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The Expanding Nexus between Space and Defence

edited by Alessandro Marrone and Michele Nones

ABSTRACT

The strategic character of space has been recognised worldwide already during the Cold War. Space and defence have continued to benefit from each other's breakthroughs and know-how and this nexus has been constantly expanding in different ways. Space was born competitive, and has evolved to become an increasingly contested and congested environment. Moreover, satellites have become a critical infrastructure for the societies and economies on Earth. Space is the ultimate frontier for political, technological and industrial competition, with new scenarios regarding space operations led by dedicated military commands. US, China and Russia pursue competitive advantages in the space higher ground, exploiting also innovative digital technologies and dual-use approaches. NATO officially recognised space as operational domain, while the armed forces of US and major European allies are undertaking policy and organisational adjustments. The EU space programme has achieved significant results on Copernicus and Galileo, the former being particularly relevant for the armed forces' navigation through its Public Regulated Service. Italy is a pillar of the European space framework, the second country in Europe for number of assets in orbit, the third largest contributor to European Space Agency and the home of a complete space value chain. Rome has recently introduced a new space governance, and upgraded the Minister of Defence structures dealing with space: a policy planning office and a space operations command. Building on a solid multi-layered base, Italy can enhance its role in space.

keywords

Space | Satellites | Defence | USA | Russia | China | NATO | UK | European Union | Italy

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edited by Alessandro Marrone and Michele Nones*

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Executive summary

by Alessandro Marrone and Michele Nones

The strategic character of space

The strategic character of space has been recognised worldwide already in 1957, when Moscow successfully launched and operated the first-ever artificial satellite in Earth's orbit – the so-called "Sputnik moment". It was a technological milestone in space exploration and a political watershed in the Cold War, prompting the race to the Moon culminated with the US Apollo landing in 1969. Since these first steps, the nexus between space and defence has been constantly expanding in different ways: space was born competitive, and has evolved to become an increasingly contested and congested environment. During the Cold War advancements in space technologies traditionally emerged from the military context, while space and defence continued to benefit from each other breakthrough and know-how. The Soviet Union even manipulated orbital mechanics, exploiting the potentials of High-Elliptical Orbits (HEO) such as Molnya to provide continued observation over the American territory and the northern hemisphere. At the same time, as soon as satellites were developed, Anti-Satellites (ASAT) and counter-space capabilities emerged. Washington and Moscow consistently tested ASAT technologies during the Cold War, while tensions and escalations on the ground transferred also to the space domain. It is the case of the US Strategic Defence Initiative (SDI) or the Soviet Fractional Orbit Bombardment System (FOBS), both cutting-edge and expensive technologies meant to elude the adversary's defence capabilities.

Over time space assets have become strategic enablers of military operations, in terms of Earth Observation (EO), Position Navigation and Timing (PNT), Satellite Communications (SatCom) and Signal Intelligence (SIGINT). EO is critical for Intelligence Surveillance Reconnaissance (ISR) from peace-time – also in terms of deterrence – to crisis and conflicts, and supports all stages of politico-military decision-making in advanced countries. The evolution of EO capabilities to provide increasingly accurate and timely imagery and geospatial data is a central part of a global, digital transformation process to secure information superiority. More and more information are delivered through geospatial services, and the combination of EO data with those coming from a wide variety of platforms and sources and with artificial intelligence (AI) is a fundamental part in such a digitalisation leap.

PNT is indispensable for military operations at tactical, operational and strategic levels, hence the critical importance of Global Navigation Satellite Systems (GNSS) such as the American GPS and the European Galileo. The PNT technology is a high priority of many states, from Japan to the United Arab Emirates, and essential element of national strategies, as shown by the Russian recovery of the Soviet-era GLONASS and the launch of the Chinese BeiDou – the latter considered a crucial component of the Belt and Road Initiative as the Space Silk Road. Actually, the consistent exploitation of PNT services provided by GNSS considerably increased

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the reliance on space of defence actors, especially since the First Gulf War.

SatCom constitute the strategic Command Control and Communication (C3) backbone of major armed forces worldwide, within and beyond NATO. Space segment is a major contributor to secure Earth-to-Earth connectivity, a key requirement for any operation on the field – as well as, for instance, for future combat air systems[1] part of much larger systems of systems.

Overall, such enabling role of space has been steadily increasing alongside progresses on the application of Information Communication Technologies (ICT) to the defence domain, in terms of military assets' digitalisation and connectivity.[2] Nowadays space is crucial to provide to commanders an accurate situation awareness, to secure real time or near real time information superiority and to support timely decisions.

Space has also begun to play a unique role when it comes to missile defence. Indeed, the US Ballistic Missile Defence and the NATO Integrated Air and Missile Defence heavily rely on space-based sensors to detect and track hostile weapons. This role is gaining new relevance in light of hypersonic weapons successfully tested by Russia and China, which require space-based capabilities to detect and track manoeuvring high speed missiles. Notably, within the EU Permanent Structured Cooperation (PESCO) the cooperative project TWISTER aims exactly to develop space-based sensors to counter these weapons.[3] Here the nexus between space and defence is extremely tight.

One other field is represented by Signal Intelligence (SIGINT), including Electronic Intelligence (ELINT), that is the capability to detect, intercept, collect and analyse communication and radio signals from several ground or space-based sources. ELINT satellites can detect a wide range of emissions, such as military radars, naval vessels, other satellites' and ground stations' signals, and they have been extensively developed by Washington and Moscow during the Cold War. Nowadays, the US control the largest set of assets, while Russia maintains partial capabilities obviating to the termination of the Soviet-era Tselina and US-P programme with the recent launch of the Liana project.[4] China also embarked on ELINT programmes:

[1] See in this regards Alessandro Marrone and Michele Nones (eds), "Europe and the Future Combat Air System", in *Documenti IAI*, No. 19|02 (March 2019), https://www.iai.it/en/node/10115.

[2] See among others Alessandro Marrone, Michele Nones and Alessandro R. Ungaro (eds), *Technological Innovation and Defence: The Forza NEC Program in the Euro-Atlantic Framework*, Rome, Nuova Cultura, April 2016, https://www.iai.it/en/node/6335; Alessandro Marrone and Karolina Muti (eds), "The Next Generation Soldier: A System of Systems Approach?", in *Documenti IAI*, No. 21|15 (November 2021), https://www.iai.it/en/node/14368.

[3] See in this regards Alessandro Marrone and Karolina Muti (eds), "Europe's Missile Defence and Italy: Capabilities and Cooperation", in *Documenti IAI*, No. 21|05 (April 2021), https://www.iai.it/en/node/13072.

[4] Spaceflight101 website: *Liana Eletronic Intelligence Program*, https://spaceflight101.com/spacecraft/?p=1830; Bart Hendrickx, "The Status of Russia's Signals Intelligence Satellites", in *The Space Review*, 5 April 2021, https://www.thespacereview.com/article/4154/1; David D. Bradburn et

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although data are more uncertain on Beijing capacities, the Yaogan constellation of approximately twenty satellites is reportedly equipped also with SIGINT/ELINT payloads.[5] More recently, France explored the space-based signal intelligence field, providing military and governmental stakeholders with the three CERES satellites.[6] For what concerns Italy, the latest Defence Multiannual Programmatic Document (*Documento Programmatico Pluriennale della Difesa* – DPP) 2021–2023 highlights the relevance of capabilities for Space Situational Awareness (SSA), ISR and SIGINT for threats assessment and operations in space.[7]

In parallel with these military developments, satellites have become a critical infrastructure for the societies and economies of most countries on Earth. SatCom often enables internet access of the array of ICT devices used by citizens, business and institutions, and could be further exploited for telemedicine and to close digital gaps. PNT allows efficient logistics through all economic sectors, from banking and financial operations to oil industries and mobility. EO serves multiple purposes from climate change's monitoring to disaster relief, weather forecasts and support to agriculture. Over the last decade, the potentialities of space have encouraged not only traditional space-faring countries but also new comers such as Middle East and North Africa (MENA) countries to launch satellites.[8] The reliance on infrastructures in orbit grows into a sort of dependence, as space is considered for instance by the 2020 US Defence Space Strategy as "enabler of the way of life and way of war".[9] Being a critical infrastructure, space assets have become a target of hybrid warfare, to be possibly waged by adversary countries in a context of increased great power competition.

Satellites can indeed be targeted in various ways, despite the existing treaties and regimes forbid the weaponisation of space. First, they can be jammed and/or spoofed, as Electronic Warfare (EW) provides effective, non-kinetic ways to disrupt their critical functions without creating debris. Similarly, due to their connectivity function, space assets are vulnerable to cyber attacks, in a context where cyber

al., *The SIGINT Satellite Story, National Reconnaissance Office*, December 1994, https://www.nro.gov/Freedom-of-Information-Act-FOIA/Declassified-Records/Selected-Historically-Significant-Documents-of-Public-Interest/sigint.

[5] Elisabeth Howell, "China Has 3 New Spy Satellites in Orbit after Long March 4C Launch", in *Space.com*, 19 March 2021, https://www.space.com/china-yaogan-31-military-satellite-launch-march-2021.

[6] Charlotte Le Breton, "France's Signal Ambition for Space-Based Intelligence", in *Military Balance Blog*, 9 dicembre 2021, https://www.iiss.org/blogs/military-balance/2021/12/frances-signal-ambition-for-space-based-intelligence.

[7] Italian Ministry of Defence, *Documento programmatico pluriennale della Difesa per il triennio 2021-2023*, August 2021, https://www.difesa.it/Content/Documents/20210804%20DPP%202021-2023%20-ult.pdf.

[8] On MENA countries and space see NATO Strategic Direction-South Hub and IAI, "MENA Space Capabilities & Security Challenges. NSD-S Hub Study Day", in *NSD-S Hub Publications*, February 2022, https://thesouthernhub.org/publications/nsds-hub-publications/mena-space-capavilities-security-challenges.

[9] US Department of Defense, *Defense and Space Strategy Summary*, June 2020, p. 3, https://www.defense.gov/News/Releases/Release/Article/2223539.

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warfare is ongoing 24/7 and the offense side enjoys several structural advantages on the defence side.[10] Third, access to space can be jeopardised through kinetic, non-kinetic (i.e. cyber) or special forces attacks to the very few launch sites operated by Western countries.

All the aforementioned ways to directly or indirectly affect space assets further expand the nexus between space and national defence. A nexus which is made crystal-clear by the revival of ASAT capabilities over the 21st century. While the latest US military test dates back to 1985, in 2007 China successfully tested a Direct-Ascent ASAT (DA-ASAT) weapon by destroying its satellite Fengyun-1C through a missile launched from Earth – and by creating 3,500 pieces of debris.[11] In 2019 India achieved the same result,[12] while in 2021 Russia destroyed its Kosmos-1408 satellite with a DA-ASAT missile, leading to further 1,500 debris.[13]

Space has already become a component of the Multi-Domain Operations (MDO) approach, and as such it constitutes a strength but also a weakness to be exploited by allies and foes. Considering that in military terms it took millennia to add the air domain to land and maritime one, the fact in just one century space and cyberspace have been added to the strategic equation represents a breakthrough whose consequences have still to be fully understood.

Against the backdrop of about 4,500 currently orbiting satellites,[14] the plans by American companies like SpaceX and Blue Origin to place dozens of thousands of small satellites *de facto* enable the US to occupy strategic nodes by preventing others to do so. According to some estimates, by 2030 about 50.000 satellites will be active on Earth orbits, and this will substantially change the features of this operational domain, making Space Surveillance and Tacking (SST) and Space Traffic Management (STM) a strategic issue *in primis* for North America and Europe.[15]

[10] On the cyber defence in NATO countries see Alessandro Marrone and Ester Sabatino, "Cyber Defence in NATO Countries: Comparing Models", in *IAI Papers*, No. 21|05 (February 2021), https://www.iai.it/en/node/12727; on the strategic aspects of cyberwarfare see among others Alessandro Marrone, Ester Sabatino and Ottavia Credi, "L'Italia e la difesa cibernetica", in *Documenti IAI*, No. 21|12 (September 2021), https://www.iai.it/en/node/14125.

[11] Brian Weeden, "2007 Chinese Anti-Satellite Test Fact Sheet", in *Secure World Foundation Fact Sheets*, 23 November 2010, https://swfound.org/media/205391/chinese_asat_fact_sheet_updated_2012.pdf.

[12] Jeff Foust, "India Tests Anti-Satellite Weapon", in *SpaceNews*, 27 March 2019, https://spacenews.com/?p=87180.

[13] Giancarlo La Rocca, " Test russo e Kosmos-1408: perché è una cattiva idea distruggere un satellite", in *AffarInternazionali*, 24 November 2021, https://www.affarinternazionali.it/archivio-affarinternazionali/?p=90572.

[14] ESA website: *Space Debris by the Numbers*, https://www.esa.int/Safety_Security/Space_Debris/Space_debris_by_the_numbers.

[15] On the EU side see for example the SPACEWAYS project: *European Ways Forward for SpaceTraffic Management – SPACEWAYS*, https://www.iai.it/en/node/12746; and the Slovenian Presidency of the Council of the EU Report on STM: Council of the European Union, *Presidency Report on Space Traffic Management*, 4 November 2021, https://data.consilium.europa.eu/doc/document/ST-13407-2021-INIT/en/pdf.

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The latest frontier of space operations are In-Orbit Services (IOS).[16] They require space rendezvous and close proximity operations, whereby two spacecraft arrive at the same orbit and approach at a close distance and eventually dock or interact. These operations enable to perform a number of actions in terms of maintenance, tugging, inspection, etc. Relevant IOS examples are refuelling and life-extension, reconfiguration of spacecraft's payloads or modules, station keeping docking of the service spacecraft with a target satellite, orbit correction relocating systems to the adequate orbit, in orbit assembly and manufacturing of large infrastructures that cannot be performed before launch due to their weight, volume, size and so on. IOS will enable a range of new activities with significant implications in terms space sustainability, safety, security and defence. For example, the same robotic arm used for maintenance activities can be manoeuvred to disrupt a target satellite by simply damaging its solar cells or radar. The IOS potentialities prompted by technological innovation open a completely new page for offensive and defensive operations in space, with huge implications for the Western armed forces. While the use of space progressed together with its military relevance since the beginning, weaponisation is not considered anymore a trivial possibility. As ultimate higher ground, today space is indeed widely perceived as the environment where to project power and obtain advantages over defence systems on Earth.

The new US military approach to space

From a US perspective, space has been traditionally interpreted and used as a way to support military operations on the ground. At the end of the 1990s space was declared to be a vital interest for Washington,[17] and then the George W. Bush administration adopted the doctrine of "space dominance" to guarantee access to space assets in case of conflict. Conflict-oriented concepts gradually gained ground until the declaration by president Donald Trump of space as a warfighting domain in 2018.

The expanding nexus between space and defence has been epitomised in 2019 by the US decision to create a new Space Force (USSF) as the sixth branch of the military and re-establish a Space Command within the Pentagon. The USSF is tasked with organising, training, equipping, and providing forces and capabilities to the US Space Command and other commands,[18] and at the end of 2020 could count on more than 2,000 military and 6,000 civilian personnel, as well as additional 8,000

[16] Giancarlo La Rocca et al., "In-Orbit Services. Policy and Business Perspectives", in *ESPI Reports*, No. 76 (December 2020), https://espi.or.at/publications/espi-public-reports/send/2-public-espi-reports/557-in-orbit-services-full-report.

[17] Mathieu Bataille and Valentine Messina, "Europe, Space and Defence. From 'Space for Defence' to 'Defence of Space'", in *ESPI Reports*, No. 72 (February 2020), https://espi.or.at/publications/espi-public-reports/send/2-public-espi-reports/502-europe-space-and-defence.

[18] US Department of Defense, "What's With All the U.S. Space-Related Agencies?", in *DOD News*, 14 December 2020, https://www.defense.gov/News/Feature-Stories/Story/Article/2446327/whats-with-all-the-us-space-related-agencies.

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temporary staff.[19] The Space Force certainly is one of the legacies passed to the Joe Biden administration, together with five Space Policy Directives and the Defence Space Strategy (DSS) released in 2020. The DSS indicates three objectives to be pursued by the DoD in order to "achieve desired conditions in space over the next 10 years": i) maintaining space superiority; ii) providing space support to national, joint, and combined operations; iii) ensuring space stability.[20]

Russia and China: West's systemic rivals on orbits

Russia and China are considered by the US as the "greatest strategic threats" also in space, as they are engaged to test and acquire operational space defence capabilities, together with ground-based ASAT weapons and space-based (co-orbital) systems. The credibility of threats posed by Russia and China has been increasing over the last years, due to overall changing postures and a renewed attention devoted to space. While Moscow is committed to revamp the legacy of the USSR, Beijing started to develop and consolidate its role in space since the 1990s, reaching the status of a mature global space power in about two decades.

The Russian Aerospace Force (RAF) is the main entity in control of developments in the space and defence dimensions, building on the structures of the Russian Space Force established already in 1992 – thus following a sort of backward path compared to the Western trend to identify single forces or commands devoted to space. Over the 1990s and 2000s investments in space declined after major budgetary cuts and a general slowdown of activities, leading also to obsolescence of the related capabilities and industry. However, Moscow remains a credible space power even with limited resources, due also to Soviet-era legacy and experience in science and technology.

China started developing space capabilities already in the 1950s and launched its first national satellite in 1970. From the 1990s, Beijing grew to be a credible and global space power, acquiring capabilities on a wide spectrum of technologies, closing substantial gaps and projecting the country to several future developments by the national anniversary in 2049. China concluded 2021 with 55 missions – more than the US[21] – celebrating also the 400th launch of the Long March family of rockets.[22] While data about budgets allocated by Beijing are uncertain, the rationale behind the race to space are well defined. Moreover, the new PLA Strategic Support Force (SSF) established in 2015 represents an effort to translate the recognition of a

[19] Ibid.

[20] US Department of Defense, *Defense and Space Strategy Summary*, cit., p. 1.

[21] According to initial data collected at the end of 2021, US completed 51 missions, while Europe completed six Ariane and Vega missions operated by Arianespace, one more compared to 2020. See Chris Impey, "2021: More Space Launches Than Any Year in History Since Sputnik", in *The Hill*, 29 December 2021, https://thehill.com/node/587630; and Arianespace website: *Missions*, https://www.arianespace.com/missions.

[22] Andrew Jones, "China Closes Record – Breaking Year with Orbital Launches from Jiuquan e Xichang", in *SpaceNews*, 30 December 2021, https://spacenews.com/?p=122607.

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new operational domains into a concrete action.

Eastern actors seem to systemically raise the level of the challenge in orbit, with limited efforts to show openness to dialogue. Their respective strategies are reinforced by the perceived threats posed primarily by the US and Western emphasis to defend space assets, in a vicious circle that may lead to less cooperation and dialogue, more competition and deadlocks.

NATO and its members: A space Alliance?

In 2019 the Atlantic Alliance has recognised space as a new operational domain, and the 2021 NATO summit of heads of state and governments led to the declaration that "attacks to, from, or within space present a clear challenge to [its security]" and that "such attacks could lead to the invocation of Article 5 [on collective defence]".[23] This principle recognises that space is essential to a coherent allied deterrence and defence posture. The Atlantic Alliance gathers under its insignia many of the most technologically advanced militaries in the world and could act as a force multiplier. However, NATO's effective use of the space domain in military operations – and the defence of Allied assets in and from space – will largely depend on the Allies' willingness not only to increase military spending in this sector, but also to put their own assets at the Alliance's disposal as needed. While NATO would not be able to respond to threats autonomously, it can offer a real added value in the space dimension of military operations as a forum "for Allies to share information and coordinate activities on various space-related issues".[24] In order to do that, it established the NATO Space Command in Ramstein (Germany), to create a "common space domain picture", as well as a new Centre of Excellence (CoE) for space in Toulouse (France). While NATO does not intend to acquire its own space-based assets, the extension of Article 5 to this domain provides a framework for its members to work towards a shared doctrine and a pooling on capabilities.

In this context, in Germany innovation in the space sector is mostly driven by technologies developed for application in the scientific and civil fields. While there are signs of a shift,[25] so far Berlin has adopted a rather normative and cautious stance on the nexus between space and defence which, although it does not necessarily exclude a more pragmatic doctrine, *de facto* neglects the current climate characterised by strategic competition among the major space-faring powers. In 2020, the German MoD established a new Air and Space Operations Centre (ASOC). Since July 2021, the German Armed Forces have also been operating the new Space Command (*Weltraumkommando*) within the Bundeswehr, which aims to bring together capabilities in cyber, information, space and air fields and to manage all

[23] NATO, *Brussels Summit Communiquè*, 14 June 2021, point 33, https://www.nato.int/cps/en/natohq/news_185000.htm.

[24] NATO, *NATO's Approach to Space*, 2 December 2021, https://www.nato.int/cps/en/natohq/topics_175419.htm.

[25] Interview, 15 October 2021.

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sides of the space domain under a single command.[26]

Defence plays a much more prominent role in the French approach to the space domain. In its 2019 Space Defence Strategy, the Ministry for the Armed Forces outlined Paris' ambitions and priorities with regard to space.[27] France stands out among European Allies in its approach to space as the most aware of the expanding nexus with defence[28] and identifies the guiding principle of "active space defence".[29] Paris has instituted a Space Command (*Commandement de l'espace* – CdE) operating under the Air and Space Force's authority.[30] Under the aforementioned Space Defence Strategy, Paris decided to spend an additional 700 million euro on top of the 3.6 billion already devolved to the complete renewal of satellite capabilities in the Law for Military Planning. The location of the NATO CoE in Tolouse is likely a sign of a growing French role in euro-Atlantic space affairs, as it will operate right at the heart of France's space ecosystem, surrounded by the French Space Academy and Space Command, the Space Lab and space industrial stakeholders.

The new UK military approach to space

Like other major European countries, the UK considers space an operational domain and has instituted a space command.[31] Notably, it has also outlined its doctrinal approach to space power through the Joint Doctrine on UK Air and Space Power.[32] Brexit had an impact also on the national posture towards space, as for instance Britain has lost direct and complete access to the Galileo's Public Regulated Service (PRS) for its armed forces' navigation. London currently relies solely on US systems for navigation and surveillance, as it has done for decades also for space access and intelligence,[33] but is looking at options for a national capability and this sets the UK on a new course. Skynet 6, aiming to enhance the country's SatCom capabilities, is under way with investments in the order of 5 billion pounds over ten years.[34] Moreover, in 2022 the MoD released the Defence Space Strategy, a

[26] Philipp Rabe, "Das Weltraumkommando in Uedem", in *Bundeswehr Aktuelles*, 13 July 2021, https://www.bundeswehr.de/de/organisation/luftwaffe/aktuelles/das-weltraumkommando-in-uedem-5181718.

[27] French Ministry for the Armed Forces, *Space Defence Strategy 2019*, https://www.defense.gouv.fr/content/download/574375/9839912/Space+Defence+Strategy+2019_France.pdf.

[28] Interview, 10 December 2021.

[29] French Ministry for the Armed Forces, *Space Defence Strategy 2019*, cit., p. 10.

[30] The French Air Force became the Air and Space Force in September 2020.

[31] Royal Air Force website: *UK Space Command*, https://www.raf.mod.uk/what-we-do/uk-space-command.

[32] UK Ministry of Defence, *UK Air and Space Power*, December 2017, https://www.gov.uk/government/publications/uk-air-and-space-doctrine-jdp-0-30.

[33] Bleddyn E. Bowen, "The Integrated Review and UK Spacepower: The Search for Strategy", in *Freeman Papers*, July 2019, p. 5, https://www.kcl.ac.uk/warstudies/assets/integrated-review-and-spacepower.pdf.

[34] UK Ministry of Defence, *Defence in a Competitive Age*, March 2021, p. 45, https://www.gov.uk/government/publications/defence-in-a-competitive-age.

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wide-ranging document addressing both governance and funding and allocating 1.4 billion pounds over ten years. The UK's National Space Strategy aims to bolster the country's space industry through increased investments, with the government gradually moving from "primary funder to an influential customer",[35] as also shown by the acquisition of the private company OneWeb.

The European way to space: What strategic evolution?

European approach to space was born in the middle of the race to the Moon. Six decades later, Europe continues to be engaged in space within a competition between world powers. Meanwhile, the EU space programme has achieved results and continuity of investments on Copernicus and Galileo, the former being particularly relevant for the armed forces' navigation through its PRS. But the Union's investments on GovSatCom are extremely limited, and those relevant for SSA are marginal.[36] The EU looks to maintain its role of space power by further expanding competences, responsibilities and technology upon with a view to achieve strategic autonomy.

In this process, the strategic character of space and its nexus with defence is finally being recognised, including by the upcoming EU Strategic Compass.[37] The establishment of Directorate General Defence Industry and Space (DG DEFIS) and EU Space Agency (EUSPA),[38] as well as the Decision 2021/698,[39] bring significant changes to the EU institutional setting dealing with space and to the related governance of security. First, there is an attempt to reinforce the overall position of the Union as a global space power. Second, there is the explicit recognition of each and every component of the EU space programmes as critical infrastructure to be secured and protected. Progresses made over the last years could help to find efficient instruments and relevant solutions 1) to create a joint framework for space and defence industry, 2) to exploit the strategic role of space for security and defence, and 3) to further upgrade the relevant institutional setting.

Clearly, there still is a long road ahead, where both an EU coherent and harmonised vision and a sum of investments comparable to other major powers should be reached and accomplished. In this light, the 2022 Strategic Compass seems to

[35] UK Government, *National Space Strategy*, September 2021, p. 23, https://www.gov.uk/government/publications/national-space-strategy.

[36] Interview, 3 November 2021.

[37] On the Strategic Compass draft see Alessandro Marrone, "Lo Strategic Compass, la difesa europea e l'Italia", in *Focus euroatlantico*, No. 19 (February 2022), p. 29-37, https://www.iai.it/en/node/14594.

[38] European Parliament and Council of the European Union, *Regulation (EU) 2021/696 of 28 April 2021 Establishing the Union Space Programme and the European Union Agency for the Space Programme...*, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R0696.

[39] Council of the European Union, *Council Decision (CFSP) 2021/698 of 30 April 2021 on the Security of Systems and Services Deployed, Operated and Used under the Union Space Programme Which May Affect the Security of the Union...*, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021D0698.

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be major step in the right direction, and a EU Space Strategy for security and defence strategy is expected by 2023. According to Commissioner Thierry Breton, supervising DG DEFIS, it is the whole space programme that should further integrate the defence dimension.[40] Ultimately, Europe needs to fully accept its role of space power and act accordingly with a space power mindset and adequate investments.

The technology dimension and duality

The space race is first a technology competition, to enable actors to position in this domain, exercise control, seek competitive advantages and eventually introduce disruption. Competition grows together with innovation and acquisition of new capabilities, which in turn increase the relative strength and autonomy of states to access and operate in space. Space technologies have rapidly evolved in the 2010s. A combination of enhanced and new technologies and business model evolution allowed to conceive and realise a novel class of space assets, by addressing new challenges and more sophisticated needs of global user community.[41] Technology deeply influences space, from the design of satellites to the nature of future scenarios and threats. The growing presence of private actors and start-ups coupled with the relevance of commercial initiatives have implications for defence stakeholders and dual use technology. On the basis of big data, machine learning and automation, AI together with as blockchain, cyber and quantum technologies may cause major disruptions to the space domain and have strategic implications.

Most space technologies are dual use, and the technology evolution is largely transversal to civil and military domains. While the construction of specific assets for the armed forces is obviously very important, the ongoing huge wave in commercial systems cannot be ignored. Global surveillance with persistent or quasi persistence requirements, global space connectivity looking at new generation broadband hybrid networks, protection from cyber threats, In-Orbit Services (IOS) to protect assets and clean up orbits: all these elements have somehow to be factored in emerging defence reflections on space, and require the most effective technology and architectural solutions potentially derived also from commercial sector. Nonetheless, government stakeholders continue to be central as customers, facilitators of innovation and regulators. The private sector's relevance somehow makes more strategic the states' industrial and technological policies. The nexus between space and defence is a two-ways street, whereby each actor has to recognise the role of the others.

[40] European Commission, *Speech by Commissioner Thierry Breton at the 14th EU Space Conference*, 25 January 2022, https://ec.europa.eu/commission/presscorner/detail/en/speech_22_561.

[41] Massimo Claudio Comparini, "Space Domain: A Global Vision", in *JAPCC Journal*, No. 33 (2021), p. 62-67, https://www.japcc.org/space-domain-a-global-vision.

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Italy and space, a strong position to enhance

This report aims to shed light on the expanding nexus between space and defence by combining complementary topics, sources and perspectives, with a focus on space powers including a special attention paid to Italy as the third country in the world to design, manufacture and launch a satellite in Earth orbit after US and USSR, back in 1964.[42] As of 2021, Italy is a pillar of the European space framework, the second country in Europe for number of assets in orbit, the third largest contributor to ESA and the home of a complete space value chain from upstream – including launchers – to downstream capacities. The first European astronaut to fly to the International Space Station (ISS) and the first ISS' European commander were Italians, as will be the first European female commander in 2022.

Rome leads the European way to space together with Paris and Berlin, while expanding cooperation with the US and other partners at institutional and commercial levels. The Italian law No. 7 of 2018 marked a tangible step forward in terms of governance, to bring a closer institutional eye on space and establish a systemic approach. The established governance and the released strategic documents lay down a coherent Italian vision of space, including its security aspects, yet the update of the governance mechanisms should not be cut short once the formal reorganisation has been achieved.

In parallel with the articulation of the new governance, a significant reorganisation occurred within the Ministry of Defence (MoD) since 2018. The Italian Defence General Staff first established in 2019 the General Space Office (*Ufficio Generale Spazio* – UGS) responsible for policy planning, space programmes and international cooperation. Then in 2020 the Space Operations Command (*Comando Operazioni Spaziali* – COS) was created to develop space operations while continuing to provide space products to the other traditional domains. The two-pillars articulation of policy planning (UGS) and operations (COS) does represent a balanced, well-structured approach towards a new and dynamic domain, whereby the UGS is set to develop its strategic outlook and the COS to increase its operational ability. Currently, the Italian Ministry of Defence is able to plan the policy for military space assets, to identify needs and procurement requirements, and then to in-house manage the launch, activities and de-orbit of such assets through operational centres active 24/7: a pioneer, unique military capability in Europe. From such a position, Italy can give an important contribution to the international reflection on the nexus between space and defence, including within EU and NATO.

An ever-evolving space context requires Italy to further develop a coherent vision, an efficient governance, and persistent update and upgrade of know-how and capabilities through adequate plans and investments. To this end, Italy has to move forward on the following ten, main issues if it wants to keep pace with a

[42] See in this regard, among others, Marcello Spagnulo, "L'Italia spaziale da terzo grande a satellite di chi?", in *Limes*, No. 12/2021 (December 2021), p. 191-208.

space domain more strategic, competitive, congested and contested than ever and secure its national interests both in orbit and on Earth.

1) Work on a national space law
2) Confirm the military mandate for the defence of Italian space assets
3) Take forward the national space governance
4) Implement the MoD reorganisation with adequate human resources
5) Articulate the MoD space strategy and military doctrine
6) Plan a more strategic military capability development
7) Develop the national approach to bilateral, European and transatlantic cooperation
8) Shape the EU Space Strategy for security and defence
9) Contribute to the NATO Strategic Concept approach to space
10) Be out-spoken on space and defence

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1. The new US military approach to space

by Karolina Muti*

From the first space activities in the 1950s, the United States played a central role in the outer space, linked to its status of superpower during the Cold War. In the aftermath of the bipolar competition, and similarly to other domains, the US achieved a strategic and operational advantage in space. Over this first era of discoveries, cooperation (with a few Western partners, with Italy having a special role) and competition in space, the US had to face challenges of a completely new and unexplored environment. Such a pioneer era brought not only Washington and Moscow, but humanity as a whole, in an unprecedented dimension thanks to a leap forward in technology and the growing dependence of the world from space activities.

In the 20th century space environment, administrations in Washington had to take into account just one major competitor – the Soviet Union (USSR) – with whom to agree the rules of the game. Paradoxically, that bipolarism made the space environment, at least in part, easier to manage and shape, despite its novelty. In contrast, in recent years a variety of state and non-state actors have crowded space, by catching up with traditional spacefaring nations and developing their own, albeit limited, ability to influence dynamics in space. The latter can be considered today as an operational domain for the military as well as an ecosystem on its own. From US systemic rivals like Russia and China, to new state actors able to invest heavily in space capabilities, such as for instance the United Arab Emirates (UAE), to commercial giants such as Space X or Blue Origin, space and its underlying rules became more complex to understand and manage, even for the US.

Against this backdrop, the US military approach to space has evolved during the Cold War period. Space was primarily interpreted and used as a way to support military operations on the ground. At the end of the 1990s, space was declared to be a vital interest for Washington,[1] while the George W. Bush administration adopted the doctrine of "space dominance" to guarantee access to space assets in case of conflict. The 2006 National Space Policy placed on an equal footing freedom of action in sea, air and space domains.[2] In the current context, with the space environment becoming increasingly congested, contested and competitive,[3] the US strategy, doctrine, and forces have developed by trying to lead the adaptation process globally and to ensure and possibly expand US advantage while denying use of space to adversaries in case of conflict.

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1 Mathieu Bataille and Valentine Messina, "Europe, Space and Defence", cit.

2 Ibid.

3 John W. Raymond, "Raymond Talks Economy, Security, Leadership at Naval Academy", in *Space Force News*, 19 November 2021, https://www.spaceforce.mil/News/Article/2849726.

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Operationally, space was integrated in the US Operation Desert Storm during the First Gulf War (January-February 1991), resulting in a strategic advantage.[4] In the doctrine, both offensive and defensive concepts were elaborated, in particular by the Air Force Space Command (2012) and by the US Strategic Command (2013).[5] Conflict-oriented concepts gradually gained ground until the declaration by former President Donald Trump of space as a warfighting domain in 2018. The recognition of space as an operational domain by the Atlantic Alliance followed soon after, in 2019.

1.1 Evolution of the US military architecture for space domain integration

In this context, the US military architecture had to adapt in order to respond to the challenges coming from the establishment of a new domain and from the deteriorating international context. Several organisational changes in the Department of Defence (DoD) took place and new structures were formed, together with the sixth branch of the US Armed Forces – the US Space Force. The latter was established in December 2019 as a new military service, under the command of the US Space Command, and the authority of the Department of the Air Force. It is tasked with organising, training, equipping, and providing forces and capabilities to the US Space Command and other commands.[6] At the end of 2020, the Space Force could count on more than 2,000 military and 6,000 civilian personnel, as well as additional 8,000 temporary staff, both military and civilian, aimed at supporting the Space Force at the beginning.[7] As per the National Defense Authorization Act (NDAA) for Fiscal Year 2022, the Space Force can dispose of 8,400 active duty personnel.[8]

The US Space Command was re-established in August 2019 after 17 years of break, and tasked with developing doctrine, techniques and tactics, protecting US interests in space, and lead space warfighting.[9] In particular, its quite broad mission is to "deter aggression, defeat adversaries, deliver space combat power, and defend US allied and partner interests".[10] The Space Command operates in fact as a geographic combatant command and it currently has 1,000 personnel assigned,[11] but this number is designed to grow if necessary. In case of a potential conflict, and subject to a previous request by the Command, the military services – Army, Navy, Marines, Air Force and Space Force[12] – have to provide ready forces to the

[4] Ibid.

[5] Mathieu Bataille and Valentine Messina, "Europe, Space and Defence", cit.

[6] US Department of Defense, "What's With All the U.S. Space-Related Agencies?", cit.

[7] Ibid.

[8] US Government, *National Defense Authorization Act for Fiscal Year 2022*, 21 December 2021, https://www.govinfo.gov/app/details/BILLS-117s1605enr.

[9] Mathieu Bataille and Valentine Messina, "Europe, Space and Defence", cit.

[10] US Department of Defense, "What's With All the U.S. Space-Related Agencies?", cit.

[11] Ibid.

[12] The US Coast Guard is not listed here since in time of conflict, it operates under the command of the Navy. See US Department of Defense website: *Our Forces*, https://www.defense.gov/About/our-

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Command in order to ensure the accomplishment of its mission. Consequently, the Space Command leverages and integrate other services components, notably: Space and Missile Defence Command from the Army, Marine Forces Space Command, Navy Space Command, and Space Operations Command from the Space Force.[13]

To avoid confusion between the US Space Force and the US Space Command, it is worth noting that the former is a new military service, similar to the Army, Navy, Air Force or the Marine Corps. On the one hand, like any other services, the Space Force recruits men and women and provides them with training to "fight" in the space domain and with uniforms specific to the Space Force.[14] On the other hand, the US Space Command, similarly for instance to the US European Command, is a geographic combatant command.[15] As such, its mission is to protect and defence US interests in space. To do so, it can use among others the forces and capabilities provided by the US Space Force.[16] The establishment of the US Space Force as a separate branch was accompanied by tensions and controversies, involving among others an obstructive attitude by part of the Air Force.[17] The establishment of a new service of the Armed Forces entails in fact a structural reorganisation that touches upon missions, tasks, authorities, bodies and capabilities of other services. Such changes can go in pair with technology developments. It is the case for instance of moving tactical-level ISR missions to orbit, through a space-based Ground Moving Target Indicator (GMTI) that will take this role from aircraft, putting it under the authority of the Space Force instead of the Air Force.[18]

It is worth noting that the Space Force, the Space Command, the National Reconnaissance Office (NRO) and the National Geospatial-Intelligence Agency have signed an agreement to increase national security collaboration at strategic level. Notably, the document is meant to "define and deconflict"[19] roles of the abovementioned bodies, and enhance coordination and communication at multiple levels. It also formalises coordination between the DoD and the Intelligence Community.[20]

forces.

13 Ibid.

14 US Department of Defense, "What's With All the U.S. Space-Related Agencies?", cit.

15 Ibid.

16 Ibid.

17 Sandra Erwin, "Air Force Changes Message on Space Force Amid Criticism It Stifled Debate", in *SpaceNews*, 2 September 2019, https://spacenews.com/?p=92544; Daniel Lyons, "End the Gag Rule, Start the Space Force", in *The Wall Street Journal*, 26 August 2019, https://www.wsj.com/articles/end-the-gag-rule-start-the-space-force-11566859485.

18 Aviation Week, "Analysis of Space-Based GMTI Expected in Spring", in *Aerospace Daily & Defense Report*, 19 January 2021, https://aviationweek.com/node/4374121.

19 Colin Clark, "NRO,NGA, SPACECOM, Space Force Hammer Out Boundaries", in *Breaking Defense*, 24 August 2021, https://breakingdefense.com/?p=172601; Nathan Strout, "Space Force Joins the Intelligence Community", in *C4ISRNET*, 14 January 2021, https://www.c4isrnet.com/battlefield-tech/space/2021/01/14/space-force-joins-the-intelligence-community.

20 Ibid.

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In March 2019, just few months before the establishment of the Space Command, the Space Development Agency (SDA) was created with the aim to provide adequate tools for warfighting in the space domain, by building the National Defence Space Architecture (NDSA) and enhancing resilience of its infrastructures. Accelerating innovation and efficiency of military space procurement programmes[21] is a core objective of the SDA which can count on about 100 units. The SDA is a "constructive disruptor"[22] for procurement in the space sector. The Agency picks out "architecture concepts, system designs, enabling technologies, and emergent capabilities to enable leap-ahead advances".[23] The SDA mainly acquires mature technologies that can be rapidly fielded to fill an operational need. However, the Agency has also a limited ability to make investments in R&D activities. The SDA is currently transitioning from the Office of the Under Secretary of Defense for Research and Engineering to the Space Force,[24] a process that will conclude by October 2022.

With regards to the NDSA, in concrete terms it will be composed by constellations of space satellites enabling for instance tracking and targeting of missile threats, including hypersonic weapons, on Earth.[25] Its first project is a mega-constellation in Low Earth Orbit (LEO) to ensure communication, surveillance and to provide a backup to the Global Positioning System (GPS).[26] In addition to small satellites in LEO, NDSA will include ground stations and will have seven layers to be developed through different stages: transport, deterrence, tracking, custody, navigation, battle management and support layers.[27] The first part, or "Tranche 0", due in 2022, should consist in 20 transport and 8 tracking satellites, while Tranche 1 will deliver more than 200 satellites with the same functions by 2024. The NDSA is supposed to obtain global outreach with Tranche 2 expected in 2026, making the delivery of information to US troops worldwide faster, including when it comes to fire control solutions and target geo-localisation.[28] This development should tackle the dependence of the US Space Command on satellites and ground systems designed decades ago,[29] thus not taking into account the current international environment, technology innovation and the related risk of hostile activities in space. Notably, these outdated space systems were not designed to guarantee the necessary level of resilience of satellites, e.g., against cyber-attacks or Electronic Warfare (EW), or the distinction between benign and hostile activities.[30]

[21] Mathieu Bataille and Valentine Messina, "Europe, Space and Defence", cit.

[22] SDA website: *Who We Are*, https://www.sda.mil/?p=264.

[23] Ibid.

[24] David Vergun, "Space Development Agency Transitioning to U.S. Space Force", in *DOD News*, 26 August 2021, https://www.defense.gov/News/News-Stories/Article/Article/2747675/space-development-agency-transitioning-to-us-space-force.

[25] US Department of Defense, "What's With All the U.S. Space-Related Agencies?", cit.

[26] Mathieu Bataille and Valentine Messina, "Europe, Space and Defence", cit.

[27] US Department of Defense, "What's With All the U.S. Space-Related Agencies?", cit.

[28] Ibid.

[29] Sandra Erwin, "U.S. Space Command Official Calls for Public-Private Effort to Avert War in Space", in *SpaceNews*, 29 September 2021, https://spacenews.com/?p=119466.

[30] Ibid.

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The National Space Council (NSC) is a cabinet-level body revived during the Trump presidency in 2017 and maintained by the Joe Biden administration. The Council is comprised mainly of administration officials and was recently extended to include the secretaries of Education, Labor, Agriculture and Interior,[31] together with the national climate advisor. The NSC advises and assists the President on the development and implementation of space policy and strategy,[32] and needs to coordinate with the National Security Council on space matters related to national security, in order for the space strategy to be consistent with US security priorities.[33] The NSC is supported by a Users' Advisory Group made by external experts from industry, academia, and other organisations.[34] After almost a year of inactivity that fostered questions on what form the Biden administration's space policy would take, the Council convened under the chairmanship of Vice President Kamala Harris on 1 December 2021,[35] and in parallel the US Space Priorities Framework was presented.[36]

1.2 Space strategies: Trump and Biden

In general terms, the space priorities of the Biden administration are focused on climate change and civilian applications of space including Science, Technology, Engineering and Mathematics (STEM) education, more than on space as warfighting domain where to retain US dominance.[37] Nevertheless, Vice President Harris called for more solid international community effort to adopt rules of behaviour in orbit to protect national security and defend US commercial interest in the space sector, particularly after the 2021 anti-satellite (ASAT) test by Russia, which Washington defined an "irresponsible act",[38] and China's glider-Fractional Orbital Bombardment System (FOBS) that apparently caught the US intelligence by surprise.[39]

The ambition for Washington is to lead in the development of global standards and norms including in Space Traffic Management (STM), and uphold and strengthen

[31] Bryan Bender, "Harris Calls for New International Rules for Space After Russia Blows Up Satellite", in *Politico*, 1 December 2021, https://www.politico.com/news/2021/12/01/biden-expands-national-space-council-523593.

[32] White House website: *National Space Council*, https://www.whitehouse.gov/spacecouncil.

[33] See Section 5(c) in White House, *Executive Order on the National Space Council*, 1 December 2021, https://www.whitehouse.gov/briefing-room/statements-releases/2021/12/01/executive-order-on-the-national-space-council.

[34] White House website: *National Space Council*, cit.

[35] US Department of State, *Vice President Harris' First National Space Council Meeting*, 2 December 2021, https://www.state.gov/vice-president-harris-first-national-space-council-meeting.

[36] White House, *United States Space Priorities Framework*, December 2021, https://www.whitehouse.gov/wp-content/uploads/2021/12/United-States-Space-Priorities-Framework-_-December-1-2021.pdf.

[37] Kristin Fisher, "Harris to Announce Biden Administration's First Meeting of the National Space Council", in *CNN Politics*, 5 November 2021, https://edition.cnn.com/2021/11/05/politics/harris-first-meeting-national-space-council.

[38] Bryan Bender, "Harris Calls for New International Rules for Space After Russia Blows Up Satellite", cit.

[39] Timothy Wright, "Is China Gliding toward a FOBS Capability?", in *IISS Analysis*, 22 October 2021, https://www.iiss.org/blogs/analysis/2021/10/is-china-gliding-toward-a-fobs-capability.

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a rules-based international order by engaging the international community.[40] Accordingly, in July 2021 the DoD issued a Memorandum on responsible behaviour in space[41] stating five principles that should be respected by the US Forces when conducting space operations ("unless otherwise directed"),[42] whose implementation lies under the responsibility of the commander of the US Space Command. The Undersecretary of Defence for policy is responsible for advancing the memorandum tenets within the US government and through international relations.[43]

The Memorandum principles include: (1) operate "with due regard of others and in professional manner"; (2) limit the creation of space debris; (3) avoid harmful interferences; (4) communicate to increase stability and safety; (5) maintaining safe separation and safe trajectory.

Space is one of the few policy areas where continuity between the Trump and the Biden administration is visible, from maintaining the NSC and the Space Force to the continuation of the Artemis Programme for space exploration. Yet, the Memorandum follows a norms-based, multilateral approach to space focused on the international community. The document is the first unclassified statement providing instructions on tenets of normative behaviour[44] produced by the Pentagon.

The upcoming Security and National Defence Strategies[45] could shed some more light on the Biden administration approach to military space. Meanwhile, the Memorandum shows how Washington is willing to lead by example and emphasises international cooperation, responsible behaviour, norms-based space governance. Differently from the 2020 Defence Space Strategy (DSS), no mention is made of great power competition, deterrence, or prevailing in conflict:[46] the US military advantage in space is rather preserved by responsible behaviour coupled with Washington's predominant position. Indeed, the DSS indicated three objectives to be pursued by the DoD in order to achieve "desired conditions in space over the next 10 years": i) maintaining space superiority; ii) providing space support to national, joint, and combined operations; iii) ensuring space stability.[47] These can

[40] US Department of State, *Vice President Harris' First National Space Council Meeting*, cit.

[41] US Department of Defense, *Tenets of Responsible Behavior in Space*, 7 July 2021, https://media.defense.gov/2021/Jul/23/2002809598/-1/-1/0/TENETS-OF-RESPONSIBLE-BEHAVIOR-IN-SPACE.PDF.

[42] Ibid.

[43] Ibid.

[44] Benjamin Silverstein, "What Is the Pentagon's New Guidance on U.S. Space Policy?", in *Carnegie Quick Takes*, 28 July 2021, https://carnegieendowment.org/publications/85052.

[45] Christopher S. Chivvis, "Biden's Forthcoming National Security Strategy: Making it Real", in *Carnegie Articles*, 10 November 2021, https://carnegieendowment.org/publications/85734.

[46] Benjamin Silverstein, "What Is the Pentagon's New Guidance on U.S. Space Policy?", cit.

[47] US Department of Defense, *Defense Space Strategy Summary*, June 2020, p. 1-2, https://media.defense.gov/2020/Jun/17/2002317391/-1/-1/1/2020_DEFENSE_SPACE_STRATEGY_SUMMARY.PDF.

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be achieved by obtaining "a military advantage in space", and integrating "military spacepower into national, joint and combined operations" and, conversely, joint warfare principles into space operations.[48] The National Space Policy published in December 2020, at the very end of the Trump administration, is another legacy for Biden.

It would seem however that Washington is currently pursuing a cautious, de-escalatory approach on paper, but it remains to be seen if the latter will be confirmed by the security and defence strategies. Simultaneously, President Biden decided to augment the budget of the US Space Force by 13 per cent for 2022 compared to 2021, with funding for classified research, technology and development programmes increasing by 22 per cent[49] – a real commitment to enhance space defence capabilities.

Overall, 2022 budget for military space programs includes more than 15.9 billion US dollars, an 18.6 per cent increase compared to 2021.[50] However, as of 12 January 2022 Congress has not yet passed appropriations bills for federal agencies and defence spending is frozen at last year's levels. The eventuality of a spending freezing would have a considerable impact on the Space Force.[51]

1.3 Military space doctrines and capabilities

After declaring a new domain in 2018 and the establishment of the Space Force as a new branch of the US Armed Forces and as the operational instrument of the US Space Command, on 10 August 2020 the US Space Force released its first doctrine, the "Space Capstone Publication".[52] The document, which can be reviewed every 4 years, builds on earlier doctrines such as the Joint Doctrine 3-14 on Space Operations[53] by the Air Force and Joint Staff, published in April 2018 that defined the types of space operations, and the circumstances under which they can be undertaken.[54] The new doctrine differs from the old one since, for the first time, it treats space as a separate, warfighting domain, with consequences for the chain of

[48] Ibid., p. 6.

[49] Jon Harper, "Classified Space Programs Poised for Budget Boost", in *National Defense*, 10 August 2021, https://www.nationaldefensemagazine.org/articles/2021/10/8/classified-space-programs-poised-for-budget-boost.

[50] Sandra Erwin, "Defense Policy Bills Gives a Budget Boost to Space Programs", in *SpaceNews*, 16 December 2021, https://spacenews.com/?p=122334.

[51] Charles Pope, "Brown, Raymond Warns of Impacts to Air Force Space Force If New Budget Is Not Approved", in *Air Force Articles*, 12 January 2022, https://www.af.mil/News/Article-Display/Article/2898181; Sandra Erwin, "Pentagon Warns Hundreds of Programs in Limbo Until Congress Passes Full-Year Budget", in *SpaceNews*, 12 January 2022, https://spacenews.com/?p=122839.

[52] US Space Force, *Spacepower. Doctrine for Space Forces*, Space Capstone Publication, June 2020, https://apps.dtic.mil/sti/pdfs/AD1129735.pdf.

[53] US Joint Chiefs of Staff, *Space Operations* (Joint Publication 3-14), 26 October 2020, https://www.jcs.mil/Portals/36/Documents/Doctrine/pubs/jp3_14ch1.pdf.

[54] Theresa Hitchens, "AF to HASC: Space War Doctrine Near; SPACECOM HQ Pick Delay", in *Breaking Defense*, 4 March 2020, https://breakingdefense.com/?p=96026.

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command, training and education and operations.

Similarly to other domains, national spacepower indicates the "ability to leverage the space domain"[55] to pursue national prosperity and security, and aims to strengthen military, diplomatic, information and economic means of national power. Military spacepower needs to harmonise and integrate with other instruments, in order to protect "[national] strategic interests in space",[56] and exert deterrence and coercion. This entails using "combat power" in space for both defensive and offensive purposes, as already mentioned in the Space Policy Directive 4 (SPD-4) issued by the Trump administration, and by using lethal and non-lethal means "in, from and through space".[57] In this framework, the Space Force is charged with three "Cornerstone Responsibilities": i) preserving freedom of action in space; ii) enabling joint lethality and effectiveness; iii) providing independent options to US national leadership to achieve national objectives.[58] Accordingly, the competencies covered by the spacepower are: Space Security, Combat Power Projection, Space Mobility & Logistics, Information Mobility, and Space Domain Awareness.

The doctrine sets definitions and concepts, but it is an initial and generic framework that will have to be followed by further documents, defining more specifically the operational and tactical levels,[59] as well as building a common and distinct culture and identity of the new branch,[60] or defining better under what circumstances offensive operations could be warranted.[61]

The US maintains the most complete operational experience in space integrated warfighting. In terms of capabilities, Washington operates a worldwide Space Situational Awareness (SSA) system including, as of 2018, 350 Intelligence, Surveillance, and Reconnaissance (ISR) satellites, providing space-based image intelligence (IMINT), signals intelligence (SIGINT), and measurement and signatures intelligence (MASINT).[62] Information from GPS satellites are integrated into a multitude of weapons systems and operational practices, and are currently a key capability in terms of Positioning, Navigation and Timing (PNT). The abovementioned SDA, with a budget of 11 billion dollars should provide the US and its NDSA with next generation communication services to be used for example in

[55] US Space Force, *Spacepower. Doctrine for Space Forces*, cit., p. 13.

[56] Ibid., p. 14.

[57] Theresa Hitchens, "Spacepower Is 'Catastrophically Decisive' in War: New Space Force Doctrine", in *Breaking Defense*, 10 August 2020, https://breakingdefense.com/?p=115229.

[58] US Space Force, *Spacepower. Doctrine for Space Forces*, cit.

[59] Theresa Hitchens, "Spacepower Is 'Catastrophically Decisive' in War", cit.

[60] Peter L. Hays, Russell Rumbaugh and Michael P. Gleason, *Developing a Foundational Spacepower Doctrine: Fostering an Independent Space-Minded Culture and Identity*, Aerospace Center for Space Policy and Strategy, October 2020, https://aerospace.org/node/124.

[61] Theresa Hitchens, "Spacepower Is 'Catastrophically Decisive' in War", cit.

[62] Christoph Schwarz and Sofia-Maria Satanakis, "Space Race 2.0 — Renewed Great Power Competition in the Earth's Orbit", in *AIES Fokus*, No. 6/2020 (June 2020), https://www.aies.at/publikationen/2020/fokus-20-06.php.

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missile defence, as well as to complement GPS system by launching 250 satellites by 2025.[63]

In terms of counterspace capabilities, the US possess Counter Communication Systems (CCS), which is a counterspace electronic asset for jamming, and is developing ground-based high-energy lasers.[64] Even if the US does not have an operational Direct-Ascent (DA) ASAT system, some of its missile defence capabilities, notably the ground-based midcourse missile defence system and the Aegis system, currently have "latent DA-ASAT" capabilities: the former through its ground-based interceptors, the latter through the ship-based STANDARD 3 missile interceptors.[65] What is more, Washington has tested and developed most of the technologies underlying co-orbital ASAT systems.[66]

For what concerns access to space, in the US it is based on the "Assured Access" to space law[67] stating that "two space launch vehicles (or families of space launch vehicles)" able to deliver every national security payload to orbit,[68] have to be available at all times. In terms of capabilities, US independent access to space is guaranteed by the Evolved Expendable Launch Vehicle (EELV) and the subsequent National Security Space Launch (NSSL) programmes,[69] currently operated by United Launch Alliance (ULA) and SpaceX from the launch sites in California and Florida.[70] The Space Force operates from six space bases, situated respectively in Colorado, California, and Florida.[71]

1.4 Space sustainability, non-proliferation and arms control

Washington is the only state that has a fully-fledged national STM framework and, as mentioned before, aims to play a leading role globally by becoming a norms-setter on STM,[72] in order to find sustainable debris removal solutions and mitigate this problem in increasingly congested orbits. When it comes to norms, international cooperation on debris removal technologies is made more difficult

[63] Ibid.

[64] Ibid.

[65] Kaila Pfrang and Brian Weeden, "U.S. Direct Ascent Anti-Satellite Testing", in *Secure World Foundation Fact Sheets*, April 2021, https://swfound.org/media/207180/swf_us_da-asat_fact_sheet_apr2021.pdf.

[66] Ibid.

[67] Legal Information Institute website: *10 U.S. Code § 2273 - Policy Regarding Assured Access to Space: National Security Payloads*, https://www.law.cornell.edu/uscode/text/10/2273.

[68] Joshua Huminski, "Moving Beyond Assured Access to Space", in *Breaking Defense*, 2 November 2021, https://breakingdefense.com/?p=186311.

[69] Ibid.

[70] Ibid.

[71] US Space Force website: *USFF Locations*, https://www.spaceforce.mil/About-Us/Space-Force-Locations.

[72] Brandi Vincent, "It's Time to Develop a Global Space Traffic Management System, White House Adviser Says" in *Nextgov*, 15 September 2021, https://www.nextgov.com/emerging-tech/2021/09/its-time-develop-global-space-traffic-management-system-white-house-adviser-says/185365.

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by the dual use nature of the latter. Indeed, the same technologies utilised for space clean up could be used for offensive operations targeted at other states' satellites.[73] In this context, the Memorandum on responsible behaviour appears even more relevant. Some observers note that the US should focus on developing non-kinetic counter space weapons with reversable effects,[74] such as EW systems and cyber capabilities, in order to avoid the damages made by kinetic weapons in outer space that risk having devastating effects for the whole planet. In this sense, space debris could be considered as "the main enemy of national security".[75] On the other side of the coin, systems capable of damaging kinetically/mechanically satellites without causing debris represent a threat as well.

1.5 Cooperation and partnerships

Multilateral cooperation in military space results for example in the Combined Space Operations Initiative (CSpO) among the Five Eyes and some key partners– encompassing Australia, Canada, France, Germany, New Zealand and the United Kingdom (UK).[76] The CSpO is a collaboration focused on Space Domain Awareness (SDA), force support, launch and re-entry assessment and contingency operations, including table-top exercises and best practices for combined space operations. In this framework, the Combined Space Operations Center (CSpOC) located in the Vandenberg Air Force Base was opened to allies, for co-participation and to gain better visibility on day-to-day space operations.[77] Additionally, in the context of the Operation Olympic Defender, space war plans have been partially made accessible to allies, in order to ensure that they can identify those areas, missions or tasks where they can contribute.[78]

Another relevant example of space defence cooperation are the Space Sharing Agreements between the US Strategic Command and allies and partners, including among others the European Space Agency (ESA) and commercial satellite operators on SSA and related data-sharing.[79]

[73] Philip Potter, George W. Foresman and Michael Horowitz, "Space Norms and U.S. National Security: Leading on Space Debris", in *War on the Rocks*, 2 August 2021, https://warontherocks.com/?p=25352.

[74] Aaron Bateman, "America Can Protect Its Satellites Without Kinetic Space Weapons", in *War on the Rocks*, 30 July 2020, https://warontherocks.com/?p=23115.

[75] Ibid.

[76] US Space Command, *Combined Space Operations Initiative Welcomes France and Germany*, 13 February 2020, https://www.spacecom.mil/Newsroom/News/Article-Display/Article/2083368.

[77] Colin Clark and Theresa Hitchens, "STRATCOM's Hyten Calls for Space Rules After India's ASAT Test", in *Breaking Defense*, 9 April 2019, https://breakingdefense.com/?p=55631.

[78] Ibid.

[79] Karen Singer, "100th Space Sharing Agreement Signed, Romania Space Agency Joins", in U.S. Strategic Command website, 26 April 2019, https://www.stratcom.mil/Media/News/News-Article-View/Article/1825882.

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2. Russia and China: West's systemic rivals on orbits

by Giancarlo La Rocca*

Nowadays, after more than sixty years since Sputnik, Russia and China are considered by the US as the "greatest strategic threats",[1] due to the development of counterspace capabilities associated with the respective national military doctrines as well as of military space assets. In 2019, former Vice President Mike Pence remarked that the US is engaged in a new space race, with higher stakes compared to the Cold War period, with more security threats and a clash on the same rules and values of space.[2] As discussed in a previous chapter, the Biden administration changed the tone on space, but several elements of continuity mark the American space policy.[3] Development of counterspace systems is advancing and expanding, involving kinetic and non-kinetic capabilities to pose intentional threats. Russia and China are indeed engaged to test and acquire operational space defence capabilities, both ground-based ASAT weapons and space-based (co-orbital) systems. Recently, the US Space Force Deputy Chief of Space Operations observed that risks of miscommunications in space with Russia and China are rising because of behaviours in orbit, suggesting the use of military hotlines to avoid accidents or miscalculation that could lead to escalations.

The test of a Direct-Ascent Anti-Satellite weapon (DA-ASAT) conducted by the Russian Federation on 15 November 2021 created more than 1,500 trackable debris along with possibly thousands of smaller fragments, endangering the activities of the International Space Station (ISS) and hundreds of other assets.[4] The test has been considered a clear example of irresponsible behaviour which has potential military implications but also unpredictable, indiscriminate effects on the congestion and sustainability of orbits. The event attracted strong condemnations from Western actors, but the political and diplomatic consequences are so far uncertain and could eventually be very limited in scope, reaffirming the status quo. Noticeably, a DA-ASAT conducted by China in 2007 led to the creation of more than 3,500 pieces of debris which continue to this day to put at risk space activities.[5]

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[1] US Department of Defense, *Defense and Space Strategy Summary*, cit.

[2] White House, *Remarks by Vice President Pence at the Fifth Meeting of the National Space Council*, Hunstville, 26 March 2019, https://trumpwhitehouse.archives.gov/briefings-statements/remarks-vice-president-pence-fifth-meeting-national-space-council-huntsville-al.

[3] See Chapter 1 of this study.

[4] Chelsea Gohd, "Russian Anti-Satellite Test a 'Dangerous and Irresponsible' Act That Threatens Astronauts, US Say", in *Space.com*, 15 November 2021, https://www.space.com/russia-asat-test-space-debris-dangerous-irresponsible.

[5] Carin Zissis, "China's Anti-Satellite Test", in *CFR Backgrounders*, 22 February 2007, https://www.cfr.org/backgrounder/chinas-anti-satellite-test; Jeff Foust, "Russia Destroys Satellite in ASAT Test", in *SpaceNews*, 15 November 2021, https://spacenews.com/?p=121139.

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The credibility of threats posed by Russia and China has been increasing over the last years, due to overall changing postures and a renewed attention devoted to space, considered a touchstone of global powers. While Moscow is engaged to revamp the legacy of the USSR, Beijing started to develop and consolidate its role in space since the 1990s, reaching the status of a mature global space power in about two decades.

2.1 Relaunching a global space power legacy: Russia's approach to space

Russia is a long-established space power, which inherited the status acquired by the Soviet Union and is rebuilding its tradition with renewed capabilities. The Russian Aerospace Force (RAF) is the main entity in control of developments in the space and defence dimensions, building on the structures of the Russian Space Force established already in 1992 – thus following a sort of backward path compared to the Western trend to identify single forces or commands devoted to space.[6] The civil space activities were also restructured and are managed by the Roscosmos State Corporation, the national space agency established in 2015 and which partially supervises also military technology manufacture. Overall, defence and military stakeholders are central in the actual space governance, having a role also in drafting the national space strategy and defining the budget. Released in 2016, the Federal Space Programme 2016–2025 allocated approximately 20 billion dollars to space. This budget was almost cut in half, if compared to the initial proposal released in 2014, with impacts on the development of many programmes for what concerns science, exploration and launchers.[7]

Approved in 2014, the Military Doctrine of the Russian Federation considers space as the domain where external military risk can arise, but also where internal threats and disruptions may occur, considering the assets in orbit and provided services as well as the ground segments. According to the document, the nature of the existing military context foresees the possibility to exert pressure on the enemy also in space. "Systems of outer space monitoring" are considered a main military threat.[8] At the same time, a main task of the Russian Federation is to strengthen the domestic "potential in the area of monitoring objects and events in the near-Earth outer space".[9] Regarding the Armed Forces, the Doctrine emphasises their role to ensure the readiness also to counter space attacks. Overall, the military organisation is given a priority to "improve the [national] aerospace defense systems" and develop "new types of [...] aerospace defence assets".[10] The

[6] Robert Farley, "Managing the Military Problem of Space: The Case of Russia", in *The Diplomat*, 20 April 2021, https://thediplomat.com/2021/04/managing-the-military-problem-of-space-the-case-of-russia.

[7] Anatoly Zak, "Russia Approves Its 10-Year Space Strategy", in *Planetary Society Articles*, 23 March 2016, https://www.planetary.org/articles/0323-russia-space-budget.

[8] Russian Presidency, *The Military Doctrine of the Russian Federation*, 25 December 2014, https://rusemb.org.uk/press/2029.

[9] Ibid., point 21(o).

[10] Ibid., points 35(c) and 46(f).

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latest strategic governmental document, the National Security Strategy of July 2021, contains minor references to space. The document mentions how space is "increasingly developed as a new sphere of military operations", affirming among others the priority to "strengthen the leading positions and competitive advantages achieved by the Russian Federation in the rocket and space industries".[11]

Over the 1990s and 2000s investments in space declined after major budgetary cuts and a general slowdown of activities, leading also to obsolescence of industry and capabilities associated with space. However, Moscow remained a credible space power even with limited resources due also to Soviet-era legacy and experience in science and technology. Since the 2010s Russia actually re-engaged in the space domain driven by an accent on military capabilities. Notably, after the dismissal of the Space Shuttle programme, the US relied on the Russian Soyuz nearly ten years to access space for human flight. From this commercial opportunity and with the retail of engines sold to the US Atlas V launcher, Russia received revenues in the order of billions of dollars.[12]

The relaunch of activities in the field of SIGINT and specifically ELINT also proves Moscow's re-engagement in the space domain. A new family of satellites, "Lotos" – part of the Liana system, entered the Russian space portfolio with focus on intelligence and reconnaissance, re-establishing some capabilities for the Navy and the Ministry of Defence from the Soviet-era Tselina assets.[13]

Furthermore, Russia invested in Tundra, a new generation space-based early warning satellites, part of the Integrated Space System (EKS), reobtaining capabilities gradually lost after 1991.[14] The Tundra satellites are launched in Molnya-type Highly Elliptical Orbits (HEO) for specific locations missile detection (US territory and northern hemisphere, but likely with gaps over the Pacific), with the end-goal of having a constellation of possibly ten assets. Yet, large parts of the SIGINT and early-warning systems remain uncertain or not public, limiting the information on the full scope and scale of the programmes. For instance, the Luch-Olymp-K satellite is also part of a family of SIGINT and generally spy/inspector satellites operating in GEO.

Besides the two programmes, Russia maintains a solid and large SSA and SST system, also identifying a strong ground-based early warning capability, based

[11] Russian Presidency, *Presidential Decree No. 400 Validating the National Security Strategy of the Russian Federation* (in Russian), 2 July 2021, points 17 and 67(8), https://www.fao.org/faolex/results/details/en/c/LEX-FAOC203816.

[12] Florian Vidal, "Russia's Space Policy. The Path of Decline?", in *Études de l'Ifri*, January 2021, https://www.ifri.org/en/node/18355; Alla Kassianova, "U.S.-Russia Science Cooperation Today", in *Russia Analytical Digest*, No. 253 (18 June 2020), p. 2-5, https://css.ethz.ch/content/dam/ethz/special-interest/gess/cis/center-for-securities-studies/pdfs/RAD253.pdf.

[13] Bart Hendrickx, "The Status of Russia's Signals Intelligence Satellites", cit.

[14] Bart Hendrickx, "EKS: Russia' Space-Based Missile Early Warning System", in *The Space Review*, 8 February 2021, https://www.thespacereview.com/article/4121/1.

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on dual approach composed of the Space Surveillance System (SKPP) and the International Scientific Optical Network (ISON).[15] The former is military-owned and provide both radar and optical capabilities. The latter is a civilian project managed by the Russian Academy of Sciences gathering telescopes from different locations around the globe, adding a wide geographical coverage to the entire surveillance and tracking system further consolidated by a third project, the Automated Warning System on Hazardous Situations in Outer Space (ASPOS OKP).

Overall, Russia aimed at completing a full set of space capabilities with communications and EO and remote sensing services.[16] In terms of communications, the Integrated Satellite Communication System (ESSS) provides the main services to the military, together with the Rodnik satellites in LEO and Garpun project in GEO. In the field of EO, Moscow has encountered more issues to obtain up-to-date capabilities but both military-dedicated (Persona, Bars-M, Razbeg) and civilian (Kanopus, Resurs, Arkitika) missions are in orbit, with several ongoing projects for perfecting the existing assets for reconnaissance and remote sensing.

Still, the economic sanctions after the 2014 war in Crimea and an over-reliance on energy prices significantly impacted the national space budget over the years. The Russian Global Navigation Satellite System (GLONASS) was not replaced for a long time with newer assets, to the point that the Russian forces had to occasionally rely on US GPS signals.[17] Repeated delays in the development of a new family of expensive launchers came across rising competition, as US private companies introduce new technologies and sharply reduce launch costs. In December 2021, the long-awaited Angara-A5 rocket experienced a failure, a dismaying outcome considering that the launcher is under development from more than twenty years.[18] Notably, Russia continues to pay a lease to Kazakhstan to operate the Baikonur Cosmodrome. In order to build a partial alternative to Baikonur, Moscow has significantly invested in the new Vostochny Cosmodrome in the Siberian far-East, operated alongside the Plesetsk site which is used primarily by military.

These structural factors of decay and inefficiency somehow co-exist with the pace and quality of military operations in space, exemplified by Direct-Ascent and co-orbital ASAT activities. A significant role is played by the Ministry of Defence (MoD), which operates GLONASS, invests to modernise current capabilities, and sponsors the development of new launchers also to maintain a full independent access to space. In terms of counterspace, as recalled above on November 15th,

[15] Interview, 17 January 2022.

[16] Samuel Bendett et al., "Advanced Military Technology in Russia. Capabilities and Implications", in *Chatham House Research Papers*, September 2021, https://www.chathamhouse.org/node/26963.

[17] Brian Weeden and Victoria Samson, "Global Counter Space Capabilities", in *Secure World Foundation Fact Sheets*, April 2021, https://swfound.org/media/207162/swf_global_counterspace_capabilities_2021.pdf.

[18] Jeff Foust, "Angara Upper Stage Reenters After Failed Lunch", in *SpaceNews*, 6 January 2022, https://spacenews.com/?p=122700.

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Moscow demonstrated to possess an operational capability of the A-235 P-19 Nudol transportable system, able to launch missiles and threaten assets in LEO.

Besides DA-ASAT, Russia has growing capabilities in co-orbital systems, which do not target spacecrafts from the ground, but rather enter in orbit and then move for espionage purposes or to pose kinetic threats based on Rendezvous and Proximity Operations (RPOs). On this front, Moscow has steadily increased the frequency of in-orbit tests, adopting a more threating posture and a hypocritical and concerning behaviour.[19] Russian satellites have often operated proximity operations on other Russian national assets. More recently, in 2020, the Kosmos-2543 is believed to have released or shoot an object at very high velocity.[20] Moreover, Russian assets on various occasions came close enough to interfere and spy on other satellites in LEO as well as in the Geosynchronous Equatorial Orbit (GEO). In these cases, targets are often American intelligence assets, but also commercial satellites. In 2018, the Luch-Olymp-K satellite, well-known for very active and unusual orbit behaviour, supposedly spied on Athena-Fidus, a French-Italian military communications asset.[21] Such unusual activity in orbit has become consistent over the last years, leading to considerations about a "persistent space strategy for close-proximity operations with foreign countries" and a "pattern of behaviour" demonstrated by Russia.[22] These capabilities have the potential to inspect satellites, spy on intercepted signals and eventually pose kinetic and non-kinetic threats to damage or capture a targeted asset through robotic arms or energy impulses.

Apart from ASAT developments, Russian forces are reported to have increasingly integrated EW and cyber into military operations, alongside other non-kinetic capabilities such as jamming or spoofing the Global Navigation Satellite System (GNSS) PNT signals. These advancements go hand in hand with reports of operational capabilities utilised in conflicts where Russian forces are employed, but also through interferences for instance during NATO exercitations.[23] Therefore, the relaunch in the last ten years of various space and counterspace capabilities and the progresses made in parallel on several fronts confirm the significant role Russia maintains in the domain. These advancements may still not be enough to

[19] US Space Command, *Russian Direct-Ascent Anti-Satellite Missile Test Creates Significant, Long-Lasting Space Debris*, 15 November 2021, https://www.spacecom.mil/Newsroom/News/Article-Display/Article/2842957.

[20] Loren Grush, "Russia Just Tested Satellite-Destroying Tech in Space, US Space Command Claims", in *The Verge*, 23 July 2020, https://www.theverge.com/2020/7/23/21335506.

[21] Thomas G. Roberts, "Unusual Behavior in GEO: Luch (Olymp-K)", in *CSIS Aerospace Security*, 31 March 2021, https://aerospace.csis.org/data/unusual-behavior-in-geo-olymp-k; "Russia Tried to 'Spy on France in Space' – French Minister", in *BBC News*, 7 September 2018, https://www.bbc.com/news/world-europe-45448261.

[22] Beyza Unal and Mathieu Boulègue, "Russia's Behaviour Risks Weaponizing Outer Space", in *Chatham House Expert Comments*, 27 July 2020, https://www.chathamhouse.org/node/15984; Todd Harrison et al., "Space Threat Assessment 2021", in *CSIS Reports*, April 2021, https://www.csis.org/node/60406.

[23] "Norway Says It Proved Russian GPS Interference During NATO Exercises", in *Reuters*, 18 March 2019, https://reut.rs/2HBwrCq.

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effectively modernise the whole spectrum of legacy capabilities, and to give Russia a solid political and commercial power in space on pair with the US. However, the unfolding developments highlight the essential role of the Russian military complex in driving activities and limiting, to some extent, the inefficiencies of the national approach to space.

2.2 Space as continuation of politics with other means: The rise of China to the orbits' elite

China started developing space capabilities already in the 1950s, with a leading role of the MoD given the similarities with ballistic missile technologies, and launched its first national satellite in 1970. From the 1990s, China engaged with substantial efforts in this domain, with multiple tests of DA-ASAT weapons that led in a relatively short time to operational capabilities. In January 2007, China tested for the third time the SC-19 ASAT system, intercepting and destroying the aging Fengyun-1C satellite, in orbit since 1999. The test created more than 3,500 pieces of debris, originated from the explosion at an altitude of 865 kilometres (km), and to this date continue to threat nominal activities in space. After 2007, more tests took place without interception of targets, nonetheless confirming the operational capability to pose from the ground intentional kinetic threats to assets in orbit.

Overall, China grew to be a credible and global space power, acquiring capabilities on a wide spectrum of technologies, closing substantial gaps and projecting the country to several future developments by the national anniversary in 2049. Beijing successfully launched an orbiter mission to Mars in 2020,[24] and conducted five Chang'e Lunar missions[25] while planning further breakthroughs. The country launched the first "taikonaut"[26] already in 2003[27] and manufactured two small space stations, with the newer Tianhe core module orbiting LEO since April 2021 and receiving crewed missions.[28]

The Chinese space strategy is sustained by a large family of space launchers, with mixed level of reliability but wide range of capabilities. In 2020, China completed 39 launch missions, suffering very limited effects from the pandemic especially compared to the Western space powers. Moreover, Beijing concluded 201 with 55 missions – more than the US[29] – celebrating also the 400th launch of the Long

[24] Zulfikar Abbany, "The Facts on Tianwen-1: Mars Orbiter and Rover", in *Deutsche Welle*, 10 February 2021, https://p.dw.com/p/3edcE.

[25] Planetary Society website: *Chang'e-5: China's Moon Sample Return Mission*, https://www.planetary.org/space-missions/change-5.

[26] Taikonaut is the Chinese wording for astronaut, from the Mandarin "taikong" which means space.

[27] "Making History: China's First Human Spaceflight", in *Space.com*, 28 September 2005, https://www.space.com/1616-making-history-china-human-spaceflight.html.

[28] Andrew Jones, "China's Tiangong Space Station", in *Space.com*, 24 August 2021, https://www.space.com/tiangong-space-station.

[29] According to initial data collected at the end of 2021, US completed 51 missions, while Europe completed six Ariane and Vega missions operated by Arianespace, one more compared to 2020. See

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March family of rockets.[30]

The large portfolio of launchers can rely on four launch sites, located in north-west and north-east of the country (Jiuquan and Taiyuan), east (Xiangshan), and south (Wengchang in the island of Hainan), while a fifth one (Xichang) is under construction in the south west of China.[31]

Limited but important developments occurred also for what concerns commercial and business industry. China completed the national GNSS system BeiDou composed of 35 satellites, developed several Earth Observation (EO) and remote sensing assets and looks to launch at least one large satellite constellation over the next years.

Besides, Beijing invested massively in acquiring a SIGINT/ELINT capability, performed by the circa twenty satellites of the Yaogan constellation, reaching full capability in 2021. With Yaogan, China managed to achieve a multi-purpose constellation project also intended for optical and radar reconnaissance, further complementing the remote sensing capability with the Gaofen set of satellites, most likely with a dual use approach for civilian EO and military reconnaissance.[32]

More capabilities are expected in the field of satellite communication, as China is developing a national large broadband constellation to operate in LEO and has multiple projects and authorisation filings aimed at comprehensively launch more than ten thousand of satellites.[33]

Furthermore, Beijing built a credible network of SSA capabilities, limited by the geographical coverage but including ground-based radars as well as telescopes. The radars are operated by the People Liberation Army (PLA) Strategic Support Force (SSF), capable of ballistic missile defence and satellite surveillance and tracking.

Besides these capabilities, China conducted several co-orbital tests in the last decade with satellites approaching other national assets and following unusual behaviours consistent with Rendezvous and Proximity Operations (RPOs)

Chris Impey, "2021: More Space Launches Than Any Year in History Since Sputnik", cit.; Arianespace website: *Missions*, https://www.arianespace.com/missions.

[30] Andrew Jones, "China Closes Record – Breaking Year with Orbital Launches from Jiuquan e Xichang", cit.

[31] "China Begins Construction of Its Fifth Rocket Launch Site", in *Reuters*, 8 April 2021, https://reut.rs/39V7X4e.

[32] Elisabeth Howell, "China Has 3 New Spy Satellites in Orbit after Long March 4C Launch", cit.; "China's Eye in the Sky: An Analysis of China's Satellite Surveillance", in *Business Standard*, 30 October 2019, https://www.business-standard.com/119103000151_1.html.

[33] Andrew Jones, "China's Megaconstellation Project Establishes Satellite Cluster in Chongqing", in *SpaceNews*, 12 January 2022, https://spacenews.com/?p=122824.

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experiments and dual use technology for in-orbit servicing or kinetic threats.[34] The country maintains EW capabilities and is supposedly developing a hypersonic technology as well as a spaceplane project, possibly mirroring the US Air Force X-37B. Indeed, in the summer of 2021 Beijing operated an undisclosed mission believed to be a hypersonic glide technology test, potentially also similar to the FOBS capability – a memory of the Cold War and an unexpected development.[35]

Moreover, China is progressing on quantum technology, potentially establishing a competitive advantage on this front compared to other powers. In 2016, Beijing launched the Micius satellite which focuses on quantum cryptography and communication.[36] A test in 2020 succeeded in establishing a completely secure and "unhackable"[37] communication between two ground stations distanced more than 1,000 km, avoiding vulnerabilities both in the uplink and downlink phases. The University of Science and Technology of China is in charge of the project,[38] and further moved forward on the technology to establish and connect a larger network for quantum key distribution.[39]

Such a massive engagement on space is based on a solid vision and plan of investments. While data about budgets allocated by Beijing over the years are uncertain, the rationale behind the race to space are well defined. According to Chinese sources, space enables the "power of initiative" and gives essential advantages, including information dominance, in the other military dimensions.[40] Space is indeed recognised as the high ground and an operational domain, with concrete consequences on the national defence structures and implementation of the military doctrine. In the 2015 White Paper on military strategy, China recognises outer space (and cyber) as a new "commanding heights in strategic competition among all parties".[41] This trend is part of an international security environment where technology and information are key and "new and severe challenges to

[34] Thomas G. Robert, "Unusual Behavior in GEO: SJ-17", in *CSIS Aerospace Security*, 31 March 2021, https://aerospace.csis.org/data/unusual-behavior-in-geo-sj-17; Brian Weeden and Victoria Samson, "Global Counter Space Capabilities", cit.

[35] Demetri Sevastopulo, "Chinese Hypersonic Weapon Fired a Missile Over South China Sea", in *Financial Times*, 21 November 2021, https://www.ft.com/content/a127f6de-f7b1-459e-b7ae-c14ed6a9198c.

[36] Karen Kwon, "China Reaches New Milestone in Space-Based Quantum Communications", in *Scientific American*, 25 June 2020, https://www.scientificamerican.com/article/china-reaches-new-milestone-in-space-based-quantum-communications.

[37] Quantum communication can not be hacked by non-quantum technology, therefore the first power to master quantum cryptography and communication will enjoy a strategic advantage until other powers will develop their own quantum computers.

[38] Juan Yin et al., "Entanglement-based Secure Quantum Cryptography over 1,120 Kilometres", in *Nature*, Vol. 582, No. 7813 (25 June 2020), p. 501-505, https://doi.org/10.1038/s41586-020-2401-y.

[39] University of Science and Technology of China, "The World's First Integrated Quantum Communication Network", in *Phys.org*, 6 January 2021, https://phys.org/news/2021-01-world-quantum-network.html.

[40] Ibid.

[41] China's State Council, *China's Military Strategy*, May 2015, http://english.chinamil.com.cn/view/2021-06/23/content_10053010.htm.

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China's military security" arise.[42] Furthermore, in a 2019 White Paper on national defence, space is recognised as a "critical domain" and one priority is "to safeguard China's security interests in outer space, electromagnetic space and cyberspace".[43]

On the one hand, the doctrine led to more integration between the air and space domain, as the People's Liberation Army (PLA) Air Force reinforced joint training and operational capabilities. On the other hand, the new PLA Strategic Support Force (SSF) established in 2015 emerges as a new type of combat force and represents an effort to translate the recognition of new operational domains into a concrete action to respond to threats and challenges. The SSF includes a Space System Department and a Network Systems Department. Thus, the new branch combines space, cyber and EW into one dimension, transitioning and repurposing units "from a discipline-centric to domain-centric force structure".[44] While some counterspace capabilities may be maintained by other PLA Forces – Air or Rocket, the latter established as well in the 2015 overall military restructure –, the SSF represents a step-forward in the Chinese approach to consider space as an operational domain potentially leading to new developments and synergies with the State Administration for Science, Technology and Industry for National Defense (SASTIND), the institutional centre entity for space.[45]

Overall, China is not an outsider in space anymore, but rather a credible actor on many technological aspects, regarded with growing concerns by the US as a major threat because of its fast development and posture on space defence capabilities. Beijing continues to invest in modernising national assets, push domestic space technologies such as BeiDou as part of a broader political strategy, and record strong numbers in satellite launches. Even during the pandemic, the internal supply chains quickly recovered and the country returned to launch to space already in February 2020, several months in advance compared to Western actors. Some capabilities, for instance in SSA and Space Surveillance and Tracking (SST), may still be inadequate for a global space power. Yet, a steady development and large investments may further upgrade the current China role in the space competition.

[42] Ibid.

[43] China's Ministry of National Defense, *China National Defense in the New Era*, 24 July 2019, http://eng.mod.gov.cn/news/2019-07/24/content_4846443.htm. The strategic character of space has been recognised also in the latest White Paper released by China in February 2022, which is more programmatic and industry-centred: China's State Council Information Office, *China Space Program: A 2021 Perspective*, 28 January 2022, http://www.china.org.cn/china/2022-01/28/content_78016843.htm.

[44] John Costello, "The Strategic Support Force: Update and Overview", in *China Briefs*, Vol. 16, No. 19 (21 December 2016), https://jamestown.org/?p=75656.

[45] Kevin L. Pollpeter, Michael S. Chase and Eric Heginbotham, "The Creation of the PLA Strategic Support Force and Its Implications for Chinese Military Space Operations", in *RAND Reports*, https://doi.org/10.7249/RR2058; Marc Julienne, "China's Ambition in Space. The Sky's the Limit", in *Études de l'Ifri*, January 2021, https://www.ifri.org/en/node/18395.

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2.3 The Eastern approach to space: A vicious circle

The advancements of Russia and China, from a doctrinal and operational standpoint, emphasise the role of defence actors and the idea of space as leverage for competition and touchstone of global power status. The perception of a threat coming from the West plays a key role in reinforcing Moscow's and Beijing's case for a space and arms race. Quite often, the two Eastern actors adopt a narrative meant to support each other's behaviours. Moreover, in the occasions of globally recognised disruptive events such as the 2007 or the 2021 DA-ASAT tests, Russia never condemns China and vice versa. This form of Eastern cooperation continues also at diplomatic level and in international platforms, where Russia and China promote the Treaty on the Prevention of Placement of Weapons in Outer Space (PPWT), disregarded by the rest of the international community, while often opposing other efforts to reduce threats and find common solutions.

Despite such ongoing cooperation, a serious and structured exchange between the two actors may not take place with regards to key technology aspects. Rather, Moscow and Beijing cooperate on a scientific level and recently signed an agreement to partner on a joint Moon base project, in response to the US-led Artemis Accords initiative.[46] In this context, Russia is increasingly seen as a sort of "junior partner" to China, in spite of the significant Soviet legacy.[47] Together or not, the Eastern actors seem to systemically raise the level of the challenge in orbit, with limited efforts to show openness to dialogue. Their respective strategies are reinforced by the perceived threats posed primarily by the US and Western emphasis to defend space assets, in a vicious circle that may lead to less cooperation and dialogue, more competition and deadlocks on several space safety, security and sustainability aspects which would require shared solutions among all concerned key actors.

[46] "China Confirms Building Moon Base with Russia by 2035", in *Spacewatch*, 31 January 2022, https://spacewatch.global/?p=38857.

[47] Andrew E. Kramer and Steven Lee Myers, "Russia, Once a Space Superpower, Turns to China for Missions", in *The New York Times*, 16 June 2021, https://www.nytimes.com/2021/06/15/world/asia/china-russia-space.html.

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3. NATO and its members: A space Alliance?

by Elio Calcagno*

NATO's designation of space as a full-fledged operational domain and the Allies' adoption of a classified Space Policy in 2019[1] represented an official if somewhat overdue recognition of the increasing importance that space and space-based assets play in contemporary and future warfare. The Atlantic Alliance gathers under its insignia many of the most technologically advanced militaries in the world. Chief among them is the US, the most capable spacefaring actor. Other allies hold widely-varying capabilities and views as to whether and how space should be exploited for military objectives. The most space-capable, namely France, Germany, Italy[2] and the UK,[3] are among the top spenders in space globally. Their government budgets, combined with that of the US, have the potential to make NATO a very influential player in the space domain. Indeed, over half of all active satellites currently in orbit are owned by NATO Allies or companies based in their territories.[4]

Ultimately, however, NATO's effective use of the space domain in military operations and the defence of Allied assets in and from space will depend largely on the Allies' willingness not only to increase military spending in this sector, but also to put their own assets at the Alliance's disposal as needed. Furthermore, a shared doctrine defining the current and future integration of space-based assets into NATO collective defence and military operations needs to be laid out. As happened in several others circumstances, the Alliance will have to navigate different interests and perceived threats in order to bolster its role in this new operational domain. This could prove to be a challenging task when even close partners such as France and Germany, major NATO allies and spacefaring states, can have wildly different approaches to the nexus between space and defence.

3.1 A new NATO Operational Domain

With the 2019 announcement that space would thereafter be considered an operational domain alongside sea, air, land and cyberspace, Secretary General Jens Stoltenberg also declared that NATO had no intention of putting weapons into space.[5] He went on to explain why this particular move was a logical step for

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1 NATO, *NATO Defence Ministers Approve New Space Policy, Discuss Readiness and Mission in Afghanistan*, 27 June 2019, https://www.nato.int/cps/en/natohq/news_167181.htm.

2 See Chapter 6 of this study.

3 See Chapter 5 of this study.

4 NATO, *NATO's Approach to Space*, cit.

5 NATO, *Press Conference by NATO Secretary General Jens Stoltenberg Following the Meeting of the North Atlantic Council at the Level of Foreign Ministers*, 20 November 2019, https://www.nato.int/cps/en/natohq/opinions_171022.htm.

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the Alliance:

> [Making] space an operational domain will help us ensure that all aspects are taken into account to ensure the success of our missions. For instance, this can allow NATO planners to make requests for Allies to provide capabilities and services – such as hours of satellite communications or data for imagery.

Space-based assets are indeed an enabler for military operations, in that satellites can enhance situational awareness, Command and Control (C2), early warning capabilities and weather forecast.[6] It is therefore crucial for a military alliance comprising some of the most advanced militaries in the world to integrate the space dimension into its planning, doctrine and training as efficiently and seamlessly as possible.

NATO did in fact own and operate its own space-based assets through the SATCOM satellite programme between 1970 and the early 2000s,[7] when this programme was replaced by SATCOM Post-2000, which provided SATCOM services to the Alliance from 2005 and 2019 by accessing national communication satellites from Italy, France and the UK directly.[8] The successor to this project involves the same European countries, this time joined by the US, who will deliver their military SATCOM programme's capabilities to NATO for the next 15 years.[9]

Space is also a domain from which new threats abound, with space powers such as China and Russia developing and testing ASAT capabilities.[10] In the long run, these advancements can potentially endanger NATO's already-diminishing technological edge over systemic rivals,[11] much of which relies on space assets, including for ISR, space surveillance, PNT, and satellite communications.[12] NATO has reportedly experienced first-hand the disruptive potential threat that ASAT capabilities pose to military operations as recently as 2018, when Finland and Norway accused Russia of intentionally disrupting GPS signals during NATO

[6] Kestutis Paulauskas,"Space: NATO's Latest Frontier", in *NATO Review*, 13 March 2020, https://www.nato.int/docu/review/articles/2020/03/13/space-natos-latest-frontier.

[7] NATO website: *The Cold War. Defence and Deterrence*, https://www.nato.int/cps/en/natohq/declassified_138278.htm.

[8] Ibid.

[9] NATO, *NATO Begins Using Enhanced Satellite Services*, 12 February 2020, https://www.nato.int/cps/en/natohq/news_173310.htm.

[10] Russia has tested the PL-10/Nudol direct-ascent ASAT system multiple times and has been accused by the US of testing a co-orbital ASAT system in July 2020. China has also developed kinetic counterspace capabilities with its SC-19 direct-ascent ASAT system. See Todd Harrison et al., "Space Threat Assessment 2021", cit., p. 10; 13-14. For a broader analysis see Chapter 2 of this study.

[11] Andrea Gilli, "NATO, Technological Superiority, and Emerging and Disruptive Technologies", in Thierry Tardy (ed.), "NATO 2030: New Technologies, New Conflicts, New Partnerships", in *NDC Research Papers*, No. 17 (February 2021), p. 5-17 at p. 7, https://www.ndc.nato.int/news/news.php?icode=1527.

[12] Mathieu Bataille and Valentine Messina, "Europe, Space and Defence", cit.

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exercises in the High North.[13]

Against this backdrop, and despite its important role as coordinator for allied military operations depending greatly on space-based assets, the Alliance has emphasised through its 2022 Space Policy that it has no intention of becoming an autonomous space actor.[14] It has rather reiterated that the ultimate goal is to ensure that its operations have the adequate level of support in the space domain.[15]

As a testament to the importance space plays in NATO military power, the 2021 Brussels summit led to the declaration that "attacks to, from, or within space present a clear challenge to [its security]" and that "such attacks could lead to the invocation of Article 5 [on collective defence]", although there is no stated threshold as to what type of challenge could lead to such a decision. The North Atlantic Council (NAC) would examine each instance individually.[16]

While NATO would not be able to respond to threats autonomously, it believes it can offer a real added value in the space dimension of military operations as a forum "for Allies to share information and coordinate activities on various space-related issues".[17] In order to do that, it established the NATO Space Centre, based in the Allied Air Command in Ramstein, Germany. Staffed by a multinational team, the Centre is tasked with working "closely with the Allies' national Space agencies and organisations and the NATO Command Structure to fuse data, products and services provided by nations, such as imagery, navigation and early warning".[18] The stated goal is that of creating a "common space domain picture" that can be shared with Allies in order to enhance effectiveness at the tactical and operational levels.[19] If successful, the Space Centre could act simultaneously as a force-multiplier and, crucially, as a redundancy-enhancing instrument for space-support and counterspace operations in conflict scenarios.

Trailing the establishment of the Space Centre, NATO is working on a new Centre of Excellence (CoE) for space in Toulouse, France. Its location is likely a sign of a growing French role in NATO space affairs, with Paris seeking to establish itself as a leading player in the space domain globally, but also within the Alliance. A

[13] Gerard O'Dwyer, "Finland, Norway Press Russia on Suspected GPS Jammed during NATO Drill", in *DefenseNews*, 16 November 2018, https://www.defensenews.com/global/europe/2018/11/16/finland-norway-press-russia-on-suspected-gps-jamming-during-nato-drill.

[14] NATO, *NATO's Overarching Space Policy*, 17 January 2022, https://www.nato.int/cps/en/natohq/official_texts_190862.htm.

[15] NATO, *Press Conference by NATO Secretary General Jens Stoltenberg ahead of the Meetings of NATO Ministers of Foreign Affairs*, 9 November 2019, https://www.nato.int/cps/en/natohq/opinions_170972.htm; NATO, NATO's Overarching Space Policy, cit.

[16] NATO, *Brussels Summit Communiquè*, 14 June 2021, point 33, cit.

[17] NATO, NATO's Approach to Space, cit.

[18] NATO Allied Air Command website: *We Coordinate NATO Space Matters*, https://ac.nato.int/missions/we-coordinate-nato-space-matters.

[19] Ibid.

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reorganisation of its military just before agreeing on the declaration of space as an operational domain, allowed it to present a winning bid for hosting the new CoE for Space in Toulouse.[20] The Space CoE will operate right at the heart of France's space ecosystem, surrounded by the French Space Academy and Space Command, the Space Lab and space industrial stakeholders.[21] The CoEs aim to "assist in doctrine development, identify lessons learned, improve interoperability and capabilities, and test and validate concepts through experimentation".[22]

The greatest challenge for NATO as it looks up to the "highest ground" will be to facilitate agreement among its membership, taking into account the high degree of diversity in terms of budgets and doctrines. A hypothetical, "grey zone"[23] attack against a NATO Ally's satellite may not necessarily pose a direct physical threat to its citizens or military personnel. Indeed, there is a risk that many such attacks could deal considerable damage to Allies' space assets while staying clear of the Article 5 threshold. Attackers could also make it difficult if not impossible to unanimously agree on attribution, for instance by relying on proxy satellites or cyberattacks, and thus make a rapid decision unlikely for the NAC. By having to find the minimum common denominator among 30 Allies on what constitutes an attack worthy of Article 5, NATO may end up blunting the edge of the collective defence principle in space.

In this context, the differences in the approaches of France and Germany – the main European space players in NATO and the EU countries with the largest pre-pandemic institutional space budgets[24] (see Chapter 5) – to the nexus between defence and space demonstrate quite eloquently how difficult it would be for NATO to make a united front in times of crisis when space is concerned.

3.2 Berlin's timid approach

Germany's first and so far only Space Strategy dates back to 2010 and exhibits a mainly civil-oriented focus. Indeed, the word "defence" is mentioned only 3 times in this 36-page document.[25] The fact that defence is not one of the priorities

[20] Interview, 10 December 2021; French Ministry for the Armed Forces, *Defence - Establishment of the NATO Space Centre of Excellence in Toulouse*, 5 February 2021, https://www.diplomatie.gouv.fr/en/french-foreign-policy/security-disarmament-and-non-proliferation/news/article/defence-establishment-of-the-nato-space-centre-of-excellence-in-toulouse.

[21] Ibid.

[22] NATO, *Centres of Excellence*, 3 November 2020, https://www.nato.int/cps/en/natohq/topics_68372.htm.

[23] Marc Ozawa, "Adapting NATO to Grey Zone Challenges from Russia," in Thierry Tardy (ed.), "NATO 2030: New Technologies, New Conflicts, New Partnerships", in *NDC Research Papers*, No. 17 (February 2021), p. 19-32 at p. 21, https://www.ndc.nato.int/news/news.php?icode=1527.

[24] Sebastien Moranta et al., *ESPI Yearbook 2020*, Vienna, European Space Policy Institute, June 2021, p. 143, https://espi.or.at/downloads/send/79-espi-yearbook/573-espi-yearbook-2020.

[25] Federal Ministry of Economics and Technology, *Making Germany's Space Sector Fit for the Future. The Space Strategy of the German Federal Government*, Berlin, November 2010, https://www.dlr.de/rd/en/Portaldata/28/Resources/dokumente/Raumfahrtstrategie_en.pdf.

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in a document drafted by the Federal Ministry of Economics and Technology (*Bundesministerium für Wirtschaft und Klimaschutz* – BMWi) is not in itself a surprise, and the Strategy explains that in Germany innovation in the space sector is mostly driven by technologies developed for application in the scientific and civil fields.[26]

The 2016 White Paper on German Security Policy and the Future of the Bundeswehr timidly included space as an operational domain for the country's armed forces, but still focused mainly on the need to create transparency on the use of space and to support confidence-building measures with other states.[27] However, while the document states that the ability to fight remains essential especially in the land, air and maritime domains, it does not exclude space *a priori*.[28]

While there are signs of a shift,[29] so far Berlin has adopted a rather normative stance on the nexus between space and defence which, although it does not necessarily exclude a more pragmatic doctrine, *de facto* neglects the current climate characterised by strategic competition among the major space-faring powers, namely China, Russia and the US.[30] Any future government publications on defence and/or space should be expected to account for the great shift that has occurred in the last 5-10 years.

At the operational level, the Air Force is in charge of space military matters. For more than a decade, the focus has been centred around situational awareness and surveillance, with the Luftwaffe operating the German Space Situational Awareness Centre (GSSAC) since 2009. The GSSAC's operations are based on data provided by the German Experimental Space Surveillance and Tracking Radar (GESTRA), which allows Germany to have a clearer picture of debris and satellites in LEO posing a potential threat to German people and assets.[31]

Germany manages a rather wide array of military and dual-use programmes. For instance, Berlin owns a constellation of synthetic aperture radar (SAR) imagery satellites called SAR-Lupe, soon to be replaced by SARah, which will consist of three satellites and two ground stations.[32] Germany has also gained access to

[26] Ibid.

[27] Federal Government of Germany, *White Paper on Germany Security Policy and the Future of the Bundeswehr*, 2016, https://issat.dcaf.ch/download/111704/2027268/2016%20White%20Paper.pdf.

[28] Ibid., p. 102.

[29] Interview, 15 October 2021.

[30] See in this regards Chapters 1 and 2 of this study.

[31] Fraunhofer Institute for High Frequency Physics and Radar Techniques (FHR), *GESTRA: Low Earth Orbit Always "In-Sight"*, 20 September 2021, https://www.fhr.fraunhofer.de/en/businessunits/space/gestra-low-earth-orbit-always-in-sight-jb2019.html; German Aerospace Center, *Improved Safety in Space – GESTRA Space Radar Ready to Begin Operations*, 13 October 2020, https://www.dlr.de/content/en/articles/news/2020/04/20201013_space-radar-gestra-begin-operation.html.

[32] Mathieu Bataille and Valentine Messina, "Europe, Space and Defence", cit., p. 63; OHB, *Satellite-based Radar Reconnaissance for Germany*, 7 August 2019, https://www.ohb.de/en/news/2019/satellite-based-radar-reconnaissance-for-germany.

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the French Optical Space Component (*Composante Spatiale Optique* – CSO) by agreeing to help finance the third satellite in the constellation.[33] Furthermore, the Georg system (three electro-optical reconnaissance satellites) is being developed.[34] The Bundeswehr operates its own SATCOM system in the SATCOMBw programme, a capability that will be further enhanced by the Heinrich-Hertz-Sat (H2Sat).[35] Finally, Germany possesses advanced surveillance capabilities thanks to the aforementioned GESTRA and its Tracking and Imaging Radar (TIRA).[36] Berlin and Paris have an information exchange agreement on the use of Tira and France's GRAVES space surveillance system (*Grand Réseau Adapté à la Veille Spatiale*).[37]

In 2020, the German MoD established a new Air and Space Operations Centre (ASOC) tasked with monitoring potentially dangerous space debris and protecting satellites.[38] The ASOC was designed to bring together the existing military and civilian structures of the Luftwaffe and German Aerospace Centre (*Deutsches Zentrum für Luft- und Raumfahrt* – DLR), respectively under a unified command that combines the military and civilian personnel.[39]

Since July 2021, the German Armed Forces have been operating the new Space Command, which aims to bring together capabilities in cyber, information, space and air domains and to manage all sides of the space domain under a single command.[40]

3.3 France's right to "active" defence

Defence plays a much more prominent role in the French approach to the space domain than it does for Germany. In its 2019 Space Defence Strategy, the Ministry for the Armed Forces outlined French ambitions and priorities with regard to space. In the forward, Minister Florence Parly stated that she sees France as the "third largest space power" in the world and puts forward the objective to push the country to the cutting-edge of space innovation.[41]

[33] Peter B. de Selding, "Germany to Invest in French Recon Satellite for Access to Full Constellation", in *SpaceNews*, 9 February 2015, https://spacenews.com/?p=41731.

[34] Gerhard Hegmann, "Diese Laserwaffe offenbart die Angst vor dem Weltraum-Krieg", in *Die Welt*, 26 July 2019, https://www.welt.de/wirtschaft/article197483339.

[35] Mathieu Bataille and Valentine Messina, "Europe, Space and Defence", cit., p. 63.

[36] FHR, *Space Observation Radar TIRA*, 13 January 2022, https://www.fhr.fraunhofer.de/en/the-institute/technical-equipment/Space-observation-radar-TIRA.html.

[37] Mathieu Bataille and Valentine Messina, "Europe, Space and Defence", cit., p. 63.

[38] Dominic Vogel, "German Armed Forces Approaching Outer Space", in *SWP Comments*, No. 49 (October 2020), https://doi.org/10.18449/2020C49.

[39] "German Military Launches Space Junk Tracking System", in *Deutsche Welle*, 21 September 2020, https://p.dw.com/p/3imdV.

[40] Philipp Rabe, "Das Weltraumkommando in Uedem", cit.

[41] French Ministry for the Armed Forces, *Space Defence Strategy 2019*, cit.

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France has instituted a Space Command (*Commandement de l'espace* – CdE) in Paris operating under the Air and Space Force's authority.[42] The Command is planned to reach 500 units by 2025,[43] starting from a baseline of 220 coming from its predecessor – the Joint Space Command (*Commandement interarmées de l'espace* – CIE),[44] the Operational Center for Military Surveillance of Space Objects (*Centre opérationnel de surveillance militaire des objets spatiaux* – COSMOS) and the Satellite Observation Military Centre (*Centre militaire d'observation par satellites* – CMOS).[45] The new Space Command's main role will be to coordinate all space-related defence capabilities,[46] while enhancing space support to operations, autonomy in SSA and capabilities in the field of active defence in the space domain.[47]

Unsurprisingly, given the developments described above, Paris stands out among European Allies in its approach to space as the most aware of the expanding nexus with defence.[48] The French document explicitly identifies "active space defence" as a legitimate response by France to threats and an addition to the more traditional functions of military space operations: "space service support, situational awareness, operations support".[49] The document takes a more doctrinal angle and asserts that space will become *per se* a theatre of military operations, rather than just being the target or point of origin.[50]

As she presented the Strategy, Minister Parly herself announced that France reserves the right to respond to threats to its satellites, including by using "powerful lasers deployed by [French] satellites or patrolling nano-satellites".[51] In her speech, she also explained that the main goal of this future capability will be to keep at a distance those satellites that get too close to French ones.[52] In operational terms, France and Italy reportedly experienced a similar scenario in 2017 when, according

[42] The French Air Force became the Air and Space Force in September 2020.

[43] Mathieu Bataille and Valentine Messina, "Europe, Space and Defence", cit., p. 53.

[44] François Quiquet, "Qu'est-ce que le grand Commandement De l'Espace (CDE) créé par la France pour la défense de l'espace", in *Space and Cyber Security*, 1 June 2020, https://www.spacesecurity.info/en/?p=1700.

[45] French Ministry for the Armed Forces, *Communiqué: Florence Parly acte la création du Commandement de l'espace au sein de l'Armée de l'air*, 9 January 2020, https://www.defense.gouv.fr/salle-de-presse/communiques/communique_florence-parly-acte-la-creation-du-commandement-de-l-espace-au-sein-de-l-armee-de-l-air.

[46] French Ministry for the Armed Forces, *Discours de Florence Parly: Présentation de la stratégie spatiale de défense*, Lyon, 25 July 2019, https://www.defense.gouv.fr/salle-de-presse/discours/discours-de-florence-parly/discours-de-florence-parly_presentation-de-la-strategie-spatiale-de-defense.

[47] Mathieu Bataille and Valentine Messina, "Europe, Space and Defence", cit., p. 53.

[48] Interview, 10 December 2021.

[49] French Ministry for the Armed Forces, *Space Defence Strategy 2019*, cit., p. 10.

[50] Ibid., p. 38.

[51] French Ministry for the Armed Forces, *Discours de Florence Parly: Présentation de la stratégie spatiale de défense*, cit., p. 9.

[52] Ibid., p. 9-10.

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to France, a Russian satellite named Luch Olymp approached the Franco-Italian Athena-Fidus satellite for secure communications, allegedly to intercept its communications.[53]

In stark contrast to the approach outlined in the German Space Strategy, where it was stated that innovation should be mainly driven by non-military investment, with its French Space Defence Strategy Paris decided to spend an additional 700 million euro on top of the 3.6 billion already devolved to the complete renewal of satellite capabilities in the Law for Military Planning (*Loi de programmation militaire* – LPM).[54]

This approach France possesses some unique capabilities among EU countries. Firstly, it is the only one to operate signal intelligence (SIGINT) satellites through the Space Electromagnetic Information Capacity (*CapacitÉ de Renseignement Électromagnétique Spatiale* – CERES), which was launched in late 2021.[55] Furthermore, France can count on its own encrypted SATCOM system in Syracuse 3 (in cooperation with Italy) and its successor Syracuse 4, the first French military satellite capable of detecting satellites that pose a threat to it.[56] Paris has at its disposal a number of tools in the field of surveillance, including the Large Radar Array for Space Survey (*Grand Réseau Adapté à la Veille Spatiale* – GRAVES) and SATAM radars.[57]

3.4 A Space Alliance?

Faced with multiplying threats in, from and to space, NATO has the potential of greatly enhancing its role in the space domain by virtue of having access to Allied assets. Yet, in the short term the Alliance will aim to act merely as a force-multiplier to bolster situational awareness by generating a common space domain picture, created by fusing data and information originating from different national systems. The efficacy of this limited approach will still depend mostly on individual Allies' willingness to share sensitive information, data and assets as needed.

While NATO does not intend to operate space-based asset of its own, the extension of Article 5 to the space domain provided a framework for its members to work towards a shared doctrine on what may constitute a threat in the space domain.

[53] "France Accuses Russia of Trying to Spy on Franco-Italian Military Satellite", in *France24*, 7 September 2018, https://www.france24.com/en/20180907-france-accuses-russia-trying-spy-franco-italian-military-satellite-espionage-athena-fidus. See in this regards Chapter 2 of this study.

[54] French Ministry for the Armed Forces, *Discours de Florence Parly: Présentation de la stratégie spatiale de défense*, cit., p. 10.

[55] Mathieu Bataille and Valentine Messina, "Europe, Space and Defence", cit., p. 57; Gunter D. Krebs, "ELISA 1, 2, 3, 4", in *Gunter's Space Page*, https://space.skyrocket.de/doc_sdat/elisa.htm.

[56] Jean-MarcTanguy, "France Launches First Syracuse IV Telecommunication Satellite", in *Janes*, 26 October 2021, https://www.janes.com/defence-news/news-detail/france-launches-first-syracuse-iv-telecommunications-satellite.

[57] Mathieu Bataille and Valentine Messina, "Europe, Space and Defence", cit., p. 57.

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While inevitable, this decision caries its risks if a suitable common denominator among Allies is not found. Allies have only recently begun to develop a doctrine for space operations: this may limit their contribution to a NATO doctrine, but also facilitate the search for a common ground as the national positions are not yet consolidated in a diverging way. In other words, NATO has the opportunity to uniform to a certain extent the Allies' assessment of the strategic aspects of space domain and assets.[58]

Beside the US leadership within NATO, France is certainly a pioneer among Europeans in this field, by openly declaring that it will respond to any perceived threat to its space-based assets or from space. Germany's spacefaring capabilities may be somehow comparable to France's at least in terms of financial investments, but the country's more cautious approach to the defence of and from space paints a clear picture of the divergence that exists among NATO European Allies' approaches to the space-defence nexus. A difference to be reflected also in the evolution of the EU posture in this domain.

[58] Interview, 10 December 2021.

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4. The new UK military approach to space

by Elio Calcagno

Like other major European countries, the UK considers space an operational domain and has instituted a space command.[1] The crucial role that space plays in security and defence matters has been enshrined in UK official documents progressively since 2014, when the government released a National Space Security Policy calling for the need to enhance resilience "to the risk of disruption to space services and capabilities, including from space weather", and to exploit space in order to advance UK national security interests.[2] The document also made it clear that London would pursue the latter by working with partners whenever possible.[3]

Indeed, cooperation with the private sector in particular is seen by the current British government as a necessity if the country is to keep up with a global space race in which it is falling behind.[4] According to the country's space industry trade association, the capabilities that London needs to build and acquire eloquently show just how much further investment is necessary, as the UK currently spends on space a third of what France does.[5] The list includes a new GNSS, EO satellites, SSA, in-orbit servicing and manufacturing, and a launch capability.[6] Only time will tell whether London will be able to follow through on a very ambitious National Space Strategy released in 2021,[7] but an analysis of the British military approach to space must hinge on its current and planned capabilities as well as its doctrine and reliance on private sector investment.

4.1 The Brexit conundrum

Brexit had an impact also on the British posture towards space. The European Union (EU) was mentioned repeatedly in the pre-Brexit National Space Security Policy as an important component of national space policy and indeed an arena in which London could play a leading role. While access to the Galileo GNSS Open Service (OS) is still possible, post-Brexit the UK has lost access to the Public Regulated Service (PRS). Indeed, London would have to negotiate an agreement with the EU in order to participate to the programme again.[8] Furthermore, London

[1] Royal Air Force website: *UK Space Command*, https://www.raf.mod.uk/what-we-do/uk-space-command.

[2] UK Government, *National Space Security Policy*, April 2014, p. 4, https://www.gov.uk/government/publications/national-space-security-policy.

[3] Ibid., p. 5.

[4] Steve Huges, *Securing our Future in Space*, London, WPI Strategy and UKspace, December 2020, p. 10, https://www.ukspace.org/?p=16784.

[5] Ibid.

[6] Ibid., p. 102.

[7] UK Government, *National Space Security Policy*, cit.

[8] European Parliament and Council of the European Union, *Decision No 1104/2011/EU of 25 October 2011 on the Rules for Access to the Public Regulated Service Provided by the Global Navigation*

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will not be able to access the European Geostationary Navigation Overlay System (EGNOS).[9]

Brexit undoubtedly represents an important loss of space capabilities, options and influence for the UK, including in terms of a sovereign access to a shared European GNSS. London currently relies solely on US systems for navigation and surveillance, as it has done for decades also for space access and intelligence,[10] but is looking at options for a national capability. This represents a departure from previous approaches and thus sets the UK on a new course. In 2018, the government commissioned a study looking into the feasibility of a national GNSS, which estimated a hypothetical future program to cost between 3 and 5 billion pounds[11] – an option that was deemed too expensive for London.

A currently ongoing follow-on study, Space Based Positioning Navigation and Timing Programme (SBPP), will "explore new and alternative ways that could be used to deliver vital satellite navigation services to the United Kingdom which are critical for the functioning of transport systems, energy networks, mobile communications and national security and defence".[12]

Despite Brexit, London has maintained access to the Copernicus Earth observation programme by virtue of being an ESA member state.[13] ESA is a partner of the European Commission in the context of Copernicus and, as such, represents a bridge of sorts between the UK and the EU in the space domain. In fact, the ESA is now the UK's most important multilateral forum in which to cooperate on technology and large space-related programs. Yet, Brexit's ripple effects have been felt here, too. While London expects to continue its participation to Copernicus following an agreement in principle with the EU,[14] there are signs that in practice this arrangement may encounter some opposition in the Commission despite ESA support for a consensual solution.[15]

Satellite System Established under the Galileo Programme, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32011D1104.

[9] UK Department for Business, *Energy and Industrial Strategy, UK Involvement in the EU Space Programme*, last updated 27 August 2021, https://www.gov.uk/guidance/uk-involvement-in-the-eu-space-programme#galileo-and-egnos.

[10] Bleddyn E. Bowen, "The Integrated Review and UK Spacepower: The Search for Strategy", cit., p. 5.

[11] Cristina Gallardo, "UK Scraps Brexit Alternative to EU's Galileo Satellite System", in *Politico*, 24 September 2020, https://www.politico.eu/?p=1461747.

[12] UK Department for Business, Energy and Industrial Strategy et al., *Government to Explore New Ways of delivering 'Sat Nav' for the UK*, 24 September 2020, https://www.gov.uk/government/news/government-to-explore-new-ways-of-delivering-sat-nav-for-the-uk.

[13] ESA website: *Europe's Copernicus Programme*, https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Europe_s_Copernicus_programme.

[14] UK Department for Business, *Energy and Industrial Strategy, UK Involvement in the EU Space Programme*, cit.

[15] Interview, 30 November 2021.

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In recent decades, as it relied heavily on partnerships with allies and shared assets, the UK focused almost exclusively on SatCom as it built up its sovereign military space capabilities through the Skynet satellites. Skynet 4 and 5 are active at present for a total of seven satellites,[16] while Skynet 6, aiming to enhance the country's SatCom capabilities, is under way with investments in the order of 5 billion pounds over ten years.[17] In the 2021 Integrated Review of Security, Defence, Development and Foreign Policy, the Ministry of Defence commits to give the UK "the ability to monitor, protect and defend our interests in and through space, using a mixture of national capabilities and burden-sharing partnerships with [allies]".[18] In February 2022, the MoD released the Defence Space Strategy, in support of the Integrated Strategy from the previous year.[19] The wide-ranging document addresses both the governance and the investments aspects and recognises a pivotal role to the Defence. Within the MoD, a Space Directorate is set up with a cross-government vocation. The UK Space Command and a National Space Operations Centre (in cooperation with the UK Space Agency) complement the governance picture. The Strategy is backed by a sum of 1.4 billion pounds over ten years, mostly devoted to the establishment of a radar constellation and sensors capabilities for EO/ISR, through the ISTARI project, absorbing almost 70 per cent of the budget (970 million pounds), with minimum investments for additional SatCom and SDA development.[20]

4.2 A doctrine for space power and space control

The UK stands out among Europe's space powers as one of the few to have published an official document outlining the country's doctrinal approach to space power: the Joint Doctrine on UK Air and Space Power.[21] The document defines space power as "exerting influence in, from, or through space", and attempts to outline the importance and potentialities of space power starting by defining its four main roles: (1) SSA; (2) space control (including the use of defensive and offensive capabilities); (3) space support to operations; (4) space service support.[22]

The British doctrine clearly resembles the fundamentals of air power doctrine,[23] *mutatis mutandis* with respect to the peculiarities of space. Indeed, the Doctrine also states that space exhibits unique advantages when compared to other

[16] Mathieu Bataille and Valentine Messina, "Europe, Space and Defence", cit., p. 78.

[17] UK Ministry of Defence, *Defence in a Competitive Age*, cit., p. 45.

[18] Ibid.

[19] Ministry of Defence, *Defence Space Strategy: Operationalising the Space Domain*, February 2022, https://www.gov.uk/government/publications/defence-space-strategy-operationalising-the-space-domain.

[20] Ibid.

[21] UK Ministry of Defence, *UK Air and Space Power*, cit.

[22] Ibid., p. 72.

[23] See in this regard, among others, Vincenzo Camporini et al., *The Role of Italian Fighter Aircraft in Crisis Management Operations: Trends and Needs*, Rome, Nuova Cultura, 2014, p. 65-68, https://www.iai.it/en/node/2155.

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domains.[24] First of all, space power offers broader and somehow better perspective than air power given that satellites orbit the Earth from the "ultimate high ground". This grants them a much wider horizon in terms of vision, but it also guarantees unrestricted access to virtually any location on Earth as states do not restrict satellites from orbiting above their territory or air space – the second unique advantage of space power. The third one is persistence, as assets orbiting Earth can transcend the range limitations inherent to air-based military assets, allowing them to operate for years if not decades without having to "return to base". According to the British doctrine, the last unique advantage of space power is a high degree of versatility, given that a single platform (i.e. satellites) can be fitted with multiple sensors, including those that are not primarily military in their nature.[25] Furthermore, many space-based capabilities are inherently dual-use, in that a sensor can serve by design or *de facto* both military operations and civil purposes.

Unlike the French explicit commitment to the use of force in space exclusively in defensive scenarios through "active defence",[26] the UK's approach does not bind in principle the use of offensive capabilities to defensive situations. Instead, the Doctrine defines "offensive space control" as seeking to "disrupt, degrade, deny or destroy the space-related capabilities and forces of an adversary",[27] without reference to being attacked first as a necessary requisite. This is one of the similarities with traditional air power doctrine with regards to control of the air.[28]

Offensive space control, the Doctrine asserts, can be targeted at an adversary's satellites in "space segment attacks", while a "ground segment attack" strikes at enemy space-related facilities on earth. Finally, a "link segment attack" focuses on a satellite's "control and data transmissions by attacking the links with its terrestrial control or receive nodes, via non-kinetic means, such as electronic warfare or cyber attacks".[29]

The UK's space power doctrine does not take any normative stance with regard to offensive space capabilities; it merely recognises that other states have the means to dispute their rivals' control over space. Furthermore, the document argues quite clearly, if somewhat implicitly, that the UK reserves itself the right to respond forcibly to enemy attempts to disrupt, degrade, deny or destroy British space capability.[30] As a whole, the British doctrine is the most articulated and detailed in Europe when it comes to the nexus between space and defence and possible military operations in space.

[24] UK Ministry of Defence, *UK Air and Space Power*, cit., p. 91.
[25] Ibid., p. 92.
[26] See chapter 3 of this study.
[27] UK Ministry of Defence, *UK Air and Space Power*, cit., p. 95.
[28] A concept which dates back to Giulio Douhet's "Il dominio dell'aria".
[29] UK Ministry of Defence, *UK Air and Space Power*, cit., p. 97.
[30] Ibid., p. 112.

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4.3 The role of the private sector

Private actors take a particularly prominent role in the UK's plans to increase the competitivity of the country's space sector. With Brexit depriving the national space industry of substantial funding and access to most European projects, boosting the private sector with public funds is seen as a mean to a stronger space sector overall. As a consequence, the UK's National Space Strategy aims to bolster the country's space industry through increased investments, with the government gradually moving from "primary funder to an influential customer".[31]

The government's acquisition in 2020 of a 42 per cent stake in OneWeb,[32] a company aiming to deliver global broadband internet coverage through a constellation of satellites, shows just how highly the private sector is regarded in London as a building block for enhanced space capabilities, looking forward. The acquisition, worth over 440 million euro, was linked from the start to the search for a sovereign GNSS to replace Galileo.[33] At the time of the acquisition, OneWeb had launched into LEO over 70 satellites out of a planned constellation of 648.[34] Although it retains a "golden share" and can thus veto new investors, London shares ownership of OneWeb with India's Bharti Group and other foreign companies.[35] This is a quite peculiar arrangement in the space and defence sectors, in that the UK is neither the sole owner of the company nor a majority shareholder, and yet it is considering to utilise its satellites to potentially host a critical national capability. Such an approach is somehow in line with a relatively market-oriented British defence industrial policy, which over time allowed American, French, German and Italian companies to partner with the MoD procurement, provided they assured not only best value for money but also a certain industrial and technological footprint in the UK.

The head of Bharti Group confirmed that the second generation of OneWeb satellites to be launched in LEO will be fitted with a navigation and positioning capabilities, while the timing component was already available in the first generation.[36] There is

[31] UK Government, *National Space Strategy*, cit., p. 23.

[32] UK Department for Business, Energy and Industrial Strategy et al., *UK Government Secures Satellites Network OneWeb*, 20 November 2020, https://www.gov.uk/government/news/uk-government-secures-satellite-network-oneweb; Matt Warman, *Answer to UK Parliament Written Question on OneWeb* (UIN 180574), 19 April 2021, https://questions-statements.parliament.uk/written-questions/detail/2021-04-13/180574; Tom Goulding, "Untangling the OneWeb Web", in *Space In Focus*, No. 3 (August 2020), https://londoneconomics.co.uk/?p=4086.

[33] Alex Hern, "'We've Bought the Wrong Satellites': UK Tech Gamble Baffles Experts", in *The Guardian*, 26 June 2020, https://www.theguardian.com/p/e73n6.

[34] Caleb Henry, "British Government and Bharti Global Buy OneWeb, Plan $1 Billion Investment to Revive Company", in *SpaceNews*, 3 July 2020, https://spacenews.com/?p=103377.

[35] Thomas Seal, "Musk Rival OneWeb Gets Funding for Next Satellite from Hanwha", in *Bloomberg*, 12 August 2021, https://www.bloomberg.com/news/articles/2021-08-12/musk-rival-oneweb-gets-funding-for-next-satellites-from-hanwha.

[36] Chris Forrester, "A GPS-Type Service to Be Added to OneWeb's 2Gen Satellites", in *Satnews*, 14 December 2020, https://news.satnews.com/2020/12/14/a-gps-type-service-to-be-added-to-

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no official confirmation from the British government on whether and how PNT is being fitted to the new OneWeb satellites. Despite criticism from some members of Parliament and experts, as well as claims that OneWeb's satellites are not compatible with a GNSS,[37] there are some inherent advantages to a LEO PNT system. Firstly, the much-reduced distance to the Earth's surface can translate into a stronger signal, which in turn leads to increased resilience to jamming and interference and penetrates deeper into buildings.[38] As pointed out by some experts, the same advantages were taken into consideration by the US Defense Advanced Research Projects Agency (DARPA) in its Blackjack Program, which is looking into how LEO PNT payloads can enhance existing GNSS.[39]

Other examples point to UK reliance on the private sector for advances in space capabilities and access. For instance, Skynet 5 is not owned by the British government or its armed forces, but by a private company – Airbus Defence and Space – which provides a paid service to them. A similar arrangement was made for the Carbonite 2 Earth observation satellite: owned by Surrey Satellite Technology, acquired by Airbus, it provides images to the Royal Air Force and the MoD.[40]

4.4 A peculiar trajectory

In conclusion, this chapter outlined how the UK's approach to the nexus between space and defence sets it apart from its European neighbours. Firstly, the loss of Galileo and its PRS service, as well as access to other EU-funded programmes, leaves a gaping hole in the UK's sovereign space capabilities. The exorbitant costs of developing and deploying a new, national GNSS are forcing the country to look into a creative path leading to PNT which may or may not involve OneWeb's satellite constellation. The private sector is a crucial component of most countries' space programmes, *in primis* the US,[41] and its role is bound to grow larger across the Euro-Atlantic area. Secondly, the UK is uniquely-placed as a country voluntarily leaving a multinational framework (i.e. the EU) which granted it ownership and access to advanced space capabilities, in a move that affects its status within the ESA, too. Observers will thus be keen to gauge the (cost-) effectiveness of London's approach to the private sector as the main driver of growth for its space industry and capabilities. Finally, the UK was the only major European country to release a document completely dedicated to defining a space defence doctrine and without much in the way of a commitment to a purely defensive attitude.

onewebs-2gen-satellites.

37 Alex Hern, "'We've Bought the Wrong Satellites'", cit.; "OneWeb: Minister Overrode Warning about £400m Investment", in *BBC News*, 22 July 2020, https://www.bbc.com/news/business-53506960.

38 Tom Goulding, "Untangling the OneWeb Web", cit.

39 Ibid.

40 Mathieu Bataille and Valentine Messina, "Europe, Space and Defence", cit., p. 78.; UK Ministry of Defence et al., *Lift-Off: Satellite Launched Into Space on RAF Mission*, 1 March 2018, https://www.gov.uk/government/news/lift-off-satellite-launched-into-space-on-raf-mission.

41 See in this regard Chapter 1 of this study.

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5. The European way to space: What strategic evolution?

by Giancarlo La Rocca

Space in Europe was born in the middle of the race to the Moon. Six decades later, Europe in space continues to be engaged during the competition between superpowers and separate blocks. The Old Continent has a variety of actors involved in space activities at multiple levels, from a substantial and traditionally leading role of national governments, to organisations and agencies at supranational and international level and can rely on a robust industrial basis. In this context, beside national governments, ESA and the EU are the central actors to consider, with an important evolution of the Union's approach to space.

ESA activities and evolution since 1962[1] brought significant scientific and technological developments, together with an independent launch capability and several missions in orbit. Nowadays, the ESA remains one of the most advanced space agencies in the world and a model of institutional setting, with historic achievements in the field of science and exploration as well as in the utilisation of data from satellites. ESA recently launched a safety and security pillar under its programmatic initiatives, centred on the more traditional idea of defence from space, planetary defence mostly against Near-Earth Objects (NEO) and Space Weather Events (SWE) and thus protection from natural hazards as well as human-made debris. Yet, ESA remains a civilian agency, with a legally-binding constraint to engage on security and defence matters which limited the collective European efforts on this front compared to other space powers, leaving initiatives and responsibilities to national level.

At the same time, with the Lisbon Treaty the EU established a specific competence on space, to carry out activities and define and implement programmes without prejudice to the role of member states (Article 4.3 of the Treaty on the Functioning of the European Union – TFEU).[2] The competence was reinforced by Article 189 and the provision of a European space policy and programme, but also limited by the exclusion of any form of harmonisations of the legislative and regulatory frameworks of states, which are often quite diverse.

[1] In 1962, the establishment of the European Launcher Development Organisation (ELDO) and the European Space Research Organisation (ESRO) led to the first series of shared initiatives by ten states. The two organisations later merged to constitute in 1974 the European Space Agency (ESA), successfully enlarged over the years to gather 22 Member States and four Associate Members. ESA member states: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, The Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland and the United Kingdom. Associate members: Canada, Latvia, Slovenia and Lithuania.

[2] *Consolidated Version of the Treaty on the Functioning of the European Union*, 26 October 2012, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:12012E/TXT.

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Notwithstanding, the EU started crafting a space programme and positioning as a space power in less than five years and with an initial budget allocation of 5 billion euro (Multiannual Financial Framework 2007-2013 – MFF).[3] From 2014 to 2020, the EU invested 11 billion euro and implemented an ambitious programme centred on three focal initiatives: Galileo, Copernicus and the European Union Space Surveillance and Tracking (EUSST) Consortium. Since the inception of the two largest programmes, the EU invested more than 15 billion euro on Galileo and 10 billion euro on Copernicus, with particularly positive outcomes. The former is the most advanced and precise GNSS, upon which 10 per cent of the total EU gross domestic product (GDP) relies. Galileo also affirmed an important element of the European strategic autonomy in the field and provided a civilian alternative to the defence-owned GPS and GLONASS. Indeed, Galileo created frictions and had to face opposition within and outside Europe since the first decisions in 1990s to set up an European satellite navigation system, independent from the American and Russian ones and whose security and defence uses and implications were not fully and unanimously recognised.[4] Copernicus is the first global provider of EO data, with as much as 16 terabytes of data transmitted per day by the Sentinel satellites.[5] Moreover, the EUSST works as a non-stop network of national capabilities, put together to provide crucial services for the security of over 240 satellites and a large pool of institutional, commercial and military actors.[6]

Currently, the EU looks to maintain its role of space power by further expanding competences, responsibilities and technology to respond to the ambition of strategic autonomy. In this process, the security and defence aspects of space and in orbits are becoming more central and strategic. According to some analysis by EU actors, "without space much of the EU's economic power and vitality would no longer be sustainable".[7] While ESA maintains a strong focus on science and exploration in broad terms, the Union and its members will need to keep the pace of a developing space dimension and of new threats and challenges, adapting through an evolution of their set-up.

[3] European Commission website: *EU Space Programme*, https://europa.eu/!hR79Vv.

[4] Gustav Lindström and Giovanni Gasparini, "The Galileo Satellite System and Its Security Implications", in *EUISS Occasional Papers*, No. 44 (April 2003), https://www.iss.europa.eu/node/75; Andrew Higgins, "Europe's Plan for GPS Limps to Crossroad", in *The New York Times*, 6 February 2013, https://www.nytimes.com/2013/02/07/world/europe/europes-galileo-gps-plan-limps-to-crossroads.html.

[5] European Commission website: *EU Space Programme*, cit.

[6] EUSST, *3rd EU SST Webinar: Building the Future of SST*, 5 October 2021, https://www.eusst.eu/?p=2116.

[7] Daniel Fiott, "Securing the Heavens. How Can Space Support the EU's Strategic Compass?", in *EUISS Briefs*, No. 9 (April 2021), p. 2, https://www.iss.europa.eu/node/2561.

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5.1 A responsible actor, not a naïve power

At international level and in relevant space *fora*, the EU often takes the role of a responsible actor and role model in space,[8] one that always refrain from reckless conducts in orbit and prioritises dialogue and sustainability. However, this role should not be translated into a naïve approach, uninterested in protecting values and assets in a changing space security environment. The path of consistent evolution toward a more strategic posture in space started with the Lisbon Treaty has not been flawless and is not complete. The European space community as a whole has to overcome weaknesses and dependences, while continuously relaunching ambitions and competitiveness to achieve strategic autonomy in space, essential for "strategic autonomy on Earth".[9]

Part of the current gaps in the European way to space are associated on one hand with a long-overdue integration of space in the security and defence domains, which instead has already shaped the approaches of main world powers. On the other hand, the political undecidedness and on some occasion limited willingness to share goals, decisions and efforts – and ultimately sovereignty – within the EU Common Security and Defence Policy (CSDP) has also negative influences on space. Progresses made at institutional level over the last years could have helped to find efficient instruments and relevant solutions. These may be identified in three steps: (1) to create a joint framework for space and defence industry; (2) to recognise the strategic role of space for security and defence; (3) to upgrade the relevant institutional setting.

The first step regards the Ursula von der Leyen Commission in charge from 2019 and self-defined "geopolitical",[10] which introduced an important innovation at institutional level through the establishment of a Directorate-General for the Defence Industry and Space (DG DEFIS). The Commissioner for Internal Market, Thierry Breton, is made responsible for a wide spectrum of activities to emphasise the economic and industrial driver, to work toward technological sovereignty, but most importantly to create synergies and spill-overs between defence and space. In the mission letter to Breton, the Commission President defines space as one of the "Union's most valuable and strategic assets" and asks the Commissioner to improve "the crucial link between space and defence and security".[11] Space is recognised by the current Commission as a central aspect and brought to the highest political

[8] See for instance the outcome document of the European STM Conference "Fostering a European Approach on Space Traffic Management", 7 July 2021, https://spacewatch.global/wp-content/uploads/2021/07/STM_Outcome.pdf.

[9] Daniel Fiott, "The European Space Sector as an Enabler of EU Strategic Autonomy", in *In-Depth Analysis*, December 2020, p. 1, https://doi.org/10.2861/983199.

[10] European Commission, *The von der Leyen Commission: For a Union That Strives for More*, 10 September 2019, https://ec.europa.eu/commission/presscorner/detail/en/IP_19_5542.

[11] European Commission, *President von der Leyen's Mission Letter to Thierry Breton*, 1 December 2019, p. 6, https://ec.europa.eu/commission/commissioners/sites/default/files/commissioner_mission_letters/president-elect_von_der_leyens_mission_letter_to_thierry_breton.pdf.

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focus. Second, the perimeter of action of the Commission and, overall, of the EU has enlarged, bringing more possibilities at political and industrial level while raising questions on the actual implementation of this new ambition.

The outbreak of the Covid-19 pandemic may represent a second moment that ultimately highlighted the role of space as strategic and reliable asset to manage crisis and implement security and resilience measures. The EU institutions recognised the critical services provided by precise navigation, secure communication and satellite imagery. The Commission launched the Galileo Green Lane project to avoid traffic at borders and ensure mobility and supply chains' resilience within the EU for critical materials. Moreover, the Copernicus programme could enable solutions in support of national authorities to manage the emergency. For instance, Italy activated the Copernicus Emergency Management Service (EMS) to have a clear picture of all facilities on the ground to enable an informed decision-making process.[12] Copernicus also provided information on the impacts of the crisis, at environmental and socio-economic level, gathering data in a dashboard with over eighty indicators.[13] In this sense, the crisis highlighted the added value of satellite imagery and geospatial intelligence for general security and defence needs, emphasising the role of the European Satellite Centre (SatCen) – in Torrejon, Spain – in providing accurate analysis on a variety of contexts, from emergencies to military activities. In 2019, the SatCen provided a record number of products to EU institutions and member states as well as to six CSDP missions and external international partners.[14]

Overall, during the pandemic space proved to be one of the very few resilient supply chains, despite slowdown of activities, especially regarding launches, occurred at the Kourou Space Centre but partially also in the United States. At the same time, the European industrial space sector suffered the multifaced economic effects of the Covid-19 and called for measures to safeguard its strength and integrate space in the recovery phase, also as a central component of the environmental and digital agendas of the EU.[15] These combined factors created more awareness on the use of space and its role for security and in emergencies within the EU. As a matter of fact, the MFF 2021-2027 agreed in mid-2020 confirmed almost entirely the budget devoted to space, with a cut of 1.1 billion euro (7 per cent) compared to the original proposal keeping the same price reference.[16] Under the new framework, Copernicus is funded with 5 billion euro and Galileo with 9 billion euro, leaving only less than 500 million euro to investments in further initiatives related to GovSatCom and for co-financing new SSA capabilities together with member states.

[12] Copernicus Emergency Management Service (CEMS) website: *EMSR433: COVID-19 Outbreak and Spread in Italy*, https://emergency.copernicus.eu/mapping/list-of-components/EMSR433.

[13] ESA dashboard Rapid Action on Coronavirus and EO, https://race.esa.int.

[14] Daniel Fiott, "Securing the Heavens", cit., p. 4.

[15] ESA et al., *A United EU SPACE for a More Resilient, Sustainable and Fair Europe*, 25 May 2020, https://www.nereus-regions.eu/?p=5480.

[16] European Space Policy Institute (ESPI), "Space Sector Watch", in *ESPI Insights*, No. 8 (August 2020), https://espi.or.at/publications/espinsights/send/72-espinsights/526-espi-insights-august-2020.

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The third step is represented by recent and ongoing law-making and strategic developments. The 2016 Communication on a "Space Strategy for Europe" contained references on "security and safety" needs and on synergies between "civil and security space activities". The EU Global Strategy of 2016 contained minor references to space and the need to maintain autonomous access and capabilities.[17] Substantial developments to strengthen the connection between space, security and defence occurred only during 2021. The first one concerns the Regulation 2021/696 which establishes the Union Space Programme and the EU Agency for the Space Programme (EUSPA) to replace the European GNSS Supervisory Authority (GSA), remarking the role of programmatic components of Galileo, the EGNOS, Copernicus, SSA and the European Union Governmental Satellite Communications (GovSatCom).[18]

The second is the Decision 2021/698 "on the security of systems and services deployed, operated and used under the Union Space Programme which may affect the security of the Union".[19] For the first time, the Decision recognises the possibility to take a collective reaction in the event of an attack or a threat is posed to the EU space systems, with roles assigned to the European Council, the High Representative and EUSPA – a quite important novelty.

Together, these two pieces bring significant changes to the institutional setting of the EU in space and to the related governance of security. First, there is an attempt to reinforce the overall position of the Union as a global space power. Second, there is the explicit recognition each and every component of the EU space programmes as critical infrastructure to be secured and protected. These developments, together with the signing of the Financial Framework Agreement (FFA) between the EU and the ESA, brought more clarity to the overall European space landscape, where the respective roles and responsibilities of each actor had remained unclear for several years.

Moreover, the latest Regulation and the Decision on space are also supported by the "Action Plan on synergies between civil, defence and space industries" and the forthcoming Strategic Compass. The Commission adopted the former in 2021 to increase synergies, spin-offs and spin-ins between space and defence, building on the dual use nature of most technologies and on those services that are shared between civilian and military stakeholders, such as STM and a secure communication system – both recognised as flagship projects.[20]

[17] European External Action Service (EEAS), *Shared Vision, Common Action: A Stronger Europe. A Global Strategy for the European Union's Foreign and Security Policy*, June 2016, https://eeas.europa.eu/archives/docs/top_stories/pdf/eugs_review_web.pdf.

[18] European Parliament and Council of the European Union, *Regulation (EU) 2021/696 of 28 April 2021...*, cit.

[19] Council of the European Union, *Council Decision (CFSP) 2021/698 of 30 April 2021...*, cit.

[20] European Commission, *EU Industry: Commission Takes Action to Improve Synergies between Civil, Defence and Space Industries*, 22 February 2021, https://ec.europa.eu/commission/presscorner/

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The Strategic Compass for Security and Defence will be adopted in March 2022, but a draft circulated in November 2021 on main European media already hinted towards an updated EU outlook on space. The document recognises this domain is increasingly contested and that competition in orbit has clear defence implications. The Compass also emphasises the need to develop a European Space Strategy for security and defence, thus shaping the approach to space renewing the EU vision on these matters. Furthermore, it affirms the priority to invest in advanced capabilities, especially in the field of SSA to defend assets from growing threats, at the same time remarking the role of space infrastructure in support of defence operations and of the future EU Rapid Deployment Capacity.

Overall, moving from legislation to implementation, the EU is already progressing and taking important steps to create synergies and collaboration at industrial and member states levels. In this regard, the European Defence Fund (EDF) and its precursors – European Defence Industrial Development Programme (EDIDP) and Preparatory Action on Defence Research (PADR) – together with the projects under the Permanent Structured Cooperation (PESCO) are breaking the tabu to address military aspects of space and launching defence-related initiatives and projects. Even if with very limited funding, the projects can stimulate cooperation at industrial level and the creation of new capabilities, such as in areas as SSA and space-based sensors.

In particular, in June 2021 the Union launched three projects under the EDIDP, for a total of 22.5 million euro, addressing SSA and early-warning capabilities and expected to be completed in 2024. The first project is "Sensors for advanced usage & reconnaissance of outer space situation" (SAURON), led by Ariane Group, and aims at developing ground and space-based sensors for identification and characterisation of orbital assets both in GEO and LEO.[21] SAURON also focuses on data, for the creation of an architecture to merge the information. With the leading role of Vitrociset, the project "Innovative and interoperable technologies for space global recognition and alert" (INTEGRAL) will build a C2 architecture to process and exploit space intelligence to provide a "complete military space picture".[22] The third project is "Multinational development initiative for a space-based missile early-warning architecture" (ODIN'S EYE), coordinated by OHB, and targets defence against ballistic missile and hypersonic threats based on space-based early warning.[23]

The three EDIDP projects could generate several opportunities for industrial cooperation, putting together consortiums of over twenty companies for each project. Moreover, these developments are meant to create synergies and lay the

detail/en/ip_21_651.

[21] European Commission, *SAURON Factsheet*, 30 June 2021, https://europa.eu/!QmnJyK.

[22] European Commission, *INTEGRAL Factsheet*, 30 June 2021, https://europa.eu/!TnKJdX.

[23] European Commission, *ODIN'S EYE Factsheet*, 30 June 2021, https://europa.eu/!KRMBBH.

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foundations for a combined hardware and software capability for space surveillance and missile defence. The advancements can be considered as initial steps toward for European strategic autonomy and are further supported by the PESCO framework. Indeed, three more projects with the leading role of France and Italy will contribute to increase the Union capabilities in space, especially considering the accent on space-based sensors. Projects "Timely Warning and Interception with space-based theatre surveillance" (TWISTER)[24] and "Defence of space assets" (DOSA)[25] are led by France with participation of other nine member states and focus on increasing the EU capabilities in the space domain. Led by Italy, the European Military Space Surveillance Awareness Network (EU-SSA-N)[26] concentrates on developing a defence approach on SSA integrating the capabilities already provided by member states and conveyed at the EUSST level. Finally, the European Defence Fund (EDF) also addresses space, allocating 50 million euro in 2021 for resilient satellite communication, related to European Protected Waveform (EPW),[27] and space-based PNT, especially in the field of Navigation Warfare (NAVWAR)[28] enhancing the progresses on Galileo PRS receivers already funded in 2019 under the EDIDP GEODE (Galileo for EU Defence) call.[29]

Beside enhancing the European space capabilities, the ongoing projects could also allow the Union to acquire a growingly credible position at international level, essential also for cooperation opportunities.

5.2 Taking stock of the EU evolving approach to space, security and defence

In 2016, the EU Global Strategy indicated the main sectors to be developed and drive the European approach to space.[30] Overall, the autonomy and security of space services was considered a topical element to shape further actions, especially to increase the assessment of threats and challenges. In this sense, the specific areas to further receive attention were identified in "Intelligence, Surveillance and Reconnaissance [...], satellite communications, and autonomous access to space

[24] PESCO website: *Timely Warning and Interception with Space-based TheatER surveillance (TWISTER)*, https://pesco.europa.eu/?p=1759.

[25] PESCO website: *Defence of Space Assets (DOSA)*, https://pesco.europa.eu/?p=2793.

[26] PESCO website: *European Military Space Surveillance Awareness Network (EU-SSA-N)*, https://pesco.europa.eu/?p=816.

[27] European Commission Funding & Tenders portal: *European Protected Waveform and Accompanying Technologies for Resilient Satellite Communications against Jamming*, https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/edf-2021-space-d-epw.

[28] European Commission Funding & Tenders portal: *Space and Ground-based NAVWAR Surveillance*, https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/edf-2021-space-d-sgns.

[29] European Commission Funding & Tenders portal: *Development of European Standardized and Sovereign Galileo PRS Navigation Receiver Capabilities Compatible with GPS/PRS Solution for Military Purposes*, https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/edidp-pntscc-pnt-2019.

[30] EEAS, *Shared Vision, Common Action: A Stronger Europe*, cit.

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and permanent earth observation".[31] Clearly, there still is a long road ahead, where both a EU coherent and harmonised vision and a sum of investments comparable to other major powers should be reached and accomplished.

The development occurred at EU level over the last years will need time to adjust, be implemented and bring meaningful effects. In this process, the Union will continue to be influenced by the developments in space occurring at international level, with growing competition, but also by trends at internal level among member states, which reinforce the nexus between space and defence. The new foundational elements introduced during 2021 identify a certain path, and the strategic evolution at a broad institutional framework needs to be followed by investments to close capability gaps and by a greater use of existing technology.

In this light, the establishment of the EUSPA is a clear step in defining a proper EU governance on space policy and programmes. The EUSPA has a larger mandate compared to the GSA, with competences on security not limited to Galileo but extended to the entire EU space programme. Through the Security Accreditation Board (SBA), the EUSPA is responsible to define and implement security requirements together with member states, that will cover the security of assets from the design and manufacturing to the launch and the initial phases of operation in orbit. In particular, this responsibility is a key step forward in the direction to more standardisation in satellite design and an overall increased protection from threats, including in cyberspace and during vulnerable phases of spacecraft's life, especially the Launch and Early Orbit Phase (LEOP).[32] Moreover, EUSPA operates the Galileo Security Monitoring Centre (GSMC), expected to be expanded in scope in the future to have competence on the whole space programme. This development would provide appropriate response to the need identified by the Regulation 2021/696 to have a universal "security monitoring structure" but also by the Decision 2021/698 to protect the EU space infrastructure.[33]

Among the components of the space programme, Galileo will experience several advancements and be central in the strategic evolution of the EU posture. Indeed, the Galileo constellation is being renewed for a second generation of satellites. Moreover, the PRS is expected to become operational over the next years, by providing essential services to defence and security stakeholders and increasing the autonomy of EU institutions and member states from the GPS. The PRS will be managed by the GSMC and overall will develop an advanced level of technology readiness and capability within the EU, offering PNT signals to a large pool of authorised users. Furthermore, the deployment of the PRS could potentially create

[31] Ibid., p. 45.

[32] European Union Agency for the Space Programme (EUSPA), *EUSPA Ready for Satellite Operations ahead of Galileo Launch 11*, 18 November 2021, https://www.euspa.europa.eu/node/48951; Spaceopal, *The Galileo Control Centre in Oberpfaffenofen Ready for Its First LEOP*, 26 October 2021, https://spaceopal.com/gcc-d_ready_for_leop_l11.

[33] EUSPA website: *Security*, https://www.euspa.europa.eu/node/39209; Marco Florissi, "EUSPA. Agenzia dell'Unione Europea per il Programma Spaziale", in *Rivista Aeronautica*, No. 4/2021, p. 94-98.

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spill-overs and synergies in the application of services for defence and security purposes based on a secure and encrypted system. While the Galileo Open Service (OS) will continue to be open to everyone, the PRS will provide the secure, resistant, authenticated and encrypted signals only to the EU member states, as stated in the Decision 1104 of 2011 and reiterated by the Regulation 2021/696. However, third parties may negotiate the access to the PRS, and both the United States and Norway are renewing the interest and the negotiations to regulate this opportunity, moving from a position of cooperation respectively on services and ground segment.[34]

Copernicus will also be expanded with new Sentinel missions that focus on environmental and climate change challenges. This expansion on EO services will need to be connected to a greater use of EO data in the implementation of EU strategies, from the Arctic to crisis management and military operations. Moreover, adding sensors to the future space infrastructures could perform supplementary missions with more direct security and defence interests.

A third traditional component of space programmes is satellite communications. Since 2013 the EU aimed at developing a common capability in the field, launching the GovSatCom programme.[35] It is targeted for a wide variety of users and use-cases, from crisis management to security and safety missions and military operations. The first phase of the programme is based on existing capabilities, pooled together from member states and commercial entities. This phase resembles the conceptual framework of the EUSST Consortium that where all involved actors put together capabilities to provide more and more efficient services, regulated at EU level to ensure the necessary security requirements. The scope of the programme is definitely ambitions and fills a gap at communitarian level, as cooperation on satellite communication is generally bilateral. Yet, the budget dedicated to the programme and the organisation arrangements to provide the appropriate ground segment may be falling behind the expectations. Nonetheless, the political attention to GovSatCom is rising and the programme is expected to secure services and bring benefits also to specific objectives of the EU, such as the regional strategy in the Arctic and the maritime strategy.[36]

Finally, SSA and SST are the third core component of the EU space programme which will advance in the coming years. The EUSST Consortium was established in 2014 and begun operations in 2016, becoming a European hub of national

[34] European Commission, *Proposal for a Council Decision on the Extension of the Agreement on the Promotion, Provision and Use of Galileo and GPS Satellite-based Navigation Systems and Related Applications between the European Community and its Member States and the United States of America* (COM/2022/9), 14 January 2022, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52022PC0009; European Commission, *Agreement with Norway on Two Galileo Ground Stations*, 22 September 2021, https://ec.europa.eu/commission/presscorner/detail/en/IP_10_1158.

[35] EUSPA website: *GOVSATCOM*, https://www.euspa.europa.eu/node/47299.

[36] EUSPA, *French EU Presidency Can Rely on #EUSpace to Support Its Priorities*, 7 January 2022, https://www.euspa.europa.eu/node/49067.

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defence capabilities. It ensures European autonomous eyes on space and is the prerequisite for security and defence of assets in orbit from intentional and unintentional threats. As such, the EUSST allows the EU to develop a position on Space Traffic Management (STM), a field where a Communication by the Commission is expected by the end of the first quarter of 2022. Notwithstanding, the EUSST services are based on radars, lasers and telescopes operated by national defence stakeholders and are located mostly within Europe. Further action will require to focus on expanding the geographical coverage of sensors and investing in ground-based and space-based capabilities, ideally shared, to advance the collective European readiness and precision to secure satellites in an increasingly congested environment.

Ultimately, altogether Europe is already a global space power with cutting-edge technological capabilities and long-established presence in space thanks also to a strong industrial sector and commercial influence. The Union itself operates more than 35 satellites for EO and GNSS services and can be considered one of the largest institutional operators in the world, a significant number considering that, overall, the EUSST Consortium provides services to 62 governmental and 29 military satellites from the EU member states all together.[37]

In the next future, the launch of additional flagship programmes could bring new opportunities to the Union: from STM to the launch of a secure satellite communication and connectivity system, these additions would represent a fresh development for the EU.[38] In particular, the secure connectivity initiative launched by Commissioner Breton is considered "an imperative" for Europe and despite initial studies and troubles in the commercial market is expected to experience an acceleration in 2022.[39] According to Breton, the infrastructure will be multiorbital, connecting LEO and GEO assets, counting on a limited number of satellites compared to other constellation and designed integrating the "military usage and needs".[40] At the same time, the new connectivity and multiorbital programme would bring many more satellites relying on safety and security measures implemented by the EUSPA, requiring advancements also in the fields of cyber technology and quantum communication.[41]

[37] EUSST, *3rd EU SST Webinar: Building the Future of SST*, cit.

[38] Jonathan Amos, "EU Must 'Move at Speed' on Space Broadband Network", in *BBC News*, 12 January 2021, https://www.bbc.com/news/science-environment-55640447; Thierry Breton, "Enhancing Europe's Space Power", in *Blog by Thierry Breton*, 9 December 2020, https://europa.eu/!mN68xB.

[39] European Commission, *Work to Build an EU Space-based Global Secure Connectivity System to Start in 2022*, 10 November 2021, https://europa.eu/!HBP9Mq; "Breton Sees No Role for Eutelsat in EU Constellation", in *SpaceWatch*, 25 May 2021, https://spacewatch.global/?p=33019.

[40] European Commission, *Speech by Commissioner Thierry Breton at the 14th EU Space Conference*, cit.; Reflex Aerospace, *Press Release UN:IO-Consortium*, 13 December 2021, https://www.unio.global/?p=1194.

[41] European Commission website: *The European Quantum Communication INfrastructure (EueroQCI) Initiative*, https://digital-strategy.ec.europa.eu/en/policies/european-quantum-communication-infrastructure-euroqci.

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Finally, a significant upgrade should occur in the field of access to space, considering both the overall launch capability, also associated with human spaceflight,[42] and the spaceport accessibility. In 2022, the new iterations of the European launchers Ariane 6 and Vega C will perform the maiden flights. Future developments also concern Vega E and the acquisition of mature capabilities for liquid propellant. Yet, the launch market is experiencing fast evolution and expansion and reusability has become a key technology to assert competitiveness, outside but also within Europe.[43]

In regards of spaceports, future developments could go beyond the one currently operative centre in Kourou, in the French overseas territory, in order to enrich the European portfolio and find alternative solutions. Progresses are taking place in Germany, fostered by the industry association BDI, to launch from sea-based platforms,[44] as well as in Sweden and Norway (non-EU member), in these two cases with launch contracts already signed with European start-ups interested in the Arctic locations of the Kiruna and Andøya launch sites.[45] New solutions may also come from Portugal, for the establishment of a spaceport in the Azores,[46] and Italy, with ongoing discussions and projects on spaceport and launch platforms in order to recover a capability once possessed with the Broglio Space Centre.[47] Still, developments are occurring at national level and often they do not meet a common vision at EU level meant to enhance the overall European capabilities.

Europe needs to keep the pace of international developments in space and ensure that the variety of European actors involved becomes more and more an advantage rather than a factor of vulnerability. Member states and institutions, intermediary bodies, organisations and agencies provide a wide and strong foundation and a network of competences. The evolution occurred since the inception of a space competence at EU level provides encouraging elements for the future. One expected outcome of 2022 could be a European space security and defence strategy, adopted

[42] Jeff Foust, "ESA Looks to Space Summit to Endorse Human Spaceflight Effort", in *SpaceNews*, 20 January 2022, https://spacenews.com/?p=123130.

[43] Eric Berger, "Concerned about SpaceX, France to Accelerate Reusable Rocket Plans", in *ArsTechnica*, 7 December 2021, https://arstechnica.com/?p=1818450.

[44] Paul Peachey, "Germany Backs Floating North Sea Spaceport Plan", in *The National News*, 7 September 2021, https://www.thenationalnews.com/world/2021/09/07/germany-backs-floating-north-sea-spaceport-plan.

[45] Isar Aerospace, *Launch Site Secured: Isar Aerospace Signs Exclusive Launch Pad in Norway for Up to 20 Years*, 14 April 2021, https://www.isaraerospace.com/press/launch-site-secured-isar-aerospace-signs-exclusive-launch-pad-in-norway-for-up-to-20-years; Kevic McGwin, "A Swedish Arctic Satellite Spaceport Is a Step Closer to Reaching Launch Capability by Next Year", in *Arctic Today*, 7 October 2021, https://www.arctictoday.com/?p=41454; Rocket Factory Augsburg (RFA), *RFA Successfully Tests Full-Scale Staged Combustion Engine*, 21 June 2021, https://www.rfa.space/?p=12338; RFA, *Rocket Factory Augsburg Secures Launch Site in Andøya*, Norway, 28 April 2021, https://www.rfa.space/?p=11964.

[46] Portugal Space website: *Azores ISLP*, https://ptspace.pt/?p=6030.

[47] On Italy and launch-related developments, see Chapter 6 of this study.

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under the auspices of the French Presidency of the Council of the EU.[48] Indeed, at the 14th European Space Conference Commissioner Breton introduced for the first-time defence as a priority in the space policy development.[49] A "Space and Defence Strategy" is therefore to be an expected outcome by 2023. According to Breton, it is the whole space programme that should further integrate the defence dimension, mentioning opportunities for joint situational awareness operations and eventually the establishment of a European Space Command. In this light, it is a must to further elaborate a cohesive voice and position between member states.

In this sense, there are many levers to pull, from industrial policy to shared commitments and political vision. Yet, more cooperation between all involved actors at multiple levels would be required to correctly position Europe in the global space context together with an overall upgrade in terms of investments. Ultimately, Europe needs to accept its role of space power and act accordingly with a space power mindset.

[48] French Presidency of the Council of the European Union, *Informal Meeting of Defence Ministers*, 13 January 2022, https://presidence-francaise.consilium.europa.eu/en/news/press-release-informal-meeting-of-defence-ministers.

[49] European Commission, *Speech by Commissioner Thierry Breton at the 14th EU Space Conference*, cit.

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6. Italy and space, a strong position to enhance

by Giancarlo La Rocca and Alessandro Marrone

6.1 Italy's stellar track record

On 15 December 1964, Italy became the third state worldwide – after US and USSR – to domestically build a satellite and manage its launch through the project San Marco.[1] After fifty-seven years, Italy has celebrated the anniversary as a key European space-faring nation: the second country in Europe for number of assets in orbit, the third largest contributor to ESA and the home of a complete space value chain.

For a long period of time, Italy also operated its launches from the San Marco base, a sea platform located at the Kenyan coast near Malindi particularly favourable for geosynchronous orbit launches.[2] Since San Marco, Italy developed a full-fledged approach to space based on a strong focus on science and technology, an inclination for cooperation and space diplomacy, a peculiar interest for dual-use applications and a commitment from defence actors to be a driving force of strategic advancements. The Italian Space Agency (*Agenzia Spaziale Italiana* – ASI), established in 1988, catalysed the efforts in this sector also from the wider scientific community orbiting around space and astrophysics. ASI assured a presence at international level in terms of diplomacy and participation to science and exploration missions,[3] from Cassini-Huygens and Mars Express to the nationally-

[1] Thanks to a memorandum signed with the United States in 1962, a Scout rocket launched the San Marco 1 satellite from Wallops Island, from the US eastern coast. Although not obtaining a full orbital capability, Italy achieved the role of spacefaring nation as the first state to reach orbit with a nationally manufactured asset after the Soviet Union and the United States. The San Marco 1 carried onboard a scientific payload for atmosphere measurements and was then followed by four other satellites, launched from 1967 to 1988, consolidating the Italian approach to space. On the San Marco project see: Roberto Della Ceca, "15 dicembre 1964: l'Italia entra nello Spazio", in *Media Inaf*, 14 December 2020, https://www.media.inaf.it/?p=1700171; Louis de Gouyon Matignon, "San Marco 1, the First Italian Satellite", in *Space Legal Issues*, 14 April 2019, https://wp.me/payOrR-9h.

[2] Central figure in the Italian approach to space was Luigi Broglio, an Air Force official and professor at the La Sapienza University, to whom is now entitled the space centre in Malindi. Broglio managed to prioritise space at political level and to funnel the efforts of the Sapienza Aerospace Engineering School for satellite manufacturing. The Malindi centre became the first operative sea platform for satellite launch globally, and it was supported by other stations, two decommissioned oil rigs provided by the Italian company Eni and repurposed to support orbital launches and enable control and logistics functions. The project created the conditions to put together efforts at national level, identifying an embryonic ecosystem composed of defence and civil stakeholders, research bodies and industrial actors cooperating towards the same goal.

[3] Among the many projects, it is notable to remark the IXPE mission in cooperation with NASA launched in December 2021 (https://ixpe.msfc.nasa.gov) and the ongoing Limadou project on the China Seismo-Electromagnetic Satellite (CSES) with the Chinese National Space Agency (CNSA). See ASI website: *CSES Mission – Limadou Italian Contribution*, https://www.asi.it/en/?p=17668. On the Italian role in space research at global level see also: Giorgio Saccoccia, "Una sfida che parte dalla ricerca", in *Airpress*, No. 129 (January 2022), p. 8-9.

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made multi-purpose and habitable modules, as well as the Cupola, on the ISS.[4] Indeed, Italian astronauts became the first Europeans to fly to the Station, with Umberto Guidoni, and then again, the first Europeans to command its operations, with Luca Parmitano and soon after with Samantha Cristoforetti – with the very first space flight performed by Franco Malerba already in 1992 thanks to Italy's cooperation with NASA shuttle missions. As a whole, Italy has contributed to made the history of space in Europe and at international level, considering the several participations to ground-breaking missions.[5]

Today, Italy has a solid presence in each segment of the space value chain. Domestic capabilities and know-how are essential components of the national and European strategic autonomy, non-dependence and competitiveness. Rome leads the European way to space together with Paris and Berlin, while expanding cooperation with the US and other partners at institutional and commercial levels. In an ever-evolving global space context, such a role requires a solid institutional setting based on a coherent vision, an efficient governance, a high-level of awareness but also a persistent update and upgrade of know-how and capabilities through adequate plans and investments.

6.2 Crafting a whole-of-government approach

Against this backdrop, the approval of the Law No. 7 of 2018 marked a tangible step forward in terms of governance, to bring a closer institutional eye on space and establish a systemic approach.[6] The legislative update was preceded and supported by a reform process started already in 2014, bringing to the creation of a "coordinating cabinet" (*Cabina di regia*) for the definition of a national space policy which tested some praxes then translated into law. The new legislation focuses on the measures for the coordination of space policies, by placing the centre of the governance to the highest political level within the government. Indeed, Law No. 7/2018 assigns to the Prime Minister "the key management, the general political responsibility and the policy coordination" of space and establishes the "Inter-ministerial Committee for policies related to space and to aerospace research" (*Comitato Interministeriale per le politiche relative allo Spazio e alla ricerca aerospaziale* – COMINT).

[4] ESA, *Node-3 and Cupola: European Technology to Complete the ISS*, 8 February 2010, https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Node-3_Cupola/Node-3_and_Cupola_European_technology_to_complete_the_ISS; ASI, "ISS: The "Home in the Space" Is Growing and It Is Also Italian", in *ResearchItaly*, 19 February 2013, https://www.researchitaly.it/en/projects/iss-the-home-in-the-space-is-growing-and-it-is-also-italian.

[5] A history marked by several exceptional personalities, from Broglio to a founding father of ESA as Edoardo Amaldi, to Rocco Petrone, the Director of Launch Operations of the Apollo programme of Italian origin, to whom the Control Centre of Cape Canaveral is entitled. Emilio Cozzi, "Rocco Petrone, l'italo americano che ci ha portati sulla luna", in *Wired*, 13 July 2019, https://www.wired.it/scienza/spazio/2019/07/13/rocco-petrone-luna-apollo11.

[6] Law No. 7 of 11 January 2018: *Misure per il coordinamento della politica spaziale e aerospaziale e disposizioni concernenti l'organizzazione e il funzionamento dell'Agenzia spaziale italiana*, https://www.gazzettaufficiale.it/eli/id/2018/02/10/18G00025/sg.

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The Law transformed the governance of the sector, by favouring a more inter-agency, whole of government approach and an increased institutional awareness on space, while accentuating the strategic attention devoted to it. In fact, the COMINT brings the coordination of national space activities to the government level and the deliberations on space matters within a framework shared by more than twelve Ministries. The government is responsible for approving the strategic documents and guidelines on which ASI works as an operative arm, directed and supported by COMINT. The Prime Minister identifies the Undersecretary of State, or a Minister, to whom assign a mandate on space affairs. The Prime Minister's Office of the Military Advisor (*Ufficio del Consigliere Militare* – UCM) supports the activities of the Committee and provides secretariat functions. Moreover, the UCM includes the National Authority responsible on the Galileo PRS and on the GovSatCom, which constitutes important competences on space matters at national and supranational level.

Law No. 7/2018 was implemented by a second regulation for the establishment of a "Coordination Structure" within UCM, to support the COMINT role and the implementation of policies at inter-ministerial and inter-agencies levels.[7] This Structure is also mandated to convey relevant topics to the COMINT for urgent consideration and to finalise preparatory and technical documents. As a whole, the new governance is a resolute step forward in addressing space, also compared to other international settings. Still, its concrete functioning depends on the political will of the government in charge and is affected by their frequent turn-over in Italy.[8]

The first outcome of the new governance has been the 2019 "Guidelines on space and aerospace": the first government-level document focused on space, which identified the strategic priorities to be pursued and the security dimension associated with the sector.[9] The Guidelines recalled the rapidly changing nature of space, which poses new challenges and requires further developments. First, the document outlined a general vision to be implemented through additional efforts in terms of industrial policy and space diplomacy, and for the realisation of a strategic plan for space economy. Then, the Guidelines gave particular relevance to few sectors, from the traditional Earth Observation, navigation, telecommunications and access to space to new SSA/SST capabilities, In-Orbit Servicing, stratospheric platforms and robotic exploration. Most of these elements have a strong defence dimension. The Prime Minister's Guidelines led to two further implementation

[7] Italian Government, Decree of the President of the Council of Ministers (DPCM) of 20 December 2018: *Istituzione della Struttura di coordinamento per le politiche relative allo spazio, all'aerospazio e ai correlati servizi applicativi*, https://presidenza.governo.it/AmministrazioneTrasparente/Organizzazione/ArticolazioneUffici/UfficiDirettaPresidente/UfficiDiretta_CONTE/COMINT/DPCM_20181220_SC-Comint.pdf.

[8] Interview, 21 January 2022.

[9] Italian Government, *Government Guidelines on Space and Aerospace*, 25 March 2019, https://presidenza.governo.it/AmministrazioneTrasparente/Organizzazione/ArticolazioneUffici/UfficiDirettaPresidente/UfficiDiretta_CONTE/COMINT/DEL_20190325_aerospazio-EN.pdf.

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documents: the Domestic Space Policy Strategic Document (DSPSN) prepared by COMINT, and the Space Strategic Vision Document (DVSS) 2020-2029 provided by ASI.[10]

Furthermore, in 2019 the government released a separate National Security Strategy for Space which focuses on specific lines of action to safeguard space infrastructures from intentional or unintentional threats, and to strengthen the whole sector with an accent on defence capabilities.[11] According to the document, security from space and of space is a "multi-sector and global issue". Moreover, the increasing commercialisation of space raises potential issues concerning sustainability, safety requirements and property rights. In this scenario, the National Security Strategy outlines five objectives for the safety and security of space assets:
"a) to ensure the security of space infrastructures [...], regarded as enablers of the national infrastructure as a whole;
b) to safeguard national security, including through space, by ensuring access to and use of national security capabilities in any given situation;
c) to strengthen and protect the institutional, industrial and scientific sectors, also with a view to protecting national classified information;
d) to promote a space governance capable of ensuring sustainable, safe and secure space operations at international level;
e) to ensure that the development of private initiatives in the space sector (upstream and downstream) is consistent with the country's overriding interests."[12]

Overall, the established governance and the released strategic documents lay down a coherent Italian vision of space, including its security aspects. Yet the update of the governance mechanisms should not be cut short once the formal reorganisation has been achieved. Rather, an ongoing process should centre on eventual gaps and limitations. A path forward should especially focus on the introduction of a comprehensive law on space, present elsewhere in Europe only in France and other few countries. This development would be crucial to regulate several aspects of the sector and better defining the juridical framework, including with regards to (i) the difference between space and higher airspace in relation with the Karman line and (ii) the specific mandate of the Ministry of Defence. Indeed, within the whole-of-government approach to space, the defence focus is still somehow underdeveloped in relation with the evolution of space threats, actors and technologies. A clearer attribution of concrete mandate to the Ministry of Defence is necessary to enable the armed forces to perform their role within this systemic approach by exploiting the military reorganisation undertaken in recent

[10] See ASI, *Documento di visione strategica per lo Spazio 2020-2029*, April 2020, https://www.asi.it/wp-content/uploads/2020/04/DVSS-2020-2022-Finale_compressed_compressed.pdf.
[11] Italian Government, *National Security Strategy for Space*, 18 July 2019, https://presidenza.governo.it/AmministrazioneTrasparente/Organizzazione/ArticolazioneUffici/UfficiDirettaPresidente/UfficiDiretta_CONTE/COMINT/NationalSecurityStrategySpace.pdf.
[12] Ibid., p. 4.

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years.

6.3 The military reorganisation and the Space Operations Command

In parallel with the articulation of the new governance, a significant reorganisation occurred within the Ministry of Defence since 2018. The Italian Defence General Staff first established in November 2019 the General Space Office (*Ufficio Generale Spazio* – UGS) responsible for policy planning, space programmes and international cooperation. Then in June 2020 the Space Operations Command (*Comando Operazioni Spaziali* – COS) was created to develop space operations while continuing to provide space products to the other traditional domains. In 2021, the COS has been placed under the authority of the Italian Join Operational Headquarters (*Comando Operativo di Vertice Interforze* – COVI), also in order to take into proper consideration the notion of multi-domain operations across the five dimensions of land, sea, air, space and cyberspace.

The creation of UGS and COS with a joint connotation acknowledges the strategic character of space for national security and defence. As such, this reform is part of the broader trend of military reorganisations occurred in the United States[13] and other European countries[14] in parallel with the NATO recognition of space as an operational domain.[15] The two-pillars articulation of policy planning (UGS) and operations (COS) does represent a balanced, well-structured approach towards a new and dynamic domain, whereby the COS is set to increase its operational ability and the UGS to develop its strategic outlook. Such an articulation brings clarity within the Ministry of Defence,[16] and this in turn provides an important and positive indication for the national aerospace industry on the direction and orientation undertaken by the military.[17]

The military reorganisation centred on UGS/COS represents an effort to create more synergies between armed forces and their capabilities. In fact, the new space command integrates and consolidates the capacities of pre-existent entities, namely the Joint Centre for Satellite Remote Sensing (*Centro Interforze di Telerilevamento Satellitare* – CITS) located in Pratica di Mare (Rome) and the Joint SICRAL Management and Control Centre (*Centro Interforze di Gestione e Controllo SICRAL* – CIGC SICRAL) in Vigna di Valle (near Rome). The two centres provide advanced capabilities and ground station functions to critical assets, including Italian, but also multi-national ones. The COS establishment is somehow a natural evolution of the military necessary to effectively operate its assets in the current and foreseeable space environment.[18]

[13] See chapter 1 of this study.
[14] See chapters 3 and 4 of this study.
[15] See chapter 3 of this study.
[16] Interview, 16 November 2021.
[17] Interview, 11 November 2021.
[18] Interview, 26 November 2021.

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In particular, the CIGC SICRAL provides 24/7services and under the direction of COS has successfully conducted in 2021 a re-orbiting operation of a satellite, to move the asset in a graveyard orbit for post-mission disposal.[19] This marked the first operation performed only by military personnel which demonstrates compliance with sustainability measures and assures control over all phases of a satellite's lifetime, from LEOP to end of life. Through UGS and COS, the Italian MoD is currently able to plan the policy for military space assets, identify procurement needs and requirements, and then manage the launch, activities and de-orbit of such assets through operational centres active 24/7: a pioneer, unique military capability in Europe.[20]

Finally, within the MoD a second relevant reorganisation occurred in 2020 also at the air force level, which transitioned from the Air Operations Command to the Aerospace Operations Command (*Comando Operazioni Aerospaziali* – COA), situated in Poggio Renatico. In particular, under the UGS and COS guidelines, the air force command leads the Joint Centre for Space Situational Awareness (CSSA), essential for national and European security and autonomy in the field of space surveillance and tracking. The CSSA integrates the military assets of the existing Italian SST Operations Centre (ISOC) and acquires the relevant information regarding orbital assets and debris, providing services as the Italian front desk to the EUSST Consortium for re-entry (RE) e fragmentation (FG) analysis.

Notably, on the basis of the MoD reorganisation and within the constraints of the current Italian legislation, a further reflection is taking place at UGS and COS towards an MoD space strategy.[21] Such a reflection includes to the possible operations to defend military satellites which are by default vulnerable to opponents' intelligence, interference or attacks.[22] Space is increasingly contested and congested, and it is perceived also by Rome as the higher ground to achieve competitive advantage. A step change is occurring in Italy as in other NATO countries: from assuming space as an enabler for defence operations on Earth, to considering it as an operational domain on its own, closely interlinked to others.[23] A domain where the attribution of adversarial activities is often very difficult and requires progresses in SSA and SST also in terms of threat's identification.[24]

[19] Italian Ministry of Defence, *Spazio: conclusa con successo la prima operazione di re-orbiting satellitare*, 12 May 2021, https://www.difesa.it/Primo_Piano/Pagine/spazio-conclusa-con-successo-la-prima-operazione-di-re-orbiting-satellitare.aspx; and *Il Capo di SMD al CIGC Sicral per la prima operazione di re-orbiting satellitare*, 12 May 2021, https://www.difesa.it/SMD_/CaSMD/Eventi/Pagine/Il_Capo_di_SMD_al_CIGC_Sicral_per_la_prima_operazione_di_re_orbiting_satellitare.aspx.

[20] Interview, 10 December 2021.

[21] Interview, 24 January 2022.

[22] Interview, 10 December 2021.

[23] Interview 15 November 2021.

[24] Interview, 10 December 2021.

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Against this backdrop, the formulation of a space strategy and subsequent military doctrine for space would be a necessary next step, aimed among other things to define competencies and responsibilities for the Space Domain Awareness (SDA) and provide a space threat assessment. Moreover, the role of military actors as one driver to strengthen Italian capabilities should not be overlooked, also in support to research and as facilitator of innovation. Italy suffers the absence of a MoD plan for investments in space defence coherent with the unfolding military approach, the country's international position and partnerships, and the national landscape of industrial and technological capabilities.

6.4 Space in the Quirinale Treaty and Franco-Italian cooperation

The new governance and the MoD reorganisation have enabled Italy to enhance international cooperation with partners on an equal foot. A major example in this regard is the Quirinale Treaty (*Trattato del Quirinale*), signed in November 2021 with France for an "enhanced bilateral cooperation".[25] Indeed, in recent years the efforts to finalise this diplomatic process on space experienced an acceleration,[26] effectively preparing the ground for a more solid cooperation.[27] The creation of UGS and COS set up the structures necessary to support the dialogue with the French counterparts and to produce a military vision on space contributing to the Quirinale Treaty related articles.[28] Indeed, the Treaty dedicates an article to security and defence (art. 2), and one specifically to space affairs (art. 7) which represents a strong and unique component of the relations between Rome and Paris.

In particular, art. 7 recognises the importance of the Franco-Italian relation, particularly for the build-up of the European space dimension and European strategic autonomy, and commits the parties to favour coordination and harmonisation of their strategies and activities on space use and European autonomous access to space.[29] The former receives specific attention with explicit support for both Ariane and Vega launchers, as well as for the Kourou launch site. Concerning assets in orbit, industrial cooperation is encouraged for space exploration, EO, SatCom, navigation and related ground segments.[30] The Treaty also sets the aim to enhance competitiveness and integration of the space industry of the two countries, while clear references are made to bilateral cooperation

[25] Italian Government, *Italy-France Treaty Signed at the Quirinale Palace*, 26 November 2021, https://www.governo.it/en/node/18662.

[26] Already in 2015, at working level, the two countries explored the possibilities of a stronger cooperation in space with a Memorandum of Understanding signed by ASI and CNES.

[27] Giancarlo La Rocca, "Il pilastro della cooperazione spaziale nel Trattato del Quirinale", in *AffarInternazionali*, 10 December 2021, https://www.affarinternazionali.it/?p=93677.

[28] Interview, 10 December 2021.

[29] Italy and France, *Trattato tra la Repubblica italiana e la Repubblica francese per una cooperazione bilaterale rafforzata*, 26 November 2021, p. 10, https://www.governo.it/sites/governo.it/files/Trattato_del_Quirinale.pdf.

[30] Ibid.

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within EU and ESA.[31] As a whole, art. 7 has significant implications for industrial cooperation in Europe for the development of highly strategic assets for security and defence. Moreover, art. 7 should be considered in combination with art. 2, in so far the former commits to promote bilateral cooperation on both procurement and operations "where their strategic interests are the same", and to promote "structural alliances" between their respective national industries also in relation to PESCO and EDF projects.[32]

As a whole, the Quirinale Treaty should be considered the starting point for the military and industrial development of proposals and actions to be brought at the table with France, as well as within EU and ESA by exploiting the synergies between bilateral and multilateral partnership.

Interestingly, the Treaty identifies the opportunity to establish a permanent consultation mechanism at the higher political level, which will be significant when applied on a regular basis also to the space affairs. In fact, these regular consultations could further activate cooperation at technical level and working groups, effectively reinforcing the already solid bilateral relations.[33] On the sidelines of the Quirinale Treaty, the two Ministries competent for space already signed a space agreement.[34] Subsequently, the respective military procurement bodies – the Italian *SegreDifesa/Direzione Nazionale Armamenti* (SGD/DNA) and the French *Direction Gènèrale de l'Armement* (DGA) – concluded as well a bilateral agreement to implement the envisaged cooperation.[35] Notably, the MoD reorganisation through UGS and COS contributes to enable Italy to implement the Treaty commitments concerning the nexus between space and defence.[36]

As a matter of fact, France and Italy already cooperate in space on a number of strategic issues. In the field of EO, agreements are in place for the constellations of *Composante Spatiale Optique* (CSO) and COSMO-SkyMed, as well as on Helios1[37] and Helios2 programmes. For satellite communication, Paris and Rome collaborates sharing the Sicral 2/Syracuse 3C satellite and ATHENA-FIDUS (Access on THeatres and European Nations for Allied forces-French Italian Dual Use Satellite). At industrial level, the bilateral relations on space are tied. Leonardo and Thales created in 2005 the Space Alliance composed of Telespazio and Thales Alenia Space. Furthermore, relations are increasing in the field of launchers, as Ariane 6 and Vega C share one engine produced by Avio (the P120C, the first

[31] Ibid.

[32] Ibid., p. 5.

[33] Interviews, 21 January 2022; 24 January 2022.

[34] French Ministry of the Economy and Italian Minister of Technological Innovation and Digital Transition, *Italy-France Space Agreement*, 26 November 2021, https://assets.innovazione.gov.it/1637942954-pr-space-agreement.pdf.

[35] Interview, 24 January 2022.

[36] Ibid.

[37] It was a multinational programme led by France and participated by Italy and Spain – the former bearing 14 per cent of costs.

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stage of Vega C and the boosters of Ariane 6). In March 2021, Arianespace signed a supply agreement with Avio for ten new vehicles,[38] also following the "Franco-Italian declaration on the future of space launchers" concluded the same month.[39] Since March 2021, Avio successfully launched two Pléiades EO satellites and three CERES (*CapacitÉ de Renseignement Électromagnétique Spatiale*) assets for SIGINT, a traditional prerogative of space powers, whose requirement in Italy should be considered and recognised by the several interested actors at national level.[40]

6.5 A broad industrial landscape

Through its history and today, Italy is a pillar of the European space framework, with critical skills in the upstream as well as advanced capabilities in the ground and downstream segments. Italy is the second country in Europe for investments in the sector as percentage of GDP.[41] The industrial landscape is composed of more than 200 companies, with a majority of SMEs, and overall it generates revenues for over 2 billion euro.[42]

Among the main industrial players, Avio has a long experience in space and is involved also in the defence sector for the development of missile technology. The Colleferro-headquartered company maintains five sites around the world, including in Kourou through Regulus for the assembly and integration of rockets and propellant loading. Vega launched the first time in 2012 and in 2020 the vehicle completed the first rideshare mission, deploying more than 50 satellites from over 20 different customers thanks to the Italian-made Small Spacecraft Missile Service (SSMS) payload adapter.[43] In 2022, Avio will fly the Vega C, with an increased payload capacity (from 1,5 t to 2,3 t). Future developments regard the Vega E (2,8 t capacity), designed with liquid oxygen and methane engines,[44] and possibly a Vega G evolution.[45]

Leonardo, Thales Alenia Space and Telespazio (Space Alliance) are leaders in the upstream and downstream segments, concerning satellite manufacturing and ground services for several national and European assets including Galileo and

[38] Arianespace, *Arianespace Signs Long-Term Supply Agreement with Avio for 10 Additional Vega C Launchers*, 19 March 2021, https://www.arianespace.com/?p=56564.

[39] French Ministry of the Economy and Italian Ministry of Economic Development, *Franco Italian Declaration on the Future of the European Space Launchers*, 19 March 2021, https://www.tresor.economie.gouv.fr/Articles/ee9bc441-5bd8-484c-a4e6-3ab69704a454/files/c7cf6804-aaaa-40f6-b366-02994896625d.

[40] Italian Ministry of Defence, *Documento programmatico pluriennale della Difesa per il triennio 2021-2023*, cit.

[41] Interview, 16 December 2021.

[42] Ibid.

[43] Arianespace website: *Vega Flight VV16*, https://www.arianespace.com/?p=53293.

[44] Avio, *Avio Company Press Kit*, April 2021, p. 4, https://www.avio.com/media-kit.

[45] ASI, *Piano triennale delle attività 2021-2023*, 10 March 2021, https://www.asi.it/wp-content/uploads/2021/06/PTA-2021-2023.pdf.

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Copernicus, as well as in international markets. The three companies assure the Italian presence in the industrial space sector and in several breakthroughs, by participating for instance to the James Webb Space Telescope, the Rosetta mission and the future exploration on the Moon.[46]

Leonardo is a global top player in aerospace, defence and security, maintaining an industrial and commercial presence in over forty countries and approximately 50.000 employees. Over the years, Leonardo participated to several national and European endeavours in space,[47] from the exploration drill for the ExoMars mission, the robotic arms technology on the forthcoming Mars Sample Return mission, and the laser payload on Aeolus, to the cutting-edge optical instrumentation on PRISMA and the atomic clocks of the Galileo constellation.[48] In particular, its Electronic Division has matured radar and sensors technology for a number of applications, from domain awareness to intelligence surveillance target acquisition (ISTAR) and electronic warfare. Specifically, the Division focuses also on satellites sensors technology, such as the star trackers to keep the orientation in orbit, as well as EO and scientific equipment. Noticeably, Leonardo participated to the Osiris-Rex NASA probe to study the Bennu asteroid, providing the star tracker.[49] Moreover, the Leonardo established a cooperation with ESA for the creation of the new Cyber-Security Operations Centre (C-SOC).[50] In 2021, Leonardo acquired and integrated the Italian SME Vitrociset, adding more services and capabilities to its space portfolio those of Telespazio. Indeed, Leonardo represents the Italian side of the bilateral Space Alliance with Thales, as it holds 67 per cent of Telespazio shares and 33 per cent of Thales Alenia Space ones. Moreover, through its participation in Avio (29,63 per cent)[51] the company is present through the whole space value chain.

Born out of the Space Alliance together with Telespazio, Thales Alenia Space (TAS) has sites in Rome, Turin, L'Aquila and Milan, by employing over 2.000 units. TAS participates to the space defence market through major national programs, such as

[46] "C'è anche un po' d'Italia sul James Webb Space Telescope", in *AskaNews*, 19 November 2021, https://www.askanews.it/scienza-e-innovazione/2021/11/19/cè-anche-un-po-ditalia-sul-james-webb-space-telescope-pn_20211119_00003; Leonardo, *Leonardo-Finmeccanica: il ruolo della missione Rosetta*, 27 September 2016, https://www.telespazio.com/documents/559023/8276139/NotaLDO_ROSETTA.pdf; Luigi Romano, "Una trivella italiana per perforare la Luna. Il contratto per Leonardo", in *Formiche*, 30 January 2020, https://formiche.net/?p=1256239.

[47] Leonardo website: *Programmes and Missions*, https://space.leonardo.com/en/programmi-e-missioni.

[48] Leonardo, *The Hyperspectral Technology of the PRISMA Satellite*, 19 April 2021, https://www.leonardo.com/en/news-and-stories-detail/-/detail/the-hyperspectral-technology-of-the-prisma-satellite.

[49] "Anche l'Italia nella missione Nasa sull'asteroide Bennu con lo Star Tracker di Leonardo", in *Sky Tg24*, 20 October 2020, https://tg24.sky.it/scienze/2020/10/20/leonardo-star-tracker-nasa-bennu.

[50] Leonardo, *ESA Chooses Leonardo for Its Cyber-Security Operations Centre (C-SOC) Which Will Protect European Space Resources*, 21 December 2021, https://www.leonardo.com/en/press-release-detail/-/detail/21-12-21-esa-sceglie-leonardo-per-il-centro-operativo-di-cyber-sicurezza-delle-risorse-spaziali-europee.

[51] Avio website: *Share Ownership*, http://investors.avio.com/En/investors/ownership-structure.

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the Syracuse and the SICRAL, and overall it is a leader in satellite communication, with orders from the US and Russia to Latin America and the MENA region. More recently, TAS has been selected by the Canadian operator Telesat to manufacture the Light speed constellation of LEO satellites.[52] TAS is also deeply involved in the EO sector, from COSMO-SkyMed to Helios and SAR-Lupe, as prime contractor for the Sentinel-1 and Sentinel-3 and for the new CHIME, CIMR and ROSE-L missions that will expand the Copernicus programme in the next future. Moreover, Thales Alenia Space Italy produced over 50 per cent of the ISS pressurised modules and contributed to several exploration missions, such as Cassini-Huygens culminated with the landing on Titan and fall on Saturn.[53]

Telespazio, the "space services" company within the Space Alliance, is one of the top satellite solutions and services provider, with wide-ranging expertise from exploration mission to system integration and a consolidated focus on the midstream and downstream segments. The company is headquartered in Italy and maintains several subsidiaries worldwide (from France, Germany, Spain, UK, Belgium and Romania to Brazil and Argentina), and has a wide network of space centres and teleports. Through the Space Centre in Fucino, Telespazio operates over 170 antennas in a 370,000 square metre location, providing ground segment services for many satellites, from COSMO to Galileo.[54] Recently, Telespazio and TAS invested in the Canadian NorthStar, focused on the development of space-based assets for SSA.[55]

The company e-GEOS is a joint venture between ASI and Telespazio and a leader in the EO downstream segment. It manages the consortium in charge of the Copernicus' Emergency Management Service (EMS), which provides critical data in the occurrence of crisis and emergencies, including the Covid-19 pandemic.[56] Moreover, the company is responsible for the commercialisation of the COSMO-SkyMed imagery and over years developed a wide-ranging offer of tailored EO products – related to land management and infrastructure, agriculture, climate change, insurance, risk management, maritime, intelligence and defence.[57]

[52] Thales, *Thales Alenia Space Selected by Telesat to Build Its Broadband 298-Satellite Constellation Lightspeed*, 9 February 2021, https://www.thalesgroup.com/en/node/2738176.

[53] Thales, *16 Years Ago Huygens Probe Landed on Saturn's Moon, Titan*, 14 January 2021, https://www.thalesgroup.com/en/node/2729198; Thales, *And the Emmy Goes to... Cassini*, 18 September 2018, https://www.thalesgroup.com/en/node/2726882.

[54] Thales, *16 Years Ago Huygens Probe Landed on Saturn's Moon, Titan*, cit.

[55] Thales, *Telespazio and Thales Alenia Space Announce an Investment in NorthStar Earth and Space Inc.*, 15 November 2018, https://www.thalesgroup.com/en/node/2727208.

[56] Telespazio, *Satellites and Security: e-GEOS Will Head Two Crucial Projects for Emergency and Crisis Management*, 7 March 2019, https://www.telespazio.com/en/news-and-stories-detail/-/detail/070319-satellites-and-security-e-geos-will-head-two-crucial-projects-for-emergency-and-crisis-management; Telespazio, *EMS, the Eagle-eye of Copernicus for Managing Emergencies*, 2 August 2021, https://www.telespazio.com/en/news-and-stories-detail/-/detail/ems-copernicus-emergencies-sardinia.

[57] e-GEOS website: *Markets*, https://www.e-geos.it.

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e-GEOS supports the Italian Navy missions in the High North[58] through the project Arctic Navigation with COSMO-SkyMed (ArNaCOSky).[59]

Sitael is the largest full-private company in the Italian space sector, with experience on small satellites and avionics and presence and collaborations abroad. Airbus and OHB also have a presence in Italy: the former Space Engineering, a subsidiary of Airbus Defence and Space since 2015, became Airbus Italy in 2019 while Carlo Gavazzi Space (former Compagnia Generale Spazio) transitioned to OHB Italia in 2017.

Overall, the landscape of the Italian space industry is broad and presents several interesting SMEs and start-ups focusing on niche markets but also developing larger projects, even in cooperation with NASA and ESA, such as D-Orbit and Argotec.[60] There are also three national industrial associations addressing space: the larger Italian Industries Federation for Aerospace, Defence and Security (AIAD) which covers also a number of other defence sectors, the Association of Italian Space Companies (AIPAS), and the Association for Space-based Applications & Services (ASAS). More recently, PrimoSpace became the first private venture firm dedicated to space in Italy, managing a growing portfolio of start-ups also in the framework of European investment funds.[61]

The Italian institutional governance, including the MoD, should look at such wide industrial landscape to systematically maintain, value, exploit and further promote the wide-ranging landscape riche of expertise and know-how, as it nurtures strategic technological capabilities for the country – including for the military. Here the aforementioned absence of a MoD investment plan on space defence assets represents a negative factor.

6.6 A strategic set of technological capabilities

Access to space

A first strategic component of the Italian technological capabilities is access to space. As recalled above, in terms of space launchers Italy plays a substantial role

[58] Italian Navy Hydrographic Office, *La Marina Militare in Artico. Programma High-North*, January 2020, https://www.marina.difesa.it/media-cultura/Notiziario-online/Documents/La_MM_in_Artico_Programma_High_North.pdf.

[59] Leonardo, Observing the Sea from Space: *SEonSE's Commitment to Protecting Marine Ecosystems*, 25 June 2021, https://www.leonardo.com/en/news-and-stories-detail/-/detail/observing-the-sea-from-space-seonse-s-commitment-to-protecting-marine-ecosystems.

[60] Italian Trade Agency and ASI, *Italian Space Industry 2021-2022*, September 2021, https://www.asi.it/en/?p=18030.

[61] Italian Trade Agency website: *Primo Space Fund, the First Italian Fund Focusing on Aerospace Start-ups*, https://www.ice.it/it/node/6516; European Commission, *'Primo Space' Has Lift-off: First Italian Fund to Invest in Space Economy*, 27 July 2020, https://ec.europa.eu/commission/presscorner/detail/en/IP_20_1417.

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contributing to the European autonomous access to space.[62] Avio, in partnership with other European companies, produces Vega, which will undergo further evolutions to seize market opportunities, as well as propulsion stages shared with the Ariane launchers. More recently, thanks to a fruitful cooperation between private and public entities, Avio also established a new Space Propulsion Test Facility (SPTF) for liquid rocket engines, located in the Joint Military Testing Range in Salto di Quirra (*Poligono Sperimentale e di Addestramento Interforze* – PISQ).[63]

Furthermore, Italy – particularly through TAS-Italia – is leading the development of Space Rider, an ESA programme for a reusable space transportation system, building on the previous domestic progresses on the Intermediate eXperimental Vehicle (IXV) demonstrator project.[64] The Space Rider would bring several opportunities in terms of space assets and possibly space operations, while providing microgravity conditions for research and developing critical capabilities for in orbit testing and atmosphere re-entry.[65] This program and its predecessor will allow to develop know how which could be further exploited in both civilian and military applications.

In terms of launch site, Italy lost the capability acquired during the San Marco project with the Broglio Space Centre (BSC). The BSC is not operational since the last launch in 1988, yet it still provides ground station services. Partial progresses in this field are taking place with the establishment of a spaceport in Grottaglie approved in 2020. Developments are unfolding also concerning eventual sea-based launches from a former aircraft carrier,[66] as the Italian Navy is studying the feasibility of the *Sistema di Messa in Orbita NAvale* (SIMONA) project, in the framework of the PNRM:[67] SIMONA studies the opportunity to launch assets from naval platforms, efficiently adapted to support launches of micro to mini satellites (reportedly up to 300 kg).[68] The Italian air force is considering launching small sat

[62] Already in 1992, ASI partnered with NASA providing the Italian Research Interim Stage (IRIS) propellant system, obtaining the qualification as a Space Shuttle upper stage. IRIS was developed by BPD, the Avio ancestor, promoting the industrial advancements on propulsion technology and consolidating the domestic efforts towards a space launcher. See ASI website: *IRIS*, https://www.asi.it/en/?p=16813.

[63] ASI, *L'ASI all'inaugurazione dello Space Propulsion Test Facility di Avio*, 5 October 2021, https://www.asi.it/?p=25786.

[64] ESA, *ESA Experimental Spaceplane Complete Research Flight*, 11 February 2015, https://www.esa.int/Enabling_Support/Space_Transportation/IXV/ESA_experimental_spaceplane_completes_research_flight.

[65] ESA, *ESA Signs Contracts for Reusable Space Rider up to Maiden Flight*, 9 December 2020, https://www.esa.int/Enabling_Support/Space_Transportation/Space_Rider/ESA_signs_contracts_for_reusable_Space_Rider_up_to_maiden_flight.

[66] Giuseppina Pulcrano, "Enac dà il via libera allo spazioporto di Grottaglie" in *Globalscience*, 28 October 2020, https://www.globalscience.it/23397; "Saccoccia (ASI): a Grottaglie per parlare di trasporto spaziale", in *AskaNews*, 15 September 2021, https://www.askanews.it/scienza-e-innovazione/2021/09/15/saccoccia-asi-a-grottaglie-per-parlare-di-trasporto-spaziale-pn_20210915_00126; Tiziano Ciocchetti, "Il Garibaldi lancerà in orbita satelliti", in *Difesa Online*, 21 January 2021, https://www.difesaonline.it/node/14598.

[67] Tiziano Ciocchetti, "Il Garibaldi lancerà in orbita satelliti", cit.

[68] Dario Sgobbi and Mauro Balduccini, "Il ruolo della Marina Militare verso l'acquisizione di un

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from its aircraft.[69]

Obviously, both ship-based and aircraft-based launches present their own limitations and cannot constitute a full alternative to land launch sites. Generally speaking, the mentioning of Kourou in the Qurinale Treaty does not preclude Italy to look for alternative, complementary, cost-effective and sustainable solutions to increase its autonomy when it comes to access to space,[70] as shown by the February 2022 launch of COSMOSkyMed satellite from Cape Canaveral.

Satellite communication

Critical capabilities are traditionally present in the SatCom[71] sector. In 2001, the MoD directly entered in the space sector with the launch of the first Italian System for Secure Communications and Alerts satellite (*Sistema Italiano per Comunicazioni Riservate ed Allarmi* – SICRAL). An exclusively military-owned asset, SICRAL 1 provided key telecommunications services for security and defence operations.[72] The first satellite was then followed by SICRAL 1B in 2009, and SICRAL 2 in 2015, the latter in cooperation with the French DGA.[73] Launched in 2014, ATHENA-FIDUS is a second satellite for military telecommunications shared by Italy and France, operating in EHF/Ka band.[74] These satellites have also provided for many years SatCom capacities to NATO. Indeed, Italy contributes in several ways to NATO requirements,[75] through pooling and sharing agreements – especially for SHF/UHF bandwidth – to enhanced communication services, and the Alliance's new approach to space may further expand this cooperation.[76] As SICRAL 1 has been successfully moved in a graveyard orbit, the Italian military is currently looking to replace and upgrade the capabilities with a set of two new satellites, SICRAL 3A and 3B, procured by Thales Alenia Space, Leonardo and Telespazio,[77] also in order to maintain the right to use the slot previously assigned to SICRAL 1 in a space environment even more congested.

accesso nazionale indipendente allo spazio", in *Rivista Marittima*, July-August 2020, p. 44-56, https://www.marina.difesa.it/media-cultura/editoria/marivista/Documents/2020/lug_ago_2020.pdf.

69 Interview, 3 November 2022.

70 Interview, 24 January 2022.

71 Already in 1977, Italy launched the first national satellite for telecommunication, labelled *Satellite Italiano per Ricerca Industriale ed Operativa* (SIRIO).

72 Telespazio website: *SICRAL*, https://www.telespazio.com/en/programmes/sicral.

73 Telespazio, *Successfully Launched the SICRAL 2 Satellite*, 26 April 2015, https://www.telespazio.com/en/press-release-detail/-/detail/260415-successfully-launched-the-sicral-2-satellite.

74 Italian Ministry of Defence, *Difesa italiana e francese: successo del lancio del satellite Athena Fidus*, 7 February 2014, https://www.difesa.it/SMD_/Eventi/Pagine/DifesaItalianaFrancese_lanciosatelliteAthenaFidus.aspx.

75 NATO, *NATO Begins Using Enhanced Satellite Services*, cit.; Peter B. de Selding, "NATO Behind Schedule on Capacity Order, Now Hopes for 2017 Decision", in *SpaceNews*, 11 November 2016, https://spacenews.com/?p=64196.

76 Interview, 24 January 2022.

77 Telespazio, *Space Alliance Will Build SICRAL 3*, 16 June 2021, https://www.telespazio.com/en/news-and-stories-detail/-/detail/sicral-3.

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Earth Observation

In the EO field, Italy has a specific competence can give a great contribute to European efforts. Rome pioneered a dual-use approach launching the COSMO-SkyMed constellation of Synthetic Aperture Radar (SAR) satellites, composed of four assets of the 1stgeneration and two of the 2nd one – while a 3rd generation is already envisioned. As a result of the joint programme between the Ministry of Defence and ASI, the first COSMO satellite was launched in 2007 while the sixth asset has been launched onboard a SpaceX Falcon 9 rocket in January 2022.[78] COSMO-SkyMed provides critical services for geo-intelligence, security and defence operations, maritime navigation, emergency and disaster management, and other activities. As such, it is an excellent example of how dual-use assets optimise resources and a pretty unique infrastructure.[79] The imagery is utilised by the Ministry of Defence and ASI according to a definite data policy – including volumes of data defined ex ante – and the regulations of the National Authority for the Security of Remote Sensing (*Autorità Nazionale per la Sicurezza del Telerilevamento Satellitare*).[80] The strategic priorities of the constellation and thus its use are defined at governmental level.[81] COSMO-SkyMed implies an extremely advanced capability to process data, which in turn fuels technological innovation on computing power and big data.[82]

The COSMO-SkyMed constellation creates also several cooperation opportunities, as for instance with the Argentinean Space Agency bringing to the establishment of the SIASGE integrated system, merging data from the two SAOCOM satellites and COSMO to enhance the observation capabilities and revisit-time in case of disasters.[83] e-GEOS is responsible for the commercialisation of the COSMO imagery and has developed tied relations with several partners and customers, as for instance in Japan, Finland, US and UK.[84] Moreover, e-GEOS and the Israeli company ImageSat International (ISI) signed a cooperation agreement to create a strategic alliance on EO and thus put together two constellation (three EROS Next Generation and five COSMO) merging SAR and electro-optical images with high

[78] Stephen Clark, "Launch of Italian Radar Satellite Shifts from Arianespace to SpaceX", in *Spaceflight Now*, 5 October 2021, https://spaceflightnow.com/?p=53641.

[79] Interviews, 30 November 2021; 11 November 2021.

[80] In addition, the Italian Navy concluded a further agreement with ASI to acquire COSMO data and increase maritime surveillance and maritime situational awareness. See Giampaolo Cirronis, "E' stato firmato ieri un accordo di collaborazione tra la Marina Militare e l'Agenzia Spaziale Italiana", in *La Provincia del Sulcis Iglesiente*, 17 July 2018, https://www.laprovinciadelsulcisiglesiente.com/?p=189553.

[81] Interview, 24 January 2022.

[82] Interview, 11 November 2021.

[83] ASI website: *SIASGE*, https://www.asi.it/scienze-della-terra/cosmo-skymed/siasge.

[84] "Italy's e-GEOS to Supply COSMO-SkyMed Imagery to Indonesia and Japan", in *SpaceWatch*, 24 September 2018, https://spacewatch.global/?p=10499; ASI, *Italian Space Agency and NASA Sign Agreement on Use of COSMO-SkyMed*, 9 September 2015, https://bandiasi.almaviva.it/en/node/32586; Finnish Meteorological Institute (FMI) website: *COSMO-SkyMed Tasking*, https://nsdc.fmi.fi/services/service_cosmo.

revisit time and resolution.[85] Broadly speaking, the constellation is a strategically valuable instrument for the space diplomacy of Italy as a whole.

The Italian military complemented the SAR capabilities with high-resolution optical ones through the launch of Optsat-3000, a reconnaissance satellite which increases the quality and quantity of acquired data.[86] Optsat-3000 was developed by Telespazio and Israel Aerospace Industries (IAI) following an intergovernmental agreement in the defence field between Italy and Israel.[87]

Furthermore, ASI advanced on observation capabilities with the PRISMA (*PRecursore Iperspettrale della Missione Applicativa*) mission, adding the hyperspectral capacity to the national set of EO satellites.[88] ASI procured the satellite by a consortium led by OHB Italia and including Leonardo – the latter responsible for the development of the electro-optical hyperspectral equipment – together with Telespazio and Thales Alenia Space.[89] More recently, ASI launched the PLATINO programme to develop a micro-satellite platform for multi-payload and multi-purpose missions. The first two satellites are expected to be launched in 2022 and 2024 and respectively test a SAR capability and a Thermal InfraRed (TIR) one, orbiting at only 400 kilometres increasing the data resolution.[90] This constellation is conceived as a national infrastructure dedicated to enhance the capability of Italian institutions and effectiveness of their policies.[91] The high-level capabilities in EO at Italian level are echoed in Europe, where the industrial expertise provided by national actors plays a large role also for the progresses and expansion of the Copernicus programme.[92]

On top of the solid capabilities and industrial skills in the EO sector, Italy will devote a substantial part of the funds allocated for the space sector under the National Recovery and Resilience Plan (*Piano Nazionale di Ripresa e Resilienza* – PNRR) to design and build a EO constellation in LEO. The programme is intended for a variety of applications, in primis environmental protection and climate research, but also other innovative services, fostering also the downstream segment.[93]

[85] Telespazio, *e-Geos and ISI Partner to Create the World's Most Capable Commercial SAR-Electro Optical Satellite Constellation*, 20 July 2021, https://www.telespazio.com/en/news-and-stories-detail/-/detail/e-geos-isi-sar-electro-optical-satellite-constellation.

[86] Italian Ministry of Defence, *OPTSAT-3000 Satellite Launched*, 2 August 2017, https://www.difesa.it/EN/Primo_Piano/Pagine/ops.aspx.

[87] "Israeli-Made OPTSAT-3000 and Venμs Satellites Successfully Launched by Arianespace", in *SpaceWatch*, 3 August 2017, https://spacewatch.global/?p=5315.

[88] Leonardo, *The Hyperspectral Technology of the PRISMA Satellite*, cit.

[89] Ibid.; ASI website: *PRISMA*, https://www.asi.it/scienze-della-terra/prisma.

[90] SITAEL website: *Earh Observation*, https://www.sitael.com/?p=5887.

[91] Interview, 28 January 2022.

[92] Thales, *Thales Alenia Space at the Forefront of High-Priority Environmental Missions*, 13 November 2020, https://www.thalesgroup.com/en/node/2737717.

[93] Italiadomani website: *New Technologies for Space Observation*, https://italiadomani.gov.it/en/Interventi/investimenti/tecnologie-satellitari-ed-economia-spaziale.html; "Via alla costellazione italiana per tutelare l'ambiente", in *Airpress*, No. 129 (January 2022), p. 26.

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Navigation

Italy also plays a significant role in satellite navigation at European level. The Fucino Space Centre (L'Aquila) established in 1963 and operated by Telespazio hosts one of the two Galileo Control Centres, in charge of the security of the whole fleet.[94] Together with the German Space Agency, Telespazio also constituted the Spaceopal company, the service operator for Galileo. Furthermore, the Italian industry is involved in the manufacture of the second generation of the Galileo fleet, building on its key role in its first generation. Thales Alenia Space Italy won a contract awarded by the EU to manufacture further six assets,[95] while Leonardo will continue to provide the atomic clocks for all the twelve new satellites.[96] In this field, Italy is also preparing for the introduction of the Galileo PRS and launched a national training exercise to present the National Centre for the Public Regulated Service and the nature and applications of the distributed services.[97] Other developments regard the capacity to receive Galileo PRS and multi-constellation GNSS signals. On this front, the Italian Army is progressing with the integration of advanced receivers on armoured vehicles.[98] A multi-constellation receiver is also part of the national Space Economy plan in the framework of the Mirror Galileo programme.[99]

Space situational awareness

Finally, Space Situational Awareness represents a field of strategic capabilities, essential for national and European assets, whereby a solid cooperation between the Italian stakeholders take place. ASI, the Ministry of Defence and the National Institute for Astrophysics (*Istituto Nazionale di Astrofisica* – INAF) collaborate on the sensor capabilities and participate to the EUSST Consortium. Italy indeed contributes with eight assets, three radars (BIRALES, BIRALET and MFDR), and five telescopes (SPADE, CAS, Cassini, PdM-MiTe, plus MLRO with lase integrated capability), that allow the acquisition of orbital data to improve the overall security of space operations. All the sensors require a cooperation among the involved

[94] Telespazio, *Galileo Control Centre Extension Inaugurated at Fucino Space Centre*, 3 November 2021, https://www.telespazio.com/en/news-and-stories-detail/-/detail/fucino-space-centre-new-building-galileo-control-centre.

[95] European Commission, *Commission Awards €1.47 bn in Contracts to Launch the 2nd Generation of Galileo Satellites*, 20 January 2021, https://europa.eu/!VB87CK.

[96] Leonardo, *The Accuracy of Leonardo's Atomic Clocks Also on Galileo Second Generation*, 1 July 2021, https://www.leonardo.com/en/press-release-detail/-/detail/01-07-2021-la-precisione-degli-orologi-atomici-di-leonardo-anche-per-galileo-second-generation.

[97] Italian Defence General Staff, *GALILEX 21: conclusa esercitazione di Galileo presso il COI*, 9 July 2021, https://www.difesa.it/SMD_/Eventi/Pagine/GALILEX_21_conclusa_esercitazione_di_Galileo_presso_il_COI.aspx.

[98] Leonardo, *The Iveco-Oto Melara Consortium Signs the Contract for the Italian Army's New VBM Plus*, 17 January 2022, https://www.leonardo.com/en/news-and-stories-detail/-/detail/17-01-2022-the-iveco-oto-melara-consortium-signs-the-contract-for-the-italian-army-s-new-vbm-plus.

[99] ASI, *Piano triennale delle attività 2021-2023*, cit.

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stakeholders as well as the industrial actors, especially Leonardo, Telespazio and former Vitrociset.

Building on the already high-level capacity of multistate radars, Italian companies are also active in the promising field of space-based sensors.[100] The sensor capabilities are necessary to ensure the protection of spacecraft in orbit, as recently shown by the Kosmos-1408 ASAT test,[101] but also to safeguard the population, as few episodes demonstrated how uncontrolled re-entries of large objects could pose threats to large areas on Earth.[102] Italy provides a full set of capabilities, considering both radar and optical ground-based sensors, that are instrumental to support cooperation in Europe and at international level. Beside the EUSST, the Italian MoD through the COS signed an agreement with the US Space Command for the exchange of classified SSA information,[103] a necessary step in acquiring a more complete set of data given the large coverage of the American space sensor network and reinforcing the already solid bilateral cooperation with the US. In the framework of Italy-US cooperation in space, it is notable the agreement signed in August 2021 for the Military Personnel Exchange Program (MPEP) between the Department of Air Force and the Italian Air Force to allow an Italian Exchange Officer to take part to the US Space Force, since it is the first foreign officer to be invited to the new branch of the American military.[104]

In parallel with European and transatlantic cooperation, the SSA field is a particularly strategic sector to invest in, updating and upgrading the national capabilities. In this sense, contributions may come also from the FlyEye telescope, developed with the Italian leadership position within ESA in the framework of Near-Earth Objects (NEO) planetary defence. Indeed, the wide field of view telescope can indeed be repurposed for tracking services too. It will be integrated at the ASI Matera Space Centre and then moved to its final location in Sicily.[105] The FlyEye will provide valuable data for the Medium Earth Orbit (MEO) region, where GNSS and Galileo satellites are usually located, thus adding autonomous capabilities for the national

[100] Interview, 25 November 2021.

[101] Italian Air Force, *Spazio: l'aereonautica Militare impegnata nel monitoraggio dei frammenti del satelitte russo COSMOS 1408*, 19 November 2021, http://www.aeronautica.difesa.it/comunicazione/notizie/Pagine/spazio.aspx; Leonardo, *Space Debris, Leonardo, and Vitrociset, and Telespazio's Contribution to Risk Monitoring and Prevention*, 14 May 2021, https://www.leonardocompany.com/en/news-and-stories-detail/-/detail/space-debris-leonardo-and-vitrociset-and-telespazio-s-contribution-to-risk-monitoring-and-prevention.

[102] Daria Guidetti, "Aspettando il razzo cinese con i radar all'insù", in *Media Inaf*, 6 May 2021, https://www.media.inaf.it/?p=1707528; "Il radar della base di Quirra sulle tracce di un vettore in rientro dallo spazio", in *La Nuova Sardegna*, 19 April 2020, https://www.lanuovasardegna.it/cagliari/cronaca/2020/04/19/news/il-radar-della-base-di-quirra-sulle-tracce-di-un-vettore-in-rientro-dallo-spazio-1.38737839.

[103] US Space Command, *US, Italy Amend SSA Memo to Include Exchanging Classified Info*, 15 July 2021, https://www.spacecom.mil/News/Article-Display/Article/2695837.

[104] Italian Ministry of Defence, *Spazio: l'Aeronautica Militare al 36th Peace Symposium*, 31 August 2021, http://www.aeronautica.difesa.it/comunicazione/notizie/Pagine/symposium.aspx.

[105] OHB Italia, *FLYEYE Telescope and SUTED Project: the Solution for Space Debris*, 19 March 2021, https://www.ohb-italia.it/?p=2602.

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and European institutions.

Moreover, advanced capabilities and expertise in the sensor field enable developments at industrial level and support cutting-edge innovation. Indeed, Leonardo is among the most successful European industry leaders in both EDIDP and PESCO projects where Italy is involved in upgrading the capabilities for SSA and SST, especially through the INTEGRAL and EU-SSA-N projects. These two projects will be particularly important for the networking of national capabilities at EU level and for the creation of C2 capabilities that can be implemented at national level. Space-based sensors are relevant also for Europe's missile defence, as epitomised by the PESCO project TWISTER,[106] further expanding the nexus between space and defence, especially if TWISTER could build a cooperative framework for missile defence and foster development of space-based capabilities in the near future. Here, considering the relation also with other missile defence technologies as well as with defence against hypersonic missiles, it will be particularly important to plan adequate and focused investments to maintain technological leadership in certain element and participation where partners will take the lead through a balanced cooperation on a equal foot.

Besides, the Matera Laser Ranging Observatory (MLRO) operated by ASI at the Matera Space Centre, a primary EO ground segment and geodesy hub, was exploited already in 2007 to test quantum communications and encryption, the first test in the world in terms of experiments for space quantum transmission.[107]

Between Earth, space and the Moon

New fields of long-term cooperation between armed forces, ASI and the private sector include sub-orbital flight. The former is particularly relevant for the air force, which already generates the majority of Italian astronauts and further cultivates orbital and human spaceflight ambitions. Such a perspective entails a commercial vocation, the involvement of the national industry and research centres, as well as relations with US private entities such as Virgin Orbit and more recently Axiom Space.[108] Together with sub-orbital, High-Altitude Stratospheric Platforms (HAPS) are identified as a priority by the Policy Guidelines of 2019 and represent a strategic opportunity to pursue.[109] HAPS may be exploited for a

[106] See in this regard Alessandro Marrone and Karolina Muti (eds), "Europe's Missile Defence and Italy: Capabilities and Cooperation", cit.

[107] Jacob Aron, "First Quantum Transmission Sent Through Space", in *New Scientist*, 26 June 2014, https://www.newscientist.com/article/dn25798.

[108] Italian Ministry of Defence, *Spazio: siglati accordi di collaborazione nel campo del volo umano spaziale con CNR e Thales Alenia Space Italia*, 15 July 2021, http://www.aeronautica.difesa.it/comunicazione/notizie/Pagine/20210715_Spazio_siglaaccordiCNRAMThales.aspx; Axiom Space, *Axiom Space to Train Italian Air Force's Col. Walter Villadei as Professional Astronaut for Future Space Mission*, 11 January 2022, https://www.axiomspace.com/news/italian-air-force-colonel-first-axiom-professional-astronaut-begins-training.

[109] Aniello Violetti, "Piattaforme stratosferiche, una strategia per essere utili al Paese", in *Rivista Aeronautica*, No. 4/2019.

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variety of surveillance missions (SAR and optical EO, SIGINT), relevant also in case of disaster management.[110] Indeed, HAPS can be configured for stationary missions for 24/7 monitoring and overall could provide higher resolutions (from approximately 20 km of altitude) at lower costs. Not least, stratospheric platforms may provide scientific research and commercial opportunities alternative to satellites, especially for communications services and EO data. Italy maintains a technological expertise in the field, especially due to projects launched in primis by the Italian Aerospace Research Centre[111] (*Centro Italiano Ricerche Aerospaziali* – CIRA), but also Leonardo[112] and Thales Alenia Space.

Moreover, it should be noticed the niche of excellence in the habitats for the ISS, which Italian industries are building for the follow-on private space station post 2030.[113] This is a promising capacity to be exploited within Artemis project, towards both Moon's orbiting station and basing.[114]

Finally, in a long-term perspective, it is worth-mentioning also the Italian army's intent to cooperate with ASI on the protection from space-originated bacteriological threats building, on the basis of the well-established Chemical Biological Radiological Nuclear (CBRN) know-how of the armed force.[115]

The MoD budgetary constraints

The whole approach of the Ministry of Defence to such strategic set of technological capabilities is negatively limited by the modest military budget so far made available for space capabilities,[116] also within the national plan for military research (*Piano Nazionale Ricerca Militare* – PNRM) whose investments are largely inferior to French, German and UK ones.[117] Suffice to say that under the DPP (*Documento Programmatico Pluriennale della Difesa*) 2021-2023, only 100 million euro are

[110] Marco Florissi, "Piattaforme stratosferiche, cosa sono e chi le impiegherà", in *Rivista Aeronautica*, No. 4/2019.

[111] "CIRA: brevettata la piattaforma stratosferica tattica", in *Spazio-News*, 30 July 2020, http://spazio-news.it/?p=9033.

[112] Leonardo also maintains a participation in the Skydweller Aero – a US/Spanish company – for the development of a solar-powered drone. According to latest updates, the Skydweller is part of the Leonardo manufacturing process located in Grottaglie. Leonardo, *Leonardo Invests in the World's First Solar-Powered Drone Capable of Perpetual Flight with Heavy Payloads*, 11 November 2019, https://www.leonardo.com/en/press-release-detail/-/detail/11-11-leonardo-invests-in-the-world-s-first-solar-powered-drone-capable-of-perpetual-flight-with-heavy-payloads; Cesare Bechis, "Leonardo a Grottaglie si diversifica: arriva il drone ad energia solare", in *Corriere del Mezzogiorno*, 13 January 2022, https://corrieredelmezzogiorno.corriere.it/bari/cronaca/22_gennaio_13/leonardo-grottaglie-si-diversifica-arriva-drone-energia-solare-f56c7b92-749b-11ec-a9b2-7b8f9777ce1e.shtml.

[113] Thales, *Thales Alenia Space to Provide the First Two Pressurized Modules for Axiom Space Station*, 14 July 2021, https://www.thalesgroup.com/en/node/2739234.

[114] Interview, 4 February 2022; Stefania Piccin, "Thales Alenia Space costruirà i due moduli europei del Lunar Gateway", in *AstroSpace*, 15 October 2020, https://www.astrospace.it/?p=5794.

[115] Interview, 10 December 2021.

[116] Interview, 15 November 2021.

[117] Interviews, 10 December 2021; 26 November 2021.

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allocated for the whole military research on technology.[118] One of the main reasons is that space is by default a joint interest of all armed forces but it is not the core business of any single service, therefore it suffers in comparison with the respective priorities of army, navy and air force.[119]

Such a MoD budgetary constraint does hamper both technological developments in the national aerospace industry, and the Italian position vis-à-vis European countries.[120] Historically, the modest amount of defence funding has been a major driver for the choice to develop dual-use assets which could serve different users and thus benefit from complimentary funds.[121] New forms of cooperation and technological development should be investigated, enlarging the procurement base and the industrial policy instruments. An alternative would be to take advantage also of innovation on the technical side and the opportunities to exploit small multipurpose platforms or secondary payload. Yet, the requirements on reinforcing SSA, ISR and SIGINT expressed in the Programmatic Plan of the Defence 2021-2023 highlight the need of renewed and increased investments.[122] More and tailored MoD funding for space would ensure to timely satisfy specific military requirements, including with regards to SIGINT.

Against this backdrop, the Italian plan to invest the funds provided by Next Generation EU programme includes important investments on space technologies and capabilities.[123] Indeed, Italy will allocate to space 2,4 billion euro within the National Recovery and Resilience Plan (*Piano Nazionale di Ripresa e Resilienza* – PNRR), to be partly managed by ASI and partly by ESA for what concerns investments in EO and access to space.[124] These funds will add to the 2 billion euro of national investments already envisaged for space, while renewed and increased contributions to ESA are expected from Italy at the next Ministerial Council scheduled in 2022.[125] In 2019 Italy doubled the contributions to ESA stated at the Council of 2016, by increasing of almost a billion euro the subscriptions to the Agency's optional programmes, but more is needed to match the ambitions laid down by the new governance and the related strategic documents.

[118] Italian Ministry of Defence, *Documento programmatico pluriennale della Difesa per il triennio 2021-2023*, cit.

[119] Despite the Air Force has also the mandate to ensure national air defence and missile defence, also through the aforementioned Aerospace Operations Command in Poggio Renatico.

[120] Interview, 15 November 2021.

[121] Ibid.

[122] Italian Ministry of Defence, *Documento programmatico pluriennale della Difesa per il triennio 2021-2023*, cit.

[123] Interviews, 11 November 2021; 15 November 2021.

[124] Italiadomani website: *New Technologies for Space Observation*, cit.; Chiara Rossi, "Perché sui fondi Pnrr per lo spazio Draghi e Colao si affidano all'agenzia europea Esa", in *Startmag*, 2 December 2021, https://www.startMag.it/?p=171365.

[125] Italian Minister of Technological Innovation and Digital Transition, *15° Seduta del Comitato interministeriale relativo a spazio e aerospazio*, 1 December 2021, https://innovazione.gov.it/notizie/articoli/15a-seduta-del-comitato-interministeriale-relativo-a-spazio-e-aerospazio; Interview, 15 November 2021.

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7. The technology dimension and duality

by Giancarlo La Rocca

The space race is first a technology competition, to allow actors to position in this domain, exercise control, seek competitive advantages and eventually introduce disruption. Competition grows together with innovation and acquisition of new capabilities, which in turn increase the relative strength and autonomy of states to access and operate in space.

7.1 Innovation and new space

As recalled in Chapter 2, the retirement of the Space Shuttle programme forced the US to rely for about a decade on the Russian Soyuz launcher to access space for human spaceflight and carry astronauts to the ISS. It took a political decision to rebuild the traditional capabilities and invest massively in new ones, relying on commercial actors to end such a critical dependency. Eventually, the US regained after almost ten years an autonomous capability with cutting-edge technology both in the launcher and the capsule systems developed by SpaceX. The latter has become a regular partner also of US defence institutions for the development and launch of assets, as well as provider of services.

This case emphasises two relevant aspects: (1) technology deeply influences space, from the design of satellites to the nature of future scenarios and threats; (2) the growing presence of private actors and start-ups coupled with the relevance of commercial initiatives have implications for defence stakeholders and dual use technology.

Artificial intelligence (AI) based on big data, machine learning and automation, as well as blockchain, cyber and quantum technologies may cause major disruptions to the space domain and have dual use implications. For instance, automation and AI can be applied to EO data but also to SSA and in orbit manoeuvres. Blockchain may be investigated to add layers of security to satellites. Cyber-attacks in particular change the nature of threats in space and the security requirements of assets. Moreover, cyber threats could already represent somehow a silent and nonphysical form of weaponisation of space. According to the Director of the US Space Development Agency (SDA), cyber-attacks indeed represent "the most worrisome threat to satellites".[1] Finally, quantum technologies could create unhackable satellite services, impossible to eavesdrop, and establish an additional layer for the exchange of information, secure communications and signals through encrypted keys.[2]

[1] Sandra Erwin, "DoD Space Agency: Cyber Attacks, Not Missiles, Are the Most Worrisome Threat to Satellites", in *SpaceNews*, 14 April 2021, https://spacenews.com/?p=113307.

[2] QTSpace, *Policy White Paper*, August 2019, https://www.qtspace.eu/sites/testqtspace.eu/files/other_files/QT%20In%20Space%20-%20White%20Paper%20Final_0.pdf.

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All these leaps at technological level highlight the critical value of data and increasingly bring the digital dimension into space.[3] Together with this dimension come the information technology (IT) big players. Amazon Web Services and Microsoft both launched a space segment to apply data processing and cloud services to satellites, and are establishing closer ties with defence stakeholders.[4] Indeed, in May 2021 the US Space Force adopted the "Vision for a digital service" to become "an interconnected, innovative, digitally dominant force" seizing the "unique opportunity to be 'born digital'".[5]

In this sense, private actors contribute to a shift of paradigm from a traditional approach where space was dominated by institutional actors since its first human exploration. Commercial actors increasingly bring unprecedented capital and risk propensity, innovation and disruptive mindset to the space sector. Few of these actors are already responsible for a steep increase in the number of satellites in orbit and some among them have begun to change the launchers' market. This new paradigm implies also that technology develops faster and originates from many more actors whose drivers are largely different from the past. Companies look for profit and commercial opportunities and not only for the acquisition of key capabilities for strategic purposes: that becomes a product to sell. The so-called "new space" is indeed expanding the users base of satellite applications. Nonetheless, government stakeholders continue to be central as customers, facilitators of innovation and regulators.

7.2 Dual by nature and by application

The dual nature of space technology thus remains a key feature, from the design to the use of assets, also in light of technological innovation and new actors. Space is born in a highly competitive environment where the military drove the development of capabilities and shaped their nature and requirements. From V2 rocket to Ballistic Missile Defence, signal intelligence (SIGINT) satellites and sensors, the space sector evolved also thanks to defence know-how and for defence purposes eventually transferred to civilian ones.

This characteristic continues to occur today, as new spacefaring nations develop space launch capabilities starting from missile technology and build satellites first for military purposes and then for other civilian applications. It is the case of Israel

[3] See in this regard, from a European perspective, Jean-Pierre Darnis, "Space as a Key Element of Europe's Digital Sovereignity", in *Notes de l'Ifri*, December 2020, https://www.ifri.org/en/node/18275.

[4] AWS website: *Cloud Computing for Defence*, https://aws.amazon.com/government-education/defense; Brad D. Williams, "DoD Issues Cloud Solicitations to AWS, Google, Microsoft, and Oracle", in *Breaking Defense*, 19 November 2021, https://breakingdefense.com/?p=191309; Richard Lawler, " Now Microsoft Is Protesting after Amazon Won a $10 Billion NSA Cloud Contract", in *The Verge*, 10 August 2021, https://www.theverge.com/2021/8/10/22618764.

[5] US Space Force, *Vision for a Digital Service*, May 2021, p. 2, https://media.defense.gov/2021/May/06/2002635623/-1/-1/1/USSF+VISION+FOR+A+DIGITAL+SERVICE+2021+(2).PDF.

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but also Iran and North Korea. For instance, the US imposed sanctions on the Iran Space Agency as launch developments are believed to be a cover-up of missile technology. Overall, more and more states target space capabilities for regional projection of power and competitive advantages. From South Korea to countries of the MENA region, space is becoming a priority of technology investments and economy differentiation. More states want to acquire a level of autonomy in space technology, starting from satellite manufacturing, aiming also at developing regional GNSS systems.

Space technology continues to be mostly dual by nature, while the use of assets may be civilian or military. The new space does not change this aspect, as commercially-driven actors generally speaking do not make differences between clients, but are rather interested in partnering with defence stakeholders as anchor customers who ensure a high and secure level of demand. Moreover, the shift of paradigm allows defence actors to reduce costs while acquiring innovative capabilities. Besides, mission requirements for satellites are often the same regardless of the nature of customers. The duality aspect, while often existing by default, can be highlighted from different applications provided by same satellites or by the very same nature of assets, especially those which can offer commercial services or cause intentional threats at the same time.

7.3 Satellite communication, navigation and EO

Regarding dual applications, satellite communication, navigation and EO, all provide relevant cases. The Starlink large satellite constellation, both developed and launched in-house by SpaceX, is meant to provide broadband connectivity to a wide number of customers and offer fast internet connection from orbit as alternative to terrestrial infrastructures. The project is highly complex and requires to put a constellation of satellites in LEO, that in the case of SpaceX is composed of over a thousand satellites and filings to authorise more than 40,000. Starlink mainly targets ordinary people and businesses as customers, but recently SpaceX participated to the US Rural Digital Opportunity Fund to bring connectivity to remote areas.[6] Most importantly, defence actors valued the potentiality of the project to close connectivity gaps and provide high-throughput[7] and low latency[8]

[6] Rachel Jewett, "SpaceX Wins $885m in First Phase of FCC's Rural Digital Opportunity Fund", in *Via Satellite*, 7 December 2020, https://www.satellitetoday.com/broadband/2020/12/07/spacex-wins-885m-in-first-phase-of-fccs-rural-digital-opportunity-fund.

[7] "High-throughput Satellite or HTS is a communication satellite that provides more throughput than conventional communication satellites (Fixed Satellite Service). Higher-throughput refers to a significant increase in capacity when using the same amount of orbital spectrum. The increase in capacity typically ranges from 2 to more than 100 times as much capacity as the classic FSS (Fixed Satellite Service). This significantly reduces the cost per bit." See "What Is a High-Throughput Satellite?", in *everything RF*, 3 March 2021, https://www.everythingrf.com/community/what-is-a-high-throughput-satellite.

[8] "Low Earth Orbit satellites circle the earth at a distance of about 1000km, your typical satellites are either Geostationary Earth Orbit (GEO) satellites located at a distance of 36,000km or your mid-range satellites MEO located at about 8,000km. Being closer to the earth has its benefits as the latency delay

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services. Indeed, the US military started cooperating with SpaceX to ensure connectivity to operations in the remote Arctic region.[9] The US Army signed an agreement to use Starlink across military networks and the use of satellites in multi-domain operations is being investigated and tested in exercitations.[10] Moreover, the potential use of the SpaceX LEO constellation to provide military with robust PNT signals instead of GPS is currently examined.[11]

OneWeb as well is engaged to bring connectivity to businesses and rural areas with a LEO satellite constellation. The company was recently acquired out of bankruptcy with substantial investments of the UK government, also in view of possibly using the constellation as a national GNSS system after Brexit and the subsequent exit from the EU Galileo PRS.[12] Moreover, OneWeb signed agreements with the US Defense to test services in the Arctic and on ships, and it recently demonstrated to the Pentagon the feasibility of multi-orbit communication between GEO and LEO.[13]

For what concerns specifically satellite navigation, the penetration of this technology reached a very high level. For instance, mobile phones have built-in receivers for Galileo signals that are daily used by millions of people. At the same time, the Galileo fleet will also provide PRS and emit signals utilised by government actors in the security and defence domains, more resilient and robust to jamming and spoofing attempts, with ongoing efforts to further develop defence applications and readiness.[14]

will drop, that is the time it takes for your data to complete a round trip (RTT), going from earth to satellite and back again. The GEO latency is of 600 milliseconds, MEO of 180ms and LEO of 40ms, the new LEO satellite 'Constellation' will allow you to access noticeably faster response times that are important for various applications". OminiAccess website: *What Is LEO?*, https://www.omniaccess.com/leo.

[9] Malte Humpert, "U.S. Military to Cooperate with SpaceX to Overcome Arctic Communications Blackout", in *High North News*, 26 February 2020, https://www.highnorthnews.com/en/us-military-cooperate-spacex-overcome-arctic-communication-blackout.

[10] Sandra Erwin, "U.S. Army Signs Deal with SpaceX to Assess Starlik Broadband", in *SpaceNews*, 26 May 2020, https://spacenews.com/?p=102057; Brett Tingley, "The Air Force and SpaceX are Teaming Up for a 'Massive' Live Fire Exercise", in *The Drive*, 25 February 2020, https://www.thedrive.com/the-war-zone/32346; Brian W. Everstine, "Mobility's Role in the JADC2 Movement", in *Air Force Magazine*, 6 March 2020, https://www.airforcemag.com/?p=62695.

[11] Mark Harris, "SpaceX's Starlink Satellites Could Make US Army Navigation Hard to Jam", in *MIT Technology Review*, 28 September 2020, https://www.technologyreview.com/2020/09/28/1008972.

[12] Jasper Jolly, "UK Buys £400m Stake in Bankrupt Satellite Rival to EU Galileo System", in *The Guardian*, 3 July 2020, https://www.theguardian.com/p/e8tbn.

[13] Nathan Strout, "Hughes and OneWeb Working to Fill Military's Arctic Communication Gap", in *C4ISRNET*, 6 May 2021, https://www.c4isrnet.com/battlefield-tech/space/2021/05/06/hughes-and-oneweb-working-to-fill-militarys-arctic-communication-gap; Sandra Erwin, "OneWeb Signs Distribution Deal with Peraton, Broadens Reach into Military Market", in *SpaceNews*, 16 September 2021, https://spacenews.com/?p=119064; Rachel Jewett, "Intelsat and OneWeb Demonstrate GEO/LEO Service to U.S. DoD", in *Via Satellite*, 4 November 2021, https://www.satellitetoday.com/government-military/2021/11/04/intelsat-and-oneweb-demonstrate-geo-leo-service-to-u-s-dod.

[14] On PRS receivers see the EDIDP GEODE project: Tracy Cozzens, "GEODE Begins Working on Military User Equipment for Galileo", in *GPS World*, 9 February 2021, https://www.gpsworld.com/?p=84850; European Commission, *GEODE Factsheet*, 15 June 2020, https://ec.europa.eu/

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EO and remote sensing are driving the expansion of the downstream market of the space sector. The applications are potentially limitless, from global climate studies to targeted local environmental and agriculture issues or disaster management. Start-ups and companies emerge in North America, Europe and other developed countries to offer specific solutions and applications of EO data coupled with AI. At the same time, optical and radar satellite imagery provides the big picture from orbit with increasingly high resolutions, customised data and frequent revisit-time,[15] delivering crucial intelligence to defence stakeholders. For instance, the EU Satellite Centre processes Copernicus EO data and provide analysis and assessments for military operations.[16] On this front, Italy has advanced capabilities secured by the Cosmo-SkyMed constellation, born with a dual use purpose from the cooperation between the Italian Space Agency (*Agenzia Spaziale Italiana* – ASI) and the MoD.[17] Cosmo-SkyMed provides crucial imagery for the security of navigation, the protection of infrastructures, military operations, intelligence and law enforcement activities. Having renewed Cosmo-SkyMed for a second and a third generation, Italy will maintain this dual use capability, enhanced also by the creation of the company e-GEOS that is responsible for the commercialisation of the constellation's data.

As recalled above, the availability of EO data from Copernicus and other satellites leads also to the emergence of start-ups that specialise in software development and image processing for the customisation of data to specific users. For instance, the star-up company Preligens managed to start a partnership with the French Ministry of Armed Forces to deliver selected AI-powered information for defence analysis.[18] The Italian landscape of small and medium-sized enterprises (SMEs) and start-ups is very dynamic and innovative.[19]

Besides typical satellite services, the utilisation of radar and telescope sensors traditionally associated with missile defence purposes, is of growing importance for the safety of satellites against debris but also to detect and characterise threats for a better SSA. National governments and military stakeholders maintain a leading role on sensors and look to further advance capabilities through space-

commission/presscorner/detail/en/fs_20_1084.

15 "Rapid revisit is a qualitative term used in satellite monitoring to describe the ability of the system to make repeated image captures separated by short time intervals." James Mason, "What Is Rapid Revisit and Why Does It Matter?", in *Planet Pulse*, 16 September 2016, https://www.planet.com/pulse/?p=143908.

16 SatCen website: *Military Capabilities*, https://www.satcen.europa.eu/page/military_capabilities.

17 Telespazio, *All Eyes on Protecting the Environment: COSMO-SkyMed Is Here*, 17 May 2021, https://www.telespazio.com/en/news-and-stories-detail/-/detail/cosmo-skymed-telespazio-fucino.

18 French Ministry of Armed Forces, *The French Ministry of Armed Forces Renews Its Confidence in the Technologies Developed by Preligens*, 8 July 2021, https://www.preligens.com/resources/press/press-release-french-ministry-armed-forces-renews-its-confidence-technologies; Tugdual Ceillier, "A Civilian Start-Up in Defence, the Reasons for a Success", in *Preligens website*, 15 November 2021, https://www.preligens.com/resources/press/civilian-start-defence-reasons-success.

19 Interview, 16 December 2021.

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based technology.[20] At the same time, commercial and private companies such as ExoAnalytic Solutions, AGI and LeoLabs increasingly participate to the development of technology and offer SSA-as-a-service to satellite operators and defence actors, providing the added value of targeted data analysis as well. The company LeoLabs recently announced the establishment of a new radar located in Australia, essential to increase the geographical coverage of sensors and fill a gap of infrastructure and data in the Southern hemisphere.[21] Furthermore, the Canadian NorthStar Earth and Space is developing a small constellation of satellites equipped with optical sensors to provide space-based SSA.

These technologies are essential to face the space debris challenges but can perfectly be exploited for precise and real-time situational awareness by defence stakeholders. Space-based optical and radar satellite and sensors could then become a critical component of future strategies and investments, in view of acquiring C4ISR from space and possibly expanding the current scope of aeronautics operations, as for instance in the case of NATO AWACS.[22]

7.4 In-Orbit Servicing and Active Debris Removal

Data from a single multi-purpose asset can be processed for different uses and users, thanks also to more innovation and a flexible approach brought by private actors. The majority of space technology remains intrinsically dual by nature, also considering assets that apart from providing innovative solutions for sustainability may be utilised to pose intentional kinetic threats. In this sense, In-Orbit Servicing (IOS) and its subcategory of Active Debris Removal (ADR) represent one of the most relevant developments for the future of operations in space.[23]

IOS technologies can provide life-extension services to aging satellites, increasing their lifetime and thus their return on investment. Moreover, IOS could offer refuelling, repairing and maintenance services to satellites that suffered failures and prevent further damages or explosions in orbit. IOS developments are also associated with tug services to re-orbit or de-orbit satellites. Indeed, a major application of this technology would be to remove uncontrolled assets or debris from orbits, massively contributing to the issues of sustainability of outer space. ADR could be based on a variety of applications, from harpoons and robotic grappling arms to nets, capable of capturing and removing debris.

[20] See in this regard: Alessandro Marrone and Karolina Muti (eds), "Europe's Missile Defence and Italy: Capabilities and Cooperation", cit.

[21] Debra Werner, "LeoLabs to Construct Radars in Western Australia", in *SpaceNews*, 19 October 2021, https://spacenews.com/?p=120221.

[22] Sandra Erwin, "Space Force Looking to Deploy Radar Satellites to Track Moving Targets on the Ground", in *SpaceNews*, 12 May 2021, https://spacenews.com/?p=114404.

[23] Giancarlo La Rocca et al., "In-Orbit Services. Policy and Business Perspectives", cit.

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Overall, IOS and ADR are based on the execution of Rendezvous and Proximity Operations (RPOs) with cooperative or uncooperative assets, to engage or dock with satellites and debris. Yet, RPOs and servicing technology may as well be performed to damage satellites and critically compromise their operations. Major developments in the IOS field are occurring today. Northrop Grumman successfully carried out two life-extension missions to Intelsat commercial satellites.[24] The Japanese company Astroscale is engaged to test and offer ADR services.[25] The ESA is also committed to acquire ADR capabilities and recently funded a start-up to develop the ClearSpace mission to remove a Vega launcher's component from LEO.[26] The DARPA is leading efforts in the US to obtain IOS capabilities.[27] The dual use nature of the technology highlights the perception of threats related to RPOs and at the same time serves as a justification of the development and testing of capabilities. Russia and China are actively engaged to test RPOs in GEO and LEO.[28] In some cases, the explanation to unusual operations in orbit regards the nature of missions, intended to test debris mitigation capabilities, dissimulating what according to analysts and defence institutions may be co-orbital anti-satellite weapons.[29]

In conclusion, it is worth noting that space technology was quite basic and unsophisticated during the race to the Moon of the 1960s in comparison with current state of the art. The Apollo 11 mission completed the Moon landing in 1969 with an onboard computing technology less advanced than the one contained in mobile phone today. Nonetheless, the future of space increasingly relies on innovation and interactions with the digital dimension. These trends, together with the entrance of several new private actors in orbit, do not change a traditional and structural feature of space, that is the dual nature of the involved technology. In some cases, more innovation even expands the nexus between space and defence.

[24] Northrop Grumman, *Northrop Grumman and Intelsat Make History with Docking of Second Mission Extension Vehicle to Extend Life of Satellite*, 12 April 2021, https://news.northropgrumman.com/news/releases/northrop-grumman-and-intelsat-make-history-with-docking-of-second-mission-extension-vehicle-to-extend-life-of-satellite.

[25] Astroscale, *Astroscale's ELSA-d Successfully Demonstrates Repeated Magnetic Capture*, 26 August 2021, https://astroscale.com/?p=5863.

[26] ESA, *ESA Commissions World's First Space Debris Removal*, 9 December 2019, https://www.esa.int/Safety_Security/Clean_Space/ESA_commissions_world_s_first_space_debris_removal.

[27] Ana Saplan, "Robotic Servicing of Geosynchronous Satellites (RSGS)", in *DARPA Research*, https://www.darpa.mil/program/robotic-servicing-of-geosynchronous-satellites.

[28] Marissa Martin, Kaila Pfang and Brian Weeden, "Chinese Military and Intelligence Rendezvous and Proximity Operations", in *Secure World Foundation Fact Sheets*, April 2021, https://swfound.org/media/207179/swf_chinese_rpo_fact_sheet_apr2021.pdf; Marissa Martin et al., "Russian Military and Intelligence Rendezvous and Proximity Operations", in *Secure World Foundation Fact Sheets*, April 2021, https://swfound.org/media/207178/swf_russian_rpo_fact_sheet_apr2021.pdf.

[29] Bloomberg, "China's Space Debris Cleanup May Be Cover Story For Arms against U.S. Satellites, Pentagon Says", in *The Japan Times*, 12 February 2019, https://www.japantimes.co.jp/?p=1754969; Andrew Jones, "China Launches Classified Space Debris Mitigation Technology Satellite", in *SpaceNews*, 24 October 2021, https://spacenews.com/?p=120358; Ken Moriyasu, "China Can 'Grapple' US Satellites with Robotic Arm, Commander Says", in *Nikkei Asia*, 12 February 2019, https://asia.nikkei.com/Politics/International-relations/US-China-tensions/China-can-grapple-US-satellites-with-robotic-arm-commander-says.

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Beyond specific advancements on automation, computing, cyber and quantum, science and exploration may also have implications for space and defence. Studies on nuclear propulsion, aerodynamics, 3D printing, additive manufacturing, space mining and other fields of research may well define the future of human exploration of outer space, while possibly contributing to define the future of space as a military operational domain.

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8. Conclusions

by Alessandro Marrone and Michele Nones

The nexus between space and defence has been expanding and will continue to expand, bringing unprecedented and surprising implications to both fields. A combination of out-of-the-box thinking and pragmatic realism is worthy when looking at this issue in a mid- to long-term perspective. This is particularly true for a European middle-power like Italy, part of broader transatlantic and European frameworks.

On the basis of the analysis laid down by the previous chapters of this study, the following conclusions aim to provide food for thought mainly to Italian stakeholders, with a view to relations with US, France, Germany and UK, as well as within NATO, EU and ESA.

8.1 Space: More strategic, competitive, congested and contested than ever

Space enjoys a strategic character for Italy as for many advanced countries worldwide. Nowadays it is more competitive, congested and contested than ever and the situation is set to worsen in the future. Major and middle powers worldwide strive to acquire space capabilities, including access to space if possible and this trend is likely to widen and accelerate over time with a view to gaining a competitive advantage and operational options. It will impact the regional balance of power, i.e. with Iran and/or North Korea acquisition of space capabilities, as well as the whole international security environment. Moreover, the possibility to buy off the shelf certain space technologies, assets or services further increases the chances for regional powers – or even small states – to join the competitive race towards a more congested and contested space.

Over time space assets have become strategic enablers of military operations, in terms of EO, navigation and SatCom, as well as crucial part of integrated air and missile defence for NATO countries. They already represent a critical infrastructure for globalised economies and societies. As such, despite the existing treaties and regimes forbid the weaponisation of space, assets in orbits are de facto target of multiple actions, from electronic warfare to cyberattacks, to possible kinetic manoeuvres through ASAT capabilities and an offensive use of in-orbit services.

Against this backdrop, a step change in military posture is taking place with the recognition of space as operational domain by NATO, alongside with cyberspace in a perspective of multi-domain operations. This is likely to represent a real game changer, with strategic, multi-faced and structural consequences on each and every domain and on the whole interaction between space and defence. For instance, Space Situational Awareness is going to turn into Space Domain Awareness by applying the same military logic of other domains. The potentialities of IOS open a new page for space operations, including offensive and defensive counter-space.

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The orbital and sub-orbital levels are becoming increasingly connected, albeit they maintain different features. One telling, concrete example of the changing military posture across space and other domains is the current US study on technologies that can serve a space-based Ground Moving Target Indicator (GMTI) mission, moving this role away from aircraft and into orbit.[1] The study is going to be conducted by the US Space Force in synergy with intelligence agencies, and is part of a broader reflection within the Pentagon on what ISR activities could and should be moved from the traditional services to the Space Force established in 2020. This is but just one example of the fact developments in terms of strategies, doctrines, capabilities and investments are going to emerge from military reorganisation including the newly established space commands in major NATO countries – France, Germany,[2] Italy, the UK[3] and obviously, first and foremost the US.[4] The same applies, in a way more difficult to ascertain, in major space powers like China and Russia.[5]

Considering the intrinsic dual use of space technologies and assets,[6] as well as of European programmes like Copernicus and Italian ones such as COSMO-SkyMed, the increasing nexus between space and defence is going to affect also the civilian side. And vice-versa, when it comes for example to the role of US civilian companies which are congesting LEO with waves of satellites and spacecrafts. The leap forward from the current 4,500 satellites in orbit towards an estimated 50,000 by 2030 is a game changer for space as operational domain, *in primis* in terms of space traffic management, debris and SDA, but also saturation of spectral bandwidths. US, Russia and China are increasing their capabilities for space surveillance and tracking, and aim to obtain a more accurate picture, including exploiting smaller satellites. Such a congestion may also force some actors to move from LEO to middle Earth Orbits – also considering that GEO are already congested too – with a number of military and technological implications.[7] In this context, space traffic management is rapidly becoming a priority for space policy in the US and worldwide.

Broadly speaking, emerging space technologies offer novel and wide opportunities. Digitalisation and miniaturisation of on board systems enable the construction of new generation, reconfigurable payloads and satellites, make possible to build global constellation and mega-constellation, federated and fractioned space infrastructures, extremely high resolution sensors and very large high throughput satellite for civil and military SatCom – not to mention re-usable and manoeuvrable spacecrafts and vehicles capable to operate in lower sub-orbital

1 Aviation Week, *Analysis of Space-based GMTI Expected in Spring*, cit.
2 On France and Germany see Chapter 3 of this study.
3 See Chapter 5 of this study.
4 See Chapter 1 of this study.
5 See Chapter 2 of this study.
6 See Chapter 7 of this study.
7 Interview, 3 November 2021.

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space, both manned and unmanned,[8] as well as electric propulsion. The new generation of mini and micro-satellites bring the added value of provide timely solutions for contingency requirements, i.e. in times of crisis, and do complement larger satellites by increasing resilience as a whole in case of disruption of other space assets.[9] Space and digital technologies are more and more combined in a transformative mode relevant for the military, as enabling technologies are essential to provide a new dimension of information superiority from quantum communication to persistence surveillance, from AI based advanced information algorithms to space robotics.[10]

8.2 US, NATO, and a wake-up call for Europe and Italy

The US is leading the space way in military, technological and industrial terms, as on the other new, cyber operational domain.[11] The American case is unique in terms of size and quality of military capabilities and defence industrial ecosystems, therefore solutions like the US Space Force cannot simply be translated in the European context. Yet by leading the way Washington is able to set up doctrines, standards and regulations related to the nexus between space and defence, including on Space Traffic Management, which by default are tailored and favourable to American actors in comparison with others. Therefore, the developments in a Western ally like the US should be considered as a wake-up call to Europe – including to Italy – to update, upgrade and speed it up its own approach to the space-defence linkage. Beyond the West, both China and Russia are massively investing in space, and while Moscow holds a strong basis for further developments, Beijing has the economic resources and politico-strategic commitment to catch up competitors. In different ways, each and every rival of the Atlantic alliance is competing across the board of defence, technology and industry, and this should represent an even worrying prospect for Europe.

As for NATO, the recognition of space as operational domain and the decision to apply, in principle, Washington Treaty's article 5 on collective defence to "attacks to, from, or within space" opens a completely new page for the Alliance, which has released a first-ever NATO overarching space policy in January 2022.[12] As a long-standing group of sovereign states working through political, civil and integrated bodies, NATO posture evolves gradually with respect to new challenges, opportunities and tasks. But once a new element is added on its agenda, usually it remains there for the long term, and the Alliance is able to make the difference in terms of political guidelines, strategic communication, evolution of military doctrine, individuation of requirements and capability gaps, and indications on

[8] Massimo Claudio Comparini, "Space Domain: A Global Vision", cit.

[9] Interviews, 20 January 2022; 4 February 2022.

[10] Interview, 15 November 2021; Massimo Claudio Comparini, "Space Domain: A Global Vision", cit.

[11] See in this regard Alessandro Marrone and Ester Sabatino, "Cyber Defence in NATO Countries: Comparing Models", cit.

[12] NATO, *NATO's Overarching Space Policy*, cit.

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how to fill these gaps through the NATO Defence Planning Process.

Currently, NATO is approaching space with a number of caveats stated by the incumbent Secretary General Stoltenberg, including the commitment to not weaponise space. Yet this pledge does not guarantee that other players will apply the same self-restraint, generating consequences on allied posture. Broadly speaking, the Strategic Concept to be approved by June 2022 with a 2030 perspective represents a stimulus to creative thinking also on space, and a number of other initiatives are unfolding. For example, the NATO assets AWACS for airborne surveillance are likely to be replaced by a system of systems encompassing manned and unmanned air capabilities as well as space assets.[13] France has obtained the establishment of a NATO space centre of excellence in Toulouse, the main French district in terms of space-related industrial capabilities. Germany hosts the NATO Space Centre, in synergy with its pivotal role within the allied integrated military command when it comes to both air domain and missile defence. Italy, the third European spender on space capabilities, so far has not achieved meaningful results within the Atlantic alliance on space, and the developments among allies should be considered by Rome a kind of wake-up call on its own.

Europe as a whole is adjusting its own way to space[14] by slowly moving across the civilian-military continuum. ESA perimeter and horizon remain firmly civilian, albeit with important dual-use implications and some overture towards civil security. The EU space programme has ensured for the next seven years continuity of investments on Copernicus and Galileo, the former being particularly relevant for the armed forces' navigation (actually PNT) through its PRS. But the EU investments on GovSatCom are extremely limited, and those relevant for SSA are marginal.[15] There is hope that the forthcoming Commission Defence and Space package and the EU Strategic Compass will raise the level of ambition and resources.

Within the European Commission, the establishment of the Directorate General for Defence Industry and Space marks an important step forward in taking a comprehensive view on the close connection between space and defence. A view strongly articulated by the French Commissioner Breton: not only his proposal of a new connectivity constellation has once again strong dual-use implications, but he has explicitly proposed to expand the defence dimension in existing and upcoming EU infrastructures, develop new ones by integrating the defence needs from the outset, set up a new governance for EU space programme to best reply to the threats in terms of joint situational awareness and even with a view to true European Space Command.[16]

[13] Interview, 3 November 2021.
[14] See Chapter 4 of this study.
[15] Interview, 3 November 2021.
[16] European Commission, *Speech by Commissioner Thierry Breton at the 14th EU Space Conference*, cit.

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At the same time, certain PESCO projects are potentially relevant for space, including the European Military Space Surveillance Awareness Network and the Defence of Space Asset coordinated respectively by Italy and France, as well as TWISTER concerning space-based sensors for missile defence. The EU co-funded project INTEGRAL is also relevant for Italy as it aims to develop command and control software for SSA. Against this backdrop, the drafts of the EU Strategic Compass assigns great importance to space, articulate a number of principles and ambitions, and mandates the elaboration in 2022 of an EU Space Strategy for security and defence. The bottom line is that EU is gradually developing the right ambitions on the nexus between space and defence, but it is crucial to timely define the European approach and match it with adequate resources.

8.3 Ten recommendations for Italy

In this context, and building on a six decades-long track record of satellites manufactured and successfully launched and operated, frequently well beyond the target date, Italy holds the second place in Europe for number of assets in orbit and is also the third largest contributor to ESA. Noticeably, it presents a complete space value chain from upstream, including launchers, to downstream capacities. Since 2018 Rome equipped itself with a new governance advancing a whole-of-government approach, centred at the prime minister's office, and underwent a serious reorganisation of the Ministry of Defence approach to space. In particular, the MoD has established a policy and planning office (UGS) at the defence chief of staff level and a joint space operations command (COS), becoming able to plan the policy for military space assets, to identify procurement requirements, and then to in-house manage the launch, activities and de-orbit of such assets through operational centres active 24/7: as a whole a pioneer, unique military capability in Europe.[17]

Against this backdrop, Italy has to move forward on ten main, complementary issues if it wants to keep pace with a space domain more strategic, competitive, congested and contested than ever and secure its national interests both in orbit and on Earth. In some cases, Italy can and shall act through domestic initiatives, while in many others has to bring its proposals to bilateral partnerships, the NATO, EU and ESA tables to support a multinational step forward. Certain recommendations entail new laws or regulations, other can be implemented through policies based on the existing legal framework. The set of proposal is ordered starting from the legal and institutional aspects, by moving to a MoD focus, and then broadening towards bilateral, European and transatlantic dimensions.

1) Work on a national space law. First, there is the need for a comprehensive space law to support the sustainability, safety and security of Italian activities in space through a coherent approach bringing licenses, authorisations and regulations under a same framework, assuring as well compliance to international norms and

[17] See Chapter 6 of this study.

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facilitating further implementation of standards. In particular, the congestion of orbits also due to small and mini-satellites poses the question of their vulnerability, their ability to damage other satellites and the ultimate responsibility of Italian state in this regard. Security and liability requirements have to be addressed, together with a design meant to reduce debris – i.e. by facilitating de-orbiting. Such a law represents the opportunity to refine and the detail the national governance with regards to COMINT, MoD – including the mandate for the defence of Italian space assets – intelligence agencies and ASI. It should also introduce the right to further legislate on forthcoming legal issues such as the use of Moon resources to sustain the activities of the Artemis, project participated by Italy, something extremely important whereby the international law is still *in fieri*.[18]

2) Confirm the military mandate for the defence of Italian space assets. The NATO recognition of space as operational domain implies that allies' armed forces are going to operate in this environment in principle as in other domains, in terms of deterrence and defence as well as broadly speaking of military operations, obviously bearing in mind space is a peculiar environment with its own rules, including physics. It is important for Italy to confirm the MoD mandate and framework concerning the defence of Italian space assets, *in primis* those owned by state institutions. Such a confirmation is even more needed considering the aforementioned NATO decision to extend the collective defence clause to attacks to, from, or within space. A clearer attribution of concrete mandate to the Ministry of Defence is necessary to enable the armed forces to perform their role by exploiting the military reorganisation undertaken in recent years.[19]

In particular, an attack against a military satellite by itself should be considered in the same category of an attack against a military ship sailing in international waters, and be subject to a similar MoD response – as well as a political decision on whether or not invoke the NATO article 5 on collective defence. A more complex issue is an attack against a civilian asset which constitutes a critical infrastructure for Italy or another NATO member, i.e. Galileo satellites providing GNSS to European countries. However, once again, the example of an Italian private company's tanker attacked or threatened in international waters and requiring military protection serves as good example for the clarification and confirmation of the MoD responsibility for the protection of Italy's assets in space.

3) Take forward the national space governance. The Italian space governance laid down by the 2018 law and the subsequent implementing regulations is rather effective and advanced, and reflects the strengths, weaknesses and specificities of the broader Italy's institutional landscape. As a relatively new setting, it works better if all involved actors adopt the most coherent and cooperative praxes over time, *in primis* at the Presidency of the Council of Ministers, in order to mitigate the negative effects of frequent political turnovers of the Italian executive – a specific

[18] Interview, 4 February 2022.

[19] See Chapter 6 of this study.

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Italian weakness in comparison with France or Germany. An enhancement of the COMINT role would help in this regard, including through an upgrade of its support offices at the Presidency of the Council of Ministers,[20] working in close coordination with the Military Advisor Office to prepare the options and proposals for COMINT decisions. Such enhancement should obviously respect the MoD competences on the armed forces role in space.

Actually, the current governance should be taken forward with regard to the nexus between space and defence, also considering that back in 2018 space was not yet recognised by NATO as operational domain, nor the UGS and COS were established. On the one hand, the Ministry of Defence would benefit from a more focused reflection and consultation on the strategic character of space within the COMINT, considering the political role of this body, the dual-use nature of most space assets, the necessary pooling of public investments, and the implementing activities of ASI. On the other hand, specific reflection and actions should be developed and implemented primarily within the MoD and particularly through UGS and COS, in order to move forward in military terms from the strategic to the operational levels and with regards to capability development.

4) Implement the MoD reorganisation with adequate human resources. Within the Italian MoD both UGS and COS are new structures with relatively modest resources. They have to be enhanced firstly in terms of human resources in order to cope with the tasks currently assigned and the foreseeable evolution of space as operational domains. A legal and institutional development not matched by adequate, proportional capabilities is not only a paper tiger, but a danger in terms of un-effectiveness, un-efficiency and strategic surprises. The joint character of both UGS and COS is an important character to be preserved and enhanced, in order to leverage from the respective, specific contributions of each service within a comprehensive and consistent approach.

5) Articulate the MoD space strategy and military doctrine. The Italian MoD is currently developing its own Space Strategy, to be complemented and implemented by a tailored military doctrine. As mentioned before, a balance of out-of-the-box thinking and pragmatic realism is worthy when looking at space in a mid- to long-term perspective. Consolidated elements of military methodology such as threat assessment have to be applied *mutatis mutandis* to the space domains.

Concepts like deterrence could and should be applied *cum grano salis*. As mentioned before, an attack against a military satellite by itself is in the same category of an attack against a military ship sailing in international waters. In space, as in cyberspace, the attribution is more difficult than in the other three domains and requires adequate SDA, including for instance equipping own satellites with sensors and systems do detect an electronic warfare act or a mechanic attack made

[20] Interviews, 29 January 2022; 4 February 2022.

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possible by IOS technologies.[21] Better and joint SDA would enhance the knowledge on space environment and potentially discourage the conduct of irresponsible or offensive behaviours in orbit by making their attribution more rapid, accurate and crystal-clear. Generally speaking, it will important for the MoD to better define competencies and responsibilities for the Space Domain Awareness and for the conduct of space operations.

In this context, it is useful to borrow concepts from armed forces approach to other domains, for example in terms of space superiority, again *cum grano salis*. While in the air domain is possible to obtain an air superiority for a limited period on a given airspace, this is simply not possible in space. Yet the fact US is explicitly thinking in terms of space superiority – or even space dominance – is likely to influence strategic and doctrinal developments within NATO, with direct and indirect effects on Italy. Space domain is likely to see the emergence of new missions and operational concepts, to some extent similar to the ones that we already know in the air domain, from defensive counter space to offensive counter space.[22] Should the aforementioned approach of multi-domain operations move forward within NATO, it entails not only a steady acceleration in terms of jointness, but also new thinking on how eventual counter space operations, both defensive and offensive, could and should be conducted on space as well as on Earth. It has to be ensured space assets continues to provide support for military operations in other domains despite hostile actions in orbit, and each service has to rethink which new space products may need and have in the mid- to long-term. Beyond space support, SDA and IOS opens a new page for space operations as such, which has to be conceptually developed in extremely forward-looking perspective.

Such a defence reflection on space strategy and military doctrine entails several implications for future space assets in terms of hardening measures. In a congested and contested environment satellites have to be more numerous, more manoeuvrable, with more sensors aimed to SSA, more resilient and more active vis-à-vis IOS also in terms of their ability to defend themselves from mechanic disruption. There is a general need to increase resiliency and survivability of space assets, including ground and launch capabilities.[23] It should be noted that assets like space stations, shuttles and space-planes like X37-B have all sensors which can perform – and in many cases have already performed – intelligence tasks crucial for SSA and military actors. Interestingly, ESA has launched a first project on spacecraft to test technologies and materials, particularly in relation to its manoeuvrability.[24]

6) Plan a more strategic military capability development. On the basis of the national governance on this field and related government documents, of the

[21] Interviews, 3 November 2021; 21 January 2022.
[22] Massimo Claudio Comparini, "Space Domain: A Global Vision", cit.
[23] Ibid.
[24] Interview, 3 November 2021.

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Italian track record in terms of dual-use capabilities, and of the upcoming space strategy and military doctrine, the MoD should articulate a more strategic plan for space capability development. A plan to match ambitions with resources, guide the articulation of military requirements and contribute to the broader defence industrial policy laid down by the 2021 ministerial directive.[25]

In the mid- to long-term, if the appropriate governance is defined, shared capabilities and infrastructures could progressively constitute the solution for Italian needs also in the defence domain.[26] The same applies to all major European space powers, since no single country in Europe can aspire to develop on a national basis the capabilities in the making in the US, Russia or China. This is a process to build step by step by working on complementary tracks.

On the one hand, Italy should consolidate the core capabilities based on specific areas of competence and technology excellence, that can be developed and effectively managed at national level. They include EO – encompassing radar, optical and hyperspectral capacities – secure satellite communication and access to space.[27] Within the MoD there is also a growing interest for new, space-based, dual-use sensors, which once again would require an inter-agency commitment.

On the other hand, most capabilities for SSA, in-orbit services – particularly in LEO – and active debris removal, require a broader effort to be more effectively approached within a cooperation framework, at bilateral, European and/or transatlantic levels. Italy can contribute in various ways to SSA cooperative initiative, including through the FlyEye telescope developed within ESA, where further cooperative investments can be sought.[28]

SIGINT, a traditional prerogative of space powers, is a segment that could be managed via a form of federation of national capabilities: in terms of technology some basic components should be developed autonomously, while a federated capacity could be established at bilateral level with European partners and more broadly within the EU. In this context, the MoD is not the only institutional actor capable to express capabilities in the SIGINT branch, therefore the definition of related requirements, investments and partnerships should involve all the national security and intelligence community. In turn, only some specific SIGINT outputs should fall within the intelligence rules and perimeter, in order to allow an effective military action at national and international level.

Finally, the whole military approach to space is changing in major NATO countries also in terms as defence industrial implications, as the MoD are even more a sort of

[25] Italian Ministry of Defence, *Direttiva per la politica industriale della difesa. Edizione 2021*, luglio 2021, https://www.difesa.it/Documents/Direttiva_Ministro_Guerini2907.pdf.

[26] Interview, 28 January 2022.

[27] Interviews, 20 January 2022; 24 January 2022; 28 January 2022.

[28] Interview, 24 January 2022.

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"anchor customers" for the private sector to facilitate the development of certain strategic technologies, and Italy should consider this aspect too.[29] The bottom line is to invest domestically to consolidate competitive technological and industrial capabilities to be brought at bilateral/European level, in order to build fruitful cooperation in a win-win logic. This is particularly the case of SSA, whereby today investments are crucial ensure to future Italy's positioning at bilateral, EU and NATO levels.[30]

7) Develop the national approach to bilateral, European and transatlantic cooperation. The nature and scope of the challenge brought by the expanding nexus between space and defence require Italy to further develop its approach to European and bilateral cooperation. In doing so, France is the first partner to look at in Europe, on the basis of a number of governmental agreements covering EO and SatCom, as well as of an industrial space alliance through the whole space value chain. As mentioned before,[31] the Quirinale Treaty should be considered the starting point for development of the bilateral partnership in a number of sectors, considering also the French interest for SIGINT, by safeguarding the principle of cooperation on equal foot on the whole space value chain, from to upstream to downstream activities including access to space. The closer are the relationship, the more effective and timely Italy should be in strategically develop its position in order to have fruitful and balanced dialogue with Paris: in the end, the Quirinale Treaty's potentialities are wide and great, but their exploitation will depend from the modalities to implement it, and the ability of both parties to cooperate in a fair way.

Within the EU, Berlin is more likely to invest in dual-use technologies than in purely defence one, but its involvement in European programmes remains key. Accordingly, Rome has significant room of manoeuvre to partner with France and other major countries in a win-win logic. The Quirinale Treaty should represent the starting point of a European core cooperation on space and defence including also Germany. PESCO projects like DOSA, EU-SSA-N and TWISTER shall be moved forward through a holistic approach as the building blocks to implement such core cooperation among few willing and able countries, and here Italy holds a key responsibility as leader or participant of those projects. Participating to PESCO and EDF initiatives is the way to be actively present, develop technologies and contribute to the cooperative process, also considering they will set up the reference for future positioning.[32] For Italy it will be particularly important to plan adequate and focused investments to maintain technological leadership on certain elements, and participation in others where partners will take the lead through a balanced, win-win cooperation. The upcoming initiatives of EU SST consortium should be another building block of such core cooperation, as it enables the

[29] Interview, 15 November 2021.
[30] Interviews, 28 January 2022; 4 February 2022.
[31] See Chapter 6 of this study.
[32] Interview, 28 January 2022.

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upgrade of existing radars towards a true network among participating countries; here Italy should enter the consortium's workstream on conjunction calculus including collision avoidance since it is crucial for SDA. In the end, bilateral and multilateral agreement have to be seen as building blocks to put together national strategies in a European framework.[33]

The synergy between EU and ESA framework should be pursued to optimise their different resources and memberships, including with regards to UK showing a novel ambition and increasing resources for space programmes, as well as the net of Italian bilateral cooperation with major European countries. Moreover, the increasing demand for space services and capabilities also by medium and smaller states in Europe should be channelled via the EU/ESA frameworks in order to generate economies of scale and increase European strategic autonomy also in relation to space. From access to space to SSA, EO and connectivity, by combining national, EU and ESA investments Europe as a whole can and should address the challenges of the nexus between space and defence. All these efforts need an adequate, timely and multi-layered presence within EU and ESA bodies, in terms of both human resources and political engagement.[34]

Last but not least, bilateral cooperation with the US is already advanced on a number of aspects of space activities.[35] Italy should continue to develop tailored cooperative initiatives, from the agreements on GPS (M-Code) and on data sharing favouring SSA, to the scientific cooperation within the Artemis and other projects. At the same time, at strategic-military level Italy should pursue a greater, stronger and wider cooperation with the Pentagon based on a consistent MoD vision, as there is large room of improvement in comparison with both civilian US-Italian partnerships and the military-to-military relations undertaken by other European capitals with Washington. It is important that specific military initiatives towards the Department of Defence are part of a consistent MoD vision, which in turn is part of a broader national approach to space. Provided it is wisely managed, the transatlantic cooperation also complements and even enhances the Italian role in European cooperative frameworks.

Generally speaking, participation in international programmes and integration of capabilities with partners should continue to ensure both the full exploitation of data produced and the growth of Italian technological and capacities, and this should remain one of the main criteria in selecting and developing bilateral and multilateral partnership.

8) Shape the EU Space Strategy for security and defence. As the EU becomes less naïve on the strategic character of space, and the Strategic Compass represents a

[33] See in this regards Enrico Savio, "Una strategia per l'Italia", in *Limes*, No. 12/2021 (December 2021), p. 212.

[34] Interview, 4 February 2022.

[35] Interviews, 20 January 2022; 4 February 2022.

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watershed in this sense, Italy should shape with France the definition of an EU Space Strategy for security and defence. Paris has begun to work on the former already in 2021, and consulted Rome which gave an articulated feedback even before space was elevated by the Quirinale Treaty to a priority for bilateral cooperation. Italy has to rapidly assume a pro-active role to shape the document from its early drafting in light of its approach to both space and EU defence cooperation and integration: it is a crucial issue for Italian defence, foreign and European policies. For instance, synergies between Union's Space Programmes, PESCO and EDF projects, EU SST consortium should be pursued in order to adopt a more mature and coherent EU approach to the nexus between space and defence. Concerning EO, the Torrejon EU Satellite Centre should be the starting point for a greater collection and processing of data coming from a variety of military and civilian assets, which extremely useful to satisfy the ISR needs of EU institutions – particularly those working on common security and defence policy – and member states. On SatCom, Italy should support a greater pooling and sharing of capabilities within EU at strategic level, as a similar path has been already successfully pursued within NATO.[36]

Finally, since the Union is developing its own approach to space traffic management,[37] Italian – and European – military stakeholders should assess the challenges and opportunities associated with STM and become completely engaged in the European debate. Given the congestion of Earth orbits STM is a priority *per se*, but it is also important for military doctrine and space operations: defining with allies and partners which are the rules for responsible space activities makes easier to identify at international and national levels those hostile activities to be eventually addressed by the armed forces. Last but not least, such a Space Strategy should serve also as politico-strategic indication for the European Commission to increase the EU investments on the space capabilities more relevant for the armed forces and currently under-financed, such as government SatCom.

Generally speaking, Italy should contribute more to develop an EU strategic and military approach to space, in order to move forward European defence cooperation and integration in a balanced way also towards this domain – considering that the industrial and technological drivers already witnessed an acceleration with the establishment of both EDF and DG DEFIS.[38]

9) Contribute to the NATO Strategic Concept approach to space. As the Italian MoD supported and welcome the evolution of the Alliance posture on space, the ongoing NATO reflection within and beyond the elaboration of the new Strategic Concept presents significant opportunities for Italy and other European allies. First, to engage with US in a multilateral framework on conceptual and doctrinal development, interoperability and standards. Second, to foster current NATO agreements on SatCom and create new ones on data sharing which would

[36] Interview, 21 January 2022.
[37] See in this regard, among others, the SPACEWAYS project: https://www.iai.it/en/node/12746.
[38] Interview, 4 February 2022.

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substantially enhance national and transatlantic SSA as well as EO. Third, to advance the strategic partnership between the Alliance and the Union also on space, considering the EU's unique portfolio of competences and investments on space technologies – a point already made by Minister of Defence Lorenzo Guerini in 2021.[39] Forth, to exploit the new NATO initiative on defence innovation, such as the Defence Investment Accelerator for North Atlantic (DIANA) also in relation with the space domain. In the global competition with China increasingly central in the NATO agenda, it will be essential for allies to protect the entire value and supply chain when it comes to space, aerospace, defence and security technological and industrial capabilities. A transatlantic, coordinated and cooperative effort in this respect con be very effective and NATO may play an important role in this perspective.[40] These and further eventual elements should be timely developed and brought to the table by Italian actors involved in the allied reflection on the new Strategic Concept.

10) Be out-spoken on space and defence. Last but not least, a cross cutting recommendations concerns the features of Italian debate on the linkages between space and defence. Until recent years the public institutions have been often very cautious in talking space in terms of risks, threats, great power competition, defence and the role of the military. Dual-use proved to be a convincing and useful narrative in terms of political debate and strategic communication. Yet the self-limitation of the language could cause a self-limitation in terms of strategic thinking, necessary legal or institutional adaptation, military doctrine or requirements and, not least, defence investments. Italy should certainly maintain the Northern Stars on the pacific use of space and the responsible behaviour in it, the pursuing of international law and cooperation, the value of multilateralism, and the benefits of dual-use technologies, which are traditionally part of its approach. But, as for other aspects of Italian defence policy, a more explicit, mature, systematic debate and language would greatly benefit the whole country.

8.4 Space, the ultimate frontier

As discussed by previous chapters, space as the ultimate frontier becomes more and more a contested domain for great powers competition, congested by private commercial actors and with scarce recognition of the value and sustainability of Earth orbits. Star wars are not at sight, yet the expanse of the nexus between space and defence marks the strategic character of space with consequences hard to predict.

This changing nature makes largely outdated the early distinction between civilian and defence developments in space, and Italy somehow anticipated such

[39] Italian Ministry of Defence, *Il Ministro Guerini a Bruxelles per il Consiglio Affari Esteri e Difesa dell'Unione Europea*, 16 November 2021, https://www.difesa.it/Primo_Piano/Pagine/Il-Ministro-Guerini-Bruxelle-%20per-Consiglio-Affari-Esteri-e-Difesa-%E2%80%99Unione-Europea.aspx.

[40] Massimo Claudio Comparini, "Space Domain: A Global Vision", cit.

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a trend through many interconnections in this sector. Indeed, over time Italy had constantly supported the PRS within Galileo, the GovSatCom project and broadly speaking a reasonable position in favour of dual-use applications at European level – a position which nowadays is widely shared by EU members. Recent years have witnessed a further convergence of civilian and defence actors, and today Rome is fully part of the global space context. For instance, Italy has been the first European state to sign the NASA Artemis Accords for the return to the Moon and will participate to the scientific and industrial developments scheduled in the next decade. Nowadays, there is a solid multi-layered base on which Italy can improve its position in space. The ongoing process at national level to guide the country into the new paradigms of space should continue to pursue a systemic approach, bringing together different competences and wide-ranging capabilities. Building on such a solid basis, the expanding nexus between space and defence should be fully recognised, with consequences on commitments and priorities, the gaps to be filled and the specific role each actor can and should perform to enhance the Italian position in space.

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List of acronyms

ADR	Active Debris Removal
AI	Artificial Intelligence
AIAD	Italian Industries Federation for Aerospace, Defence and Security
AIPAS	Association of Italian Space Companies
ArNaCOSky	Arctic Navigation with COSMO-SkyMed
ASAS	Association for Space-based Applications and Services
ASAT	Anti-Satellite
ASI	Agenzia Spaziale Italiana
ASOC	Air and Space Operations Centre
ASPOS OKP	Automated Warning System on Hazardous Situations in Outer Space
BMWi	Bundesministerium für Wirtschaft und Klimaschutz
BSC	Broglio Space Centre
C-SOC	Cyber-Security Operations Centre
C2	Command and Control
C3	Command Control and Communication
CBRN	Chemical Biological Radiological Nuclear
CCS	Counter Communication Systems
CdE	Commandement de l'Espace
CERES	CapacitÉ de Renseignement Électromagnétique Spatiale
CIE	Commandement Interarmées de l'Espace
CIGC SICRAL	Centro Interforze di Gestione e Controllo SICRAL
CIRA	Centro Italiano Ricerche Aerospaziali,
CITS	Centro Interforze di Telerilevamento Satellitare
CMOS	Centre Militaire d'Observation par Satellites
COA	Comando Operazioni Aerospaziali
CoE	Centre of Excellence
COMINT	Comitato Interministeriale per le politiche relative allo Spazio e alla ricerca aerospaziale
COS	Comando Operazioni Spaziali
COSMOS	Centre Opérationnel de Surveillance Militaire des Objets Spatiaux
COVI	Comando Operativo di Vertice Interforze
CSDP	Common Security and Defence Policy
CSO	Composante Spatiale Optique
CSpO	Combined Space Operations Initiative
CSpOC	Combined Space Operations Center
CSSA	Centre for Space Situational Awareness

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DA	Direct-Ascent
DA-ASAT	Direct-Ascent Anti-Satellite
DARPA	Defense Advanced Research Projects Agency
DG DEFIS	Directorate General Defence Industry and Space
DGA	Direction Gènèrale de l'Armement
DLR	Deutsches Zentrum für Luft- und Raumfahrt
DNA	Direzione Nazionale Armamenti
DoD	Department of Defence
DOSA	Defence of Space Assets
DPP	Documento Programmatico Pluriennale della Difesa
DSPSN	Domestic Space Policy Strategic Document
DSS	Defence Space Strategy
DVSS	Space Strategic Vision Document
EDF	European Defence Fund
EDIDP	European Defence Industrial Development Programme
EDIDP	GEODE Galileo for EU Defence
EELV	Evolved Expendable Launch Vehicle
EGNOS	European Geostationary Navigation Overlay System
EKS	Integrated Space System
ELINT	Electronic Intelligence
EMS	Emergency Management Service
EO	Earth Observation
EPW	European Protected Waveform
ESA	European Space Agency
ESSS	Integrated Satellite Communication System
EU-SSA-N	European Military Space Surveillance Awareness Network
EUSPA	European Union Space Agency
EUSST	European Union Space Surveillance and Tracking
EW	Electronic Warfare
FFA	Financial Framework Agreement
FG	Fragmentation
FOBS	Fractional Orbital Bombardment System
GDP	Gross Domestic Product
GEO	Geosynchronous Equatorial Orbit
GESTRA	German Experimental Space Surveillance and Tracking Radar
GLONASS	Global Navigation Satellite System (Russian programme)
GMTI	Ground Moving Target Indicator
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GRAVES	Grand Réseau Atapté à la Veille Spatiale

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GSA	European GNSS Supervisory Authority
GSMC	Galileo Security Monitoring Centre
GSSAC	German Space Situational Awareness Centre
H2Sat	Heinrich-Hertz-Sat
HAPS	High-Altitude Pseudo-Satellites/Stratospheric Platforms
HEO	Highly Elliptical Orbits
IAI	Israel Aerospace Industries
ICT	Information Communication Technologies
IMINT	Image Intelligence
INAF	Istituto Nazionale di Astrofisica
INTEGRAL	Innovative and Interoperable Technologies for Space Global Recognition and Alert
IOS	In-Orbit Services
ISI	ImageSat International
ISOC	Italian SST Operations Centre
ISON	International Scientific Optical Network
ISR	Intelligence Surveillance Reconnaissance
ISS	International Space Station
ISTAR	Intelligence Surveillance Target Acquisition
IT	Information Technology
LEO	Low Earth Orbit
LEOP	Launch and Early Orbit Phase
LPM	Loi de Programmation Militaire
MASINT	Measurement and Signatures Intelligence
MDO	Multi-Domain Operations
MENA	Middle-East and North Africa
MEO	Medium Earth Orbit
MFF	Multiannual Financial Framework
MLRO	Matera Laser Ranging Observatory
MoD	Ministry of Defence
MPEP	Military Personnel Exchange Program
NAC	North Atlantic Council
NAVWAR	Navigation Warfare
NDAA	National Defense Authorization Act
NDSA	National Defence Space Architecture
NEO	Near-Earth Objects
NRO	National Reconnaissance Office
NSC	National Space Council
NSSL	National Security Space Launch

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ODIN'S EYE	MultinatiOnal development INitiative for a Space-based missilE earlY-warning architecturE
OS	Open Service
PADR	Preparatory Action on Defence Research
PESCO	Permanent Structured Cooperation
PISQ	Poligono Sperimentale e di Addestramento Interforze,
PLA	People Liberation Army
PNRM	Piano Nazionale Ricerca Militare
PNRR	Piano Nazionale di Ripresa e Resilienza
PNT	Position Navigation and Timing
PPWT	Prevention of Placement of Weapons in Outer Space
PRISMA	Precursore Iperspettrale della Missione Applicativa
PRS	Public Regulated Service
RAF	Russian Aerospace Force
RE	Re-entry
RPOs	Rendezvous and Proximity Operations
SAR	Synthetic Aperture Radar
SASTIND	Science, Technology and Industry for National Defense
SatCom	Satellite Communications
SAURON	Sensors for advanced usage & reconnaissance of outer space situation
SBPP	Space Based Positioning Navigation and Timing Programme
SDA	Space Development Agency
SDA	Space Domain Awareness
SDI	Strategic Defence Initiative
SGD	SegreDifesa
SICRAL	Sistema Italiano per Comunicazioni Riservate ed Allarmi
SIGINT	Signal Intelligence
SIMONA	Sistema di Messa in Orbita Navale
SKPP	Space Surveillance System
SMEs	Small and Medium-sized Enterprises
SPD-4	Space Policy Directive 4
SPTF	Space Propulsion Test Facility
SSA	Space Situational Awareness
SSF	Strategic Support Force
SSMS	Small Spacecraft Missile Service
SST	Space Surveillance and Tracking
STEM	Science, Technology, Engineering and Mathematics
STM	Space Traffic Management
SWE	Space Weather Events

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TAS	Thales Alenia Space
TIR	Thermal InfraRed
TIRA	Tracking and Imaging Radar
TWISTER	Timely Warning and Interception with space-based theatre surveillance
UAE	United Arab Emirates
UCM	Ufficio del Consigliere Militare
UGS	Ufficio Generale Spazio
UK	United Kingdom
ULA	United Launch Alliance
USSF	United States Space Force

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