NATO PARLIAMENTARY ASSEMBLY

SCIENCE AND TECHNOLOGY COMMITTEE (STC)

SPACE AND SECURITY – NATO'S ROLE

Preliminary Draft Special Report

by Karl-Heinz BRUNNER (Germany)
Special Rapporteur

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EXECUTIVE SUMMARY

Space technologies and space-based data and services are also crucially important for the global economic and financial systems, communication, scientific progress, earth observation and natural disaster management, to name but a few. Not surprisingly, space has become a key security issue. In recognition of the opportunities and the challenges of space, several Allies have embarked on adapting their armed forces by setting up space commands or created a new military service. Similarly, NATO has agreed on a space policy and recently decided to establish a Space Centre and a Centre of Excellence.

This preliminary draft report sheds a light on the significant increase of actors, both state and commercial, and their activities in space. It briefly describes the progress key space-faring nations, such as the United States, Russia, and China have made in space technology. Special attention is given to Russian and Chinese activities and progress in the development of space-denial technologies. The draft then discusses possible implications of these developments for the existing space infrastructure of Allied member states. A brief analysis of international agreements on space activities and existing gaps that the international community needs to address is followed by an analysis of NATO's evolving role in space.

The report concludes that the existing space infrastructure of Allied nations is susceptible to attack. Developing a common understanding of the security-related challenges and opportunities of space is an important step towards making existing and future Allied space-based assets resilient. Member states should use NATO as a forum to discuss the operationalisation of space. Moreover, as the use of space for peaceful purposes is in the interest of all nations, the Allies should develop a joint approach to towards closing existing gaps in international agreements.

This preliminary draft report will be presented and discussed at the 2021 Spring Session's online meeting of the Science and Technology Committee.

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I. INTRODUCTION

1. Secretary General Stoltenberg noted that "What happens in space is of great importance for what we can do on the Earth: communications, navigation, cell phones, military communications, transmission of data and a lot of activities on the Earth, at sea and on land, is dependent on capabilities in space, not least satellites. So, this is important for our civilian societies, but also, of course, for military capabilities" (NATO Secretary General Jens Stoltenberg) (NATO, 2020).

2. The importance of space is constantly increasing, it has moved towards the top of NATO's agenda. With the adoption of space policy and the declaration of space as an operational area in its own right NATO has recognised the need to adapt to a rapidly changing security environment. The agreement on the creation of a NATO Space Centre at Allied Air Command in Ramstein, Germany, and on a Centre of Excellence (CoE) in Toulouse, France[1], are first steps towards responding to the challenges Allies are facing in space. Although these are noteworthy decisions, it is still only the beginning of a long process for the Alliance.

3. This draft report provides a short background on the developments in space and space technology and identifies possible implications for the security of the Alliance. The report concludes that NATO can play an important role in policy coordination and the development of procedures and technologies. Your rapporteur also wants to emphasise that cooperation, not confrontation, among all space-faring nations, is needed.

4. This draft report will be presented at the 2021 virtual Spring Session to the Science and Technology Committee for discussion and review. It will be updated for the 2021 Annual Session.

II. THE SCRAMBLE FOR SPACE

5. "Space is essential for our ability to navigate, communicate, and detect missile launches. And fast, effective and secure satellite communications are vital for our troops" (NATO Secretary General Stoltenberg) (NATO, 2020).

6. Space technologies and space-based data and services are not only crucially important for security and defence. The global economic and financial systems depend on space assets, as does scientific progress. Space technologies also play a key role in the monitoring of the global climate and in natural disaster management. Satellites enhance services for many civilian and security-related activities while also reducing costs and limiting necessary resources for many economic activities.

7. Today, the majority of space investments goes to commercial satellite services and equipment, satellite manufacturing, and satellite ground equipment (NATO PA, 2020). Operating predominately in low-earth orbits (LEO), satellites provide invaluable contributions to navigation, safety and emergency management, environmental monitoring, and science applications.[2]

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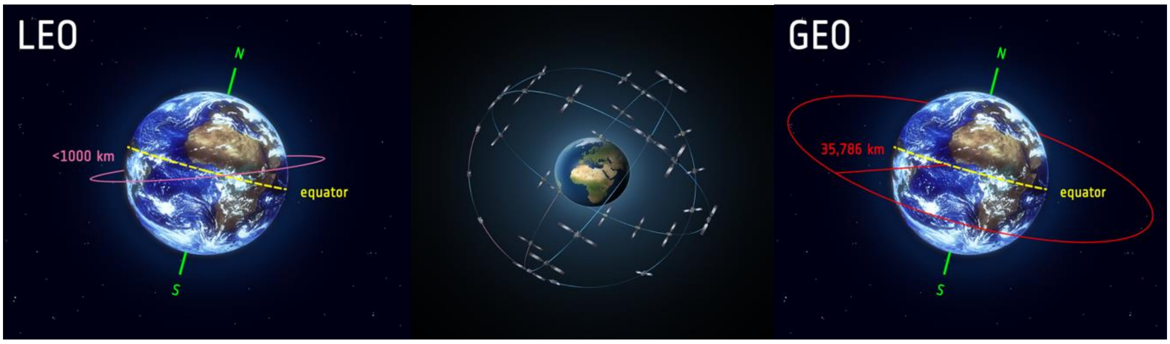
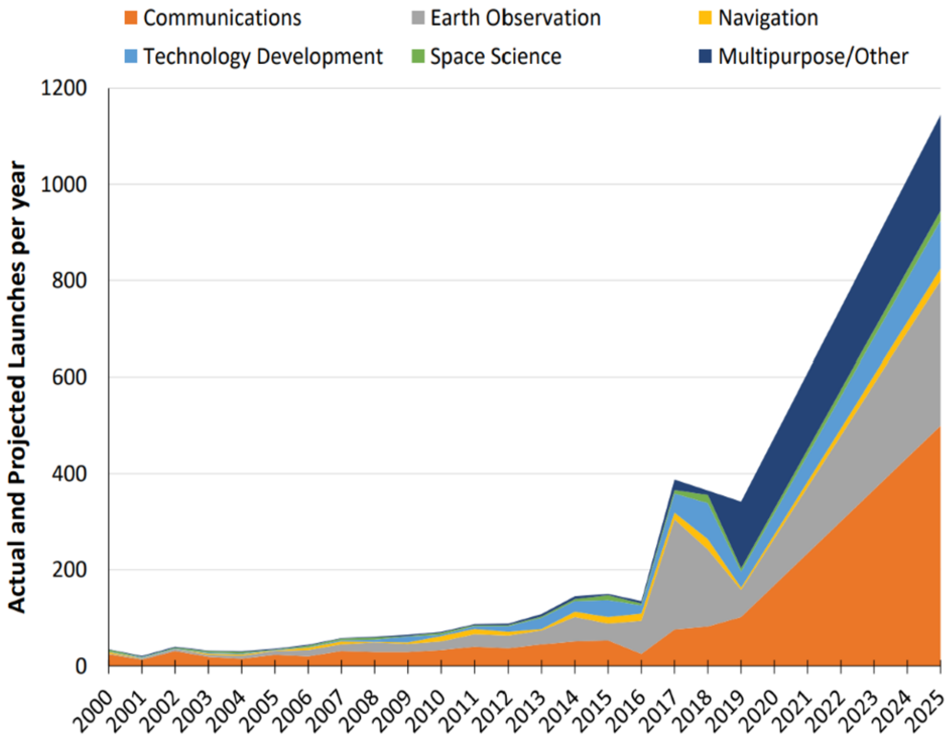
[1] At the time of writing, the creation of the CoE was accepted by NATO Military Authorities (the Military Committee). Final approval by the North Atlantic Council will come when the accreditation process is complete.

[2] LEO satellites orbit the globe at a comparatively short distance from the Earth's surface of 160 to 2,000 kilometres. They move faster than the Earth's rotation and can only be reached from specific locations on Earth for a limited time. Medium Earth Orbits (MEO) comprises a wide range of orbits



https://www.esa.int/Enabling_Support/Space_Transportation/Types_of_orbits

8. Since the first satellite, the Soviet "Sputnik", was launched into orbit in 1957, the space above Earth has become increasingly crowded. More than 30 space-faring nations have emerged in recent years; 84 countries currently operate satellites above Earth (Stewart, 2020). Including launches scheduled through the coming year, close to 3,400 operational satellites will orbit Earth by the end of 2021 (UCS, 2021).[3] Space-based assets are now part of most countries' critical infrastructure (Stewart, 2020). In the meantime, space exploration, including missions into deep space, is becoming a strategic priority as countries to develop a robust presence in space.



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between LEO and the Geostationary Orbit (GEO) and is mostly used by navigation satellites. Similar to LEO, satellites in MEO do not require specific paths around Earth. Finally, satellites in GEO are located at the height of the equator, 35 786 kilometres from Earth. Moving at the speed of the Earth's rotation, they therefore appear to be fixed in the sky when seen from Earth.

3 Broken down by different orbits: LEO (2,612), MEO (139) GEO (562), other (59).

Actual and forecast satellite launches per year (Source: MIT Technology Review)
https://www.technologyreview.com/2019/06/26/755/satellite-constellations-orbiting-earth-quintuple/

9. The increasing number of countries interested and active in space is due to their recognition of the importance of space for their economic, financial, and military security. Moreover, engaging in space activities has become easier and less expensive. As technology progresses, satellite capabilities will increase, and new applications will develop. Therefore, space activities will increase as will the dependence of activities on earth on space-based assets. Beyond satellites and scientific exploration, increasing access to space resources has spurred hopes and driven competition.

10. The 1967 Outer Space Treaty, discussed in more detail on the following pages, stipulates that celestial bodies "not subject to national appropriation by claim of sovereignty". As resources on earth get increasingly scarce and celestial bodies such as asteroids can contain nickel, platinum, iron, or cobalt, space mining activities will become an issue in the coming years. Government agencies like the European Space Agency (ESA) have called for new rules to regulate the emerging space mining efforts (Bockel, 2018).

11. Space activities are much less dominated by governments today, as a thriving private sector has moved into what had been almost entirely the province of governments (Cookson, 2020). Today, government spending accounts only for a total of 22% of all spending on space-related activities globally (NATO PA, 2020). Commercial enterprises continue to depend on government contracts, however.

12. Public funds and actors such as the National Aeronautics and Space Administration (NASA) continue to drive commercial research & development (R&D) efforts. Washington has been very successful in integrating private actors into its space activities which are increasingly attracting innovative start-ups from abroad. As other countries lag behind in creating these kinds of public-private partnerships and still prefer traditional industrial partners, observers have raised concerns that promising younger companies like the German specialist for micro-launchers, Isar Aerospace, or engine developer Morpheus Space might move to the United States to gain access to US funds (Stölzel, 2020).

A. UNITED STATES

13. The United States are undoubtedly the most advanced space-faring nation and the largest contributor to space programmes worldwide. In 2018 global expenditures for space-related activities were estimated between USD 360 billion and 414 billion (European Space Policy Institute, 2020). With around USD 50 billion, including funding for NASA, the United States spent more than all other governments combined that year (NATO PA, 2020).[4] The budget of NASA for 2021 is just over USD 25 billion, representing less than half a percent of the total federal budget (NASA, 2021).

14. While the U.S. government spending on space has increased between 9% and 14% between 2016 and 2018 it should be noted that the US percentage of global institutional spending on space has decreased from 75% in the early 2000s to 58% in 2018 (European Space Policy Institute,

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[4] The total budget of all other governments combined was estimated at USD 30.5 billion in 2018, as Dr Stamatios Krimigis informed the joint session of the Science and Technology and Economics and Security Committees during the Annual 2020 session (NATO PA, 2020).

2020). This decreasing percentage reflects the emergence of new actors that increasingly challenge the US dominance in space.

15. The Global Positioning System (GPS) symbolised this dominance for a long time. As of January 2021, the GPS constellation comprised a total of 31 operational satellites (NOAA, 2021). The total number of US satellites in space estimated to stay just under 1,900 in 2021 (UCS, 2021). Yet, several actors have emerged in recent years and today there are three more operational global navigation satellite constellations: The European Space Agency launched the first satellites of the Galileo system in 2011 (EC, 2021), Russia started modernising its Soviet-era Global Navigation Satellite System (GLONASS) in 2012 (IAC, 2021), and China completed the BeiDou constellation with a series of successful launches in 2020 (Howell, 2020).

16. Despite this recent evolution, the United States remain the most ambitious nation in space. Through the Artemis programme, NASA plans to return humans to the moon by 2024 (Butow, Cooley, Felt, & Mozer, 2020). The agency views the Moon as a steppingstone to further space exploration as sustained lunar infrastructures could enable deep space explorations, including to Mars. In February 2021, NASA successfully landed the perseverance rover on the red planet (NASA, 2021). In the past years, US commercial companies like SpaceX, Blue Origin or Virgin Galactic, have emerged on the scene and succeeded in significantly lowering launch costs and spurring innovation at the same time (Schütz, 2021).

B. CHINA

17. The second biggest public investor in space activities in 2018 was China with at an estimated USD 6 billion (European Space Policy Institute, 2020). Up from USD 4.9 billion only two years earlier, the 18% growth in China's space budget was reflected in the significant increase in the number of space launches. Since then, China has again increased the pace of its space programme and last year, China had more than 40 successful launches which put over 60 satellites into orbit (Harrison, Johnson, Roberts, Way, & Young, 2020). The total number of Chinese satellites in space expected to surpass 400 by the end of 2021 (UCS, 2021).

18. Throughout recent years, China's civil space programme has been focused on its network of BeiDou positioning, navigation, and timing (PNT) satellites. The constellation has been promoted to China's regional partners in the context of its "Belt and Road Initiative" (BRI as an alternative to the US GPS system. Thus far, China has directly assisted 60 countries, and recent data shows that 165 out of 195 countries are already more frequently overflown and observed by BeiDou satellites than by GPS systems today (Tsunashima, 2020). This assistance and the related financing provided by the PRC, provides Beijing with an opportunity to generate dependencies or even control over recipient countries' space sectors (Manson & Shepherd, 2020). To support its growing space capabilities, China has also increased investments in an extensive ground support infrastructure (Harrison, Johnson, Roberts, Way, & Young, 2020).

19. China advances its space capabilities by investing considerable financial resources into this field. More generally, the US National Science Foundation's biennial review reported that from 2000 through 2017, Chinese R&D spending grew at an average annual rate of around 17% (Slaughter, 2020). Between 2000 and 2020, its share of global technology spending has increased from approximately 5% to more than 23% (Darby & Sewell, 2021). Sophisticated cyber espionage campaigns have also contributed to China catching up in space technologies. The U.S. has charged several Chinese nationals with running a multi-year campaign to steal critical aviation, space, satellite, manufacturing, communications, computer processor, and other technologies (Center for Strategic and International Studies, 2021).

20. Although commercial space activities in China remain primarily driven by state-owned enterprises, the Chinese government increasingly supports private commercial actors to become active in this field. In the coming five years, a series of a dozen launches are planned to set up China's own space station, the Tiangong-3 (Shepherd, 2020). China's 30-year space goals (2019-2049) include establishing a permanent presence on the moon, space mining, and developing solar power stations in geo-synchronous orbit (Goswami, 2019). It is also accelerating the modernisation of military space institutions (Broad, 2021).

C. RUSSIA

21. After the United States and China, Russia comes third in terms of budget with an estimated USD 4.2 billion in 2018. Due to its longstanding space experience dating back to the Soviet Union, Russia remains a key player in space. Counting launches planned for 2021, Russia still operates the third-largest number of satellites in orbit, 176 (UCS, 2021), and is engaged in partnerships with many nations in international human spaceflight (Harrison, Johnson, Roberts, Way, & Young, 2020).

22. However, Russia is increasingly at risk to fall behind the United States and China. Moscow lost its long-standing monopoly on transport flights to the International Space Station (ISS) in November 2020, when SpaceX succeeded its first manned mission (Brown, 2020). Moreover, structural problems in the Russian science and technology sector, poor governance, and misguided allocation of funds are putting Russia's status as a leading space power at risk. Private Russian space companies lag behind and have difficulties to compete against the likes of SpaceX or Blue Origin. State-run space projects have suffered from a lack of innovation and widespread corruption.

23. Russia's response to these trends has been twofold. On the one hand, recent shifts from the Soviet-era Baikonur Cosmodrome in Kazakhstan to the newly constructed Vostochny Cosmodrome in Siberia illustrate Moscow's determination to renew its space programme. Russia has also increased cooperation with China in recent years, a move which has been largely interpreted as an attempt to diversify its partnerships and counter the US dominance in space (Vidal, 2021).

24. Although Russia's civilian programmes are plagued by structural difficulties, the country disposes of significant military capabilities in the space domain. Counting in the infrastructures on the ground as well as costs for personnel, Russia's budget for military space programmes is estimated at USD 1.6 billion (Luzin, 2020).

D. OTHER COUNTRIES

25. Other leading space-faring nations include, among others, France, Japan, and India. France's budget spent on space activities ranked fourth in 2018 at USD 3.1 billion. Japan follows as the fifth country with the highest expense in government space expenditure. Tokyo has announced the expansion of its existing programmes on Navigation (Quasi-Zenith Satellite System - QZSS) and the development of the next generation of the HTS ETS-3 satellite. If implemented these announcements would reflect a modest budget growth (2% per year) in the near future.

26. India, which launched its first satellite in 1980, has since developed a series of launch vehicles, as well as a range of imaging and communication satellites. Indian space activities are driven by the Indian Space Research Organization (ISRO), one of the six largest space agencies in the world. Thus far, it has concentrated its activities primarily on earth observation and utilising space to advance India's economic development (Tellis A. J., 2019).

27. Beyond the actors discussed above, many more nations and commercial actors have or will become active in space in the coming years. This development is reflected in the growth rates of investments in space activities – which are twice as high as that of the global economy at large (NATO PA, 2020). Moreover, costs for reaching LEO have declined by a factor of 20 (Space Economy: Rocket fuel, 2020): The cost to launch one kilogram into LEO has decreased from USD 54,500 (on board NASA's space shuttle) to USD 2,720 (with SpaceX's Falcon 9).

28. Decreasing launch costs and technology transfers will also increasingly enable actors like Iran or North Korea to engage in space activities. Iran launched its first nationally produced satellite (Safir-1) in 2009, while North Korea appears to have launched a satellite in 2016 (Al-Rodhan, Cyber security and space security, 2020). As a consequence, space is not only increasingly crowded, but also risks being increasingly contested.

29. The increasingly crowded orbits above Earth create serious challenges. Since the Sputnik launch in 1957 some 9,000 objects have been launched into space. The European Space Agency (ESA) estimates that more than 3,000 abandoned satellites are in orbit (Cookson, 2020). These and the debris caused by collisions and explosions over the year poses growing risks for satellites and space launches. Approximately 34,000 pieces of debris longer than 10cm, 900,000 between 1cm and 10cm, and 128 million between 1mm and 1cm, are estimated to be in orbit — which could destroy or damage a satellite (Peel, Shepherd, Williams, 2019). Enough debris could lead to a chain reaction known as Kessler syndrome, which could render entire swathes of near-Earth space unusable for decades (The Economist, 2020).

30. Unfortunately, there is no international agreement in place which regulates the removal of non-operational spacecraft from the orbit. The UN and international organisations like the International Telecommunication Union (ITU) have made only partial progress in addressing the issue. The 2007 UN Space Debris Mitigation guidelines are one example for this but fall short of solving the problem (Cookson, 2020).

31. The increasingly crowded and contested orbits increase the level of vulnerability of space-based infrastructures. Innovations such as reusable and cheaper launchers, CubeSats made access to space easier and cheaper. New states and non-state actors have access to this domain and multiply the presence in the LEO, and thus the risk of malicious interactions (Al-Rodhan, 2020).

III. SPACE AND ALLIED SECURITY

32. "A future conflict may not start in space, but I am in no doubt it will transition very quickly to space, and it may even be won or lost in space," - UK Air Chief Marshal Sir Mike Wigston, chief of the air staff (Warrell, 2020).

33. Space is essential to the Alliance's deterrence and defence (NATO, 2020). NATO Allies rely heavily on space for the protection of their homelands and for military operations around the globe. Space is an "enabling domain" as it is closely interconnected with the other security domains relevant for NATO: maritime, air, land, and cyber space. Together with cyber, space will therefore play an increasingly critical role for the security of Allied nations.

34. Satellites provide precise information on movements by friend and foe through imagery or via signal interceptions. They transfer huge amounts of data from and to the battlefield: operating a single Global Hawk, for instance, requires roughly 500 megabits of satellite bandwidth per second.

This is five times the total amount of satellite communications that US forces used during operations in the First Gulf War (The Economist, 2019).

35. During the 1991 Gulf War, often referred to as “the first space war”, space systems evolved from strategic assets to tactical enablers. Satellites provided near real-time information down to the tactical level throughout operation *Desert Storm* for the first time. Space assets, originally developed to detect strategic missile launches, were transformed into tools that worked “down to do scope reporting” in 1991 (Strout, 2021). The use of satellite-based information contributed to the quick and decisive victory of the US-led forces.

36. Today, many of NATO’s most advanced systems depend heavily on space-based assets. Examples include the Alliance’s Ballistic Missile Defence (BMD) programme, the Airborne Warning and Control Systems (AWACs) and the Ground Surveillance System (AGS) (Moon, 2017). NATO’s Joint Air Power (JAP) is equally dependent on the national capabilities in the space domain of Allied states as they support operations in the air as well as on the ground and on the seas (Bockel, 2018).

37. The Alliance defines five core areas where it heavily depends on space-based assets (NATO, March 2020): (1) positioning and navigation, enabling precision strikes, force navigation or combat search and rescue (CSAR) missions; (2) integrated tactical warning and threat assessment, securing force protection, providing crucial information on missile launches and thus allowing attribution; (3) environmental monitoring, enabling meteorological forecasting and sound mission planning; (4) communications for command and control purposes and (5) intelligence, surveillance and reconnaissance (ISR) capabilities, providing intelligence on and off the battlefield and informing targeting decisions.

38. Free access to space and resilient space infrastructures are essential for operational capability and defence. As a consequence, the dependence of modern armed forces on space has become one of their greatest vulnerabilities. In the early days of space infrastructure during the Cold War, only the U.S. and the Soviet Union were capable of launching satellites into orbit. Space-denial technologies were either non-existent or in their infancy. After the fall of the iron curtain, the threat to western space assets and capabilities was significantly diminished. The recent evolution of space capabilities, especially on the commercial side, as well as the increased number of space-faring nations, has changed this situation, however.

39. Space denial capabilities of NATO (near-)peer competitors have significantly increased in recent years, and so have the number of tests of such technologies. Several countries possess weapon systems that have the potential to harm space assets at any time. According to CSIS’s 2020-Space Threat Assessment there are four types of systems that can be used to damage or destroy space-based assets (Harrison, Johnson, Roberts, Way, & Young, 2020): (1) kinetic physical counterspace weapons, built to directly strike satellites or the ground stations operating them; (2) non-kinetic weapons, including lasers, high powered microwave (HPM) weapons, and electromagnetic pulse (EMP) weapons, that can physically affect space assets without any direct contact; (3) electronic attacks targeting signal transmissions to and from satellites by interfering with radio-frequencies (RF) by creating noise in the same frequencies (jamming) or by falsifying a signal and tricking the receiver into it (spoofing), thus corrupting the data; (4) cyberattacks, that target data instead of transmission frequencies.

40. Kinetic physical counterspace weapons have by far attracted the most attention. Tests of direct-ascent anti-satellite (ASAT) weapons have increased as more countries develop capabilities in this domain (Harrison, Johnson, Roberts, Way, & Young, 2020). The most prominent of these tests has arguably been the destruction of a satellite by China in 2007 which increased space debris in LEO by roughly 10% and was followed by broad international condemnation (Ohlandt,

McClintock, & Flanagan, 2021). A more recent ASAT test by China, conducted in 2018, was further evidence of Beijing's growing prowess and ambition in space. Building on extensive experience from Soviet-era ASAT-programmes, Russia has also invested in numerous kinetic physical counterspace capabilities and allegedly disposes of a range of ground-based and air-launched direct-ascent ASAT missiles that could target satellites (Harrison, Johnson, Roberts G., Way, & Young, 2020).

41. In addition to direct-ascent systems, co-orbital ASAT-weapons have also already been deployed in space. Their activity is more difficult to detect, however, as it is very similar to on-orbit maintenance or debris removal mission. As most space technologies, co-orbital weapons are a dual-use technology and can be used for both civilian and military purposes. Arguably, any asset in the orbits above earth can be qualified as a weapon just because of its high velocity. With speeds between 11,000 (GEO) and 28,000 (LEO) kilometres per hour a satellite that changes orbit becomes a kinetic weapon by definition.

42. Some of the most advanced space denial assets have been developed and tested by the People's Republic of China (PRC). The Pentagon's annual China military power report notes that Beijing's space capabilities include orbiting space robots (U.S. Department of Defense, 2020). Similarly, Russia has repeatedly launched inspection-satellites into LEO, which could potentially serve as co-orbital ASAT weapons. Although Moscow has not officially announced any plans to develop space based ASAT weapons, US Space Command accused the Kremlin of testing such weapons-systems under the guise of maintenance in 2020 (US Space Command, 2020).

43. Other than China and Russia, many more states, including France, India, and Japan, are working on counter-space capabilities (Raju, 2020). India successfully conducted an ASAT test in 2019, using a ballistic missile defence interceptor to destroy an Indian microsatellite (Tellis A. J., 2019). New Delhi is also developing systems for so-called rendezvous and proximity operations (RPO) in cooperation with France (D'Souza, 2020). These RPO-capabilities essentially consist in bringing satellites in close range to each other. While officially being presented as a key technical capability for India's efforts to develop a national space station, allowing for maintenance operations, they could potentially enable the country to conduct co-orbital ASAT operations.

44. While receiving less public attention than their kinetic counterparts, non-kinetic weapon systems such as lasers and electronic technologies enabling jamming or spoofing, have also been increasingly developed and tested. According to the Rand Corporation, China continues to develop space weapons in secret and has developed jamming capabilities and tested them in exercises (Manson & Shepherd, 2020). The development of China's non-kinetic capabilities dates back to the purchase of Soviet-era equipment from Ukraine in the late 1990s (CSIS, 2018).

45. Since then, Beijing's indigenous space industry has made the ability to jam satellite communications one of its priorities (USCC, 2015) and has developed and tested several systems (DIA, 2019). China's electronic warfare capacity includes an ionospheric radar located on the island of Hainan that is able to influence particles up to 2,000 kilometres. In 2020, officials announced an airborne laser which, although developed to target military aircraft or missiles, could potentially be used against satellites (Zhen, 2020).

46. Russia, too, has been consistently enhancing its space denial capabilities. The state armament programme for the period until 2027 lists the development of defensive space-based systems deployed to protect Russian satellites (Zak, 2018). Moreover, Russia is commonly believed to be testing electronic counterspace warfare, jamming and spoofing adversaries' satellites in conflict zones as well as in nearby territories (Harrison, Johnson, Roberts, Way, & Young, 2020) and even on GPS-Satellites within its own state borders (BBC, 2018).

47. Finally, several actors in space have developed substantial knowledge in the cyber realm. As cyber-attacks are significantly cheaper and much harder to attribute than direct-ascent or co-orbital ASAT, they are a compelling alternative to these weapon systems. Russia has demonstrated its cyber capabilities as early as 1998, when it allegedly took control of a US-German satellite, pointed it at the Sun and thus destroyed its instruments (Tucker, 2019). The Chinese government appears to also have tested its cyber capabilities in several instances such as during the 2014 National Oceanographic and Atmospheric Administration (NOAA) hack (Al-Rodhan, 2020). The attack disrupted weather information and impacted end users around the globe (Al-Rodhan, 2020).

48. These successful tests are only a few examples of a potential “militarisation” of space. An arms race in this domain would generate considerable geopolitical tensions which will only escalate if the international community will not address it soon (Al-Rodhan, In Space, either we all win, or we all lose, 2020). The urgency of addressing the potential “militarisation” of space is amplified by the dual-use character of the majority of space assets: it is very difficult, if not impossible, to verify if space infrastructure launched today is used for civilian purposes of observation, communication, navigation, or for military objectives (Al-Rodhan, 2020).

IV. LACK OF SPACE GOVERNANCE

49. However, these developments are taking place in a virtual vacuum of international law. The legal framework for state action in space is far behind the rapid technological development and commercialisation of space. There is no binding international agreement in place that governs the activities of an increasing number of actors.

50. The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, the “Outer Space Treaty”, remains the bedrock of international space law. The Treaty, dating back to 1967, prohibits the deployment of weapons of mass destruction in space and has been signed by more than 130 countries. Four international agreements reached during the late 1960s and 1970s supplement the Outer Space Treaty. They regulate the rescue of astronauts, liability for damage, registration of launches and lunar activities. No further space treaties have been drawn up since then (Cookson, 2020).

51. While the Outer Space Treaty prohibits the deployment of nuclear weapons, it does not refer to other space-based weapons nor address the interference with other countries’ space assets. Moreover, they do not ban the use of ground based ASAT missiles. This lack of legal clarity has created a vacuum that many countries, including Russia and the PRC, but also Iran and the People’s Republic of Korea (DPRK – North Korea) have exploited (Al-Rodhan, 2020).

52. The Outer Space Treaty does also not feature a dispute settlement mechanism, nor does it address orbital debris and vehicle collisions. It also lacks adequate provisions to govern satellite mega-constellations or asteroid mining, both of which will become an issue sooner than many observers anticipate. Existing multilateral institutions such as the Committee on the Peaceful Uses of Outer Space (COPUOS) and the Conference on Disarmament have thus far failed to adapt international agreements to the dynamic technological developments.

53. Another example is the International Telecommunication Union (ITU). Since 1959, it has had the mandate to coordinate the use of radio frequencies internationally. This also applies to the radio frequencies earmarked for the new satellite constellations. The ITU also regulates the use of orbits. However, the ITU's coordination function was originally designed for a time when the number of actors in space was limited and the total number of satellites stationed in space was

manageable. The development of new applications for satellites and the deployment of mega-constellations threaten to overload the ITU's allocation system.

54. ITU regulations and export controls mechanisms can help in managing the launch of satellites and management of space traffic, yet military satellites are often not registered. The overall result of this conglomerate of instruments is a loose environment where cooperation is limited (Al-Rodhan, Cyber security and space security, 2020). Space security cannot be understood as a zero-sum game, however. Rather, it has to be approached as a multi-sum game where good governance ensures access and safety for all actors (Al-Rodhan, Cyber security and space security, 2020). As more nations become active in space and increasingly dependent on space assets, they share a common interest in a safe and accessible space. Development and deployment of counterspace weapons could quickly escalate into a global arms race. The pervasiveness of dual-use technologies in space and the according risk of miscalculation and escalation only strengthen this argument (Stewart, 2020).

55. It is important to emphasise that all space strategies that have thus far been published by space-faring nations underline the need for international cooperation. What is lacking for now is an international legal framework that clearly defines the rights and responsibilities of all participants. The international community needs to address this lawlessness as a matter of urgency. A first step towards building internationally guiding legal framework, actors need to agree on definitions and norms. It is necessary to reach an international consensus among the most advanced spacefaring nations to establish long-lasting norms that may be able to lead to distinct arms control measures.

56. Given the dependence on space-based assets for daily critical needs, any conflict in space, even if unintentional, will compromise space and terrestrial security for everyone. However, despite the fact that the growing number of civilian and commercial actors share the interest in establishing norms in space, the Outer Space Treaty and a few associated agreements and conventions from the Cold War era are still the only binding pacts (Ohlandt, McClintock, & Flanagan, 2021).

V. NATO'S SPACE POLICY

57. Space-based assets are owned and controlled by NATO member states. Becoming increasingly aware of the importance of and dependence on space-based assets for NATO operations, the Allies have gradually put space on NATO's agenda. Interest has picked up significantly within the last 10 years, due to, among others, cheaper and more available access to space technology, which resulted in a more contested environment, and the appreciation that more cooperation among Allies is needed.

58. NATO recognised unimpeded access to space as a priority at the Lisbon-Summit in 2010 (NATO, 2010). Two years later, the creation of the Bi-Strategic Command Space Working Group acknowledged the crucial role space assets have played in missions like the International Security Assistance Force (ISAF) in Afghanistan (Bockel, 2018). In June 2019, Defence Ministers agreed NATO's first-ever space policy and in late 2019, NATO Heads of State and Government officially declared space as the Alliance's fifth operational domain after land, sea, air and cyber (NATO, 2019). This decision reflected the recognition of the unique role of space for NATO's deterrence and defence. As a result, NATO planners can now "make requests for Allies to provide capabilities and services, such as hours of satellite communications" (2019). Although space is considered a domain of operations, the increased engagement of the Alliance in space is defensive. NATO is looking into ways to protect against attacks or reduce their negative effects, like disrupted communication and navigation systems, on allied forces.

59. In October 2020, NATO Defence Ministers announced the creation of a new Space Centre which will be located at Allied Air Command in Ramstein, Germany (NATO, 2020). The Centre will help to coordinate Allied space activities and provide support to NATO operations from space, including by using satellite communications and imagery. The NATO Space Centre is still in the phase of being established and is performing functions on a limited basis. A small team of experts from several Allied nations is assigned to the Centre. It will continue to grow in size and expand its responsibilities and functions over time.

60. The Centre will work closely with Allies' national space agencies and organisations and the NATO Command Structure to fuse data, products, and services (DPS) provided by nations. The Space Centre will streamline the links between NATO and national space agencies through a single entity and provide Alliance commanders with mission critical DPS such as imagery, navigation, and early warning. By strengthening the links between NATO and national space entities, the Centre will increase space domain awareness at all levels. Moreover, The Centre will also help to facilitate training and exercises and sharing of information about potential threats. Thus, in the medium to long term the Space Centre can also offer opportunities for multidimensional integration that can prove to be innovation drivers for the Allied armed forces. It is important to point out, though, that the Alliance does not dispose of any space-based capabilities of its own. NATO receives space related DPS from member nations, whose space capabilities vary widely.

61. In January 2021, NATO agreed to a French proposal to create a new Centre of Excellence (CoE) dedicated to space, which will be established in Toulouse (Dupont, 2021). The decision, in principle, has been taken, but the implementation process will take several years. Similar to other CoEs, Toulouse will not be part of the NATO Command Structure, but it can be expected that it will assist in doctrine development, training, identify lessons learned and improve interoperability. The CoE in Toulouse could therefore make an important contribution to educate specialists.

62. A longstanding, and important, part of NATO's space activities is played by the NATO Science and Technology Organization (STO), which has been driving NATO cooperation on technology/military related space research. This research includes the use of Artificial Intelligence (AI) and satellite sensing to track maritime vessel traffic, maritime surveillance, space-based sensors, space weather, high performance imaging, operations on Global Navigation Satellite Systems (GNSS) denied environments and transforming space derived data into knowledge.

63. Another concrete example of close cooperation is the STO's project on the management of large constellations of small or cube satellites. This is important to understand space as an operational domain as the management of large numbers of small satellites, or cube satellites, which have no, or only very limited propulsion capability of their own, is very different from managing large, legacy satellites. Related research is done in the STO's Advanced Vehicle Technology (AVT) panels which has done research on propulsion for small satellites.

64. In total, the STO has produced over 50 major reports on space-related issues over the past ten years. Moreover, the STO has identified relevant research areas for space in its "Science and Technology Trends 2020-2040" (Science and Technology Organization, NATO, 2020). For example, among the technologies that will profoundly impact the future intelligence, surveillance, and reconnaissance (ISR) architecture will be space-based quantum sensors which are currently being developed. Although NATO nations conduct most of their space research on a national level the STO provides a valuable forum for member states to advance space research in areas the nations are comfortable pushing forward together.

65. NATO and the STO serves a crucial function as an information sharing forum. However, under the STO nation collaborate on the development of space technologies such as novel

sensors, data fusion, vehicles, propulsion, and operations. NATO Allies can work together to push forward their national and joint space capabilities. Closer cooperation among NATO Allies, and with partners, is urgently needed to make their space-based infrastructure more resilient. As space becomes increasingly competitive, congested, contested and commercial, the challenge of protecting critical space assets will increase, as will the pressure to better understand how to use commercial systems. Protecting Allied space assets and capabilities will require both technical, policy, and legal developments. Moreover, NATO needs to adapt and develop procedures and competencies in terms of personnel, for example through specific training and deployment models.

VI. PRELIMINARY CONCLUSIONS

66. In an Alliance of 30 member states with widely varied space programmes and capabilities, it is vitally important to develop a common understanding of the security-related challenges and opportunities of space. New actors, both state and commercial, as well as new applications and technologies will profoundly transform the space domain.

67. Creating awareness of the importance of space-based systems for the security of our nations, economies, and societies – and promoting greater understanding and appreciation for safeguarding the use of those capabilities is a crucial first step. Better space domain awareness also requires joint efforts to monitor military and civilian technologies closely so that they can be integrated into a more robust space architecture.

68. As space is becoming much more accessible, making existing and future Allied space-based assets resilient is a priority. NATO's STO network helps to leverage the scientific and technological prowess of NATO Allies (and Partners) to promote the joint exploration and development of space S&T. This is prerequisite for the development of a robust network in space.

69. Although NATO does not have a leadership role in defining space policy or priorities, it can influence those by providing a forum for information exchange on interoperability, standards, policy consultations, capability development, and S&T activities. With regard to the latter, the NATO STO serves as a pivotal platform for Allies to identify risks to space-based assets and to propose solutions to protect these assets. It can coordinate activities among Allies, and with partners, to avoid duplication of efforts. Moreover, the STO activities in space are a first, important step to increase operational capabilities of the Alliance.

70. The next step NATO needs to engage in is to define how Allies work together and how they can operate systems together. An effective way to advance critical space awareness and develop procedures and policies to share space-fed data and information could be the creation of a small initial NATO satellite capability. In any case Allies need to provide more resources to NATO to rapidly expand the Space Centre. Given the very limited number of space experts at NATO, personnel development and training need to have high priority.

71. The use of space for peaceful purposes is in the interest of all nations. As NATO Secretary General Stoltenberg has repeatedly pointed out, NATO has no intention of putting weapons in space. NATO will carry out activities in space in accordance with international law.

72. Moreover, using NATO as a forum allows member states to discuss the operationalisation of space, including necessary legal frameworks which need to be put in place. This also expands to the international arena. As nations become increasingly dependent on space-based technologies, the need to maintain space as a peaceful and cooperative environment for technological and scientific progress is ever more paramount. This task is further complicated by the proliferation of

actors operating in space, and the potential deployment or use of offensive weapons in outer space. Allies should therefore also consider using NATO as a forum to discuss, and agree, on joint initiatives aimed at updating the international legal framework. The first, crucial and necessary step for Allies, and indeed all space-faring nations, will be to discuss and agree upon standards and definitions. NATO as an organisation can act as a clearing house to conduct analysis on what space norms benefit Allied security interests and generate consensus among Allies and partners on necessary standards and definitions. A joint approach is likely to be more effective in closing existing gaps in international agreements on space.

73. This would also include strengthening relevant multilateral institutions such as the ITU which will be under pressure with the arrival of new mega-constellations and actors. In the absence of a clear international legal framework, individual countries are formulating national laws that allow their companies and citizens to exploit natural resources on celestial bodies. A possible way to help advance international space law is the "Space Law for New Space Actors" project initiated by the UN Office for Outer Space Affairs (UNOOSA). The project is designed to help countries starting to develop space programmes to draw up legislation in line with international space law.

74. This preliminary draft report will be updated for the 2021 Annual Session of the NATO Parliamentary Assembly.

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