DSC

162 DSCFC 17 E rev.1 fin
Original: English

NATO Parliamentary Assembly

DEFENCE AND SECURITY COMMITTEE

THE SPACE DOMAIN AND ALLIED DEFENCE

REPORT

Madeleine MOON (United Kingdom)
Rapporteur
Sub-Committee on Future Security and Defence Capabilities

www.nato-pa.int

8 October 2017

TABLE OF CONTENTS

I. INTRODUCTION

1. Governments and private agencies continue to hone their abilities to utilise the space domain at a rapid pace. Long-range satellite communications and data transfers weave the globe's highly complex $78 trillion economy together and allow national defence forces to train and operate. As private industry moves quickly to become a central player in the space domain, the benefits of space investment are expanding to a proliferation of actors allowing for the rapid privatisation and democratisation of the domain.

2. NATO forces depend greatly on the use of space-based systems for essential communications, navigation, tracking, and targeting capabilities, as well as weather forecasting. Space-based system coordination plays a vital role in all current NATO key pillars of defence; allowing for the effective management of conventional forces at home and abroad, nuclear deterrent systems, and the evolving ballistic missile defence system. Rapid development, use, and dependency on space, however, imply growing risks.

3. Renewed attention to kinetic anti-satellite (ASAT) capabilities as well as other forms of non-kinetic space denial capabilities such as jammers and lasers is increasingly bringing space to the forefront of security policy planning and debate. As great power strategic competition rises again in Europe and Asia-Pacific, the ability to deter and defend space assets is more important than ever due to the rising costs associated with a space denial campaign.

4. While the costs of disruption to space-based architecture are high, the arena inherently lends itself to collaboration rather than confrontation, largely due to the difficulty of verification mechanisms for space-related activities. As a result, many governments continue to push for a space code of conduct to enhance the prospects for peaceful space cooperation by reducing the opportunities for miscommunication, misperception, and misuse of the domain. To date, the Alliance has no official space policy, though it does have the recently published Allied Joint Doctrine for Air and Space Operations. Given its critical dependence on space, NATO Allies must look for a way to consolidate their approach to and understanding of defence and deterrence in space.

5. This report will examine the rapid evolution and increasing necessity of space-based systems security. It will seek to demonstrate the role space-based systems play at all levels in Alliance security. It will then highlight steps parliamentarians can take to push for an effective NATO space policy.

II. WHY A DEFENCE COMMITTEE REPORT ON SPACE?

6. The 21st century will prove to be the race for space. Space-based systems are the key enablers of national and international infrastructures of today and tomorrow. The current speed of technological developments indicates the pace of diffusion of technology with some form of dependence on space-related hardware will only accelerate. Accordingly, outer space is becoming increasingly congested, contested, and competitive.

7. The **benefits** to investing in space-based assets are clear: Space-based infrastructure provides data for global positioning, navigation and timing; enables communication systems via large-scale data relay; guarantees the accuracy and efficacy of global financial transactions and trade; supports a wide range of private and public scientific research; as well as oversees environmental monitoring and forecasting. As such, satellite constellations are vital for the efficient functioning of modern aviation, maritime navigation, and ground transportation (both civil and military).

8. As dependence on space-based infrastructures grows, the **costs** associated with the disruption, denial, or even destruction of such assets will have increasingly distributed and devastating effects. In military operational terms, space-based assets allow for critical manoeuvre of forces, strategic and situational awareness, and precision-strike capabilities. The loss of space assets would significantly hamper any modern military's ability to respond to not only defend vital assets and populations, but also to respond quickly and efficiently in a crisis.

9. As a result, understanding the evolution of the space security environment is critical for the NATO PA Defence and Security Committee (DSC). As the scale of impact of space denial scenarios grows, it is clear the disruption, denial, or destruction of any Ally's space assets will have an Alliance-wide resonant effect. Just as NATO forces require freedom of action in the land, air, and sea of their territories, so do they require the freedom from interference with their space-based assets.

A. MILITARY USES OF SPACE

10. Throughout the Cold War the United States and the Soviet Union utilised a range of satellites in conjunction with their strategic nuclear forces: to both link together their respective command and control systems and to monitor and track the other side's movements. The first Gulf War in 1991 put the benefits of space-enabled systems on dramatic display; even television audiences could witness the tracking and elimination of Iraqi military assets by US precision-guided weaponry. In the ensuing quarter of a century, the centrality of space-based assets to modern militaries is undeniable.

11. Today, space-based assets are essential strategic enablers of modern forces. Since the advent of net-centric warfare during the US invasion of Afghanistan in 2001, NATO military forces depend on satellite services to link and integrate information into land, air, and sea platforms. Effective and real-time inter-services integration enhances decision-making and facilitates navigation. As a result, space-based assets are serious force multipliers for today's militaries.

B. SPACE PROLIFERATION: MANY NEW ACTORS

12. Technological advances over the last two decades have greatly expanded the breadth and depth of possibilities for space access. As a result, a proliferation of actors hoping to have a stake in space is changing the nature of the three principal geocentric orbits. The flood of new actors is making these orbits increasingly congested and dirty.

13. Currently almost every country either owns a satellite or has a stake in space. There are approximately 1,100 operational satellites in orbit around the Earth, causing some orbital planes to be severely overcrowded. The recent advent of new, dynamic commercial actors has renewed public interest and ignited a second space race (UK Parliament Briefings). Companies such as SpaceX and Virgin Galactic are providing competition between service providers to build, launch, and operate new space systems: the outcome being a steady decline in the cost barrier to space entry and the proliferation of new systems operators (Insinna, 2016).

14. As entry costs continue to fall, the space domain is becoming more easily and more widely accessible, not only to the military and the commercial sector, but also to ordinary citizens due to the development of a range of new, increasingly smaller satellites from mini to micro, and even nano, pico, and femto-satellites – which range from over 500kg to less than 100g. While providing many of the capabilities of current satellites, they will be cheaper to produce and easier to launch, but harder to track and regulate (Lewis and Livingstone, 2016).

15. The scope of the challenge of the growth of satellites in space will only continue to grow because of this relative democratisation of space entry and use. In 2016, the Federal Communications Commission of the United States alone, for example, had received over

8,700 filings for launches of Non-Geosynchronous Orbit (NGSO) communications satellites (Messier, 2016). If these projects are completed, along with the thousands of other projects planned by nations around the globe, Low Earth Orbit congestion will pose a significant regulation challenge.

III. GREAT AND RISING POWERS IN SPACE

16. New actors are changing the geostrategic space environment and will shape space policies in the 21st century. The United States and Russia are still the world's leading space powers; other countries, however, are steadily advancing their space capabilities, particularly China, which has developed successful launch capabilities and a multifaceted space programme over the last decade (Robinson and Romancov, 2014).

17. The United States is still widely considered the world leader in space. It has the largest space budget, a vast network of military and commercial satellites, and a burgeoning commercial space sector. The rise of the commercial sector's involvement in space has spurred on a second space race, with companies such as SpaceX and Blue Origin racing to see who can get to Mars first (Briefings UK Parliament). European space and defence sector giant Airbus Defence and Space is working on the ExoMars rover to explore the surface of that planet (Briefings Airbus Defence and Space).

18. As noted above, the rapid pace of commercial development of space launch, control, and satellite assets is changing the nature of space access and exploration. A clear benefit to the United States's growing commercial space sector is the competition's cost reduction effect and the added resiliency to the US military's vital assets in space. The US military has used Boeing-Lockheed Martin's United Launch Alliance to launch its payloads, but the recent certification of SpaceX's Falcon 9 rocket to launch US national security payloads is adding price-lowering competition to the market. In addition, Blue Origin and Virgin Galactic are competing to supply the US Space Agency with a reusable spaceplane for its Defense Advanced Research Projects Agency (DARPA) (Insinna, 2016). The continued growth of US involvement in space at both the governmental and private sector levels has allowed it to remain the clear leader in space.

19. Second to the US presence in space is Russia. Moscow owns a massive constellation of military satellites. Most provide the Russian military with globe-spanning communications capabilities (Luzin, 2016). In 2014, the Russian government announced it would increase funding for the Russian Federal Space Agency to modernise and expand infrastructure and capabilities by 2020 (World Economic Forum, 2016). However, international sanctions following Russia's annexation of Crimea have crippled the Russian space industry by depriving it of the advanced components needed to build many new communications and navigation satellites (Luzin, 2016).

20. Despite recent tensions and growing strategic competition in Europe and the Middle East, Russia and the United States maintain relatively strong levels of space cooperation. The long tradition of US-Russia space cooperation, dating back to the earliest era in space exploration in the 1950s and 60s, continues today with the countries' use of the International Space Station (ISS). The ISS is the cooperative project supported by the United States, Canada, Europe, and Russia; the ebb and flows of the US Space Agency has made the US dependent at times on Russia's shuttle capacity, and the United States currently depends on the Russian-made RD-180 engines for its Atlas rockets, which launch US payloads into space.

21. After years of investment and strategy, China is on its way to becoming a space superpower. While China's estimated space budget is still dwarfed by the US, in 2016 it had 19 successful space launches — the second-highest number for the year behind Russia's 26, and ahead of America's 18. China has put up sophisticated communications and intelligence satellites, offered

cheap launch services to other nations, and launched manned mission initiatives. In addition, China developed a “quantum satellite” designed to transmit quantum-encrypted information from space, which is theoretically hack-proof and ensures any attempt to intercept or tamper with the transmission would alert both sender and receiver (Dillow et al., 2016).

22. A full third of global satellites today are European: yet demand from European Union member states continues to grow, outpacing the amount of investment any single member state can handle on its own. As such, in recognition of its increasing reliance on space-based systems as well as the proliferation of threats to these systems, the EU has invested in three space programmes: the European global navigation satellite systems (Galileo), the European Geostationary Navigation Overlay Service (EGNOS) – and the Earth observation programme (Copernicus). The protection of space assets is vital for the implementation of the EU’s security and defence strategy and is another key element of the EU’s overall space policy. At the multilateral level, the EU is seeking to further advance space security by negotiating an international code of conduct (Robinson and Romancov, 2014). The 2016 Global Strategy affirms the EU’s commitment to strengthen the security of its space-based services and focus on establishing principles for responsible space behaviour. In addition, the European Commission recently adopted a comprehensive Space Strategy for Europe.

Civil-military ambiguity and dependence in the 21st century space environment

23. A key challenge to regulating and monitoring the use of space is the growing indistinguishable nature between civilian and military applications of space-based assets. Currently, most space programmes were at least initiated by the military – about 40% of all spacecraft in orbit are active military satellites. As such, space is a highly-militarised domain by the virtue that almost every satellite provides what could potentially be dual-use services (Haas, 2015).

24. As such, the growing dependence on space-based assets presents an increasing number of vulnerabilities with potentially very widespread consequences. The disruption, denial, or even destruction of space-based architecture will not only affect civilian sphere functioning, but also the effectiveness of any potential military response. As a result, guaranteed future access to and the functioning of space-based assets is a key concern for policy planners and implementers.

25. As more actors can launch and operate space-based systems there will be inherently fewer orbital paths and communication frequencies available. Access to space orbits is not just limited to launch systems or the ability to gain access to communication frequencies, but it is also increasingly complicated by the phenomenon of space debris.

IV. THREATS AND VULNERABILITIES OF SPACE-BASED ASSETS: DEBRIS AND DENIAL

A. DEBRIS

26. Space debris, resulting from collisions, defunct satellites, and decades of ill-regulated activities in space, poses a serious problem to space access and use. Today there are nearly 500,000 pieces of human-generated space debris in orbit, of which approximately 23,000 are pieces of junk larger than 10 centimetres, causing a dirty and increasingly high-risk space domain (Lewis, 2016).

27. Rising levels of space debris raise the risk of damage to critical infrastructure. For example, satellite operators are forced to perform almost routine manoeuvres to change their satellite’s trajectory to avoid a collision with debris. For example, the International Space Station (ISS) was forced to take emergency evasive measures in 2014 to get out of the pathway of a 14cm piece of debris hurdling toward it – the near miss avoided a potentially very costly collision (Pigoni, 2015).

The costs of space debris colliding with satellites vary from the small and repairable to total incapacitation.

28. On 10 February 2009, a Russian satellite collided with a US satellite 800 kilometres above Siberia, leaving a cloud of debris consisting of approximately 500-600 pieces (CNN, 2009). This was the first instance of two intact space vehicles accidentally running into one another.

29. For many space missions, the risk of losing a mission because of the impact of orbital debris is the third-highest risk after the dangers associated with launch and deployment (ESA, 2014). Orbital debris poses the greatest danger to satellites in low Earth orbit, where they can reach a speed of over 27,400km/h. Their orbits vary in direction, orbital plane and speed, which means the threat of collisions is ever-present (Adushkin et al., 2016).

30. Even a miniscule piece of debris is a serious hazard for satellites, spacecraft, and spacewalking astronauts. While the impact of small space debris does not necessarily cause serious structural damage, chips, craters, holes, scratches, erosion and small cracks created by them can gradually degrade the surface of a spacecraft, thereby making it more vulnerable to the external environment and later impacts. But very small debris can also potentially destroy satellites, as was the case in 2013, when a small Russian satellite known as BLITS collided with debris weighing less than 0.08g, splitting the satellite into two trackable fragments (Adushkin et al., 2016).

31. In the past, there have been repeated military spacecraft failures, the causes of which could not be determined. There are usually two explanations, one is a collision with space debris, and the other is hostile interference. There is also the troublesome phenomenon of the wilful creation of space debris. As will be discussed further in the section below on anti-satellite weapons, China shot down a defunct weather satellite in 2007. The incident left a large cloud of debris in a heavily used earth orbit and was widely condemned internationally (Zissis, 2007). The action drew attention to not only the need for more active attention to space debris removal, but also to the actions that may create such debris irresponsibly.

B. DENIAL: SPACE DEFENCE AND WARFARE: WEAPONRY IN SPACE AND ANTI-SPACE WEAPONRY

32. The use of outer space for active military purposes with the intent to destroy or disable a competitor's assets exists in many forms and is continuously developing. As such, space-enabled or based weapons can take the form of Earth-to-Space, Space-to-Earth and Space-to-Space. Earth-to-Space capabilities denote ground-based or ground-air launched anti-satellite weapons (ASAT) or antiballistic missile (ABM) systems, ground-based lasers, used for tracking and blinding, and kinetic kill vehicles. Space-to-Earth capabilities do not currently exist, nor do Space-to-Space, however, any satellite can, at least theoretically, be converted into such a weapon (Marboe, 2010).

33. The first decade of the 21st century witnessed the acknowledgment of the vital nature space-based assets play in modern armed forces. In response to Chinese space programme advances and aggressive manoeuvres, the US Air Force published a Counterspace Operations Doctrine Document in 2004, which noted the critical nature of counterspace operations to successful modern warfare: “These operations may be utilised throughout the spectrum of conflict and may achieve a variety of effects from temporary denial to complete destruction of the adversary's space capabilities.” (USAF, 2004). The 2006 US Space policy declared “freedom of action in space is as important to the United States as air power and sea power” (US National Space Policy, 2006).

34. For many years, the United States controlled the only global satellite navigation system, the Global Positioning System (GPS), which it has demonstrated as an essential force multiplier for its armed forces in operations from the first Gulf War to the present day. Over the past decade, more

nations developed their own independent satellite navigation systems accordingly, least they expose their modern forces to the control of the US GPS system. There are three other global navigation satellite systems currently in operation (or in the final implementation phase) in addition to GPS: Russia's Global Navigation Satellite System (GLONASS), while the European Space Agency's Galileo system only recently started limited operation and is projected to provide global coverage by 2020. China's Beidou system also aims for worldwide coverage by 2020 (Wilson, 2017).

35. Both China and Russia have also developed modern space warfare programmes over the last decade. The Chinese programme is well funded and, as tests have shown, diverse in its capabilities. China's investments have been particularly directed towards acquiring a range of ASAT weaponry.

The return of space weaponry

ASAT Weapons

36. The most concerning recent trend is the development and testing of new ASAT capabilities by a proliferation of countries, adding yet another dynamic to the complexity of the current international security environment in an era of renewed geopolitical rivalry in Europe and Asia. ASAT weapons are designed to incapacitate, damage or destroy satellites for strategic military purposes. China, Russia and the United States all possess these capabilities (Leopold, 2016). India's recent development of a layered missile defence system indicates it is likely to have the capability (at least in the near-term) of direct-ascent ASAT capabilities (Haas, 2015). Japan, Israel, and France can also be considered turn-key ASAT players in today's international space defence environment, as they are currently only barred from entry by the political will to do so, rather than by technological capabilities (Haas, 2015).

37. In 2007, China shot down one of its old weather satellites in an ASAT test in low-Earth orbit. A ground-based, medium-range ballistic missile intercepted the FY-1C polar orbit satellite at an altitude of 865km. This incident demonstrated China's ability to disable and destroy the space assets of other countries. China is determined to have a deterrence and defence policy in space in parallel to the United States. The test produced tremendous amounts of space debris and elicited widespread international condemnation.

38. In 2008, the United States took out one of its own defunct military satellites at an altitude of 240km, shortly before it re-entered the atmosphere. The satellite was intercepted by an SM-3 missile launched from an Aegis sea-based missile defence system-equipped warship. The US government noted the destruction of the malfunctioning satellite was due to concerns the leftover hydrazine fuel aboard the satellite may survive re-entry and pose a threat to populations on the earth's surface. Due to the lower altitude of the satellite, debris from the satellite's destruction was shorter lived and largely burned up when entering the earth's atmosphere (Grego, 2011; Billings, 2015).

39. China has been particularly active since its initial 2007 ASAT test, with four additional tests from 2010 to 2014 of its direct-ascent SC-19 missile system (Haas, 2015). In addition to honing its direct-ascent ASAT capabilities, China is also likely developing co-orbital attack capabilities. Co-orbital armed satellites could have capabilities as complex as kinetic energy weapons or lasers to a grappling-capable robotic arm (Chow, 2016).

40. In response to Chinese ASAT testing, Russia has been developing and testing its own ASAT capabilities, and may have conducted an ASAT test as recently as 2016. A lot of secrecy surrounds these tests and the exact parameters are often unclear, for example, they could be part of a missile defence test (Leopold, 2016). In addition, suspicions of a Russian co-orbital space

weapons system were aroused by the launch in May 2014 of Object 2014-28E, which engaged in manoeuvres consistent with the testing of a co-orbital weapon capability (SpaceNews, 2015).

41. The United States is currently testing unmanned, manoeuvrable space vehicles. The X-37B, for example, is an unmanned, reusable spaceplane currently in its fourth mission, which was launched in May 2015. Most of the orbital activities of the X-37B are secret, though it is speculated the spaceplane is at least being used for intelligence gathering on space-based activities. The development of manoeuvrable, unmanned spacecraft is pushing the development of spacecraft into a whole new generation.

42. Non-kinetic means, for example, cyber hacking, laser dazzling, or the emission of electromagnetic pulses, can also be used to interrupt or disable rather than destroy satellites. While considered less damaging to the space environment and potentially less traceable, many forms of non-kinetic attacks are very difficult to attribute, stirring fears of quick escalation and questions of proportionality of response in a near future conflict where space-assets would likely be involved. Russia and China are already heavily invested in this domain, ultimately seeking the means to disrupt US hegemony in space (Pellegrino, Stang, 2016).

Non-kinetic means: cyber-attacks, jamming, spoofing, and dazzling

43. Because of the resulting debris, which can have a mutually destabilising impact, destroying satellites with kinetic force is not an ideal method for damaging satellite capability. Non-destructive and covert methods, such as **cyber-attacks**, jamming, spoofing, or dazzling are alternative means to disrupt and deny access to satellite capabilities. In fact, space warfare is more likely to involve the denial of vital information flows supporting command and control of an enemy’s forces, rather than the exoatmospheric destruction of its space-based assets.

44. By attacking a satellite’s control system, or mission package, an actor could take over control of the satellite, shut it down, change its orbit, put it on collision course with other space objects, or destroy its solar panels by exposing it to damaging levels of radiation. In addition, a satellite’s global network of ground stations might be subject to attack with potential serious consequences.

45. Rather than ASAT weaponry, cyber-attacks can instead be used to take control of a satellite or the whole communication network, including the ground stations (Suzuki, 2016). As implied above, cybersecurity and space security are inherently linked. As satellite technologies and space assets are sourced from a broad international supply base they require regular security upgrades to their software systems via remote, distributed connections, which make them vulnerable to cyber-attacks (Livingstone and Lewis, 2016).

46. Due to the nature of their missions, the military pays more attention than commercial operators to the defence of their space systems. As a result, commercial satellite telecommunications are more often than not less resilient than military ones. Still, as commercial satellites are increasingly co-opted or leased for military communications or other civilian mission-critical functions such as air traffic control, train rail traffic, electrical grid management, and other critical civilian infrastructure, commercial satellites can be considered high-value soft targets for adversaries (Suzuki, 2016). In addition, radio frequencies for satellite communications are limited and the increase in the number of commercial and private satellites puts pressure on scarce resources. Some operators are therefore using less secure frequencies, which are easier to hack (Suzuki, 2016).

47. As such, it is clear a range of cyber threats exists against space-based systems. The large amount of data transmitted through satellites presents an opportunity for adversaries to corrupt accuracy and reliability with a relatively low probability of discovery. Examples could be: States seeking a military advantage via the theft of intellectual property; organised criminal elements with sufficient resources seeking financial gain; amateur or professional hackers showing off their skills;

or even capable terrorist groups wishing to disrupt services provided by space-based assets or inflict damage on the space environment. Of course, any combination of these threats is also imaginable depending on the adversaries's assets and capabilities (Livingstone and Lewis, 2016).

48. Satellite feeds can also be **jammed** via the intentional interference in signal transmission and reception through the deliberate use of radio noise and electromagnetic signals. In particular, global navigation satellite system (GNSS) signals are vulnerable to jamming attacks because civil applications have not always been designed with security in mind. Often, jamming of GPS signals or other radio telecommunications can even be carried out using simple, commercially-available tools (Suzuki, 2016). By way of example, North Korea has carried out a series of coordinated jamming attacks against the Republic of Korea, which affected GNSS signals in the Seoul area and led to the degradation of infrastructure such as mobile phone networks (Livingstone and Lewis, 2016).

49. **Spoofing** allows an adversary to manipulate the information about the location, position and condition of a satellite. Spoofed data is relatively hard to detect. If successful, the spoofing attack could damage critical infrastructure, such as the national power grid, by introducing false timing signals, or cause economic damage by targeting trading systems in the financial services sector (Livingstone and Lewis, 2016). Spoofing could also confuse the coordination of command and control of a nation's armed forces in a time of crisis.

50. **Dazzling** is a way of blinding a satellite with a laser. If the laser is powerful enough, it can even burn satellite sensors and disable them (Airbus Space briefing). Docking and rendez-vous methods are alternative ways of damaging a satellite by using electronic or kinetic force. While docking would have the benefit of not producing space debris, it would expose the attacker to detection. To mitigate the potential consequences of a docking attack, the United States and its allies are developing a programme of Space Situational Awareness, which monitors any objects approaching existing space assets (Suzuki, 2016).

51. The trend toward the development of increasingly disruptive and non-attributable non-kinetic means puts the long-term stability of the space environment at risk. Increasing dependence on space-based architecture coupled with hybrid and asymmetrical disruption tactics will create a space environment ripe for rapid escalation and instability.

V. NATO AND THE SPACE DOMAIN

A. WHY SPACE MATTERS FOR NATO

52. As is clear from above, improvements in space technology drive the development of advanced military systems; they are important force multipliers when integrated into joint operations. Therefore, a clear and mutual understanding of how military, civil, commercial, national and multinational space capabilities contribute to military operations in order to achieve Alliance security objectives is essential. Increased awareness about the potential for adversaries seeking to exploit their own access to space for military purposes to the detriment of Allied assets and capabilities is vitally important (NATO Allied Joint Doctrine for Air and Space Operations, 2016).

53. At the strategic level, NATO is well positioned to strengthen deterrence in space. NATO's collective defence and economic prosperity rely on space-based infrastructure, and an attack on the space assets of one Ally would impact the security of all. As such, NATO needs a whole-of-alliance approach to protect its interests in space to enhance resilience and deter any threat to its space-based capabilities. At the operational level, space needs to be incorporated in NATO planning and command structures. At the tactical level, relevant training should be provided to personnel and NATO exercises should reflect space warfare scenarios wherein Allied space-assets are denied or temporarily disabled (Schulte, 2012).

54. Today's modern operational environment relies heavily on guaranteed access to space-based architecture – Allied forces' daily training, and maintenance and execution of ongoing operations are all made capable by a vast network of shared space assets. Allied space capabilities provide a number of products and services, including: global, strategic and intra-theatre satellite communications; positioning, navigation and timing services; terrestrial and space environmental monitoring; real-time space, geological, meteorological and oceanographic situational awareness; advanced intelligence, surveillance and reconnaissance capabilities; as well as NATO Shared Early Warning and transponder tracking such as Friendly Force tracking and maritime tracking (NATO Allied Joint Doctrine for Air and Space Operations, 2016).

55. NATO's most advanced military systems are dependent upon space-based assets in order to execute missions successfully, particularly Airborne Warning and Control Systems (AWACs), the Alliance's Ballistic Missile Defence programme, and the Alliance Ground Surveillance System (AGS), set to become operational in 2017. The AGS system consists of air, ground and support segments and will perform all-weather and persistent terrestrial and maritime surveillance in near real-time, contributing to a range of missions[1], providing military commanders with a comprehensive picture of the situation on the ground (GovSat, 2016).

56. Space capabilities contributing to the Alliance's mission planning and execution at all levels of warfare come from government, military, civilian and commercial providers. NATO does not currently own any orbit spacecraft. It does, however, own and operate several terrestrial elements (e.g. SATCOM anchor stations and terminals). The United States provides the majority of space support NATO currently uses. However, in 2013, there were approximately 39 'military or government' satellites owned by NATO Member States other than the US providing communication, imagery and automatic identification system detection.

57. The primary European NATO Member States who have space capabilities are France, the United Kingdom, Germany, and Italy: The availability of a space capability in support of NATO operations, however, is determined exclusively by the nation or company that owns the satellite. It should be noted that France, Germany, Italy, and the United Kingdom have advanced and capable observation systems supporting their conventional forces today: they are the Pléiades; SAR-Lupe (radar) and Helios 2 (optical, infrared); COSMO-SkyMed; and Skynet 5 respectively.

58. Currently the SATCOM Post-2000 programme provides the Alliance with satellite communications capabilities. The British, French, and Italian governments work in concert to provide the Alliance with advanced SATCOM capabilities. Under the signed Memorandum of Understanding between the three governments, the Alliance is allowed access to the French SYRACUSE 3, the Italian SICRAL 1 and 1Bis, and the British Skynet 4 and 5 military networks (Briefings NATO officials).

59. The current contract negotiated by the consortium is for a 15-year period, scheduled to end in 2019. The NATO Communications and Information Systems Services Agency (NCSA) needs a contract upgrade, however, as the Alliance's current satellite bandwidth requirements have outpaced what is available under the current contract. Among other deficiencies, the current arrangement does not include EHF-/Ka-band capabilities, which will be critical to future Alliance SATCOM needs (De Selding, 2016).

60. To contract the necessary upgrade of its SATCOM capacity, NATO can look to eight Allies currently developing or in possession of the satellite capacity necessary for military communications; France, Germany, Italy, Luxembourg, Spain, Turkey, the United Kingdom, and the United States (De Selding, 2016). In November 2016, NATO awarded a contract to support the operational phase of the above mentioned AGS system to Luxembourg's GovSat, an affiliate of

---

[1] Such missions range from the protection of forces and civilians on the ground, border control and maritime security, and counterterrorism operations to crisis management and humanitarian assistance.

satellite operator SES. Launching in 2017, the GovSat-1 satellite will provide an end-to-end service including the delivery of satellite capacity in commercial Ku-band and sensor data communications between the NATO Global Hawk UAVs and ground segment over the AGS operational area. With this contract, Luxembourg Authorities and the NCI Agency as procurement executive agent acquire and manage these services.

61. While the centrality of space is also recognised in NATO's Strategic Concept, which mentions technological trends that could potentially impede access to space (NATO, 2010), NATO has not issued any policy or military strategy for space operations. So far, only the Allied Joint Doctrine for Air and Space Operations provides some guidelines on the role of space support in operational planning. In 2013, NATO also released the NATO Space Handbook, which explains space fundamentals for commanders and their staff.

B. NATO AND THE SPACE DOMAIN: A WAY FORWARD

62. NATO should renew its focus on space cooperation. Every NATO country relies on safe and reliable access to space assets for both commerce and military operations. However, NATO doctrine and planning have lagged and the Alliance has not issued any military strategy or policy for space operations. For example, the Joint Airpower Competence Centre (JAPCC) has proposed a narrow framework for a NATO Space Policy concentrating on the employment, coordination, and defence of space capabilities used to support NATO operations and core business (JAPCC, 2012). Any NATO policy should furthermore be coherent with existing policies, such as those of the EU and the US. The JAPCC proposes five guiding principles:

- Alliance collective defence and security is applicable to space capabilities supporting NATO operations;
- International standards and norms contribute to the preservation of space capabilities for all;
- The coordination of nationally-owned and controlled space capabilities will result in improved operational effectiveness and efficiency for the Alliance and nations;
- Space capabilities, along with technology in general, are rapidly improving, resulting in the levelling of previously stark disparities; and,
- Coordination and collective defence of space capabilities employed on behalf of NATO is an active and continuously evolving process.

63. Operations up to the present have taken place within a relatively benign space environment. NATO must prepare for future scenarios, when its access to space is challenged and satellites are compromised, for example by jamming or cyber-attacks. Alliance doctrine and planning should reflect the reality that NATO is increasingly enabled by space, and thus heavily affected by the challenges associated with this domain. A unified approach to protecting the Alliance's interests in space and enhancing resilience of allied space capabilities is needed (Schulte, 2012).

C. A CODE OF CONDUCT FOR SPACE?

64. The proliferation of new actors with access to space and the continued advancement of various types of technology to exploit space orbits are forcing governments to consider upgrading the current 'rules' for space use. When placed in the current context of growing geopolitical competition between the biggest space powers, the urgency for a renewed focus on the establishment of a code of conduct for space is clear. The current international legal framework for space exploitation relies on a series of treaties and conventions dating back to the 1960s and 70s, ranging from the 1963 treaty banning nuclear weapons testing in outer space to the 1975 Convention on the Registration of Objects Launched into Outer Space.

65. The goal of the peaceful use of outer space, announced in the Preamble of the 1967 Outer Space Treaty, is challenged daily. While the military and economic dominance of the US is decreasing and the conduct of international relations is affected by the geopolitical tensions with

China in the Asia-Pacific and with Russia in Eurasia, rivalries are spilling over into the space domain (Haas, 2015). So far there has never been a direct military clash between hostile actors in outer space, and the development and use of weapons for military operations in and from space is still far costlier than forces and weapons deployed on land, at sea, or in the air (Arbatov and Dvorkin, 2011).

66. It is difficult to apply traditional approaches to newly created instruments of war or rules on disarmament and non-use of force to outer space, due to its relative novelty and unique characteristics as a military domain, as well as the absence of binding rules. There are currently two principal efforts to establish new conduct measures and arms control for space: the UN Committee on the Peaceful Uses of Outer Space (UNCOPUOS) to advance international space law, and the Conference on Disarmament is working on the Prevention of an Arms Race in Outer Space (PAROS) (Pigoni, 2015).

67. Attempts to establish legal provisions to prevent an arms race in space, however, have been unsuccessful. A failed draft treaty proposed by Russia and China, for example, which aimed to expand the prohibition of Weapons of Mass Destruction in space to include “any weapons”, was rejected by the United States due to the fact that many forms of future weapons technology may fall under the parameters of the treaty – further, the exemptions of Chinese ASAT testing from the treaty further confirmed US scepticism about the bone fides of the treaty, as it failed to recognise and condemn Chinese and Russian actions undermining the very spirit and principle of the treaty itself. Efforts to push forward a Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force Against Outer Space Objects (PPWT) will likely continue to fail for the principal reason they do not address earth-based weapons threatening satellites (Bowen, 2017).

68. Because of this deadlock, efforts have focused on negotiating a code of conduct, which would be less formal than a treaty. It is furthermore essential to develop a shared understanding of potential space risks and pursue strategic interaction while continuing efforts to update the existing rules of international law governing space activities.

D. THE PREVENTION, MITIGATION AND REMEDIATION OF SPACE DEBRIS – AN OPPORTUNITY FOR ALLIED ACTION

69. Without efforts to clean up the space environment, researchers have warned about the Kessler syndrome, whereby pieces of debris keep crashing into one another, resulting in a cascade reaction creating ever-more and ever-smaller debris, thus fatally contaminating the orbital environment (Suzuki, 2016).

70. Space agencies around the world are treating orbital debris as a serious problem and are currently devising policies and plans to mitigate existing space junk and limit future debris. The Inter-Agency Space Debris Coordination Committee (IADC) is the primary organisation involved in the development of guidelines. It represents 13 national space agencies and, while it is not a regulatory body, the IADC provides consensus guidelines and supporting technical analyses and advises UNCOPUOS on space debris issues. In 2007, the UNCOPUOS adopted the Space Debris Mitigation Guidelines (Sorge and Vojtek, 2015).

71. Through prevention, mitigation and remediation, nations are trying to slow and eventually reverse the trend of increasing quantities of space junk. Preventions are mechanisms to ensure that all future launch vehicles and satellites are equipped with devices that allow them to be disposed of at the end of their life cycles. The technologies for such devices are still in development, but ideas include balloons, tethers, or solar sails (Rossettini, 2015).

72. Mitigation is the process of reducing the likelihood a space object will cause more debris. It involves the tracking of all space debris to try to limit the number of collisions, as well as the

passivation of rocket bodies and decommissioned spacecraft (Rossettini, 2015). Mitigation guidelines are not binding and not all the spacefaring nations have implemented them as mandatory requirements into their space programmes (Listner, 2012).

73. Remediation techniques include the development of technologies for active debris removal (ADR) missions, aimed at removing existing space junk. Suggestions include missions capable of grabbing a defunct satellite to remove it from orbit. Another alternative is a refurbishing mission, where a robotic spacecraft services and refuels a satellite near the end of its life cycle (Rossettini, 2015).

74. However, methods of remediation or removal of existing orbital debris are still in their infancy and face technical, financial, and political hurdles. One issue surrounding the clean-up of orbital debris is related to Article VIII of the Outer Space Treaty, which states that space objects continue to belong to the country that launched them (Listner, 2012). For example, it would be problematic for a European ADR vehicle to dispose of a nation’s satellite without that nation’s permission.

75. In addition, according to some experts, about 10 big satellites would have to be removed per year to reduce the risk of collisions significantly. Given the fact that over 100 satellites are launched into space every year, removing 10 does not constitute a significant contribution (Rossettini, 2015). In addition, while countries have developed tools to clean up debris, it would be difficult for satellite operators to distinguish between those tools and small satellites (Lewis, 2016).

76. The IADC is currently considering proposals for the design and operation of large Low Earth Orbit constellations (from large satellites to smaller ‘cube’ satellites as well as for the active removal of space debris. These recommendations are expected to supplement existing IADC guidelines, which currently outline mitigation measures to address current and future operational satellites in orbit. Such measures currently include a range of ideas from refuelling vehicles to onboard repair robots to embedded thrusters designed to take the satellites out of orbit at the end of their life cycles (Roesler, 2017; Pultarova, 2017). Maintenance and debris removal systems are clearly becoming essential elements to new satellite architectures.

77. Due to the demands of the new orbit environments, governments are thinking more creatively about which agencies are responsible for tracking space vehicles and debris. The United States, for example, is currently considering shifting such responsibility from the Air Force to the Federal Aviation Administration. Such a division of labour would free a military institution from many of the decidedly non-military tasks associated with tracking objects in space, from messaging and notifications about possible conjunctions to impending collisions (Everstine, 2017).

VI. CONCLUSIONS

78. The renewed race for space is a clear benefit for humanity in many ways. The ability to transmit a broad spectrum of information and imaging to and from space allows for the efficient functioning of all modern economies and armed forces. Increasing dependence on space-based assets, however, is increasingly exposing every actor benefiting from them to a parallel risk.

79. The potential costs at the civil and military level of the denial, disruption, or destruction of space-based assets can run from a mild inconvenience to a vital security threat – from economic paralysis, critical infrastructure disruption, to the inability to coordinate and operate modern forces in a crisis. Growing kinetic capabilities, such as ASAT weaponry, to non-kinetic capabilities, such as hacking, jamming, or dazzling, are broadening the spectrum of threats to Allies' space-based infrastructure.

80. In the absence of an international legal framework allowing for the realities of today's space environment raises the chances for potential conflict. The continued privatisation and democratisation of space will only further compound the problem. Allied access to space and the freedom from denial of space-based assets is crucial to 21st-century defence and deterrence.

81. Continued efforts to mitigate key problems challenging access to space are, therefore, crucial. Allied parliaments can do their part to push for a code of conduct for space agreeable to all actors. The ability to translate a working code of conduct into a set of modern treaties and conventions establishing a viable international legal framework for space exploitation could more easily result from this. To get there, Allied parliaments can encourage international efforts advocating the peaceful use of space with those seeking to disarm the arena to work together to find a common platform.

82. More immediately, member state parliaments can push for the conclusion of the contract for the provision of satellite bandwidth for advanced SATCOM capabilities for the NATO Alliance. Currently, a consortium between France, Italy, the United Kingdom, and the United States has been created to respond to NATO satellite bandwidth requirements from 2019 to 2034. NATO should move quickly to award the contract and guarantee the seamless provision of the vital bandwidth needed for Allied operations, exercises, and other core day-to-day functioning.

83. Parliamentarians can also raise the issues of funding more research into space debris removal programmes. As more governments and private sector actors seek to launch space assets in orbit, there will be more and more competition for access to orbit paths and transmitting frequencies: effective space debris removal programmes can mitigate some of this pressure.

BIBLIOGRAPHY

Adushkin, Vitaly, Veniaminov, Stanislav, Kozlov, Stanislav, Silnikov, Mikhail, “Orbital missions safety – A survey of kinetic hazards”, Acta Astronautica, Issue 126, 2016, 510-516

Arbatov, Alexei, Dvorkin, Vladimir, Outer Space; Weapons, Diplomacy and Security, Brookings Institution, 2011

Billings, Lee, “War in Space May Be Closer Than Ever”, The Scientific American, 10 August 2015, https://www.scientificamerican.com/article/war-in-space-may-be-closer-than-ever/

Bowen, Bleddyn , Briefing Defence Select Committee, UK Parliament, 8 March 2017

Chow, Brian, “China’s New Space Threat and the Justification of US Pre-emptive Self-defense”, The Space Review, 18 January 2016.

CNN, “Russian, U.S. satellites collide in space”, 12 February 2009, http://edition.cnn.com/2009/TECH/02/12/us.russia.satellite.crash/index.html?_s=PM:TECH

De Selding, Peter. B, “NATO behind schedule on satellite capacity order, now hopes for 2017 decision”, SpaceNews, 11 November 2016, http://spacenews.com/nato-behing-schedule-on-satellite-capacity-order-now-hopes-for-2017-decision/

Dillow, Clay, Lin, Jeffrey, Singer, P.W., “China’s Race to Space Domination: To gain an edge here on Earth, China is pushing ahead in space,” Popular Science, 20 September 2016, http://www.popsci.com/chinas-race-to-space-domination

ESA, “Space Surveillance and Tracking – SST Segment”, 11 February 2014, http://www.esa.int/Our_Activities/Operations/Space_Situational_Awareness/Space_Surveillance_and_Tracking_-_SST_Segment

Everstine, Brian, ÜSAF, FAA in Talks to Hand Off Tracking of Space Traffic” Air Force Magazine, 17 April 2017

GovSat, “Press Release: NATO AGS Contract Awarded to GovSat”, 8 November 2016, http://www.govsat.lu/news/press-release-nato-ags-contract-awarded-to-govsat-2016-11-08

Grego, Laura, “The Anti-Satellite Capability of the Phased Adaptive Approach Missile Defense System” Federation of American Scientists, Public Interest Report (winter 2011). https://fas.org/pubs/pir/2011winter/2011Winter-Anti-Satellite.pdf

Haas, Michael, “Vulnerable frontier: militarized competition in outer space”, Strategic Trends 2015: Key Developments in Global Affairs, 2015, http://www.css.ethz.ch/content/dam/ethz/special-interest/gess/cis/center-for-securities-studies/pdfs/Strategic-Trends-2015-Vulnerable-Frontier.pdf

Iannotta, Becky, Malik, Tariq, “U.S. Satellite Destroyed in Space Collision”, Space.com, 11 February 2009, http://www.space.com/5542-satellite-destroyed-space-collision.html

Insinna, Valerie, “30 Years: Commercial Space – A Second Space Race Reignited”, DefenseNews, October 25, 2016.

Joint Airpower Competence Centre, Filling the Vacuum: A Framework for a NATO Space Policy, June 2012, https://www.japcc.org/portfolio/filling-the-vacuum-a-framework-for-a-nato-space-policy/

Leopold, George, “Russia Might Have Just Tested the Ultimate Weapon: Satellite-Killer Missiles”, The National Interest, 23 December 2016, http://nationalinterest.org/blog/the-buzz/russia-might-have-just-tested-the-ultimate-weapon-war-18849

Lewis, Patricia, Livingstone, David, “What to Know About Space Security”, Chatham House, 27 September 2016a, https://www.chathamhouse.org/expert/comment/what-know-about-space-security

Lewis, Patricia, “The 21st Century Star Wars,” The World Today, February & March 2016

Listner, Michael, “Legal issues surrounding space debris remediation”, The Space Review, 6 August 2012, http://www.thespacereview.com/article/2130/

Livingstone, David, Lewis, Patricia, “Space, the Final Frontier for Cybersecurity?”, Chatham House, September 2016 https://www.chathamhouse.org/sites/files/chathamhouse/publications/research/2016-09-22-space-final-frontier-cybersecurity-livingstone-lewis.pdf

Luzin, Pavel, “Russia's Position in Space: Cooperation and Decline,” Foreign Affairs, 21 September 2016, https://www.foreignaffairs.com/articles/2016-09-21/russias-position-space
Marboe, Irmgard, Militarization of outer space: present and future challenges from the international legal perspective, 2010, http://acuns.org/wp-content/uploads/2012/06/Militarization-Outer-Space-Irmgard-Marboe-AM-2010.pdf
Messier, Doug, “Companies Propose Launching 8,700 Satellites into Non-Geosynchronous Orbit,” Parabolic Arc, 29 November 2016, http://www.parabolicarc.com/2016/11/29/companies-propose-launching-8700-satellites-nongeosynchronous-orbit/
NASA, “Space Debris and Human Spacecraft”, 27 September 2013, https://www.nasa.gov/mission_pages/station/news/orbital_debris.html
NATO, Active Engagement, Modern Defence, 2010, http://www.nato.int/cps/fr/natohq/official_texts_68580.htm?selectedLocale=en
NATO, NATO Space Handbook, https://www.japcc.org/wp-content/uploads/20131220-NU-BI-SC-Space-Handbook-2013.pdf
NATO, Allied Joint Doctrine for Air and Space Operations, 2016, https://www.japcc.org/wp-content/uploads/AJP-3.3-EDB-V1-E.pdf
Parliamentary Office of Science and Technology, “Military Uses of Outer Space”, Postnote, No 273, December 2006, http://www.parliament.uk/documents/post/postpn273.pdf
Pellegrino, Massimo, Stang, Gerald, “Space security for Europe”, ISSUE, No 29, 07 July 2016 https://www.iss.europa.eu/sites/default/files/EUISSFiles/Report_29_0.pdf
Pigoni, Livio, CSS Analysis in Security Policy, “Space: The New Frontier of Security Policy”, April 2015
Pultarova, Tereza, “Space Junk Solution? Tiny Cubesat to Test New De-Orbiting Thruster,” Space.com, 1 July 2017. https://www.space.com/37370-cubesat-deorbit-space-junk-experiment.html
Roesler, Gordon, Paul Jaffe, and Glen Henshaw, “Inside DARPA’s Mission to Send a Repair Robot to Geosynchronous Orbit,” IEEE Spectrum, 8 March 2017
Robinson, Jana, Romancov, Michael, “The European Union and Space: Opportunities and Risks”, EU Non-Proliferation Consortium, No. 37 January 2014, https://www.sipri.org/sites/default/files/EUNPC_no-37-1.pdf
Robinson, Jana, “Is the world ready for space security to go ‘live’?”, Space Security Index 2016, 13th edition, http://www.pssi.cz/download/docs/363_global-assessment-for-2016-space-security-index-ssi-report.pdf
Rossettini, Luca, “Space Debris: Prevention, Remediation or Mitigation?”, SpaceNews, 3 March 2015, http://spacenews.com/op-ed-space-debris-prevention-remediation-or-mitigation/
Schulte, Gregory L., “Protecting NATO’s Advantage in Space”, Transatlantic Current, No 5, May 2012, http://www.dtic.mil/dtic/tr/fulltext/u2/a577645.pdf
Sills, Ben, “Lost in space: the killer screwdriver”, The Guardian, 11 October 2004, https://www.theguardian.com/science/2004/oct/11/sciencenews.spaceexploration
Sorge, Marlon E., Vojtek, Mary Ellen, “Space Debris Mitigation Policy”, Aerospace, Fall 2015, http://www.aerospace.org/crosslinkmag/fall-2015/space-debris-mitigation-policy/
SpaceNews Editor, “Russian Satellite Maneuvers Illustrate Why U.S. Alarm Bells are Ringing” SpaceNews, 6 November 2015.
Stuart, Jill, “Star laws – the legal framework in which the militarization of space has evolved”, The World Today, February & March 2016
Stuart, Jill, “The Outer Space Treaty has been remarkably successful – but is it fit for the modern age?”, The Conversation, 27 January 2017, http://theconversation.com/the-outer-space-treaty-has-been-remarkably-successful-but-is-it-fit-for-the-modern-age-71381
Suzuki, Kazuto, “Satellites, the floating targets”, The World Today, February & March 2016
The Guardian, “Astronauts take emergency shelter after junk threatens space station”, 17 July 2015, https://www.theguardian.com/science/2015/jul/17/astronauts-take-emergency-shelter-after-junk-threatens-space-station

United Nations, “Technical Report on Space Debris”, 1999, https://www.orbitaldebris.jsc.nasa.gov/library/un_report_on_space_debris99.pdf

US Air Force, Counterspace Operations, Air Force Doctrine Document 2-2.1, 2 August 2004. http://www.space-library.com/0408_afdd2-2.1.pdf

U.S. National Space Policy, Office of Science and Technology Policy (OSTP), Executive Office of the President (Presidential Decision Directive), The White House, 31 August 2006. (accessed at: https://fas.org/irp/offdocs/nspd/space.pdf

Wilson, Jordan, “China’s Alternative to GPS and its Implications for the United States”, U.S.-China Economic and Security Review Commission, 5 January 2017, http://origin.www.uscc.gov/sites/default/files/Research/Staff%20Report_China's%20Alternative%20to%20GPS%20and%20Implications%20for%20the%20United%20States.pdf

World Economic Forum, “Which countries spend the most on space exploration?”, 11 January 2016, https://www.weforum.org/agenda/2016/01/which-countries-spend-the-most-on-space-exploration/

Zissis, Carin, “China’s Anti-Satellite Test,” *Council on Foreign Relations*, 22 February 2007, https://www.cfr.org/backgrounder/chinas-anti-satellite-test