with the author, April 2022

Loesekrug-Pietri said it was taking the European Defence Fund on average 18 months to award tenders for disruptive projects. "We live in an era where **speed is often more important than money.** We're sure to miss the target at that pace," he said. "When it's so slow, you lose the best people and the best companies."

ESA's Aschbacher acknowledged that **the time it took to award contracts was a major problem**, which he was committed to remedying. "Speed – we have to increase our reactivity and be more dynamic and more risk-taking," he said. He pledged to accelerate the process of opening a competition, evaluating proposals and then supervising trials.

Another issue raised by entrepreneurs – and recognised by Aschbacher – is **the time to register a patent in Europe**. Alfredo Muñoz, a Spanish space architect who has designed a prototype for a self-sufficient settlement on Mars, says he left Europe and moved to the US because of such obstacles. "I appreciate the level of support for innovation in the US compared [with] Europe," he said. [18]

"I filed applications for design patents in the US, the EU and China at the same time in 2015. I got three patents in the US for $1,800 each without legal costs. So, within six years, I had three patents for $5,000. In the EU, I got an acknowledgement once from the EU Patent Office and they are charging me €1,500 a year just for sitting on the file," he said.

Given the lack of support for entrepreneurship, it was not surprising that the EU was behind in AI, big data, machine learning and quantum computing. "The US is politically a mess but the innovation ecosystem is there and it works," Muñoz said.

Two more potential barriers to European success are worth noting. The way that ESA enshrines in its rules the principle of geographical 'fair return' to spread work among its members is widely regarded as **inflating the cost of European space projects** artificially at a time when costs in the space industry have fallen worldwide. ESA officials respond that it has stimulated the emergence of growth-enhancing space sectors in countries such as the Czech Republic and Poland.

Another potential risk is that **the EU's planned taxonomy of sustainable investments could deter private sector investment** in the defence and aerospace sectors if it classifies weapons production as socially harmful. The green classification system is meant to support EU climate and environment goals, but the AeroSpace and Defence Industries Association (ASD) says the label would "restrict funding options and therefore the ability to deliver defence systems to European militaries". The Commission says it is still considering how to classify defence-related activities and has taken no decision.

Despite the obstacles, Europe's scientific and technological knowledge base and its collective and national space assets mean it is by no means out of the space race if it can focus its efforts on key capabilities.

(18) Interview with the author, March 2022

One of the EU's Galileo satellites in orbit, providing global navigation and positioning services

Astronaut in space

CHAPTER 5

Conclusions and recommendations

Running out of space, running out of time

The world is running out of space, and Europe is running out of time to help fix this conundrum.

Without urgent progress in space traffic management, at least in LEO, **humanity risks turning the most utilised bands of the cosmos into a celestial wasteland**, just as it risks making our planet progressively more uninhabitable through pollution and climate change.

Preserving the heavens as a common good and fighting space pollution require a similar sort of collective international effort that is being applied – albeit insufficiently – to combating global warming.

While climate action is the focus of ministerial conferences, multilateral agreements, research and foresight by the UN Intergovernmental Panel on Climate Change (IPCC), restless activism by environmental groups and constant media attention, there is no such mobilisation for space.

On the contrary, the cosmos is a theatre of strategic muscle-flexing among the major powers, a no-man's land subject to unilateral land grabs by commercial interests and a playground for billionaires with money to burn.

When the media focuses on space, it is usually either because a tycoon in a space suit is being blasted into the heavens on a vertical ego-trip or a scientific rover is prowling telegenically on Mars. These "Boy's Own" adventures mask the mounting dangers lurking in orbit.

The US, China and Russia are engaged in a space arms race that lacks the guard rails that have been applied to the nuclear weapons contest. Emerging powers, such as India, Brazil, Iran, the UAE and North Korea, are trying to muscle their way to the top table by investing in military space programmes. Among European nations, only France is working explicitly to develop 'defensive' space weapons, while the UK, Germany, Italy and Spain are seeking ways to protect their space assets.

Indian space entrepreneur and think-tanker Susmita Mohanty is right to say that when a single company can fire thousands of satellites into space with no international regulation – amounting to more than half of all the active satellites in orbit – it resembles a form of "colonialism 2.0", even if no one is being enslaved. "It reeks of a plutocrats' takeover of space," Mohanty said. [1]

(1) Interview with the author, February 2022

Space may not be entirely the "Wild Wild West" that she asserts, since commercial satellite operators do have to be licensed by their launching state, properly insured and allocated radio frequencies by the ITU. But the US government is happy to license its billionaires' constellations, not least because their companies also provide services to the Pentagon and NASA. There are no international space traffic rules, no littering fines or driving bans for states or companies that leave hazardous debris in space, and no allocation of parking spaces in LEO.

Safety and security at risk

Both space safety – the threat to all orbiters from cascading debris – and space security – the protection of nations' and companies' satellites from hostile activities – are at risk.

Space is an under-governed *terra nullius*, or 'nobody's land', where international norms and the rule of law have been eclipsed by humankind's increased access to it. **There is an urgent need for governance to catch up with reality.**

Without international rules of the road or at least codes of conduct that are politically binding, we will sooner or later face either a catastrophic chain of collisions that makes some orbits unusable, or a war in space – perhaps the former triggered by the latter. Moreover, given our everyday dependency on space, a rogue actor could potentially shut down a city or a region by disabling a satellite.

ESA and the Japanese space agency are funding laudable pilot projects with New Space companies to recover and remove space debris. **Catching floating space junk will always be more expensive, and less effective, than preventing it in the first place.**

That requires market tools, such as SSRs linked to insurance premiums to provide a financial incentive for best practice, but also coercive tools – such as heavy fines and denying licenses to companies that pollute. Europe and Japan – the 'civilian' space powers – should press the US, China and Russia harder to embrace and enforce the principle of Zero Net Space. [2]

UN committees charged with preventing an arms race in space and organising the peaceful uses of the cosmos toil in the shadows in Geneva and Vienna at a glacial pace. Meanwhile, new facts are being created on the ground and in the

(2) https://parispeaceforum.org/en/initiatives/net-zero-space/, interview with Justin Vaïsse, Director General of the Paris Peace Forum, February 2022

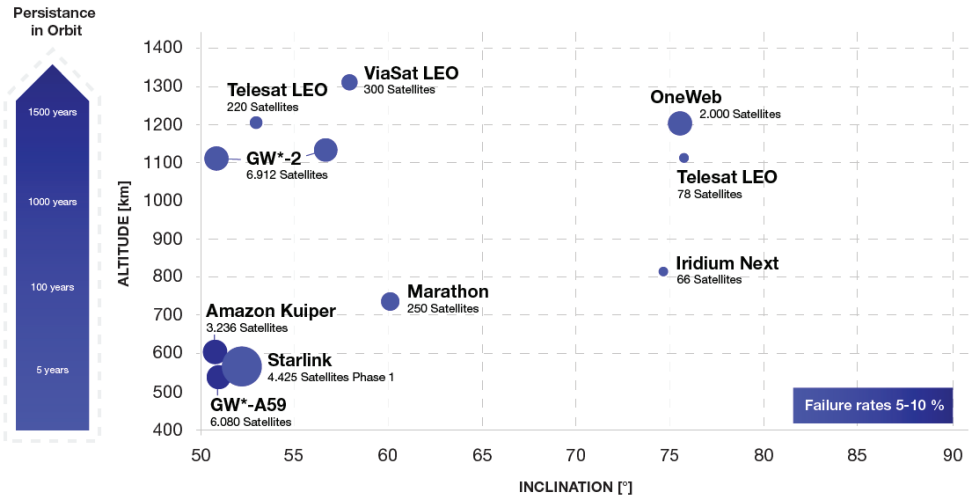
sky, with ASAT tests, experiments with lasers and other directed energy or electromagnetic weapons, and the deployment of inspection and potential interceptor satellites – not to mention cyberattacks on satellite uplinks and downlinks. UN leadership does not devote even a fraction of the political attention to space that it does, rightly, to climate change.

The militarisation of space is a fact of life. Europeans must stop being naive and protect their own interests in space as others do. **The Commission is on the right track with its recent space package but should cooperate pragmatically with like-minded third countries**, such as the UK, Norway, the US and Canada, rather than shutting them out in the name of strategic autonomy.

On the commercial side, companies are fast filling LEO with mega constellations on a first-come-first-served basis without any international regulation or supervision. States are legislating unilaterally on the sensitive issue of space resources, entrenching the 'finders, keepers' principle, while claiming it does not contradict the Outer Space Treaty's ban on appropriation of space or celestial bodies.

Given current geopolitical tensions, the chances of energising the UN regulatory process appear dim, though perhaps not entirely hopeless, given all spacefaring nations' common interest in keeping space open for business, climate monitoring and weather forecasting, science and communications, and navigation and earth observation.

Mega constellations of satellites



*Guo Wang - Chinese company founded in 2020, now called China SatNav, which has applied to the ITU for lots of frequencies but not yet launched a satellite.

The Russian and Chinese approach of seeking to ban by treaty the placement of weapons in space, but not the use of earth-based weapons that threaten other countries' space assets, is transparently flawed. While many nations, including emerging powers such as India, have a preference for legally binding rules, **it would make more sense to start by banning the ASAT weapons that create the most space debris.**

The UK-led approach of seeking consensus on norms of responsible behaviour in space could lead eventually to legally or politically binding agreements on certain categories of weapons. **One priority would be to achieve a moratorium on vertical-launch ASAT tests**, which could be agreed among the main spacefaring powers – the US, Russia, China, India, Japan and the main European players. It will be harder to persuade developing nations that have not yet tested an ASAT weapon but may be working on the technology to join such a moratorium. But the political weight of a major power agreement would be significant.

The EU can play an important role in helping to craft international regulation of space traffic management and sustainable use of space provided it acts modestly to build a consensus on norms and standards by listening to others, rather than first adopting its own regulations and then seeking to impose them on the world. The EU must learn the lesson of the failure of its past Code of Conduct initiative. It cannot take the same approach in space as with the General Data Protection Regulation (GDPR) or the REACH chemicals regulation because it cannot leverage the power of its single market in the same way.

SENTINEL-2B satellite's launch adapter

Recommendations

On funding and resources:

- Europe needs to act fast and **invest more in space**. Only a step change in public investment will enable the European space sector to remain competitive and catch up in areas where it is lagging, notably in reusable launchers, micro-launchers, spaceports, space situational awareness (SSA) capabilities and constellations. This will require additional contributions from member states, as well as from the EU budget.

- The EU is the appropriate level to lead **public investment in a secure connectivity constellation and in space surveillance and tracking.** Europe cannot afford to rely so heavily on the US for SSA. European capabilities will complement US efforts and offer resilience for NATO and EU member states.

- The EU should equip the next generation of Galileo and Copernicus satellites and its planned secure connectivity satellites with sensors to **track space debris** as part of its SSA efforts.

- EU member states should **increase resourcing of the EU Satellite Centre**, which provides geospatial intelligence analysis for the Union, member states and international organisations.

- Germany should ensure that some of its new €100bn defence fund is channelled into **joint space programmes with government or military utility**, such as space surveillance and tracking.

- The EU should adapt its tendering procedures, speed up the award of contracts, ensure tenders are genuinely open to New Space companies and not slanted towards incumbents, and speed up processing of patent applications. The Commission should make sure its taxonomy classification does not penalise defence and space investments.

- ESA should conduct a similar review, including of its geographical fair return rules, to ensure they do not artificially inflate the cost of projects.

On international cooperation:

- The EU and NATO should **extend their cooperation into collaboration** in SSA and space domain awareness, secure connectivity, and positioning, navigation and timing. NATO could become a customer for some EU space services.

- The EU should engage with a coalition of like-minded nations, including the US, Japan, Canada, Australia and the UK, and with the commercial space sector on **a set of norms and standards for responsible stewardship of space**, including space traffic management and debris removal and mitigation, building, inter alia, on the Paris Peace Forum's Zero Net Space initiative.

- The EU should endorse the WEF proposal of the **Space Sustainability Rating (SSR)** system that would be linked to insurance rates for spacecraft.

- The EU should engage with the US and its partners on **a wider internationalisation of norms on space resources**, adapting the Artemis Accords to build a wider consensus in the UN Committee on the Peaceful Uses of Outer Space (COPUOS). This could in time lead to an updating of the Outer Space Treaty.

- The EU should advocate the rapid creation of **an independent international body** modelled on the IPCC, but including private sector players, **to provide foresight on the dangers facing the space environment** and raise public and government awareness.

- Once Brexit trade disputes have been resolved, **the EU and the UK** should work to establish as **close industrial and strategic cooperation** as possible on civilian and defence space capabilities.

NASA's DART Mission Blasts Off. Spacecraft hitches a ride on a Space-X Falcon 9 rocket

ANNEX

Comparison of space strategies

The nine countries (the US, Russia, France, China, Germany, the UK, Italy, Spain and Japan) and two international organisations (the EU and NATO) explored in this annex have each produced unique space strategies. Comparing and contrasting these doctrines gives a meaningful overview of their understanding of space, of each other and of themselves.

While these strategies vary in length and scope, some common themes emerge: the perception of **space as a domain of potential conflict**; the **risks, threats and challenges** associated with the use of space; the **key role and approach** of each actor towards space; and concrete **areas of effort** underpinned by objectives and specific tools.

Space as a domain

All strategies highlight the increasing relevance of space as a new playing field. While they acknowledge the importance of space technology, data and services in the daily lives of citizens, as well as the multiple benefits brought by commercial space activities, **many also note the strong security component that comes with international engagement in space.**

The US considers space a new warfighting domain and, like Russia, understands space-based capabilities as an indispensable component of military power at a time of increased global competition. China's discourse on space is less overtly aggressive, as it centres its military doctrine around the principles of defence, self-defence and post-strike response. As for NATO, it declared space an operational domain in late 2019. Germany talked about a "paradigm shift" within space as early as 2010 but it has kept classified the Strategic Guidelines for Space adopted by the Ministry of Defence in 2017. France's delimitation of the space domain is more recent, though it now considers it the "theatre of the rivalry between great powers" and, as such, a domain that is slowly becoming a fully-fledged field of operation. The UK also identifies space as the fifth operational domain, which includes satellites and other aspects of the information layer connecting ground and space.

Besides the military component, **all strategies lay focus on the role of space as a driving force for economic growth.** Japan highlights the importance of space as a frontier of science and technology, which other countries mention to varying degrees. The Chinese space strategy focuses heavily on the pursuit of economic, scientific and technological development as well. Spain considers outer space as a "knowledge repository".

Risks, threats and challenges

The identification of risks is common to almost all space strategies. Most of them outline in detail the types of risks and threats faced in the space realm, mainly man-made (like debris, collision or human error) and nefarious (hostile actors seeking relative advantage), and focus on the threats created by other actors. While **the US, NATO, the UK and Russia explicitly recognise the threats posed by potential adversaries**, who they say are developing and operationalising potentially dangerous counter-space technologies, **the EU Space Programme does not – for the most part – refer to the external threats and risks in space.** However, the European External Action Service has been tasked with devising a space defence strategy by the end of 2023. Some European countries, like Italy and Germany, acknowledge space's increasingly congested and contested nature.

In its 2020 Defence Space Strategy, the US notes that external threats to itself and its allies may be aimed at reducing their military effectiveness, rendering them vulnerable in future wars, and deterring and countering possible US interventions during a regional military conflict. NATO's policy document provides specific examples, including non-kinetic systems (e.g., dazzling, blinding and jamming of space assets) and high-end kinetic capabilities (e.g., ASAT missiles and on orbit anti-satellite systems), where both space-based and ground-based segments can be targeted. For Russia, one of the main military risks is the disruption of its systems for monitoring outer space. A few strategies, mostly from European countries, also note the role which natural phenomena, such as space weather storms, can play as threats to space-based infrastructures.

For the UK and the US, China and Russia pose the greatest strategic risk, while North Korea and Iran are also seen in Washington as growing threats. On the other hand, **Moscow pinpoints the US and NATO as potential enemies**, and perceives a US first strike against its nuclear forces from space-based weapons as a key security threat. The increasing great power competition is well reflected in Germany's strategy, which foresees that traditionally leading nations will seek to defend their positions as China, India and South Korea gradually break through the space sector.

Besides the perceived risks posed by specific countries, the NATO strategy highlights the potential of non-state actors, namely terrorist organisations, to pose dangers in space. This view is shared by Spain, which assesses that terrorist and criminal organisations can develop the capabilities necessary to neutralise a satellite and are, therefore, a source of risk.

Key role and approach

Most strategies underline that activities in outer space are to be carried out in the interest of promoting international cooperation, benefiting humankind and maintaining global peace. **For some, the aim is also to ensure becoming – or remaining – a global leader in the space realm**. This is the case for the US and Russia, and to a lesser extent, France. While France is some way behind the leaders, the creation of a dedicated space command in 2019 and the increase in budgets testifies to its ambitions to not only protect its interests but to become a leading player in the space domain. Japan, for its part, focuses on the preservation of its autonomy in its space activities.

Each stakeholder has a unique understanding of its own role in space. The US and Japan strive to generate superior space power capacity and maintain their space superiority, with the former also providing support to joint operations and upholding responsible standards of behaviour as a "good steward of space".

China's doctrine states that it will "never seek hegemony, expansion or spheres of influence", which it considers as its "distinctive feature". However, the growth rate of the Chinese space industry, notably visible in the rapid annual increase in launches and active satellites, suggests that Beijing is nonetheless seeking to be a central actor in space – technologically and probably militarily. Officially, its space programme is a means to further economic, scientific and technological development, rather than strategic or military hegemony. Security is nonetheless the key component of the Chinese strategy. The People's Liberation Army Strategic Support Force (PLASSF), the de facto space force of the Chinese military, has centralised control over most of Beijing's space capabilities.

Russia strives to remain a leading global power in space, through both maintaining strategic stability and beneficial partnerships in a multipolar world. The recent Russian invasion of Ukraine has compromised these goals for the foreseeable future. For its part, Germany understands its role as a top-level industrial and research power, which it is striving to maintain.

NATO does not aim to develop space assets of its own or become an autonomous space actor but seeks to coordinate member nations' capabilities and ensure allied commanders have access to the space services they need. Halfway between Washington's or Moscow's full independence and NATO's supporting role, the EU acknowledges the relevance and expertise of ESA, with which it cooperates in the technical design and operational implementation of its space programme. Along these lines, **most European countries seek the establishment of international frameworks of cooperation for mutual support in crisis situations.**

Areas of effort

Each strategy presents a rationale for the actor's objectives in space, ranging from military advantage to service upgrading and shaping of the strategic environment. The US strategy gives priority to achieving space superiority to counter threats, as well as cooperation with allies and the private sector to enhance effectiveness and knowledge-sharing. Along these lines, NATO aims to enhance military cooperation and strengthen deterrence and resilience. Russia and China oppose the placement of any type of weapon in outer space as they seek to hinder rivals from achieving military superiority in space. Germany is also striving to advance and strengthen arms control specifically for the space domain.

Since 2019, countries that have established or initiated efforts to establish specific military units for space include the UK, the US, France, Japan, Germany and Italy. China and Russia have each had a dedicated space force since 2015, though the Russian space force has existed under various names and structures. **Common to all strategies is the ambition to expand and formalise bilateral and multilateral ties with like-minded actors.**

The EU's strategy mainly strives to strengthen existing space assets and foster a strong and innovative space industry, while increasing the security of Europeans. Most European countries, including Italy and Spain, aim to focus their efforts on enhancing institutional coordination and capacities. Similar objectives are mapped out by even the most martial strategies, which advocate for economic development through the use of space technology and goods. Both Japan and the US highlight the importance of public-private cooperation and improving the investment climate.

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Square de Meeûs 5-6,
1000 Brussels, Belgium
+32 2 893 98 23
info@friendsofeurope.org
friendsofeurope.org