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Resiliency in Space as a Combined Challenge for NATO

Joint Air Power Competence Centre

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The Executive Director of the Joint Air Power Competence Centre (JAPCC)

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Resiliency in Space as a Combined Challenge for NATO

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Today's military operations rely significantly on Space support. NATO Allies are operating modern and technically advanced armed forces. This technical advantage can be seen as a kind of deterrence, but recent worldwide developments in counter-Space and Space technology are challenging NATO's technical advantage.

Spacefaring nations such as the ones inside the Alliance attempt to secure their Space-based services as much as possible and design them to be as resilient as realizable. This is accomplished mostly through technical protection means or redundancies. NATO as an agreed-upon non Space actor (as of today) has to organize a different approach to resiliency. The overall goal for NATO is to ensure persistent Space support that is provided by the nations or commercially purchased. In NATO, the responsibility to provide Space support is mostly taken on by the USA. Due to technical developments, more NATO nations have established Space services or developed Space-related products and are willing to offer them to NATO, which should not be seen as a competition but as a chance to gain resiliency by burden-sharing. This may include a more federated Space support by the Allies to be beneficial to NATO.

This White Paper assesses dependencies stated in national and relevant NATO doctrine. It addresses Space functional areas and their importance based on current and historical NATO operations. A wide threat assessment is undertaken, based on the capability as well as the foreseeable threats in different operation types and intensities. Potential outcomes are discussed and addressed.

As planning considerations, the term 'resiliency' and its adaption for NATO is discussed, and the current Space support organization in NATO is addressed. This includes a deeper look into the role of various NATO agencies dealing with Space topics, as well as the chances and challenges of commercial Space support. Resiliency for NATO in this context means in NATO´s current role that coordination and organization is in the focus. It also gives an outlook for potentially changing responsibilities of NATO in the future.

Based on a questionnaire where the majority of the NATO member nations formulated their requirements, a deeper analysis about future means of resiliency for NATO was undertaken. In conjunction with the above-mentioned analysis, advice is given to be considered in the future planning of the implementation of the Space domain inside NATO.

All this leads to a conclusion and the formulation of recommendations for NATO to increase its resiliency in Space. For the unique role of NATO in not being an 'autonomous' Space actor, options to achieve resiliency by ensuring a persistent and robust Space support provision to NATO are discussed.

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This White Paper provides recommendations to NATO internally and to spacefaring Allies, as well as to member nations that are interested in or currently working on implementing Space support in their armed forces. Finally, it should provide a wider perspective and help understand the complex topic of Space support in NATO operations.

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TABLE OF CONTENTS

CHAPTER 1

Introduction

Space support plays an important role in NATO operations. It is mainly responsible for the technical advantage of NATO in comparison to potential opponents. Without Space support military operations worldwide would be executed on the technical level of 'industrial age' warfighting techniques.

After the 'Space Race' between the United States of America and the former Soviet Union, the USA became the major Space power in the world. Their role got even more privileged, when in 1989 the iron curtain fell and the Soviet Union – as well as Russia – was no longer able to sustain its Space systems. For nearly twenty years, there was no threat to Space systems, satellites in particular, present for the USA. In this period, other Space users like the European Union and its member nations as well as Asian countries like China, India and Japan became more active in Space. Today there are more than ten nations worldwide that are able to launch satellites into Space.

Nevertheless, today the USA is mainly responsible for the Space support in NATO operations.

Beside the reconfiguration of the Russian Space power in the years 2007 to 2012, the worldwide development and proliferation of mainly ground-based counter-Space technology is ongoing. Prominent examples are the Chinese ASAT test in 2007 and the Indian one in 2019.

Additionally, the dependence of the civilian life on Space services and applications is increasing as well as the commercial market to ensure it. In the past, Spaceflight had mainly been a governmental mission, but modern companies like SpaceX and Rocket-Lab offer commercial transport for satellites into Space.

Space plays a more crucial role within military services worldwide. Especially since the governments of Space-faring nations base their political and security decision making processes more on Space services or products. The statement of Lt Gen Thompson, US Air Force Space Command Vice Commander at that time, 'If you win in Space, you will not necessary win the war, but if you lose in Space, you will most definitely lose the war' describes the military dependency very clearly.[1]

Due to the complexity of Space, it is often seen as an arcane topic. The importance of Space has to be better understood by all military personnel, while Space personnel often have to be retrained on Joint Operational thinking. As Lt Gen Thompson points out, one of the main tasks for the USA is to 'Train our Space guys from engineers back to warfighters', a statement that can be adapted as well to NATO.[2]

This study will focus on methods and actions to increase resiliency for Space support in NATO operations especially based on the agreed upon specific role for NATO in Space. There will be a threat assessment of the six currently existing Space functional areas based on the specific NATO operation types and intensities. The dependency on Space services and products will be assessed for NATO as well as for the NATO member nations themselves. The organization of Space support in NATO will be discussed, especially due to the current developments within NATO.

Although NATO is not a dedicated Space actor, it is an important Space user. The more complex cooperation, as well as the elevated threat to Space systems and their services, came when NATO's role had to be reassessed. This project will focus on the guarantee of Space services in NATO operations under the current circumstances. It will also discuss potential upcoming roles and capabilities as well as authorities that NATO could also have in the future to be the guarantor for peace in (at least) the next 70 years.

1. Thompson, D. (2019) Keynote speech at the 2019 JAPCC Conference: Shaping NATO for Multi Domain Operations in the Future. (speech) JAPCC Conference 2019, 9 Oct.
2. Ibid

CHAPTER 2

Dependency on Space Services for National Security and Military Operations

Space services or services provided by Space systems have changed military operations and security issues significantly over the last sixty years. In 1959, when the USA launched their first dedicated military satellite,[1] it started a military Space race between the Soviet Union and the USA as the two first Spacefaring nations[2] and the two superpowers that dominated the cold war era. First developments on the positive effects of Space-based services for military operations were discussed and assessed in the late 1940s after World War II, but they were not realized due to the limited launch capabilities of the time. Over time and due to technological developments, more Space services or Space related services were made available for military use. On the one hand, this caused more flexible operations in the transition from industrial age to information age warfighting, but on the other hand, it created massive dependencies on these services while procedures and doctrines have been adapted to the technical options. Western countries have moved more intensively to an increased use of Space services as a military benefit in comparison to other nations worldwide. This allowed the Western countries to have reduced armed forces in number based to these technical advantages.

The biggest advantage of Space assets is that data gathering and transmission by these systems cannot be denied via political means because these systems use orbits in Space above controllable airspace, so territorial borders do not limit their operations. The services can be used by the military in the preparation and execution of an operation. For general security needs and requirements, especially decision-making processes, intelligence gathering relies significantly on data collected by Space-based assets. Beneath the military or governmental use of Space, commercial services today play a more and more important role than it has been in the past and they are usually available to anyone who is able to pay.

Furthermore, Space plays an important role not just for military operations, but also for the general security needs of sovereign nations. The synergistic effects are often stated in national security and/or Space policies. Depending on national Space strategies, different countries have implemented these conditions in different ways into their basic military or security policies.

Canada states their dependence on Space services in its Intergovernmental Space Strategy and formulates security needs that include military requirements.[3]

Space capabilities and sovereignty in Space are significant for France, not only in the military, but for the whole security architecture of the country.[4] The French define that apart from security and designated military needs, Space capabilities also serve specific strategic functions. One of these functions is the protection of its own Space-based assets. It is stated that Space dependence is crucial, especially for political decision making and military operations. France is the only western nation except the USA that claims an independent decision-making process and military operations solely based on French national intelligence assets, which includes Space-based ones.

In its Space Strategy,[5] Italy has formulated the need for security and pointed out the dual-use (civilian/governmental as well as military) availability of the Italian assets and services.

Great Britain states its Space dependency in terms similar to those in NATO doctrine.[6] The National Air and Space Power Doctrine focuses on the military aspects of Space support in military operations and mentions them in four of eight chapters, covering nearly half of the Joint Doctrine. In comparison to the French strategy document, Great Britain uses a slightly different approach by specifying any kind of militarily usable Space support. The intergovernmental overall security approach is mentioned, but is less emphasized than the military dependencies.

The USA, as the largest Space power in the world, states military dependencies as benefits from Space assets in operations.[7] Similar to the Air and Space Power Doctrine of Great Britain, the USA has formulated the dependencies in a Joint Doctrine that only covers the military perspective. The general Space dependency in security aspects of the intergovernmental approach is covered in the National Security Strategy.[8]

The German Space Policy defines the dependence on Space services for the overall security architecture.[9] All military-related tasks and dependencies are exactly defined and their protection was given as a task to the German Armed Forces[10] but using an intergovernmental and interagency approach.

The European Union assessed its Space dependence on the overall security architecture and defined Space assets as critical infrastructure.[11] The dependencies applicable to civilian life are also stated.

The NATO Alliance formulates their dependencies on Space services in an Allied Joint Publication for Air and Space Operations (AJP 3.3.).[12] By defining the dependencies and structures, NATO is the only entity stated in this context that does not operate its own Space-based assets. All definitions and comments in the AJP rely on services either commercially procured or given on a voluntary basis by the NATO member nations. Other policies and strategies of NATO on Space use are stated and analyzed in a later chapter. In 2020, the NATO Communications and Information Agency (NCIA) has planned to release an actualized version of the current assessment on Space dependencies for NATO.

The above-mentioned doctrines and policies address militarily usable Space services that have been developed over time. In NATO, these are currently defined as the six functional areas of Space support in operations.[13] The definition of militarily usable services includes certain levels of data collection and data distribution. From the technical perspective not all communication frequencies are usable for the military. Imaging systems require a certain ground resolution or a certain revisit- or system response time to provide data to fulfill military needs. These technical factors define the number of militarily usable satellites. The services of the functional areas are listed in the following paragraphs 2.1 to 2.6.

2.1 Satellite Communication (SATCOM)

In general this service describes the data exchange between satellites and ground stations. The two connections used are the Up-Link (from the ground to the satellite) and the Down-Link (from the satellite to the ground). Communications between satellites is also referred to as SATCOM and defined as inter-satellite-link or cross-link. This service allows, for example, direct communication between national headquarters and deployed troops. Most of the western communication satellites are in Geostationary Earth Orbit (GEO) and allow communication between 70° North and 70° South. Outside this area the visibility of the satellite due to the low angles of the antennas over the horizon is not guaranteed. For persistent communication north of 70° North, satellites in High Elliptical Orbits (HEO) or larger constellations in Low Earth Orbits (LEO) are needed. The transmitted data could be either voice or data exchange in general. The service allows direct communication with single vehicles on the ground, in the air and even at sea. It is also needed to operate Unmanned Air Vehicles (UAVs) from ground stations outside an area of operation, mainly from inside the territory of the operating nation. There are three frequency bands that are mainly used for military applications, the Ultra High Frequency (UHF), the Super High Frequency (SHF) and the Extremely High Frequency (EHF). All of these frequencies are offered by military and commercial satellites.

2.2 Positioning Navigation and Timing (PNT)

The basic principle is a timing signal sent out of a constellation of satellites usually operating in Medium Earth Orbits (MEO). Based on the timing signals, a receiver can calculate a position on the earth's surface. For this calculation the visibility of at least four satellites is needed. These services are provided by Global Navigation Satellite Systems (GNSS) or Regional Navigation Satellites Systems (RNSS) and are used by the military as well as civilian users. Examples for GNSS are the Global Positioning System (GPS) operated by the US Air Force, the Galileo system, operated by the European Union, the Globalnaja Nawigazionnaja Sputnikowaja Sistema (GLONASS) operated by the Russian Space Agency Roscosmos or the BeiDou-III system operated by the Chinese military. An example for a RNSS is the NAVIC system operated by the Indian Space Agency. PNT Services are needed so that users can navigate accurately. Military navigation applications include: supporting the use of Precision-Guided Munitions (PGM), locating


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missing personnel for Personnel Recovery (PR) missions and for Combat Search and Rescue (CSAR). There are also comparable civilian applications for Search and Rescue. The second important service is the timing itself which is used, for example, to coordinate advanced communication networks. Without a timing signal, users of advanced communication links are for instance not able to log into the network. In civilian life, for example, money transfers or cash withdrawal from Automated Teller Machines (ATM) are coordinated by the PNT signal. The same technology is used for the coordination of traffic lights, or the organization of medical and security services, which are widely coordinated by PNT signals in western countries.

2.3 Intelligence Surveillance and Reconnaissance (ISR)

This service uses Earth Observation (EO) satellites with various sensors as well as Signals Intelligence (SIGINT) sensors. EO sensors are mostly electro-optical sensors that can take panchromatic, Infrared, multispectral or even hyperspectral images of the earth's surface. Due to their terrestrial weather independence, Synthetic Aperture Radar (SAR) sensors are also used. In military applications, the ground resolution of the sensor is important to gather and assess information in a three-step approach: detect (e.g. a land vehicle), categorize (e.g. a battle tank) and identify (e.g. a Russian T-80 medium battle tank). Civilian areas of application are, for example, harvest assessments, land development issues as well as disaster management. SIGINT sensors are usually able to detect and geo-locate electromagnetic emitters or receive data transmissions for further assessments. ISR data collected from Space-based assets are usually used for strategic as well as operational decisionmaking. The use this type of data in tactical operations is currently limited due to the long time between tasking a satellite and receiving data. All kinds of ISR sensors can be found on military as well as commercial satellites.

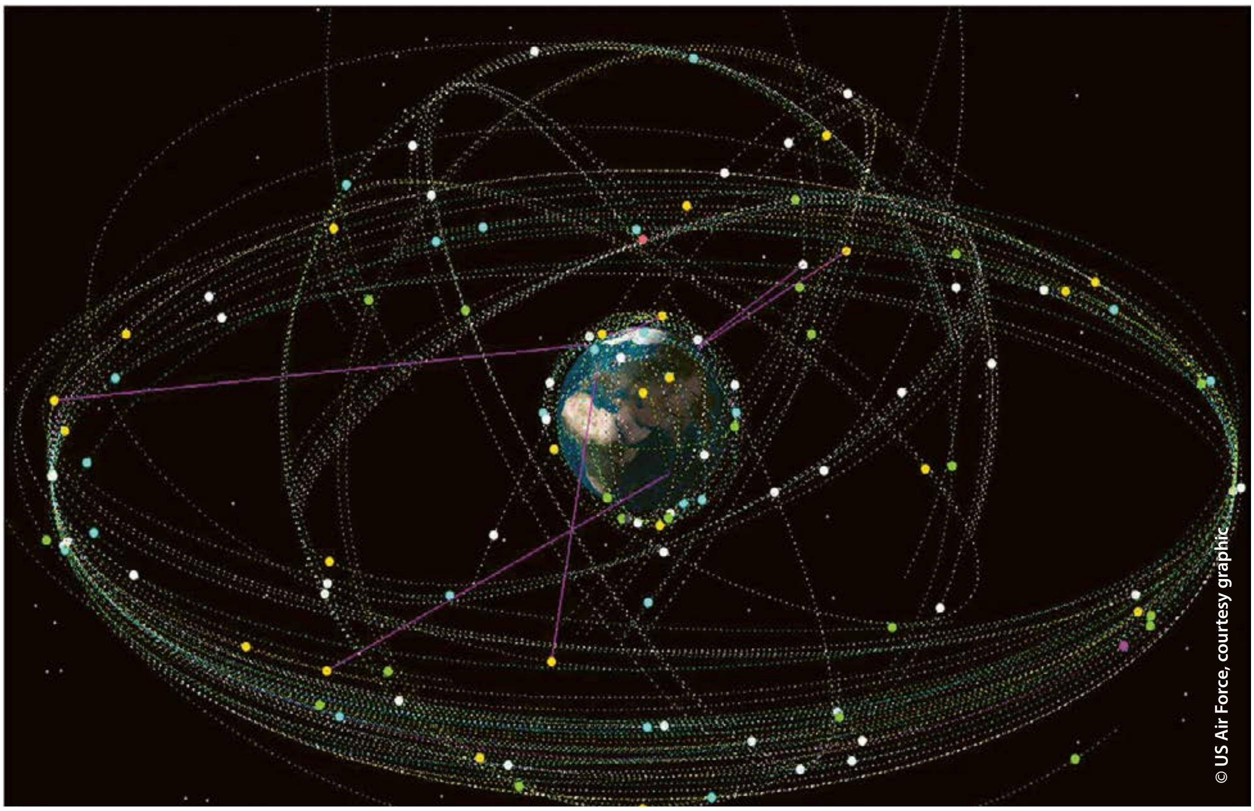
2.4 Terrestrial and Space Environmental Monitoring (METOC)

These services mainly include the terrestrial weather forecasts as well as Space Weather (WX) – and their impacts on operational planning and the operation of technical systems such as satellites. Space weather is defined as the population of charged particles in several layers of the atmosphere having an impact on electromagnetic signals passing through these layers,

such as radar or radio transmissions as well as PNT signals. The effect is a degradation in accuracy for PNT services as well as frequency glitches, local breakdowns or in the worst case could lead to a complete uselessness of communication services for satellite operations or satellite-based communication services. The effect is later described in-depth as 'physical influence'.

2.5 Space Situational Awareness (SSA)

This service monitors the position of orbiting satellites as well as Space debris. Between collision avoidance assessments and re-entry monitoring campaigns essential for satellite operators, services such as Satellite Reconnaissance Advance Notifications (SATRAN) or overflight warnings are the most important products for military operations. SSA also collects and assesses information about the missions of foreign satellites later described as 'Space intelligence'. The sensors used for this service are mostly ground based. Depending on the Space organization of specific nations, this service is provided either by civilian or military providers. Western countries rely on an object catalogue that lists every object orbiting the earth, currently having a size larger than 10 cm. This catalogue is currently provided by the US Air Force and will in the future be released by the US



Federal Aviation Authority (FAA). It tracks roughly 20,000 objects such as satellites, upper stages of launch vehicles and Space debris. Other Spacefaring nations like China and Russia have their own catalogues, but use the US catalogue for collision avoidance.

2.6 Overhead Persistent Infrared (OPIR)

This service is also known as Shared Early Warning (SEW) within NATO, and sensors are Space- as well as ground-based. The service is an 'as-early-as-possible' warning of the launch of ballistic missiles. This service gives nations and alliances an option to prepare countermeasures, such as Ballistic Missile Defense (BMD), or even to have the time to prepare optional counter attacks. It could also be used to monitor test launches as well as to conduct surveys or to monitor sanctions compliance, with respect to the development of missile technologies. Advanced sensors can detect a launch, categorize the size of a missile and potentially identify the type based on the plume of the engine.

2.7 Interim Assessment

Technical improvements have become more important in warfighting over the last 60 years. The most important and critical technical improvement was the development of Space-based capabilities. Services provided by Space systems allow warfighters to have services available to them globally. The integration of Space services in every kind of warfighting has not only been a challenge over the last decades, but it has also brought dependencies and risks with it. The advantages of these services have had a significant impact on 'classical' military education and training. Due to the complexity in education and training, 'fallback procedures' were less important, and training was often minimized due to technological advantages. Having integrated Space into their operational focus is a significant advantage for both western countries and also NATO in comparison to potential opponents. This conclusion describes not only the situation for potential technologically hindered or 'low-tech' opponents, but also for potentially near-peer (comparable to Chinese capabilities) as well as peer (comparable to Russian capabilities) opponents. The relevancy of a Space-operational focus is not only limited to direct usable services like SATCOM or ISR. The PNT service, besides navigation, also plays a key role within a lot of services that rely on the timing signal of the GPS satellite constellation. A navigation receiver compiles the signals of several satellites to the popular navigation service that, in turn, provides a position, direction and velocity. The timing signal is even more relevant in synchronization of communication and advanced radar services. If the timing signal is degraded or disrupted, advanced communication services like NATO's 'Link-16' are no longer usable in their primary operations mode. The same goes for most encryption services. Advanced radar services need the timing signal to 'identify' the right signal reflection and to calculate the right position of the reflected item. Space support in operations works like a complex and interconnected network that uses several 'sub-services' to provide the required primary service. For example, a US Stryker Brigade, which consists of 3,200 to 3,700 soldiers,[14] has 2,500 GPS enabled equipment elements.[15] All of these Space services are essential to modern decision-making processes, both military and political. The loss or even the reduction of these services could have critical implications, not merely for the decision itself (which could potentially rely on alternatives), but on the timeline of the process – and time is always a crucial factor in military planning. While Space systems and Space services offer a lot of advantages, operating Space assets is complex and costly. It requires technical knowledge to develop and build a satellite, the access to Space, the ground infrastructure to control it and finally but most importantly the personnel, educated trained and experienced, to do the job.

If you look at the different national approaches of the western countries referred to in this paper, the military and security use of Space services is highlighted as critical. Ensuring the availability of the service is the critical task. Depending on the nation's experiences and operating infrastructure, this is planned to be assured via international cooperation agreements or national capabilities. In this case, the special role of France, as well as the very similar approaches of Great Britain and the USA, have to be mentioned. Due to the complexity, there are world-wide developments ongoing to use the so-called 'near-Space' region that is defined as the area above the used airspace by regular airframes and below 100 km in altitude. This area offers relatively easy to operate services like ISR and communication over certain areas without the physical limitation of Space-based assets. The High Altitude Airship (HAA) project is an example of a platform that could be used for a communication payload or an ISR application.[16] Developments like this will only be successful as long as they operate outside the controllable air-space that is defined by the detecting and effecting capabilities of ground-based air defense systems wherein parallel technical improvements are still on-going. These new developments for high altitude applications can only close gaps in coverage or set regional priorities as a support to Space assets, but will not affect the important role of Space-based services in the foreseeable future.

Today, there are not only Spacefaring nations like the USA, Russia, China, India, Japan, and other western countries operating military and/or governmental satellites, but on the basis of economical contracts and military cooperation, even countries like Nigeria[17] or Venezuela[18] operate their own governmental satellites, which usually include at least a military sub-use. These assets are usually equipped with ISR or SATCOM payloads. China and Russia are also offensively promoting PNT services provided by their national systems to other countries for civilian and governmental use. Sometimes the proliferation of high-tech weaponry includes the PNT service. Technical improvements and the proliferation of high-tech weaponry in 'low tech' countries make the use of alternatives like high flying UAVs more complicated, while the use of Space assets was more secure in the past. This condition is currently also changing, and Space assets or Space services are becoming more vulnerable. The current threats and the threats expected in the future to Space systems and services, in several types of operations based on the NATO definitions, will be discussed in the next chapter.

1. Krebs, G. (2019), List of orbital launches 1959 (online), Available from https://space.skyrocket.de/index.html (accessed 12 Aug. 2019).
2. Stares, P. (1985), US and Soviet Military Space Programs: A comparative assessment. Daedalus, Ed. 114 (spring), p. 127-145, Available from https://www.jstor.org/stable/20024982?read-now=1&seq=1#page_scan_tab_contents (accessed 12 Aug. 2019).
3. Canadian Ministry of Innovation, Science and Economic Development (2019), Exploration, Imagination, Innovation – A new Space strategy for Canada. ST99-60/2019E-PDF. Ottawa: Government of Canada. Available from http://www.asc-csa.gc.ca/pdf/eng/publications/space-strategy-for-canada.pdf (accessed 13 Aug. 2019).
4. Republique Francaise (2017), Defence and Security National Strategy Review. Paris: French Ministry of Defence. Available from (Accessed 13 Aug. 2019); French Ministry of the Armed Forces (2019) Space Defence Strategy. Report of the 'Space' working group. Paris: Office of the minister for the armed forces.
5. Agenzia Spaziale Italiana (ASI) (2016), Strategic Vision Document 2016 – 2015. Rome: ASI. Available from https://www.asi.it (accessed 11 Apr. 2019).
6. British Ministry of Defence (2017), UK Air and Space Power. JDP 0-30. Shrivenham: UK MOD Development, Concepts and Doctrine Centre. Available from https://www.gov.uk/government/publications/uk-air-and-space-doctrine-jdp-0-30 (accessed 13 Aug. 2019).
7. US Department of Defense (2018). Space Operations JP 3-14. Washington: Joint Chiefs of Staff. Available from https://www.jcs.mil/Portals/36/Documents/Doctrine/pubs/jp3_14.pdf (accessed 13 Aug. 2019).
8. President of the United States of America (2017), National Security Strategy of the United States of America. NSS. Washington: White House. Available from https://www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905.pdf (accessed 13 Aug. 2019).
9. German Ministry of Economics and Technology (2012), Die Raumfahrtstrategie der Bundesregierung / German Space Strategy. Berlin: BMWI. Available from https://www.bmwi.de/Redaktion/DE/Publikationen/Technologie/zukunftsfaehige-deutsche-raumfahrt.pdf?__blob=publicationFile&v=8 (accessed 13 Aug. 2019).
10. German Ministry of Defence (2016), Weißbuch zur Sicherheitspolitik und zur Zukunft der Bundeswehr / Whitebook for Security politics and the Future of the German Armed Forces. Berlin: BMVg. Available from https://www.bmvg.de/resource/blob/13708/015be272f8c0098f1537a491676bfc31/weissbuch2016-barrierefrei-data.pdf (accessed 13 Aug. 2019).
11. Pellegrino, M. and Stang, G. (2016), Space Security for Europe. Report No. 29 Paris: European Union Institute for Security Studies. Available from https://espas.secure.europarl.europa.eu/orbis/sites/default/files/generated/document/en/Report_29_Space_and_Security_online.pdf (accessed 10 Jun. 2019).
12. NATO Standardization Office (NSO) (2016) NATO Allied Joint Publication AJP 3.3 Air and Space Operations Edition B Version 1. Brussels: NSO. Available from: https://nso.nato.int/nso/nsdd/listpromulg.html (accessed 13 Aug. 2019).
13. Giudice, F., and Patrick, J. (2017) The key role of Space Support in NATO operations. The Three Swords Magazine, Ed. 32 (7), p. 57-65.
14. Globalsecurity.org (2018) Stryker Brigade Combat Team (SBCT) (online) Available from https://www.globalsecurity.org/military/agency/army/brigade-ibct.htm (accessed 23 Oct. 2018).
15. Lane R., MajGen (ret,) (2018), Does NATO have the required mindset to fight on Day Zero? (speech) JAPCC Conference in Essen, Germany, 10 Oct. 2018.
16. Globalsecurity.org (2011) High Altitude Airship (HAA). (online) Available from https://www.globalsecurity.org/intell/systems/haa.htm (accessed 15 Aug. 2019).
17. Surrey Satellite Limited (SSTL) (2011) NigeriaSat-X and NigeriaSat-2 launched. (online) Available from https://www.sstl.co.uk/space-portfolio/launched-missions# (accessed 15 Aug. 2019).
18. China Great Wall Industry (CGWI) (2011) Contract on Venezuelan Remote Sensing Project signed. (press release) 26 May. Available from http://www.cgwic.com/news/2011/0527_VRSS-1_Remote_Sensing_Satellite_Program.html (accessed 15 Aug. 2019).

CHAPTER 3

Threats to Space Services in NATO Operations

3.1 Spectrum of Conflict

The Allied Joint Publication 01 (AJP-01) defines the 'Spectrum of Conflict' as the first discriminating factor, in which NATO operations will be conducted.[1] It spreads from a peacetime-like military engagement up to regular and irregular warfighting (Figure 1). Depending on the nature of the operation, there are no clear borders in the discrimination of conflict. In the full spectrum of conflict, Space related services are required.[2] Navigation and communication services are needed in every operation while Intelligence, Surveillance and Reconnaissance services may differ in their usage. For example, in times of 'calmer', stable peace, the focus will be on surveillance missions, but that focus will change to target acquisition and battle damage assessment in the high-intensity conflict phase. Meanwhile, counter-Space measures can be used in all phases of the conflict.

The second discriminating factor is the theme of the operation. NATO has defined four themes.[3] These range from warfighting against a near-peer opponent, through security operations, to peace support operations. All of these operation types include additional threats, such as terrorism and organized crime, any or all of which could make the operation more complex. The fourth operational theme is peacetime military engagement, both to build up a trusted environment as well as to have a deterrence factor. Space support plays an important role here, even though it may just be a minor role in peacetime military engagement.

The third discriminating factor is the type of operation.[4] On the one hand, there is the combat operation, which is what NATO was founded to deter. Normally this is an operation against regular forces to defend a NATO

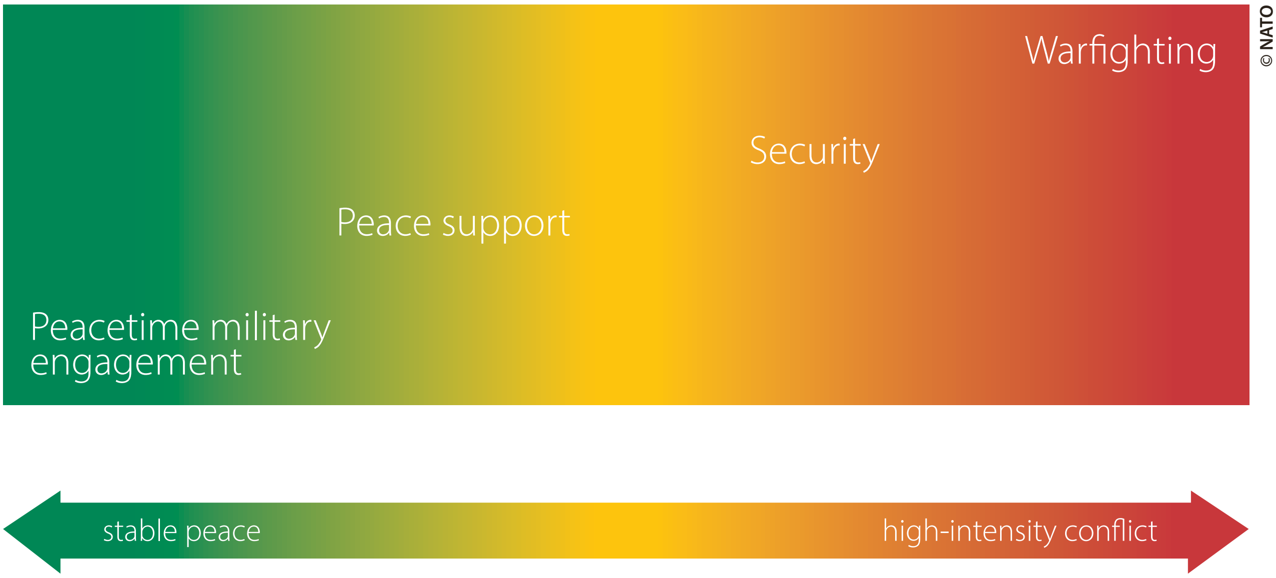


Figure 1: The spectrum of conflict (taken from NATO AJP-01).

member country's territorial integrity. This kind of operation uses the full spectrum of Space services to support the operation. On the other hand, there are crisis response operations that cover a wide range and are defined in different ways.[5] Probably the most complex operations are the ones countering irregular activities such as insurgency, terrorism and criminality. However, these threats can also occur in any of the other types of operation. Additionally, the military often contributes to peace support, humanitarian assistance, and stabilization and reconstruction. An operation can also step through all three of these types, one after another. Other types of operations include protecting people, which can include the evacuation or even the extraction of personnel from foreign countries. The final operation type is preserving the freedom of navigation and overflight as well as surveying and the support of sanctions and embargos. In all of these types of operations Space support is at least of minor importance.

3.2 Potential Threats to Space Systems and Services (Counter-Space)

There are different threats or impacts on satellites that have to be considered[6] and if possible mitigated. Firstly, there are physical influences that affect all satellites in Space, independently of the operating nation. Secondly, there are the 'manmade' counter-Space actions, which can be separated into passive and active means.

The physical influences are primarily related to Space weather, as explained above: the population of charged particles in the layers of the Ionosphere. Space weather is mostly caused by solar activity. In addition to the effects on signal use, solar activity has a major influence on satellite operations. These effects include the degradation of command signals. Solar activity also pushes satellites in the direction of the earth. To fulfil its mission, a satellite must stay in its optimum orbit as designed. That means there have to be manoeuvres made with propulsion systems to maintain this orbit. During these manoeuvres which can last from a few hours up to several days, a satellite may not be able to fulfil its mission. In this context, manoeuvres to avoid collisions with Space debris are also defined as physical influences, because of the same potential for temporary loss of the ability to fulfil the mission.

Passive counter-Space means are actions that can be taken without having effects on Space systems. Examples include the use of decoys to feint EO collection, such as inflatable tanks, or the use of camouflage equipment. Passive counter-Space also includes the large-scale use of smoke to veil movements on the ground. This smoke used does not need to be special military use smoke; it can also be created by fires, for example, by burning crude oil. The use of Space services based on SSA generated data, such as Satellite Reconnaissance Advance Notifications (SATRAN) or overflight warnings (to move troops on the ground only outside the times when foreign satellites make over passes) is another example. Orbital data of passing satellites (unclassified as well as classified) are available online with sufficient accuracy to be useable.[7] Furthermore, software can be easily purchased as student versions. Even well-financed terrorist organizations could gather this information through foreign support or smart IT experts.[8]

Active counter-Space means cover a wider spectrum and are defined as reversible actions and irreversible actions. While reversible actions have a timely and regional influence on Space systems and their services, irreversible actions normally cause permanent damage to the Space systems or to parts of the systems. Active counter-Space actions are as follows:

3.2.1 Cyberattacks: Cyberattacks on Space systems, or the Space related ground infrastructure, could be both reversible actions as well as irreversible actions.[9] Deployed spacecraft are normally not the main target of this kind of attack because of the short contact times to potential transmitters, even in LEO. Ground-based infrastructure, such as command and control stations, are more likely targets for cyber-attacks.[10] The primary aim is not the takeover of the satellite by the attacker. The objective is primarily the suppression of their services. To protect communications between the ground stations and the spacecraft, high end, encrypted communication is used to create the best possible protection against any kinds of cyber-attacks.

3.2.2 Jamming: Interrupting the transmitted signals or links between satellites, ground stations, and user segments on the ground is part of the next spectrum of counter-Space actions.[11] Jamming means 'overloading' the receivers with additional signals sent by the opponents' transmitters. The aim is to override the 'original' signal with a false one, usually transmitted with greater power. Jamming attacks are normally reversible attacks and can affect SATCOM, PNT and even some ISR services. For ISR in particular the SAR services can be affected.

SATCOM jamming, in the counter-Space context, principally means jamming the satellite itself. Jamming of the receiving station on the ground is also possible, but to reach the receiver, the jammer needs a line of sight to the receiver. Normally a higher position (on a hill or a large building) or an airborne system is needed.[12] Jamming by a Space system is possible, but requires powerful jammers that are not easily operated in Space.

In order to jam PNT services, there are a large number of different, mainly militarily developed, jammers available. All worldwide available Space-based navigation systems (GNSS or RNSS) are operated by the military, or have at least one secured frequency that is reserved for governmental and military use. In order to jam the full service of a system, a wideband jammer or several jammers, are required. Nevertheless, this means an opponent could jam the US operated GPS system which is agreed as the standard system for NATO.[13] This effect is even more significant whilst the opponent relies on another system. This could cause non-usability of PNT services for NATO, while the opponent has full service. Highly capable PNT jammers can be fixed or mobile, and are normally used for military purposes. The size and power of the jammers define the range. Even very small, Commercial off the Shelf (COTS) based jammers, down to the size of a cigarette-box, allow a regionally short (several hundred meters up to a few kilometers) jamming of at least one frequency.[14] Manuals to build these kinds of systems can be found online, technical parts can be purchased at a regular electronics store. If the PNT jamming effect covers a wide area that includes areas of civilian activity, there will be a major impact on civilian life. PNT services are not only used in navigation devices but also in the control of traffic. They also coordinate worldwide financial transfers. This means that in a jammed PNT environment, the use of ATM machines, and financial trades on stock markets would not be possible.

A more developed version of PNT jamming is referred to as 'spoofing'. This special kind of jamming does not only suppress the correct signal, it also replaces it with a new but false one. Spoofing can only be effective in smaller areas where the difference in the position will not be recognized directly by operators. The new signal provides 'wrong' signal data that normally causes erroneous position data.[15] Particularly in valleys, or in close combat positions, this 'wrong' data could lead to casualties or damages.

To jam a SAR-satellite in LEO, a high power jammer, as well as accurate SSA data are required. These jammers are normally located at fixed sites. There are just a few mobile, highly developed military systems available worldwide.

3.2.3 Directed Energy Weapons (DEW): The most developed systems to be used against Space systems in this category so far are lasers.[16] Lasers can cause a reversible counter-Space effect on optical ISR satellites called 'dazzling'. To achieve this, a continuous waveform laser is pointed at an LEO satellite while it is passing its target. The laser is supposed to 'blind' the sensor during its use. The presumption is that this effect suppresses the data collection of the satellites, but the sensor has to be 'hit' directly. Like the jamming of SAR satellites, the use of directed energy weapons requires precise SSA data to locate and target the satellite. Laser dazzling can be achieved by operating from 'upgraded' Satellite Laser Ranging stations (SLR) that are located worldwide. There have also been some mobile systems developed which are available on the market.

Lasers can also have irreversible effects on satellites in all orbits by damaging them.[17] A few countries worldwide are developing such weapons. These systems are normally based on fixed, ground facilities, because the amount of energy that is needed to create a directed energy beam that can cause damage to satellites is extremely high. Mobile airborne platforms are also under development, using chemical lasers. The advantage of mobile systems is the usability worldwide, the disadvantage is that they have to be recharged for several minutes between 'shots'. An example of damage could be the loss of several electronic parts because of

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overcharging, likely making the satellite itself unusable. It also seems possible that a satellite could explode after being hit, creating a cloud of debris. Nevertheless, even if a satellite is hit by a directed energy weapon, but not damaged, the satellite will be out of service while passing several calibration tests after the restart by the operator. If the satellites of commercial operators contracted by NATO are threatened by a DEW, their temporary withdrawal from the contract could be an outcome, as long as the threat is still active.

3.2.4 Intercepting a Satellite: Intercepting a satellite means targeting via a ground or air-launched missile and destroying or disabling it with a direct hit.[18] The effect is irreversible and creates a lot of Space debris. Satellites, especially in LEO, need to be targeted very precisely, so SSA data also plays a major role. There are only a few countries worldwide that are able to handle this kind of technology, but once a system is developed, it can be used by a potential purchaser after a straightforward training program. Some highly developed surface-based air defence systems (SAM) have the capability to be used against LEO satellites. Using counter-Space systems such as this will create a major Space debris cloud that pollutes the targeted orbit regime.[19] Space debris clouds can cause additional collisions in Space, and can easily start a cascading effect. Opponents often do not care about potential collateral damage.[20]

3.2.5 Co-orbital Counter-Space Systems: The science used in this kind of counter-Space capability is a dual-use technology.[21] The commercial application is the option to service, refuel or repair satellites on-orbit and is often called On-Orbit Servicing (OOS). It could also be used to remove or de-orbit defunct satellites and clean up frequently used orbital regimes. From the military perspective, this kind of technology could also remove or 'service' active satellites operated by an opponent, as well as hitting it directly.[22] The so-called 'killer satellite' could already be in orbit or could be launched at short notice, and then manoeuvre to approach the targeted satellite. It could also be transported into Space as a hidden piggy pack payload by another satellite, waiting to be activated. This procedure requires precise SSA data as well as experience in orbital manoeuvering. Additionally, co-orbital manoeuvres could be observed by SSA sensors and provide data to the affected satellite operator. Based on this data, mitigation and protection measures could then be conducted, and information then used as evidence claiming a hostile act.

3.2.6 Ground Site Attack: Space-based systems need to be commanded from the ground, and ground stations are needed to download their data. The attack on any kind of ground infrastructure, from command and control centres, also used in peacetime, down to deployed SATCOM antennas, is defined as a counter-Space action.[23] This kind of attack could be realized by the use of Precision-Guided Munitions (PGM), terrorist attacks or by simply throwing stones onto SATCOM antennas to prevent their adjustment. Attacks could also focus on supporting infrastructure, such as power supplies or transmission cables. This threat has to be considered in deployed missions in particular and seems to be one of the most likely means of adversary attack on Space systems.

3.2.7 Nuclear Detonation in Space: This kind of detonation would create massive physical effects, such as an electromagnetic impulse (direct) and a massively charged Ionosphere (see Space weather effects). These effects are not controllable and create, over a period of weeks or months, damage to all satellites in Space passing through the charged area.[24] Due to their orbital parameters and the orbits used, especially nearly all satellites in LEO, most would pass the charged area several times. Pre-installed radiation hardening may increase the survival time of military satellites, but it raises the cost level significantly.[25] This is the most unlikely counter-Space action because it adversely affects both friendly and adversary satellites indiscriminately.

3.3 Counter-Space Actions and Anticipated Threats in Different Operations

Based on the AJP-01 definitions of operation types, the counter-Space threat is analyzed. Where possible, examples of ongoing or past operations are given.[26]

3.3.1 Combat Operations: In a potential conflict with a near-peer opponent, especially if it is a Space-faring nation, all of the above mentioned counter-Space actions can be expected, with the exception of the nuclear detonation. Counter-Space actions will range from highly developed military systems down to COTS systems, used by irregular forces to destabilize the NATO member's homeland. A near-peer opponent will most likely first use reversible actions, either to prevent the Space debris problem and not cause collateral effects, or to have the option to escalate during the conflict. The mitigation of Space debris via counter-Space actions is a substantial need for a potential near-peer opponent because he normally has a similar dependency on Space services.

In a potential combat operation against a regular, structured albeit weaker adversary, all passive counter-Space actions, as well as jamming activities, cyber-attacks and attacks on ground sites, can be anticipated (e.g. combat against the Serbian Armed Forces in the early stages of the Kosovo invasion). The potential use of DEW, as well as satellite interceptors may be possible, but depends on the opponent's military equipment available.

3.3.2 Crisis Response Operations: In a large scale operation, that includes elements of combat in the first stage and then changes over time through all operational themes down to the peacetime military engagement (Figure 1), and with an opponent below the level of regular structured Armed Forces, all kinds of passive counter-Space as well as attacks on ground sites and cyber-attacks could be expected. Jamming of PNT systems with COTS jammers, as well as, depending on available technology, jamming attacks by highly developed military equipment and the use of DEW to dazzle satellites, all seem to be possible (e.g. Balkans as well as the Afghanistan operations).

In operations against irregular forces, including counter-insurgency, counter-terrorism and counter-crime, passive counter-Space actions such as the use of overflight warnings to veil actions on the ground, could be expected. Furthermore, the use of smoke could be expected, as well as the use of decoys and camouflage. The attack on Space-related ground infrastructure, especially by terrorist organizations, seems to be the most likely threat. Cyberattacks, as well as the use of COTS jammers against PNT services to prevent the use of PGMs, are also anticipated (e.g. Balkans in the last stages as well as Afghanistan in the calmest areas; counter-piracy at the Horn of Africa). The effects on PGMs may differ depending on the power used by the jammer and the technical protection of the specific PGMs.

In the range from full military operations to simply the military's contribution to peace support, the full spectrum of passive counter-Space means should be expected. Depending on the status of the country or area where the operation has to be conducted, jamming activities by military systems are possible, up to the use of DEW as dazzlers. Attacks on ground infrastructure, jamming by COTS systems, as well as cyber-attacks, all have to be expected (e.g. Balkans).

In humanitarian assistance operations requested by the countries where the operation is to be executed, there is normally no expected real threat to Space support in operations (e.g. Pakistan earthquake relief assistance or hurricane Katrina).

In military operations as with military contributions to stabilization and reconstruction activities, there are normally no highly developed military jamming systems in use any more. This means that the spectrum of passive counter-Space means can be anticipated rather than the use of military decoys. Active counter-Space means may include cyber-attacks, attacks on ground infrastructure as well as the use of COTS jammers (e.g. supporting operation of the African Union).

Non-combatant evacuation operations are normally realized by diplomatic initiatives. Normally there are no counter-Space actions to be expected. According to the status of the country where the evacuation is carried out, the most likely threat is the use of COTS jammers against PNT services.

In extraction operations, evacuations occur under a higher threat level. Normally the country where the extraction has to be carried out uses military means to


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hamper that kind of operation. Passive counter-Space means, such as the use of smoke, could be expected. Depending on the technical options of the opponent, active counter-Space actions such as jamming, and especially PNT services interference, have to be expected as well as cyber-attacks.

In operations to support sanctions and embargos, depending on the technical options available to an opponent, the full spectrum of passive counter-Space means can be expected. In particular, the use of overflight warnings to coordinate movements or to hide loading activities, is very likely, even when the SSA services needed are provided by a third country that could be the supposed embargo-breaker. On the active counter-Space side, the use of jammers could be expected, mostly against PNT services, as well as cyber-attacks, likely by the assumed embargo-breaker (e.g. securing the Mediterranean Sea).

In operations to secure the freedom of movement and overflight, depending on the potential opponent, all kinds of jamming activities can be expected. If it is a highly developed opponent, the reversible use of the dazzling function of DEW can also be expected as well as cyber-attacks. The use of all possible passive counter-Space actions can be expected (e.g. securing the Mediterranean Sea; Air-Policing in the Baltics).

3.4 Conclusions and Interim Assessments

Not only the military, but also the civilian sector relies on Space support.[27] As discussed in this paper, it may be the source of a critical vulnerability for the execution of NATO operations. The loss of Space support in operations, or even degraded services, has massive impacts on the planning process carried out by the military staff. Counter-Space means and their effects are widespread and cover all defined types of NATO operations. To create slight effects, only simple actions, or easily built and used electrical equipment that can be purchased and used by everyone, are required.

To preserve resiliency and ensure the guarantee of service, some proactive steps can be taken to lessen the impact of the adversary's counter-Space actions quite easily. These are the ones that can be done by nearly everyone anywhere as discussed in this chapter.

On the PNT side, the GPS system is designated as the only system to be used in NATO operations. By 2020 at the latest, there will be another global PNT system operational, provided by western countries. The European Union's Galileo PNT system also offers military usable services. Including the system via contracts or memorandums inside the NATO policy, makes it more complicated to jam the complete PNT services which are required for all kinds of operations, as stated above. Galileo is owned by the European Union. While seven out of twenty-eight European Union member nations are not NATO members, their western orientation, as well as the partnership programs installed with NATO, should not prevent its use. Due to Galileo security regulations, several contracts have to be signed to use the service as an addition to GPS.

Space-related infrastructure, especially in deployed locations, could be protected by physical means, for example, by finding a position inside a compound, so direct attacks using a Rocket-Propelled Grenade (RPG) could be prevented. Surrounding protection via gabion walls is also easily convertible.

On the training side, the use of alternative systems and procedures has to be promoted. Forces in NATO operations should always be able to fulfil their tasks while not relying on Space support services. Actual trends to focus the training only on the main systems and reduce the use of alternative procedures and systems should be rethought and this practice stopped.

Finally, Space is not an arcane topic that only highly specialized personnel can practice and understand. If this paper raises the attention of planning staff and military leaders in dealing with the threat, then the most important work has been done. For the future, there has to be both: Space smart military leaders as well as military smart Space leaders, educated and trained to improve the effectiveness of NATO operations, which provide as much resiliency in Space support as possible.

1. NATO Standardization Office (NSO) (2017), NATO Allied Joint Publication (AJP)-01, Allied Joint Doctrine, Edition E Version 1. Brussels: NSO. (accessed Sep. 2019).
2. Giudice, F., and Patrick, J. (2017) The key role of Space Support in NATO operations. The Three Swords Magazine, Ed. 32 (7), p. 57-65.
3. Ibid. 1.
4. Ibid. 1.
5. Ibid. 1.
6. National Air and Space Intelligence Centre (NASIC) (2018) Competing in Space. Dayton: NASIC public affairs office. Available from https://www.nasic.af.mil/News/Article-Display/Article/1733201/usaf-nasic-releases-unclassified-competing-in-space-assessment/ (accessed 13 Feb. 2019).
7. Heavens Above GmbH, DLR GSOC (2018) Website includes only unclassified objects (online) Munich: Heavens Above GmbH. Available from http://www.heavens-above.com/ (accessed 13 Mar. 2018).
Union of Concerned Scientists (2018) UCS database includes also orbits of several classified satellites (online) Cambridge MA: Union of Concerned Scientists. Available from https://www.ucsusa.org/nuclear-weapons/space-weapons/satellite-database#.Wqfv9U2WyHs (accessed 13 Mar. 2018).
8. Betts, R. (2002) Foreign affairs: Fixing intelligence. (online) Congers NY: Foreign Affairs. Available from https://www.foreignaffairs.com/articles/2002-01-01/fixing-intelligence (accessed 15 Mar. 2018).
9. Cordesman, A. (2016) Chinese Space Strategy and Developments. (online) Washington DC: Centre of Strategic & international studies (CSIS). Available from https://www.csis.org/analysis/china-space-strategy-and-developments (accessed 25 Nov. 2019).
10. MacKenzie, P. (2017) NATO Joint Air Power and Offensive Cyber Operations. Kalkar: Joint Air Power Competence Centre (JAPCC).
11. Cass, Stephen, 'How to kill a satellite', published in Discover, vol. 28, Issue 12, p. 56–57, Dec. 2017.
12. 1st NATO Signal BN (1NSB) (2018) Questions on personal experiences in SATCOM interferences. (interview) Interviewed by Tim Vasen, 30 Jan.
13. Jean-Philippe Saulay (2002) Satellite Navigation as seen by NATO, Briefing given at EUROCONTROL, Brussels, 5 Dec. 2002. Available from: www.gps.gov (accessed 12 Mar. 2020).
14. CHIP (2013) GPS Jamming increased interference published 4 Aug. 2013. (online) Munich: CHIP. Available from http://www.chip.de/news/GPS-Jamming-Zunehmende-Stoerung-echter-Signale-63473441.html (accessed 15 Jan. 2018).
15. Jafarnia-Jahromi, A. and Broumandan, A. and Nielsen, J. and LaChapelle, G. (2012) GPS Vulnerability to Spoofing Threats and a Review of Anti-Spoofing Techniques. International Journal of Navigation and Observation, May. London: Hindawi limited. Available from https://www.hindawi.com/journals/ijno/2012/127072/ (accessed 25 Nov. 2019).
16. Cass, Stephen, 'How to kill a satellite', published in Discover, vol. 28 Issue 12 p. 56 f., Dec. 2017.
17. Cordesman, A. (2016) Chinese Space Strategy and Developments. (online) Washington DC: Centre of Strategic & international studies (CSIS). Available from https://www.csis.org/analysis/china-space-strategy-and-developments (accessed 25 Nov. 2019).
18. Cordesman, A. (2016) Chinese Space Strategy and Developments. (online) Washington DC: Centre of Strategic & international studies (CSIS). Available from https://www.csis.org/analysis/china-space-strategy-and-developments (accessed 25 Nov. 2019).
Cass, Stephen, 'How to kill a satellite', published in Discover, vol. 28 Issue 12 p. 56 f., Dec. 2017
19. Grego, L. (2012) A history of Anti-satellite programs. (online) Cambridge MA: Union of Concerned Scientists. Available from https://www.ucsusa.org/resources/history-anti-satellite-programs (accessed 25 Nov. 2019).
20. NATO Standardization Office (NSO) (2017), NATO Allied Joint Publication (AJP)-01, Allied Joint Doctrine, Edition E Version 1. Brussels: NSO. (accessed Sep. 2019).
21. Rizzo, J. and Sciutto, J. (2016) War in Space: Kamikazes, kidnapper satellites and lasers. CNN online, 29 Nov., available from https://edition.cnn.com/2016/11/29/politics/space-war-lasers-satellites-russia-china/index.html (accessed13 Mar. 2018).
22. Cordesman, A. (2016) Chinese Space Strategy and Developments. (online) Washington DC: Centre of Strategic & international studies (CSIS). Available from https://www.csis.org/analysis/china-space-strategy-and-developments (accessed 25 Nov. 2019).
23. US Air Command and Staff College Space Research Elective Seminars (2009), AU-18 Space Primer. Alabama: Air University Press Air Force Research Institute.
24. NASA (1958) Nuclear Weapon Effects in Space on base of two nuclear explosions in Aug. 1958 (online) Houston: NASA History. Available from https://history.nasa.gov/conghand/nuclear.htm (accessed 13 Mar. 2018).
25. Bowman, G. (1962) Some effects of nuclear explosions on the Ionosphere. Australian Journal of Physics, Ed. 15 (5), p. 405-419. Available from http://adsabs.harvard.edu/full/1962AuJPh..15..405B (accessed 25 Nov. 2019).
26. NATO (2018) Operations and Missions: past and present. (online) Brussels: NATO. Available from https://www.nato.int/cps/en/natohq/topics_52060.htm (accessed 14 Mar. 2018).
27. Black, J. (2018) Our reliance on Space tech means we should prepare for the worst. Defence-News, Mar.. Vienna VA: Sightline Media Group Available from https://www.defensenews.com/space/2018/03/12/our-reliance-on-space-tech-means-we-should-prepare-for-the-worst/ (accessed 15 Mar. 2018).


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CHAPTER 4

Discussion on Resiliency Definition Adaptable for Space

Since this research project focusses on resiliency, it needs a short discussion of the term. All definitions given and used in this project refer to Space systems.

The US Department of Defense defines the term resiliency for Space support as the ability of a Space system architecture to ensure a persistent support to mission success in spite of hostile actions or adverse conditions.[1]

The US-Homeland Defense doctrine defines warfighting mission assurance, of which Space domain mission assurance is one element.[2] Having a closer look at Space domain mission assurance there are three main elements. The first is defined as 'defensive operations' which in this paper means preventing an enemy from detecting and targeting any kind of Space service or asset. This includes for example tactical movement of assets either Space- or ground-based. Today in NATO, the tactical movement of Space systems is limited to the tactical use of NATO owned mobile ground assets. The second element of Space domain mission assurance is reconstitution. In particular, this means the launch of new assets or the activation of spare capabilities either Space- or ground-based. In NATO, this is currently limited to NATO owned ground infrastructure. The last element is resiliency, which mainly follows the definition given by the US Department of Defense. But the US-Homeland Defense paper defines different sub-elements of resiliency which are of interest within this research paper. These are defined as:

Disaggregation, which represents mainly the technical separation of services over certain platforms and not using shared and hosted payloads on other Space-based systems. This is adaptable to ground infrastructure where also non bundled assets give a certain level of hardening.

Distribution, which represents an increased number of nodes or assets to define a service. The degradation or the loss of one node then has just a minor impact on the whole service provision. NATO has a chance to use this element of resiliency within their ground segment network.

Diversification, which represents using different platforms, orbits and/or systems to ensure access to a specific service. This also includes the use of national (military as well as governmental), international (mainly NATO member nations but also 'close' partners) and commercial assets and services.

Protection, which represents passive technical solutions in hardware protection, as well as, the use of redundant subsystems. It also includes a certain level of organizational or active protection which includes Space Domain Awareness (SDA), as well as, the option of planning and conducting Space operations. A certain level of overlapping and duplication with the defensive operations, as stated above, is likely and intended.

Proliferation, which means deploying more systems either in Space or use a wider network of ground-based infrastructure. These systems can be different, as long as they are able to contribute or perform the same service.

Deception, which means hiding or veiling the real strengths and weaknesses of the Space architecture providing the service. In order to optimize this element, usually a certain level of classification as well as the offensive use of (mis)information can be employed here.

An alternate definition is provided by the Carri report, which offers a broader definition of resiliency, not specific to Space services or assets.[3] After discussing a certain number of specific definitions of resiliency, the report comes to the conclusion that resiliency is the capability to anticipate risk, limit impact and bounce back rapidly through survival, adaptability, evolution and growth in the face of turbulent change. The NATO Science and Technology Organization (STO) activity on finding 'Resiliency Concepts to Enhance Preservation of NATO Space capabilities' tried to adapt the definition given in the Carri report.[4] During the STO meeting, the special situation of NATO in Space resiliency was discussed. While most of the resiliency requirements out of the US definitions have technical influence on the system's design or operation, most of these measures cannot be adapted for the Alliance. This implies that NATO has to find additional methods to increase its Space resiliency efforts. As an outcome, especially the improvement of education and training as well as standardization are measures to enhance resiliency that NATO can coordinate with its member nations. Using diversification and distribution via either commercial services or specific requests on nations' capabilities were also pointed out as potential NATO activities.

Resiliency is often described as an element of deterrence.[5] A resilient architecture of Space systems which leads to persistent and robust Space service provisioning, serves as a deterrence factor, especially if it leads to technical advantages that cannot be countered by potential opponents.

These definitions and the measures identified define the starting points and limiting factors of this research project. Based on these, potential future changes in responsibilities or competencies will be discussed and assessed in this paper.

1. US Department of Defense, extract out of National Security Space Strategy (2011) Fact Sheet: Resiliency of Space Capabilities. Washington DC. Available from https://archive.defense.gov/home/features/2011/0111_nsss/docs/DoD%20Fact%20Sheet%20-%20Resilience.pdf (accessed 18 Nov. 2019).
2. Office of the Assistant Secretary of Defense for US Homeland Defense & Global Security (2015) Space Domain Mission Assurance: A Resiliency Taxonomy. Washington DC: ASoD.
3. Carri report (2013) Definitions of Community Resiliency: An Analysis. Community and Regional Resiliency Institute. Available from https://s31207.pcdn.co/wp-content/uploads/2019/08/Definitions-of-community-resilience.pdf (accessed 19 Nov. 2019).
4. NATO Science and Technology Organization, STO Specialist meeting SM-308 (2018), Technical Evaluation Report on Resiliency concepts to enhance Preservation of NATO Space Capabilities. STO-MP-SCI-308. Paris: STO.
5. Console, Andrea (2018) Space Resiliency – Why and How?. The Journal of the JAPCC, Edition 27 (Autumn/Winter 2018), p. 10–16.


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CHAPTER 5

Space Implementation in Current NATO Policy

NATO has developed and agreed upon several policies, documents and plans how to organize and implement Space into NATO organizations and procedures. The majority of these documents are classified. The aim of this chapter is to give the reader a brief overview and discuss topics based on openly available sources. For the deeper analysis, JAPCC has published a classified version of this white paper on the classified NATO network. Authorized personnel can also request a digital copy of the classified version under registy@japcc.nato.int

5.1 Guidance

NATO took its first organizational steps to implement a Space coordinating function by introducing the NATO's Approach to Space, which mandated the establishment of the NATO Bi-Strategic Command Space Working Group (NBiSCSWG) which is up to now the highest-level entity working on Space topics within NATO.

5.1.1 Policy on Space Support in Operations: In May 2018, the Policy for Space Support in Operations was released. This policy gives an overview on NATO's military-focused point of view on the dependency on Space services based on previous documents such as the AJP 3.3.

5.1.2 Overarching Space Policy: In June 2019, NATO released the Overarching Space Policy.[1] It encourages the nations to use the approach to Space as a forum for political and military consultations and as a voice and a facilitator for further development.[2] This includes specifically: compatibility and interoperability in the member nations' Space services, products and capabilities within the six already stated Space support functional areas. Among the alliance member nations, this policy also names trusted commercial service providers or entities as potential partners in providing Space support. NATO states that it will not become an autonomous Space actor for the time being as agreed by the nations. However, the policy encouraged the member nations to support an initiative to recognize Space as an operational domain of NATO to allow treatment equivalent to that of the already declared domains (Land, Maritime, Air and Cyberspace). It also gives NATO a voice based on the willingness of the member nations without levying too many specifications on the providing Nations.[3] Based on the importance of the Overarching Space policy, analysts discuss the Alliance's response to an attack against a Space asset.[4] As assessed by the author, while the North Atlantic treaty is limited to attacks in Europe and North America,[5] the invocation of Article 5, which refers to collective defense, should not necessarily be assumed as an automatic, in a situation like this. It is the author's opinion, compared to the Cyber Domain,[6] but in a case-by-case approach for when a hostile action has been observed and is identified as to the applicability of Article 51 in the United Nations Charter.[7]

5.1.3 Recognizing Space as an Operational Domain: In November 2019, NATO recognized Space as an Operational domain.[8] The aim is to strengthen the Alliance's deterrence and defense posture for future security challenges. Being an operational domain sets Space on the same level as the other already existing domains (Land, Maritime, Air and Cyberspace).[9] This has impacts on the integration of Space into the internal processes of NATO, such as operational planning for example, where Space was not always included. The decision to recognize Space as an operational domain also implies the development of implementation plans to integrate the new domain inside NATO; a process that usually takes several years. Keeping the momentum the development of the NATO has agreed upon the Space Centre as the first visible element.[10]

5.1.4 Remark on NATO's Guidance Procedures: All NATO decisions on policies, strategies etc. have to be made in consensus. Usually, products or initiatives, often led by one nation or several nations, are negotiated with all nations in a standing procedure. After making an agreement, the product is then marked up in a so-called 'silence procedure' for a certain period of time, during which any NATO nation can add further comments that have to be negotiated afterwards. If there are no further comments, the product is then approved and will be published. A disadvantage of this procedure is that sometimes single words have to be discussed in detail to get the consensus and the whole process consumes a lot of time. The overall advantage afterwards is that the outcome was definitely approved by all NATO nations and can then be used for further development without any complaints.

5.2 Organization

5.2.1 Staffing in the NATO Command Structure [NCS]: As stated before, NATO does not operate its own satellites, but operates several static as well as mobile ground infrastructure components for SATCOM access. Space and Space-related services are voluntarily given to NATO by the member nations or are bought from commercial providers. A few NATO entities such as the NATO Communication and Information Agency (NCIA) play a special role in the commercially procured Space support, which will be specified in the next chapter. That implies a specific role for NATO within the Space coordination functionality in comparison to nations that operate their own satellite fleets. For nations, operating their own satellites that means having a full commanding and tasking authority for the assets directed via

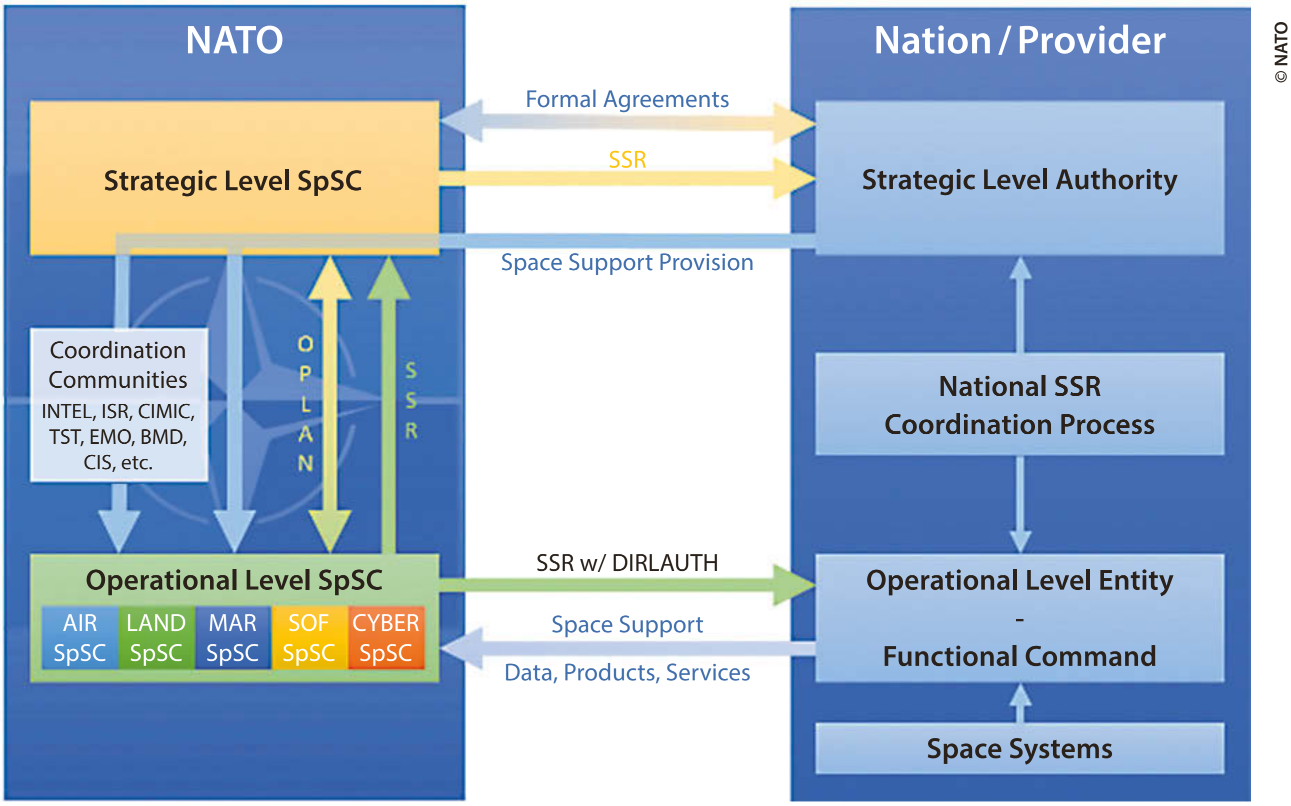

Figure 2: Space support coordination functionality within NATO (taken from NATO AJP 3.3).

national entities, either civilian or military. Depending on the available assets and services, it requires a complex coordination system. For NATO, the organization of Space support is more or less done by making a request to one of the contributing nations. Organized similar to the US Space support coordination functionality, it has a specific defined process for requesting the support. While SATCOM and ISR are requested and coordinated within the communications as well as the intelligence communities, at least three of the four remaining Space support functional areas are under the responsibility of the Space support coordination functionality.

Space Weather (WX) influences are currently under the responsibility of the METOC. While PNT, satellite operation as well as SATCOM are the most important users of WX information, it implies that a logical responsibility could be embedded in the Space support coordination functionality.

The Space support coordination functionality is located in NATO on the strategic level at (Allied Command Operations (ACO) in Mons, Belgium) as well as the operational level (Joint Forces Commands in Brunssum, Netherlands (JFCB), Naples, Italy (JFCN) and will be established in the Joint Forces Command Norfolk which is currently in the build-up phase). The single service commands (Allied Land Command (LANDCOM) in Izmir Turkey, Allied Maritime Command (MARCOM) in Northwood, Great Britain as well as the Allied Air Command (AIRCOM) in Ramstein, Germany) are also on the operational level but without a designated joint task. All these commands have permanent Space support coordinating personnel organized in Space Support Coordination Elements (SpSCE) initially staffed, but will be augmented if needed by the member nations (Figure 2). The implementation of the Space Domain is assessed to define new terms and responsibilities that encompass the Space support coordination functionality.

As already mentioned, the NATO Space Centre will play a key role in this process.

The tactical level, which is a corps-level for land forces, a Joint Force Air Component (JFAC) Command for air forces or a maritime task force for naval units, does not have any permanent personnel yet. While in the USA, for example several SpSCEs and their dedicated personnel are trained and available for exercises and operations at a certain level; for NATO - especially on the tactical level - it is always a challenge in the force generation process to find appropriate personnel.[11]

While the Spacefaring nations, except the US, that have their own career path have only a limited number of Space-trained personnel, the non-Spacefaring nations are lacking these experts entirely. Consequently, the same few nations fill all of the Space related positions. Inside the NATO command structure, this is reflected by the nation's measure in Space positions. It is logical that with the new NATO developments to implement the Space domain, which also includes HQ internal processes, lead to a significant demand of Space personnel in the NCS.

In the US system, Space support is usually organized on the Combatant Command level that is similar to the JFC level in NATO. Inside the US Combatant Commands, the Space Coordination Authority (SCA) is usually delegated to the JFAC commander. Within the JFAC staff, a position called Director of Space Forces (DS4) is established, which acts as the senior Space advisor on that level. In the major Combatant Commands, this position is filled with a Colonel (OF-5) who has a staff element to support him 24/7 during contingency operations.[12] SCA allows a special Direct Liaison Authorized (DIRLAUTH) between a Combatant Command and the Combined Space Operations Center (CSpOC) to optimize efforts and ensure direct support. The request or the task to get the required Space support is then coordinated and organized by the US CSpOC that is responsible for the Space support functional areas except for SATCOM and ISR. In Great Britain, the Headquarters of the Air Command is responsible for Space support.[13] On their behalf, the UK Space Operations Coordination Centre (UK SpOCC) then does all coordination with the British Space providers, mainly military. In Germany, the German Cyber and Information Command (Kdo CIR) coordinate the Space support functional areas of SATCOM and ISR. The remaining Space functional areas available in Germany are coordinated via the German Military Space Operations Command. All of these national entities have a 24/7 availability.

Applying this concept to NATO, the entity responsible for the Space support coordination functionality in NATO should be embedded collocated to AIRCOM, which would also take over the responsibility as JFAC for a supported JFC and hence the responsibility as the Space Support Coordinating authority.[14] NATO has reliable dedicated Space support provided by the nations based on agreements. At present, the responsible person in charge of the Space support coordination functionality does not have a dedicated 24/7 staff element or operation/coordination center to support him. Ensuring this should be considered in the development of the internal structure of the NATO Space Centre. In contrast to the US system, where the delegation of authority is mandatory, the current NATO process includes an additional step. It is currently agreed in the doctrine that Space Support Requests (SSR) have to be adjudicated and approved by a Space officer at ACO.[15] Establishing agreements on coordinating authorities in advance or establishing an overarching deconfliction authority shall mitigate these kinds of misleading discussions.

5.2.2 Special role in the interaction with the Intelligence community: Space Intelligence is information on foreign/enemies militarily usable Space and counter-Space capabilities as well as their implementation and use within military operations. On the other hand, Intelligence from Space or Space-based ISR is intelligence collected by these kinds of assets such as electro-optical, Synthetic Aperture Radar (SAR) or SIGINT satellites. The Intelligence community coordinates both processes, and services can be requested via Requests for Information (RFI). Based on the uniqueness and complexity in assessing foreign Space capacities and capabilities, a close collaboration between the Intelligence and the Space community in this topic is needed to ensure the best possible service for NATO.

5.3 Interim Recommendations

To establish a more robust structure and organization for NATO's Space support coordination functionality, the personnel base has to be broader and organized more widely. NATO has to encourage its member nations to train and educate a higher number of Space experts who can fulfil NATO's staffing requirements when needed. At the same time NATO, should define and refine its own organization to meet its Space needs in the future. Especially since recognizing Space as an operational domain, NATO must define its new and increased personnel requirements. On the strategic as well as the operational levels, the initial body of employees is defined and embedded in the HQs, however at present the tactical level is lacking these elements. This shortfall results in a lack of Space support coordination processes in tactical level exercises. This shortage of knowledge and experience often leads to misunderstanding and overestimated demands on potential Space support. Establishing an initial SpSCE, either by creating a full position or at least an auxiliary function on the tactical level will support the process of integrating the knowledge. The often-quoted saying: 'Train as you fight and fight as you train' is also true for Space support.

The actual Space support coordination procedure within NATO requires that all SSRs have to be approved by the Space personnel at SHAPE on the strategic level, which takes a lot of time. To be able to do this expeditiously, a 24/7 available staff element at SHAPE could be required. In the author's opinion, this is an unneeded parallel structure of the operational level Space Centre already agreed upon. To prevent this, the requirement during operations for the strategic level coordination mechanism should be reassessed. An option could be to make the strategic level responsible during peacetime or within the force generation process in preparation of an operation. Underneath the general coordination of Space support for NATO operations, DIRLAUTH negotiations seem to be crucial. Having defined them, the coordination authority should then be delegated to the Space Centre acting on behalf of the military commander.

Even if the Space support coordination functionality is organized as recommended above, it still performs simply a coordination function for the nations. Therefore, it will be necessary to gain resiliency by having more than one nation as a potential service provider. One way to coordinate this could be a responsibility segmentation for the Space functional areas to the Spacefaring nations of NATO, as framework nations for example. The support function can then be filled by the nations' SpOCs on behalf of NATO.

Experienced Space functional experts at the action officer level are rare even inside Allies' national forces. Most Allied Spacefaring Nations have started internal reorganisations of their military Space structure. It is assessed that the willingness of Allies to send a significant number of Space personnel to NATO is currently limited. The augmentation of a Space structure that is able to fulfil the function and importance of the Space Domain in comparison to the other Domains requires a significant increase of Space-knowledgeable personnel inside the NCS. To follow a step-by-step approach, some of the needed functions will have to be established over time. Therefore, Space positions that have to be finally staffed by career Space personnel, at least in mid- or long term approaches, may need to be staffed on short term as an exception by non-career Space personnel. However, actual Space SMEs should be placed into these positions as quickly as possible. Therefore already existing structures should be reassessed to determine if personnel within the current NCS could potentially be re-routed to augment the Space Centre.

There are no actual suggestions for staffing of the Space Centre published yet. However, the end goal should be a 24/7 capable Space Centre. As such one 24/7 position requires between 6.5 and 7.5 personnel to be properly maintained. It is envisioned that a 24/7 NATO Space Centre will be required to merge daily products to conduct all NATO activities. However, if an increased demand signal emerges for Space data, products, and services in the near term then the limited number of current Space SMEs throughout the NCS may have to be temporarily connected into a virtual Space Centre, for instance during an operational surge. Nevertheless, the short term limited manning solutions will not solve long-term Space SME shortfalls within NATO.

Besides the Space Centre and the already existing SpSCE structure, positions for Space personnel need to be established in at least every operational HQ as well as at SHAPE and ACT to foster the internal staff processes. This requires at least positions in the Intelligence, Operations, Planning, Exercise, and Force Development Divisions. As already proposed for the Space Centre staffing, it should follow a short mid and long-term approach. In the near term, it may be necessary but not ideal to staff positions with non-career Space personnel. However, these personnel should be required to attend at least a national introductory Space course. If a nation does not yet have a course, then they should be required to attend another nation's course that is currently available to Allies.

Finally, NATO should encourage Allies, especially all Spacefaring Allies, to have personnel assigned to the Space Centre. These personnel, trained within the individual nations as well as the NATO processes, can then also act, when back in a national position, as a liaison capacity to their national SpOC or Space entity. This will increase information flow, enhance communications, and give the opportunity for Allies to offer new products and services to NATO. If this cannot be realized for any reason, NATO should encourage the Allies to establish a kind of liaison function within their national SpOCs to interact with the NATO Space Centre.

Finally yet importantly, NATO should encourage Allies that have dedicated tactical level HQs assigned to NATO to also implement a SpSCE nucleus inside those HQs.

Addressing the education and training of personnel, it has to be considered that there are already several Space related courses available within the NATO nations. In addition, the NATO School in Oberammergau also offers a basic course in Space support in operations, as well as a Space Support Coordinator Course that will be available starting in 2021. This course in particular trains designated Space support coordinating personnel in the special requirements for their role inside NATO. When the requirements for additional Space related personnel are formulated and adapted in a force adaption plan, it must be considered that trained and in the best-case trained and experienced personnel are required. It is not adequate to fill the position with untrained personnel and rely on the NATO School Oberammergau´s basic course. As stated before, there are several courses available giving potential personnel the opportunity to be trained in advance and gain experience for their projected position. The staffing of the Space related positions has to be done by trained and experienced personnel first, before sending employees by national allocations to NATO.

To ensure the best possible outcome for Space intelligence, a close cooperation and collaboration with the Intelligence community has to be established. Positions have to be staffed by Intelligence personnel trained and experienced in working with military Space personnel and organizations or Space personnel who are trained to work with the Intelligence community. It depends on the internal career paths of the sending NATO member nations that have the responsibility to fill these positions with Space knowledgeable personnel. Establishing robust links to the Intelligence community potentially via staffed liaison functions will make for the maximum efficiency.

1. NATO HQ (2019), NATO Defence Ministers approve new space policy, discuss readiness and mission in Afghanistan; https://www.nato.int/cps/en/natohq/news_167181.htm [accessed 23 Mar. 2020].
2. Benjamin Silverstein (2020), NATO's return to space, available from: https://warontherocks.com/2020/08/natos-return-to-space/ [accessed 10 Aug. 2020].
3. Kestutis Paulauskas (2020), Space: NATO's latest frontier, available from: https://www.nato.int/docu/review/articles/2020/03/13/space-natos-latest-frontier/index.html#:~:text=NATO%20will%20not%20become%20an,of%20its%20missions%20and%20operations. [accessed 12 May 2020].
4. Alexandra Stickings (2020), Space as an Operational Domain: What next for NATO?, available from: https://rusi.org/publication/rusi-newsbrief/space-operational-domain-what-next-nato [accessed 12 Nov. 2020].
5. NATO (1949) The North Atlantic treaty. Washington DC. Available from: https://www.nato.int/nato_static_fl2014/assets/pdf/stock_publications/20120822_nato_treaty_en_light_2009.pdf [accessed 29 Aug. 2019].
6. NATO HQ (2019), NATO will defend itself, available from: https://www.nato.int/cps/en/natohq/news_168435.htm?selectedLocale=en [accessed 13 Mar. 2020].
7. United Nations (1945) The Charter of the United Nations. San Francisco. Available from https://www.un.org/en/sections/un-charter/introductory-note/index.html [accessed 29 Aug.2019].
8. NATO Allied Command Transformation (2019) General Lanata Attends the Leaders' Meeting in London. [online] Norfolk VA: NATO ACT. Available from https://www.act.nato.int/articles/general-lanata-attends-leaders-meeting-london [accessed 12 Dec. 2019].
9. NATO HQ (2019), Foreign Ministers take decision to adapt NATO, recognize space as an operational domain; available from: https://www.nato.int/cps/en/natohq/news_171028.htm [accessed 23 Mar. 2020].
10. NATO Allied Air Command (2020), NATO agrees new Space Centre at Allied Air Command. Available from: https://ac.nato.int/archive/2020/NATO_Space_Centre_at_AIRCOM [accessed 26 Oct. 2020].
11. Center for Army Lessons Learned (CALL) (2018) Operating in a Denied Degraded, and Disrupted Space Operational Environment. Fort Leavenworth. Available from: https://usacac.army.mil/sites/default/files/publications/18-28.pdf [accessed 23 Oct. 2019].
12. US Air Command and Staff College Space Research Elective Seminars (2009), AU-18 Space Primer. Alabama: Air University Press Air Force Research Institute.
13. UK-Ministry of Defence (2010), The UK Military Space Primer. Shrivenham: Development, Concepts and Doctrine Centre [DCDC].
14. NATO AIRCOM (2020), Responsibilities, structure, mission, available from: https://ac.nato.int/ [accessed 26 Oct. 2020].

    NATO Allied Air Command (2020), NATO agrees new Space Centre at Allied Air Command. Available from: https://ac.nato.int/archive/2020/NATO_Space_Centre_at_AIRCOM [accessed 26 Oct. 2020].
15. NATO Standardization Office (NSO) (2016), NATO Allied Joint Publication AJP 3.3 Air and Space Operations Edition B Version 1. Brussels: NSO. Available from: https://nso.nato.int/nso/nsdd/listpromulg.html [accessed 13 Aug. 2019].

CHAPTER 6

The Role of NATO Entities in Space Support

Among the nations providing Space support services to NATO coordinated by the Space support functionality, there are two NATO entities that are relevant in this process.

6.1 The NATO Communications and Information Agency (NCIA)

As stated earlier, NATO does not own or operate any satellites anymore. This decision was made in 2004 when the last NATO-owned communications satellite nearly reached the end of its designed lifespan and had to be replaced. With the replacement NATO SATCOM Post-2000 (NSP2K) program, NATO decided not to own satellite systems but to use some Alliance member nation's military communication satellites placed in GEO and to lease capacity on these national constellations.[1] This successful approach was renewed in December 2019 with the Capability Package 130 (CP130) program that started to provide new SATCOM services from national military satellite constellations as a core capability continuously available from January 2020 until the end of December 2034.

The new program also includes the option for additional SATCOM capacity on GEO satellites from commercial providers, contracted in advance, but only activated if needed. Such additional commercial SATCOM services would only be contracted in the case when insufficient capacity or coverage was available on the core military capability and could only be used to support peace-keeping or peace enforcement missions with little or no threat to these systems.

The CP130 program also includes commercial communication services on Inmarsat and Iridium satellite constellations. Apart from the leased capacity based on military satellites arranged under the CP130 program, some nations provide additional satellite capacity as a contribution to NATO.

NATO owns and operates a number of fixed, transportable and deployable SATCOM ground infrastructure elements that will also be modernized and expanded within the CP130 program. The ground segment SATCOM services are provided by the NCIA, while the fixed ground stations are operated by the NCIA itself and the transportable and deployable ground stations are operated by the NATO Signal Battalions (NSB). These SATCOM services are to support mainly NATO fixed and deployable headquarters, whether that is the Joint Force Commands (JFC) or single-service commands like AIRCOM, LANDCOM or MARCOM.[2] The SATCOM services can be requested by any other NATO entity and ensures connection within larger NATO exercises.

NCIA has a Geospatial Service Branch inside its ISR Support Centre that is responsible for Geographic Information of NATO's areas of operation. To fulfil these requirements, it has signed a contract with a US-entity to provide Space-based ISR data for further processing. The branch is focused on geospatial information, which refers primarily to infrastructure or mapping functions. The data provided by the US-entity is not usable for targeting or the tactical operations of NATO. In addition, NCIA is only allowed to provide processed data from their services to NATO users. If ISR data is required for geographical areas outside of the traditional NATO area of operations, NCIA primarily has to rely on the willingness of the NATO member nations to get this data. If data cannot be provided by member nations or the US-entity, NCIA has the authority to acquire the needed data directly from commercial companies. An additional option could be a potential contribution by Allies such as Luxembourg via a defined capacity share of the planned NAOS ISR satellite.[3] Such a contribution could create a possible tasking or at least a requesting authority with priority, while in general, the intelligence collection procedure inside NATO would be unchanged.

The NCI Agency EW and Sensor Branch of the ISR Support Centre has the scientific knowledge and Electronic Warfare assets related to Navigation Warfare (NAVWAR). The branch assets include the Ground-based Asset for Direction and Location Finding (GANDALF), which is a ground-based GNSS jammer and spoofing detection and characterization system.[4] NCIA has also developed the medium power multi-channel GNSS Jammer kit that could be used by the nations in training and exercises. For further assessment on counter GNSS, a modelling prototype tool to estimate the impact of ground-based jammers on various GNSS receivers was developed and is currently being tested within NATO exercises.[5]

The EW and Sensor Branch has also been instrumental in the development of the NATO NAVWAR playbook, which is a 'situation-response' operational book that offers suggested options on how to addresses threats to Positioning Navigation and Timing and has provided input to the PNT and NAVWAR policy.[6]

The branch also provides technical support to the NATO EW working group, which among other tasks, is responsible for meeting the operational requirements for the EW Command and Control tools, including NAVWAR aspects.[7]

6.2 NATO Intelligence Fusion Centre (NIFC)

The NIFC is a Memorandum of Understanding (MoU) organization working for NATO, in particular for the J2 branch of SHAPE HQ.[8] All NATO member nations, as well as some other nations that work closely with NATO, have signed the MoU and have a permanent or at least a temporary personnel footprint in the NIFC. Besides other tasks in the intelligence work for NATO, NIFC also works with ISR data, collected by commercial Space-based assets, turning satellite data into actionable information. The NIFC, as the hub for NATO in Space intelligence information, plays an important role in the SDA process, i.e. the technical knowledge relating to Space and counter-Space capabilities, their embedding in the military processes and doctrinal background as to how nations are using them. This information is essential for the work of the Space Centre. Establishing and maintaining a liaison function between the NIFC and NCIA will ensure and support approprite collaborative work. In the future, similar to the SATCOM support via the NCIA, contributions of ISR data collected by Space-based assets will then be available to NATO, with the NIFC playing a key role due to its specific task.

6.3 Interim Assessment

NCIA and NIFC are examples of well-organized Space Support outside the regular NATO SSR process. With its PNT expertise and modelling capability, NCIA will create a new function inside of NATO. This function will not develop or distribute operational products, but rather gives NATO member nations the opportunity to get education and training as well as give them developed and usable tools to design national products which can then potentially be shared with NATO in the future. The link between the Space support coordination functionality and this NATO entity has to be further developed, not only for PNT, but more generally.

With the NATO-owned SATCOM ground infrastructure and the range of military and commercial SATCOM capabilities, there is the chance for NATO to use these elements for technical resilience, as stated in the definition as 'protection.' A deeper assessment of the potential future role for NATO Space support seems to be substantial. This analysis should examine potential differences in providing commercial versus military SATCOM services to NATO in conflict situations, where the satellites of commercial providers themselves could be threatened by an opponent. This scenario has to be compared with the peacetime provisions, as well as conflict scenarios without threats to the satellites.

1. NCIA NITECH (2019) NATO Innovation and Technology, Issue 2 Oct. 2019 Digital Transformation. Available from: https://issuu.com/globalmediapartners/docs/nitech_issue_02_oct_2019 (accessed 24 Oct. 2019).
2. 1st NATO Signal Battalion (1NSB) (2019) Questions on SatCom support organization (interview). Interviewed by Tim Vasen, 21 Nov.
3. Arianespace (2018) Arianespace to launch the National Advanced Optical System (NAOS) for OHB Italia at the benefice of the Directorate of Defence of Luxemburg. (press release) 17 Oct. Available from https://www.arianespace.com/press-release/arianespace-to-launch-thenational-advanced-optical-system-naos-for-ohb-italia-at-the-benefice-of-the-directorate-of-defence-of-luxembourg/ (accessed 24 Oct. 2019).
4. NATO Communication and Information Agency (NCIA) (2016) Testing direction finder at GPS Jamming trials (press release) 05 Sep. Available from https://www.ncia.nato.int/about-us/newsroom/testing-direction-finder-at-gps-jamming-trials.html (accessed 13 Jan. 2021).
5. NATO Communication and Information Agency (NCIA) (2019) Agency develops software to estimate areas of degraded GNSS service (press release) 06 Apr. Available from https://www.ncia.nato.int/about-us/newsroom/agency-develops-software-to-estimate-areas-of-degraded-gnss-service.html (accessed 13 Jan. 2021).
6. Navigation Warfare Capability Team of the NATO HQ C3 structure (2019) NATO Navigation Warfare Playbook. Draft Version 3.0 – 31 Oct. 2019.
7. NCIA (2019) Questions on PNT modelling and initial NAVWAR service to NATO (interview). Interviewed by Tim Vasen, 16 Dec.
8. NIFC (2019) Questions on Space Support to NIFC. (interview) Interviewed by Tim Vasen, 3 Jun.

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CHAPTER 7

Combined Space Operations and Additional Commercial Support to NATO

NATO as an alliance has the chance not only to rely on the Space services, products and capabilities of its member nations, but NATO also has the opportunity to potentially play a future role in being a kind of coordinating hub between the member nations themselves and the potential commercial companies providing Space services.

7.1 The Multilateral Approach of a Combined SpOC

Other than the US, no other NATO nation is able to conduct and support all Space functional areas only by national means. Even Space operations which means using Space as an operational area is usually limited to their available national functional areas. However, even the US has recognized that in the current contested, congested and competitive Space area, their advantage will decrease if they do not integrate their allies.[1] In order to find a common solution and integrate more allies than the Five-Eyes community, the idea of Combined Space Operations (CSpO) and a Combined Space Operations Centre (CSpOC) has been discussed. It was a consequence of several lessons learned within the Schriever Wargame series, where starting in 2016, France and Germany had been integrated.[2] In 2018, Japan was integrated as a new partner nation as well.[3]

The idea of CSpO is a multinational approach to counter worldwide challenges in operating satellites in Space.[4] Australia, Canada and Great Britain were the first nations to sign in the CSpOC in 2018,[5] but other allies were invited as well.[6] This multinational approach provides the option to include the data of multiple sensors, operated by allies, inside the US-led Combined Space Operations Centre. Located at the Vandenberg Air Force Base in California, this Centre focusses on security in Space, but also on the coordination of Space support in military operations. Based on the former Joint Space Operations Centre (JSpOC), it was extended beyond the Five-Eyes community by adding France and Germany with liaison elements to their own Operation Centres.[7] As the next step of the combined work, the full integration of non-US personnel in the shift system of the CSpOC is planned. The first operators, currently still out of the Five-Eyes community, have already been trained and fully integrated.[8] Based on the comments given by the Chief of the US Air Force, it is likely that all other CSpOC nations will have the chance to be fully integrated as well.[9]

The European Union's Space Surveillance and Tracking (EUSST) initiative is using a similar approach, where the five Spacefaring nations of the EU (France, Germany, Great-Britain, Italy and Spain) coordinate and conduct SSA applications for the EU/ESA satellites as well as national satellites from EU member nations. It is also prepared to provide the services on request for commercial companies within the EU. This approach prevents duplication and saves resources.[10]

Considering the fact that nations which are members of NATO are partners of the CSpOC approach, there could be a potential role for NATO as an alliance. This role could be a coordinating one that offers mainly Space security services, provided by the CSpOC for other NATO member nations that operate military capable satellites. This coordinating role would most likely be dedicated to a specific NATO operation and may be seen as an encouraging option for other nations to offer their Space services to NATO, while NATO coordinates the Space security for their Space-based systems. Because NATO is not a Space actor, the coordination role ends after the services are provided by the responsible party to the requesting nations. It is not likely to have impacts on the agreed requesting role for NATO on Space services, because it then has to be agreed prior to the start of an operation. This could also be implemented by bilateral or multilateral MoUs, but in the case of military operations, it will reduce the coordination effort significantly when NATO fulfils this role as the coordinator. For some nations, NATO is the single agreed alliance or union to do so.

7.2 Commercial Services to Gain Resiliency for NATO

Commercial services can be a chance for NATO to increase resiliency in some Space functional areas by contracting different commercial providers.

Commercial applications offer a flexible and usually inexpensive option to make use of Space services.[11] The idea behind the integration of commercial companies is only to get and pay for the service when it is needed. But this does not consider the fact that even commercial applications are widely contested. This is especially the case in areas where military operations take place. Even if these operations are legitimized by a United Nations decision and mandate, they may not be recognized by all worldwide nations as such. The worldwide need for information about the local situation can make commercial services unusable for NATO or in the best case simply more expensive. If there is an additional security restriction or requirement, due to commercial satellite ISR data, by the providing nation or company, it can be even worse. To get persistent and affordable commercial Space support, NATO has to sign long-term contracts with companies. These contracts usually contain a basic payment to ensure priority access as well as additional payments, if the service is used more.

From the security perspective, there is also the matter of payment costs. Commercial companies usually try to make as much money as possible. Potential better-paying customers can become a challenge for NATO. Another security issue could be the company itself, especially if it is licensed by and located in a non-NATO nation and thus governed by national regulations. Therefore only companies based in NATO member nations should be selected to provide services to NATO. Additionally, the data sources have to be monitored tightly. NATO should use the political influence of their member nations to implement security issues in the licensing processes of new commercial companies, as well as the licensing processes for new satellites and other applications. It has to be guaranteed that in case of a conflict or a 'critical' NATO operation, neither the opponent nor critical or negative media can have the same access to the latest data. It has to be made clear that it is not a kind of censorship, but rather for security and military reasons. Delayed publishing of the data, making it unusable for military targeting could be a good way to fulfil these requirements.

To gain as much resiliency as possible, NATO should sign contracts with certain companies that belong to different countries, with priority given to NATO member nations. This reduces the danger of being 'squeezed out' of contracts due to the highly competitive market.

Finally, contracts have to be coordinated, especially if a commercial company wants to gain an advantage while being contracted by a NATO nation as well as a NATO entity. The overall goal should be to avoid as much duplication as possible. With the NCIA for SATCOM and ISR and the NIFC for ISR, there are two NATO entities established to fulfil this task.

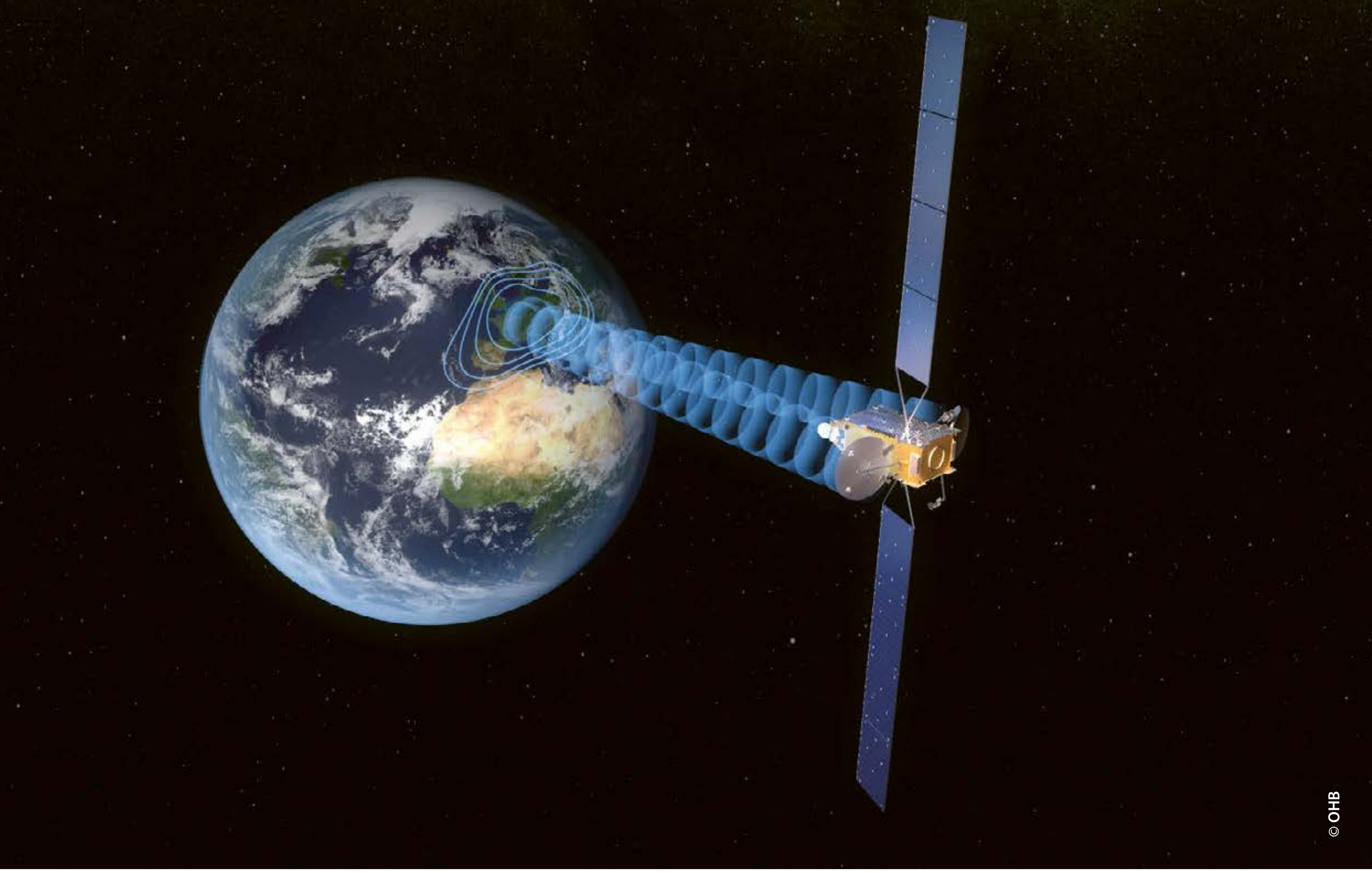
Some examples of commercially available services that could and should be available to NATO:

Commercial ISR services are offered by the US based companies Digital Globe[12] and Planet,[13] or the European Company Airbus Defense and Space.[14] HawkEye 360 is the first commercial company that offers SIGINT services.[15]

Eagle Vision is a military provider of ISR data based on commercial imagery mainly out of European sources,[16] contracted by the US Air Force and made available for NATO.[17] Eagle vision is by contract able to provide commercial satellite imagery on short notice, but only in a previously defined and contracted area. Access to these services has been given to NATO by the US. The use of this provider spreads the sources across more shoulders and makes potential adversaries' counter-Space actions more complicated.

Examples for commercial SATCOM are the Luxembourg based companies GovSat[18] and SES.[19]

1. Goldfine, D. (2019) To win in Space you must work closer with Allies. (online) Alexandria VA: SpaceNews. Available from https://spacenews.com/air-force-chief-goldfein-to-win-in-space-u-s-must-work-closer-with-allies/ (Accessed 25 Nov. 2019).
2. US Air Force Space Command (AFSPC) (2016) Schriever Wargame 2016. (online) Colorado Springs CO: AFSPC Public Affairs Office. Available from https://www.afspc.af.mil/News/Article-Display/Article/778881/schriever-wargame-2016/ (accessed 16 Apr. 2019).
3. Cozzens, T. (2018) Schriever Wargame 2018 concludes. (online) Cleveland OH: GPS-World. Available from https://www.gpsworld.com/schriever-wargame-2018-concludes/ (accessed 16 Apr. 2019).
4. US Air Force Space Command (AFSPC) (2018) Combined Space Operations Centre established at Vandenberg AFB. (online) Colorado Springs CO: AFSPC Public Affairs Office. Available from https://www.afspc.af.mil/News/Article-Display/Article/1579285/combined-space-operations-center-established-at-vandenberg-afb/ (Accessed 26 Nov. 2019).
5. US Air Force Space Command (AFSPC) (2018) Combined Space Operations Centre established at Vandenberg AFB. (online) Colorado Springs CO: AFSPC Public Affairs Office. Available from https://www.afspc.af.mil/News/Article-Display/Article/1579285/combined-space-operations-center-established-at-vandenberg-afb/ (Accessed 26 Nov. 2019).
6. Space News (2019) US Space Commands Major Components will be based in California and Colorado. (online) Alexandria VA: SpaceNews. Available from https://spacenews.com/u-s-space-commands-major-components-will-be-based-in-california-and-colorado/ (Accessed 25 Nov. 2019).
7. Goldfine, D. (2019) To win in Space you must work closer with Allies. (online) Alexandria VA: SpaceNews. Available from https://spacenews.com/air-force-chief-goldfein-to-win-in-space-u-s-must-work-closer-with-allies/ (Accessed 25 Nov. 2019).
8. US Air Force Space Command (AFSPC) (2019) Canadian Space Operators certified awarded Space Wings in CSpOC. (online) Colorado Springs CO: AFSPC Public Affairs Office. Available from https://www.afspc.af.mil/News/Article-Display/Article/1741597/canadian-space-operators-certified-awarded-space-wings-in-cspoc/ (Accessed 26 Nov. 2019).
9. Goldfine, D. (2019) To win in Space you must work closer with Allies. (online) Alexandria VA: SpaceNews. Available from https://spacenews.com/air-force-chief-goldfein-to-win-in-space-u-s-must-work-closer-with-allies/ (Accessed 25 Nov. 2019).
10. European Union (2014) What is EUSST? (online) Bonn: DLR on behalf of the European Union. Available from https://www.eusst.eu/ (Accessed 26 Nov. 2019).
11. NATO Science and Technology Organization, STO Specialist meeting SM-309 (2019), Opportunities/Implications of Large Scale Commercial Small Satellite Constellations to NATO Operations. STO-MP-SCI-309. Paris: STO.
12. DigitalGlobe (2019) Explore geospatial data in context. (online) Westminster CO: DigitalGlobe. Available from https://www.digitalglobe.com/ (Accessed 11 Dec. 2019).
13. Planet (2019) Insights at the Speed of Chance. (online) SanFrancisco CA: Planet. Available from https://www.planet.com/ (Accessed 11 Dec. 2019).
14. Airbus (2019). Defence and Space. (online) Ottobrunn: Airbus. Available from https://www.intelligence-airbusds.com/ (Accessed 11 Dec. 2019).
15. HawkEye 360 (2019). Global Radio Frequency Knowledge for actionable Insight. (online) Hernon VA: HawkEye 360. Available from https://www.he360.com/ (Accessed 11 Dec. 2019).
16. HawkEye 360 (2019). Global Radio Frequency Knowledge for actionable Insight. (online) Hernon VA: HawkEye 360. Available from https://www.he360.com/ (Accessed 11 Dec. 2019).
17. US Air Force (2018) Imagery Support made possible by the Airmen of Eagle Vision. (online) Washington DC: US Air Force. Available from https://www.16af.af.mil/News/Photos/igphoto/2001961563/ (Accessed 11 Dec. 2019).
18. GovSat (2019). Aim Secure. Aim High. (online) Luxembourg: GovSat. Available from https://govsat.lu/ (Accessed 11 Dec. 2019).
19. SES (2019). Beyond Frontiers. (online) Luxembourg: SES. Available from https://www.ses.com/ (Accessed 11 Dec. 2019).



CHAPTER 8

Recommendations Based on the Questionnaire Sent to the NATO Nations

A questionnaire of 19 questions was sent out to the NATO member nations and the two entities of NATO that coordinate or use Space services (NCIA and NIFC). The questionnaire was developed for this project, as well as an additional one that should define 'Specifications of Requirements for a national military Space Operations Centre (SpOC) with regard to potential NATO need for information'. This additional project will be released as a JAPCC project in a similar timeframe to this paper. The sent questionnaire is attached as Annex 2.

In total 16 out of 30 NATO nations sent an official response to the questionnaire, as well as the NCIA and the NIFC. One nation stated that it will not send a response because the topic 'Military and Space' is not represented in its military structure.

Even though only a little bit more than half of the NATO member nations responded to the questionnaire, it is assessed to be representative because the majority of the Spacefaring nations of NATO responded, as well as the non-Spacefaring nations that are interested in the topic and are active in doctrine development and exercise participation. In further assessment, the nations will not always be stated or quoted. If a significant majority have answered a question similarly, it will be then stated as a general answer. In cases of differing answers or nation specific procedures, these countries will be named. Not every question is specifically stated here with its answer. If the answers included duplications referring to the questions asked, they were merged.

One important question was asked about a SpOC in particular, is this centre able to fulfil military tasks in Space support in operations. Furthermore, it was asked whether there are developments in the foreseeable future that could lead to a better military capability of a national SpOC. Apart from the US, which is the only nation inside NATO that operates a SpOC capable of covering all Space functional areas, there are four nations that operate a military or an intergovernmental SpOC (CA, FR, GE and UK). In this case, intergovernmental means including the national Ministry of Defence. There are three more nations which have a military SpOC under development (IT, PO and SP). Two of them (IT and SP) are currently relying on a civilian SpOC, operated by the national Space authority that also serves their military purposes.

It has to be stated that in the case of Space-based ISR as well as SATCOM, the task of the SpOC is defined as operating and protecting the satellites themselves. The use and operation of the payload, responsible for providing the services, is under the responsibility of either the intelligence communities (ISR) or the communication community (SATCOM). In the case of specific services, at least one other nation (TU) operates a Reconnaissance Command that could be seen as an initial SpOC, but it is currently only responsible for the national ISR satellites.

The four above stated SpOCs, as well as the one in the US, offer a 24/7 service on Space support in operations at least for their national armed forces. In case of resiliency, the need for a NATO SpOC is often under discussion. If the services of the current five SpOCs and the ones planned in the future are used, in the author's opinion, there is no real need for a NATO SpOC. What seems to be necessary is a Space Centre that coordinates the Space support for NATO in times of military operations. A potential role for NATO in supporting or being part of one of these national SpOCs would be as a coordinating function by bringing together the Spacefaring nations of NATO to support non-Spacefaring nations that operate only a few satellites and do not have a military option to protect them. Whether this would be approved in a consensus or not, as long as NATO remains an agreed upon 'non-Space actor,' the real need for a NATO SpOC is not present but the need for a 24/ 7 Space Centre as the hub for Space support coordination is given.

As reflected in the questionnaire, there are several nations within NATO that are defined as military Spacefaring nations, based on criteria defined by the author. There is no fixed or agreed-upon definition available so far which defines a military Spacefaring nation. Besides commonly used, but 'unofficial,' definitions employed at the working level by mainly intelligence personnel (and so unusable for academic research) there is only one definition available. King and Blank have listed three primary actors: US, RUS, CHN as military Spacefaring nations and a limited number of emerging actors such as some NATO member nations, but without further elaboration.[1] The main characteristic and what distinguishes the primary actors and the emerging nations from others is the spectrum of Space functional areas. Spacefaring nations not only develop their own national assets for accessing and using Space, but also possess counter-Space capabilities, at least the technology to conduct these operations. Only the three primary actors proposed by King and Blank have this full spectrum of Space capabilities.

In analyzing emerging military Spacefaring nations, the author is focusing on NATO member nations. In this paper, these nations are defined as those who fulfil more than one of several criteria as highlighted below. The operation of either dedicated military satellites or dual-use satellites with a military component, not in an experimental capacity, in at least one Space functional area, is the first and only essential criteria. The second criteria is the existence of a military department or element, whether at a Ministry of Defense or at the service command level, which is focused on military Space use and that coordinates all varieties of Space support or Space operations. The third criterion is the operation of a SpOC or a Space entity, whether it be centralized or dispersed, that can be contacted by NATO via the nation's liaison representatives at ACO. The fourth criteria is the ability to provide either Space-related services or to create products for Space support in operations. The fifth criteria is possessing the technical abilities in research and development, as well as in a proven Space-related industry. The sixth criteria is the ability to integrate Space support in operations within the national training and exercise cycle, as well as generating a cadre of military experts trained with primarily nationally developed courses. The seventh, but not mandatory, criteria is having access to Space either via national or multi-lateral, non-commercial means.

Based on the responses to the questionnaire sent to NATO member nations assessed against the seven criteria, the following NATO nations were identified as military Spacefaring nations for this study. They include the US, the only nation that is fully capable in all Space functional areas as well as in Space operations. The others are CA, FR, GE, IT, ES, TU and UK. While LU has highly capable companies that offer worldwide SATCOM services, it cannot be categorized as a military Spacefaring nation in accordance with the seven criteria described above.

A closer look at the Space support products offered by the NATO nations suggests that there are some redundancies that may increase resiliency. The only Space functional area that is service-wise only provided by a single nation is the SEW function provided by US satellites. Based on these data, two more nations besides the US out of the Five-Eyes community (CA, UK) offer specific SEW-based missile defence products.

As far as PNT support is concerned, meaning the provision of PNT products not just the service itself, there are more nations capable of providing products. Apart from the US, there are four other SpOC functional nations (CA, FR, GE and UK) that offer different PNT or NAVWAR related products. The NCIA, as a NATO entity, has developed tools that can be used by nations to develop and provide PNT and NAVWAR products.

Militarily usable SSA and SDA products are created and distributed by the same five nations at different levels of detail. Currently, these are mainly based on US measurement data. This will be changed in the future, when other NATO member nations will have access to a wider database by using new national assets and sensors.

Consensus between the answering nations is that the already approved channels in ISR and SATCOM should not be changed or duplicated within the Space support coordination functionality and its process. For the WX provision, which has been thus far under METOC's responsibility, there is a discussion ongoing as to whether to keep it with them or give it to the Space support coordination functionality. Especially for WX, the knowledge and training of the personnel are essential. Only competence can prevent misinterpretations. It has been proven in exercise scenarios that METOC personnel do not have sufficient WX training, while Space personnel are better qualified in this field of work.

In the case of Space intelligence, to collect and assess Space capabilities of potential opponents – which is by definition within NATO under the responsibility of NIFC – there is currently only a very limited service available.

Most of the NATO nations are willing to share data collected by Space-based assets, as well as Space related services with NATO. Unfortunately, the most hampering issue is either the classification or the source of the data. As far as the classification is concerned, several declassified products can be made available, but this requires a high level of effort. Also, sometimes the priority of the products are different and while national forces, which could also be under NATO command, will get services more frequently or faster, the distribution to the rest of NATO may be delayed. The two NATO entities active in Space support in operations (NCIA and NIFC) have agreed by contract, that every service and product they offer is available to all NATO member nations. The way this procedure will be coordinated and decided by the national SpOCs is very similar when compared. When an SSR is received by one of the nations, mostly via the national SpOC or the defined point of contact, it will be decided on a case-by-case basis whether and when to answer it. Appointing one nation as a framework or leading nation for the provision of a specific product could be very helpful. That would require NATO to appoint another nation, not the US because they are the only nation capable to fulfil all tasks and able to respond to all requests. As stated earlier, 'resiliency' in this study is defined as ensuring a specific service or the whole Space support to a specific operation by another NATO member nation or a group of them. This assessment has the intention to put the Space support in operations on a wider support base and hence take a certain amount of workload off the US, as it is mentioned in the NATO treaty as collective support and defence. In this case, all the administrative issues and preparations will have been done prior to the time they are needed and can then just be requested. The future NATO Space Centre could then be the turnstile to request, receive and distribute the services via a similar method to the DIRLAUTH definition. If there are products of different nations on the same Space functional area available, an assessment board should be convened that approves the interoperability and the standards for NATO use.

When the nations were asked about agreements and memorandums, they stated that all support based on Space-based ISR as well as SATCOM is coordinated within the J2 or the J6 channels and that there are no specific Space functional areas, coordinated via the Space support coordination functionality. This was specially stated by some NATO member nations (CA, FR, GE, UK and US) to avoid duplication in staffing on the one hand and confusion on who is responsible for requesting these services on the other hand. Nevertheless, in the case of technical questions and the understanding of the use of these Space-based services in general, it is one functionality of the Space support coordinating personnel to always be able to give advice how to use a service and to explain the advantages, disadvantages, as well as the limiting factors.

Considering the national responses to the question of the need for additional MoUs or agreements, there is a common message. All nations who have responded to that question pointed out that, in the first place, bilateral and multilateral agreements have to be signed between the NATO member nations before NATO could start an initiative to obtain overall agreements. The idea came up to install 'framework' or 'lead' nations for certain operations and/or the support of specific Space products, as already stated in the products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distribution. Nevertheless, national differences in priority between national and NATO requirements were stated. Already signed agreements with NATO for Space support in operations are currently only signed with the US for the use of GPS as the primary PNT system, as well as the data distribution within the SEW service. Additionally, there are agreements signed by FR and the US with the NIFC for ISR data within the Intel fusion concept. For SATCOM FR, IT and UK have signed contracts with NCIA to ensure SATCOM services for NATO. All services distributed by these standing agreements are fully usable within the whole NATO community.

Most of the nations have bilateral agreements with other NATO partners for specific Space functional areas. The widest 'networks' of agreements are the Five-Eyes nations inside NATO, as well as the Spacefaring nations FR, GE and IT. The NATO entities NIFC and NCIA certainly have agreements with all NATO member nations. The use of GPS as the PNT system as well as the SEW services are agreed and signed between NATO, the member nations as well as the US, as the service provider.

To fill the gap of the above-mentioned lacking agreements and MoUs, the answering nations have achieved consensus about the way this should be organized in the future. First of all, there have to be bilateral agreements between nations on data sharing. These have to be extended as far as possible on the multilateral level. Once agreements have been reached, a potential overarching MoU or agreement for NATO seems to be a valid requirement. Alternatively, NATO should focus on either commercial support that is usually releasable to all NATO member nations or NATO should define needs or products that are requirements-wise releasable to all. The classification level of these products could be low (e.g. NATO restricted). At least one nation (TU) stated that is was not asked via an official SSR so far, and it had actually no need for an agreement.

The question of how to organize exchange mechanisms and ensure secure data transmission, was answered in principal by consensus. In the case of data transmission, data distribution and data exchange, the answering nations would like to use existing networks instead of new ones that have to be built. The best network to distribute data seems to be the NATO Secret WAN (NS-WAN). When deciding to use this network, classification and data exchange issues have to be resolved which are comparable to the already stated challenges. Additionally, it has to be agreed that Space personnel working in national positions, but designated to send data to NATO, are authorized and technically able to transmit their answers to NATO requests. To ensure this, either they or at a minimum the answering entities (e.g. the national SpOCs) have to be equipped with a capable workstation. Secure data transfer from national systems in the NS-WAN has to be ensured and technically realized at these entities in the particular data distribution area (e.g. SpOCs). This is also vice versa to ensure the secure transmission and distribution of SSRs as well. In the case of ISR data exchange, the already existing systems INTELFS and BICES seem to be sufficient. Additionally, it is stated, especially by some of the non-Spacefaring nations (BE, DE), that the whole architecture should rely on secured landlines inside the NATO nations' territories. It should also be backed up by a robust and capable SATCOM service. From an organizational perspective, the need for a push-/pull-data exchange structure was mentioned. The role of AIRCOM in the organization of Space support in NATO's ad hoc operations was outlined by FR, which also pointed out again the responsibilities of the JFCs in standing operations as well as the requirement of SpSCEs on the tactical level.

Answers to the survey questions on training and education pointed out large requirements for all NATO nations, especially the non-Spacefaring nations. While the Spacefaring nations offer a certain amount of courses, all of them, except the US, have their own requirements. To gain a certain level of resiliency by education and training, it seems to be essential that as many national courses as possible should be made available to other NATO member nations. The limiting factors in this area are also the pending data sharing agreements and resolution of the classification issues. In some cases, the primary teaching language also limits the number of possible foreign attendees. Space related courses at the NATO School Oberammergau are open to any NATO nation, but they focus on the NATO specifics. If a NATO position has to be filled with a Space expert, simply attending the NATO School Oberammergau Space courses is not sufficient.

A lot of NATO nations have already included Space support in their national exercises. The degree of integration of Space support differs between the option of Space support functional areas or the functional areas that can be provided via national capabilities. There is a consensus on the need to include Space support as much as possible. Some of the non-Spacefaring nations of NATO stated the need to get training from their more experienced allies. It is likely that in the future, through the support of potential bilateral agreements there will also be the need for education and training to be formulated and requested.

Questions on requirements for NATO specific products raised the question about NATO needs. NATO has to define what it needs and wants in the area of Space resiliency. Some MoUs that are in place should be reassessed after a certain time and to include the chance to get access to products from different nations. To gain advantage and not to decrease a potential willingness of nations to provide services to NATO, an assessment board to define standards and the usability, especially on national products could be sufficient. In case of the format of products, as long as the content is usable and correct, different layouts could be sufficient as well. In addition, an assessment about specific questions and specific outcomes (e.g. regional specifications) could be very beneficial and should be used. Finally, the recognition of Space as an operational domain offers the opportunity to integrate, as much as possible, Space support in national as well as NATO exercises at all leadership levels.

In the questions of NATO requirements for specific products and services, it was stated again that the difference between SSR and RFI as well as SATCOM requests has to be specified. NATO must improve the SSR process and should avoid duplications and confusion. The overall consensus is that NATO has to define what kind of Space support it really needs, specified for the type of operation. Some nations stated within the definition process the assessment of potential future areas of operation and specific geographical requirements for Space support. If in the future NATO has a chance to either formulate requirements on future products to the member nations or to develop specific NATO required products, in direct coordination with the nations, this will be sufficient as well.

Some European NATO nations want to deepen their involvement in services and products that are provided by several EU entities. Nevertheless, the cooperation and coordination not only between NATO entities and NATO member nations, but also between the national SpOCs, has to be improved. If the above-mentioned idea of 'framework-' or 'lead-nations' for specific Space related services or products will be discussed


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further, operator exchanges to gain a common understanding may be sufficient to provide products that are as standardized as possible for NATO.

Another element of resiliency that was stated by FR is finding a process to send SSRs and RFIs to all capable NATO nations and not just to one that has already provided a specific service or product to NATO in the past. This process has to be reassessed periodically because the number of capable and interested nations is increasing continuously.

Considering the process for NATO requests for Space services and products, nations who operate a SpOC have given the SpOC as the point of contact for NATO. Other nations that are able to provide products, but do not operate a SpOC, have listed different entities. It has to be coordinated via the responsible NATO Space Centre that the points of contact are known, including their mode of operation (24/7; working hours). The services or products provided to NATO have to be identified and assessed, because it must be clear to which nation and to what entity of the nation the request has to be sent, whether it be an SSR, a RFI or a SATCOM request.

The comments on direct recommendations to NATO given by the nations made it evident that especially the cooperation between the nations is crucial. As further requirements to ensure the availability of services, cooperation and coordination were mentioned. One nation pointed out that the coordination has to be conducted within NATO. It has to be avoided that the same SSRs are sent to the nations from multiple different NATO HQs. The exchange mechanisms have to be defined clearly, especially the responsibilities in SSR, RFI and SATCOM requests. CA stated that if it has to take over the Space support lead for a specific Space service or for a specific NATO operation, it will have consequences on the actual staffing which is currently optimized for national needs.

More cooperation in Space related topics inside NATO is required. The non-Spacefaring nations would like to have better opportunities to be involved in further developments. This will enable them to gain understanding and better train their personnel for future requirements.

The role of AIRCOM as the Space advisor to SACEUR and Space support provider was stated by FR and its importance to standardization and data formats was highlighted. Importantly, the already existing SpSCE at AIRCOM should be included in that process, potentially in some kind of leading role. In addition to national developments and acquisitions on the sensor side, the reliance on either direct US Space data or the US generated raw data for further Space products will exist for the foreseeable future.

On the potential requirements for a NATO SpOC or Space Centre, the answering nations agreed on establishing a robust data exchange infrastructure. Staffing-wise the need for trained and capable personnel is considered critical, especially for providing Space support. A requirement should be set in the future for getting trained personnel first, instead of the national basis of allocation, where personnel could not fulfil the individual standards needed to act on a NATO Space position. General knowledge of the classification and declassification process of data is also required within the Space support coordination functionality.

Finally, a question was posed about a potential future role of NATO in Space, implying additional responsibilities that go far beyond the already existing role. Consensus of the nations on this point is that NATO has to define its requirements. Based on the NATO Policy on Space Support in Operations and the Overarching Space Policy, the need for products and services and the concept of how to organize this is assessed to be the first step. If all of these requirements are already formulated, then they need to be provided and better explained to the nations to reach a common understanding and a consensus for everything that follows.

In the case of the lack of agreements and the classification issues which may take longer to be solved, it was mentioned that NATO should focus more on commercial providers to close potential gaps and mitigate those issues. It is stated that there has to be a single entity for NATO that negotiates contracts and acts on behalf of all NATO members as a smart customer. This could also mean, at least for the Space support functional areas, only one entity to be responsible. This is especially true for ISR, where most the problems in classification and data exchange are anticipated by the nations.

Already established ways of data exchange and Space support should be kept. Potential new ideas and changes in the NATO Space support structure should be assessed and should support the established processes and not compete with them. BE stated that NATO has to be heard in the capability development phase of national Space support structures and has to define and discuss its needs as early as possible to give smaller nations the chance to contribute in niche areas, where they can best support the overall structure within their financial and personnel resources. Finally, Space support topics should be included in the NATO Defense Planning Process (NDPP). The aim is to find shortfalls and identify dependencies to give these back to nations for further development. That may lead to assessments in national programs to mitigate shortfalls and contribute to NATO needs in the future.

All responding nations agreed that NATO's role in the future is to coordinate, either by finding the right standards and formalizing them or by requesting and distributing the right services and products. Therefore, the standards and products of the nations have to be assessed and made available and usable for NATO applications.

Discussing the topic of training and exercising, the consensus is to include Space support in operations for as many exercises as possible, which includes national ones, if NATO is invited to join.

In the preparation of operations, NATO's role could be the coordination of the preparation of the environment, whether in Space Intel or as identifying NATO's needs in Space support for the specific operation. This identification of needs must be coordinated with the other domains to gain as much understanding for the whole process and dependencies as possible.

IT sees a potential future function of NATO in the building of trust within the alliance to sharing potential malfunctions and interferences of national Space systems across the alliance. Additionally, it sees NATO's function as giving the alliance good internal insight into a nation's capabilities by letting them know who to ask when a specific service or product is requested.

Finally, it was stated that one enormous element to gain resiliency in operations is to keep training to fight in any environment without any Space support.

1. King, M. and Blank, L. (2019), International Law and Security in Outer Space: Now and Tomorrow. (online) Cambridge: Cambridge University Press. Available from: https://www.cambridge.org/core/services/aop-cambridge-core/content/view/2591D90C09C4A9375DE81F750DA98DDE/S2398772319000151a.pdf/international_law_and_security_in_outer_space_now_and_tomorrow.pdf (accessed 17 Feb. 2020).


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CHAPTER 9

Overall Assessment and Recommendations

Based on the definitions of resiliency presented in the chapter 'discussion on resiliency definition adaptable for Space' and finally based on the comments made and requirements stated by the nations, within the context of the questionnaire, there are a certain number of options for NATO to increase its resiliency.

9.1 Definition of NATO Needs

NATO has to define its needs for Space support. A specific assessment has to be done to find out which command level and which domain needs what specific Space related information, service or product. Actually, a good example is the established ad-hoc Space Weather Working group. As a next step, we must ensure that already established responsibilities in Space support will be kept. It has to be made clear that the Space support coordination functionality is not responsible for all types of Space support in operations. As already stated, ISR and SATCOM are Space support functional areas that are outside of the Space support coordinating process. To clarify this, NATO has to change the existing SSR process, which incorrectly includes these functions and as a consequence often causes confusion.

After defining the support or products needed, which are then coordinated by the Space support coordination functionality, NATO has to ask the member nations about the optional support they are willing to provide to NATO. To start that process, a general questionnaire for the nations about the existing support products seems to be necessary. As an annex to the answers the nations should include a list, as well as examples of their products, which can be shared with all NATO member nations. These products and services then have to be reviewed by the NATO Space support coordination functionality and the nations as well. Especially for products that include assessments and forecasts, this process will take a longer period of time and offers the chance to compare these forecasts to the effects measured when they occur. After this process, certain national products can be declared as proven and usable for NATO. Another critical assessment in the process of reviewing national products for their usability for NATO is 'standardization.' All products have to be converted to a standard data format that is usable by existing software programs employed by NATO. This is an additional chance to reduce the file size to ensure smooth data transfer inside secured networks under low bandwidth. In this process, the topic of sharing agreements and classification has to be kept in mind. For further developments, a periodic actualization of the already known products or the introduction of new ones should be implemented. In the author's opinion, this task could be fulfilled by the NBiSCSWG, until the NATO Space Centre is fully established. Then the Space Centre should take over this responsibility.

9.2 Doctrine and Agreements

As discussed earlier and specifically mentioned by the NATO member nations, the data-sharing agreements, as well as the MoUs, are a crucial element for achieving more resiliency. As stated earlier, the implied procedure for solving this problem should be to start with bilateral agreements and then extend them to include more nations to provide overarching understanding and applicability NATO wide. This process will be even more complex if the classification issues are included as well.

One complicating factor is that products based on classified data, shared between two nations or a group of nations, cannot be shared with other nations outside the existing agreement, especially on the higher classification levels. When procedures for resiliency are developed, NATO should start with the lower classification level products. Even these, based on lower classified, but approved data, are usable for NATO operations. When a process for sharing new Space support products for NATO is started, this should encourage the member nations to discuss and sign agreements at a lower classification level (e.g. NATO restricted) to make sure that these products and services can be shared alliance-wide. These products could be less accurate than the one available at a higher classification, usually due to the lower classification of the raw data. However, in the author's opinion, even lower classified products are still valid and approved on an accuracy level that is usable for military operations. NATO should avoid, solely due to classification issues, using products that rely on open source and unapproved data. This is also the case for exercises and training.

Finally, when it comes to Space services like PNT, where NATO has the chance to gain resiliency by using more systems now, NATO should accelerate the process for making the Galileo service available for NATO as a supporting system to GPS. Therefore MoUs between the EU and several NATO member nations outside the EU have to be signed. Once this has been done, existing STANAGS regulating the PNT use for NATO should be adjusted.

9.3 Organization, Structure and Staffing

Even now, when Space acts based on its new status as a domain, it has ensure that cooperation, not only between NATO and its member nations, but between the member nations themselves and also the cooperation between the other domains as well as the relevant staff functions inside the HQs will be increased significantly. To establish a resilient SDA, the interaction at least of the staff functions J2 (INTEL), J3 (OPERATIONS), J5 (PLANS), and the Space support coordination functionality has to be increased.

Within the domain, installing a NATO Space Centre and a direct advisor element to SACEUR is required. In the author's judgement, both of them should be established within the same organization. If NATO follows in principal the US approach to organizing its Space

support, as it already does, the NATO Space Centre has to be established at AIRCOM as already agreed upon in October 2020. Within the framework of AIRCOM, it can also take over the operational responsibility of Space support inside the JFAC for NATO operations as long as only one JFC is involved. To ensure this, DIRLAUTH authorizations have to be established. Due to its foreseeable realistic tasks and responsibilities, it should be named as simply Space Centre. On the SHAPE level, no additional Space Centre is required. In the author's opinion, the role of the permanent SHAPE personnel is to be a part of the doctrine work, as well as being responsible for the peacetime contracts, MoU and agreement work. This includes the force generation responsibility in preparation for an operation and DIRLAUTH negotiations between the NATO nations and its entities.

Additionally, the Space Centre can take another significant step in the direction of resiliency, if it follows a courageous approach. As stated in the previous chapters, the threat to Space systems is real and significant, especially in operations against near-peer or peer opponents. Threatening Space systems is a high-level deterrent for an opponent against NATO member nations, especially if they only operate a limited number of assets that have additional national governmental tasks to fulfil, apart from their military requirements. The CSpOC offers a chance for the Spacefaring nations within NATO to support the other nations in protecting their assets when they are not able to, especially at the threat levels stated above. The role of the NATO Space Centre could then be to take over coordination between NATO member nations, both inside and outside the CSpOC organization, to ensure the support as a kind of 'privileged partner' to the CSpOC, while keeping NATO's agreed upon role as a non-Space actor. This is a good example that duplications, in this case a SpOC is not needed for NATO, could be avoided. To have at least the chance to discuss such an approach further, executing the above mentioned MoUs and agreements should be top priorities.

The NATO Space domain recognition will very likely trigger a request for additional personnel. The already existing structures inside the NATO Command Structure (NCS) on the strategic and operational levels seem to be sufficient. The major shortfall is currently the staffing of the already existing positions either with trained personnel or any personnel at all. Especially the Air and Space Policy Centre inside the AIRCOM HQ, which has already six Space related positions, can be transformed as the nucleus of the required Space Centre without an urgent significant increase of personnel. It has to be assessed further, whether there is a need to establish an OF-5 (Colonel) position as the head of the Space Centre. It could be sufficient to have a rank equivalent here, which then interacts with the commanders of the national SpOCs of the member nations. Nevertheless, it has to be considered that even the rank equivalent will potentially increase the resiliency, but will not get the authority that a DS4 or equivalent in a national position has.

If the NATO member nations agree on additional personnel, in the author's opinion, it would make sense if NATO encouraged the nations to establish new positions mainly on the tactical level, where currently no positions are planned. This will give the tactical level HQs the option to integrate Space support in operations directly. It will also help to increase the resiliency significantly on that level due to the inclusion of a permanent member in the HQ, who could be fully integrated into all planning processes. This person could also be the initial member of a SpSCE that could be augmented if needed for a NATO operation. The position shall also be responsible for fostering the cooperation inside the HQ processes. Recognizing that the number of trained Space personnel is limited within the NATO member nations, except for the USA, any potential request of NATO should not be focused on the Staff Officer level (OF-3/4). If trained personnel on the officer level (OF-2 Captain or equivalent) or in the higher ranked NCO levels (OR-7/8/9) are available, they should be sufficient when being fully integrated into the processes.

The Integration of more commercial services can be seen as one element of resiliency. Especially if you keep the overall classification and data sharing challenges in mind, based on pending or missing agreements. The obvious advantage is the chance to share all data with the whole alliance, if NATO or one of its entities are the customers of the commercial companies. To negotiate as strongly as possible on the commercial market, NATO should act as a smart customer via one responsible entity. The availability of commercial services could be problematic in times of intensive military competition with technically developed opponents that are popular in the world, especially with the media worldwide. To ensure constant support by commercial companies, especially in case of an increased number of financially strong customers, some well-prepared arrangements are needed. Furthermore, it has to be ensured that the priority for NATO's required services will not be changed. If NATO needs to gain more services on short notice and does not want to compete with other customers, long-term and often costly contracts are required to ensure the support needed is available on demand. In case of classification and military relevance, especially for Space-based ISR support, a timely delay for data should be contracted as well, which means that if this data is distributed further by a commercial company to customers other than NATO, it must ensure that it has no further tactical and operational relevance for NATO. This implies a constant observation of the commercial market to see what is available and what chances and vulnerabilities these worldwide developments can cause. In the area of SATCOM services, especially the new technologies based on large-scale constellations, should be made available for NATO. On the one hand, this includes smart contracting with the companies and on the other hand it requires a technical preparation of the ground infrastructure by NATO, mobile as well as fixed.

It has to be included in the implementation plan whom is responsible at each stage of the implementation since Space has been recognized as an operational domain by NATO in November 2019. Therefore, the already existing structures should be used and adapted, but with more inclusion of the interested NATO member nations. That seems to be necessary while the domain recognition will change the importance within the planning processes significantly. The NBiSCSWG should be the vehicle to start this process. Whenever the first standing NATO Space entity is established, it should take over the lead this responsibility but still act in close collaboration with the NBiSCSWG. This Space entity may be the Space Centre that should be established according to the domain recognition paper. Therefore it has to be assessed very thoroughly, where this Space Centre will be established. The function of being a direct advisor to SACEUR as well as the structure described in the Space support coordination process, gives even more credence to the argument to establish this centre at AIRCOM to avoid duplication in other HQ levels in NATO, not only because of the staffing requirements, but also because of operational needs.

Currently, there is no duplication of effort nor overlap of Space-related areas of responsibility. The major concern is whether this efficiency will change when forces adapt their structures and functions due to the recent declaration of Space as an operational domain. NATO has the opportunity, now, to prevent duplication by performing a critical analysis of all requests for additional Space-related positions for unit establishment.

9.4 Training, Education and Exercises

The often-claimed need for training and exercises has to be ensured by integrating Space in as many exercises as possible within NATO. For member nations that want to include this training in national exercises, but do not have their own Space support coordinating functionality, NATO could offer support. The need to ensure a nearly constant availability of Space smart personnel to support exercises, underlines the requirement for personnel on the tactical level to act like an initial SpSCE.

Personnel assigned to NATO must be trained in advance by the contributing nation and meet all the requirements of the position. Normally, only NATO-specific training is planned to be undertaken after the deployment. For the Space discipline, this reduces the potential number of contributing nations to the small collection previously defined as military Spacefaring, when education and training is restricted to only those nations. Otherwise, it requires that courses be made available NATO-wide, which can be either national courses open to other nations, or courses taught at NATO entities such as the NATO School Oberammergau to give non-Spacefaring nations inside NATO the opportunity to have their personnel trained.

NATO offers the 'Introduction to Space Support' course at the NSO which is open to all NATO member nations. This course contains basic information on Space support in NATO and is mainly designed to train personnel that will collaborate with NATO Space support staff. This could be national personnel designated to interact with the NCS, as well as those that interact with the Space support coordination functionality such as J2 or J6. The course is not overly detailed and does not prepare a student with no Space support background to perform in a NATO Space support coordination position.

Nevertheless, the course is assessed to be highly important, especially due to the increasing importance of the Space domain to military operations. In contrast, the number of requests for training is slightly decreasing, dropping from 64 in 2015 to 47 in 2019. The number of students being trained is nearly constant, at around 20 to 21 students per class over the last five years, with the lowest being 14 (December 2016) and highest at 28 (December 2015).[1] The course has two terms per year and has an overall capacity of a maximum of 44 students per year. This trend reflects the willingness of the nations to train additional personnel, and this decreasing trend should concern NATO. Considering the continuously increasing importance of Space support, it is the author's opinion that, in future, even more students must be trained. It is essential for NATO to encourage nations to contribute more personnel to the 'Introduction to Space Support' course in order for the students and their nations to gain a deeper understanding of how Space can support military operations. The trend of decreasing participation must be stopped within the next few years. Furthermore, the requirement for education due to the Space domain declaration is increasing, so consideration must be given as to whether a third term should be implemented to facilitate demand in the future.

Apart from the 'Introduction to Space Support' course at the NATO School Oberammergau, eight NATO member nations have listed national courses in the Discipline Alignment Plan (DAP).[2] Six of these nations offer national Space fundamental courses, but only three of them are offered to either NATO in general or to selected NATO member nations based on data-sharing agreements. Nations usually do not offer any kind of advanced Space courses to NATO. The only exceptions are for advanced courses on very specialized topics like SAR, geospatial analysis or WX. Within the Electronic Education and Training Opportunities Catalogue (ETOC), NATO lists courses that belong to certain disciplines such as Space.[3] These courses can be taught at the NATO School Oberammergau or at other NATO entities, such as NATO accredited CoEs or at training and education centres of NATO member nations. Currently, ETOC lists only the 'Introduction to Space Support' course. It is the author's opinion that all military Spacefaring nations are able to train and educate their personnel to fulfil the requirements for serving in Space positions inside the NCS. The information in the DAP, as well as in the ETOC tool, demonstrates which courses are open to personnel of the non-military Spacefaring nations NATO or NATO member nations.

Nations design courses primarily to meet national needs. Nevertheless, there is no doubt that the content permits personnel in their own nations to become well-trained, whether through basic or advanced courses. The challenge for NATO, and in the author's opinion, an important role for NATO in future will be the coordination of training and education for the personnel of non-Spacefaring nations. Therefore, it is necessary to assess the content of a nation's courses to determine if they satisfy NATO requirements, especially taking into account that the courses must most likely be adjusted due to classification issues, when international students are in attendance. An additional argument for a review of the national course content is to confirm that all Space functional areas are included. It is highly likely that these national courses incorporate some, but not all, Space functional areas or that they are focused only on those areas made available by national means. NATO should encourage the course contributing nations to allow NATO to review course content in order to assess compliance with NATO standards. After this process has been finished, NATO can then approve or accept the courses and offer them via the ETOC. To make as many courses available as possible, NATO should encourage more nations to offer their courses for NATO members. Having more personnel trained improves resiliency and is a key element in achieving burden-sharing.

Securing attendance on a national Space-related course could be problematic, similar to the arrangements for sharing Space products and services, in that it may require establishment of official MoUs and data sharing agreements. Negotiating these arrangements and coordinating training opportunities for all NATO member nations could be part of NATO's future role as well, but success will depend on the nations' willingness to commit to these agreements.

The development of the 'Space Coordinator Course' at the NSO, which should be available in 2021, has been governed by NATO requirements and the special role of NATO as a coordinating entity in Space support. This course provides NATO with an excellent opportunity to educate and train personnel already experienced and trained in national courses, as described above, on the specifics unique to NATO. This course should be mandatory for newly assigned personnel within the NCS, especially when serving in Space support coordination positions. Currently, plans are to conduct one term of the one week course per year. As long as the number Space support coordinating personnel in the NCS remains below 40 positions, the capacity will be sufficient. However, if the cadre of Space support coordinating personnel in NATO´s Space organization exceeds 40 positions, consideration must be given to increasing the training capacity.

For Schriever Wargame 2020, a NATO delegation has been invited to participate. It is yet unknown if this is in the capacity of an observer or to play an active role. Further details cannot be discussed due to classification issues. It is the author's opinion, based on previous experience that the NATO team should consist not only of Space personnel, but rather a delegation consisting of leadership personnel from across all staff functions that rely on Space services and data. This delegation, supported by Space personnel, will bring the most benefit for strategic and operational planning within the NCS by enabling a greater collective understanding of the worldwide connections and dependencies on Space support in both the military and the civilian environments. This statement is also valid for potential further initiations of NATO delegations to other Space focused exercises.

For the major NATO exercises, where training on the Space support coordination process is conducted, it is always a challenge for organizers to gather enough qualified personnel, especially when it is an exercise planned by the Joint Warfare Centre (JWC). This is a challenge because there is only a very limited capacity internally at the JWC to prepare and conduct the training. On the one hand, the SpSCEs have to be fully staffed to support the training audiences, meaning it is adequately augmented to support an operation, including at the tactical level. This level of effort would employ more than the existing number of personnel qualified in Space within the NCS. On the other hand, there are additional personnel required for exercise control, OPFOR and for the assessment and evaluation process. For example, during Exercise Trident Javelin 2017 the overall Space team consisted of 44 positions, similar to the two follow-on exercises (with 45 and 42 positions each) and this numbers are planned to be increased to more than 60 positions for Exercises Trident Jupiter 19-2 and Steadfast Jupiter/Jackal 20. These numbers demonstrate the need for additional personnel to be temporarily recruited from the national positions of the NATO member nations. This resource requirement offers opportunities to keep former NATO Space personnel trained and qualified for future postings. Alternatively, they might train national personnel, especially from smaller NATO member nations, helping them to educate and train their personnel for potential future NATO postings. Overall, this exchange of training and education builds resiliency by creating and sustaining a kind of virtual Space cadre which aims to have sufficient numbers of qualified personnel available to augment the Space support coordination positions whenever needed.

Training and education has to be fostered between the staff functions inside the HQs. At a minimum, a placeholder for Space support in operations has to be included in any kind of military planning processes at every level. Even if there are no trained personnel in place immediately, it has to be ensured that the leadership is aware of the role of Space support in operations, its opportunities and vulnerabilities as well as the process to request it. Playbooks or handbooks on Space support in operations developed by NATO, covering NATO's processes and structures for non-trained personnel, will be very helpful to integrate and create understanding.

For the improvement of SDA, the interaction between J2 (INTEL), J3 (OPERATIONS), J5 (PLANS) and the SpSCEs seems to be crucial. Having the chance to brief the topics inside certain specific courses will promote deeper knowledge and understanding. The interaction and understanding between the J2 (INTEL), J6 (COMMUNICATONS) and the Space support coordination functionality in planning and understanding should be similar. Clarifying the responsibilities and request procedures, but also finding sensible and effective ways to support different nations based on specific knowledge levels, will have major impacts on general resiliency.

On the subject of gaining resiliency by training and education, the NCIA is an important organization to help out. As stated earlier, the NCIA offers some already developed tools as an additional capability. The nations should take advantage of these capabilities in combination with the offered education and training to build a robust and capable capacity in NAVWAR, first for themselves and later for NATO. To do so, it will be necessary for a nation or several nations to take the by NCIA developed prototypes and enhance them to be used for national purposes. Once this is established, the products can be assessed for usability across NATO. When accepted by the NATO member nations as an additional standard product, they will gain the resiliency that is required for the future. The example of NAVWAR, supported by the research and development activities of NCIA, shows how NATO can use its entities for further developments to benefit the entire Alliance.

9.5 Technical Improvements and Exchange Mechanisms

Technical improvements to gain resiliency for NATO are quite limited. In the current environment, NATO can only focus on its owned and operated ground infrastructure for SATCOM. The responsible entities within NATO should monitor the technical developments as well as the new systems of its member nations to keep up with the infrastructure on a technical level, so that it can use as many systems as possible. This includes commercially available systems or national ones, as long as the operating nations have at least stated some kind of willingness to offer the service to NATO. For SATCOM, there is an option to use the services of the upcoming mega-constellations based in LEO.

Increasing the NATO resiliency in Space support in operations would also be a potential chance for NATO to be integrated in national projects, if the nation is willing. NATO could define requirements or technical advice to make the Space system, service or product directly usable for NATO. This potential role can only be based on the willingness of the offering nations, but this would be an option to realize projects by using combined funding. NATO will not be a Space actor, but it could at least participate more deeply in services than it is now.

The second technical improvement of NATO, in order to increase resiliency, refers to data exchange mechanisms and standards. As it is stated by several nations, there is no need to develop and establish new systems. NATO already operates secure networks that can be used to exchange Space-related data and products. The existing secure NATO network seems to be sufficient. The challenge is to get the data, service or products into the network. As stated earlier, the national SpOCs or points of contact are the ones who create the data based on NATO needs, and they should also be the ones to feed it into the secured NATO network. Having a NATO body that has the authority to transfer the data does not seem to be an efficient solution, because in the worst case, it would have to be connected to at least one national system per member nation. In the author's opinion, it is important to connect each SpOC or point of contact that can feed in Space data, services or products to NATO's secured network and equip them with a technical solution to exchange data between their national system(s) and the selected secured NATO system on the agreed appropriate classification level. In order to realize this, there is a need for national personnel to have access while supporting NATO, but not being inside the NCS. The demand has to be defined based on the national structure of the providing nations. This could be focused on named personnel or better on functional positions. Because this may have an influence or impact on the national Space support coordination structure of member nations, NATO should encourage the nations to do their own analysis. For national Space support coordination or SpOC structures that are currently under development or in the build-up phase, the previously mentioned study by JAPCC on NATO requirements for a national SpOC to support NATO is a valid document to consider.


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Exchange systems for the Intelligence, SATCOM and SEW services that already exist and are well tested and should not be touched in principal, but some kind of interoperability tool to be able to transfer data between these NATO systems seems to be necessary. This could be realized either as a technical application to exchange data on the existing classification levels or via a single centre for data transfer between the NATO owned systems. The single centre will potentially delay the transfer, but could be used as the entity to ensure compliance with the MoUs and agreements that have to be signed to enable this process.

9.6 Potential Further Roles and Responsibilities

If in the future the decision is made to purchase NATO-owned satellites again, as it has been with the former NATO communication satellites, it is assessed that this would not require the establishment of a NATO SpOC. If this decision is made to operate NATO-owned satellites, they will likely be operated by one of the Spacefaring nations on behalf of NATO. This nation could fully rely on its national infrastructure and potential protection services offered by the CSpOC.

If future conflicts will be fought out in Space and not just be significantly supported by Space services and products, the described role of NATO in this study has to be reassessed based on future developments. In the author's judgement, there will be no significant changes in the mid-term timeframe. NATO still has to use its SDA, which must be further developed, to continuously reassess the overall situation. A chance for NATO to participate in multinational strategic high-level exercises or wargames focused on conflicts in Space, would seem to be sufficient as well.

Resiliency in Space and the capability to conduct combined actions in Space, based on the given definitions of this study, will be future key elements for NATO's deterrence. The capability, capacity and willingness of the alliance to adapt to the Space domain, shows its combined strength, and demonstrating this as transparently as possible will underline NATO's future role in keeping the peace and security worldwide.

All the requirements and assessments addressed in this study have to be discussed further. Therefore the NATO member nations, as long as they are interested in Space development, have to be integrated. As stated earlier, NATO has established the NBiSCSWG to be the entity for Space developments. In this profound situation with the integration of the Space domain in NATO, it may be beneficial for the alliance to also integrate entities outside the NCS in this process. While keeping up the momentum, this could be a fruitful approach to define further requirements and advice for the potential changes necessary in the NATO Space support coordination functionality, without being too focused on already existing structures and dependencies.

1. NATO School Oberammergau (2018) Intro to Space Support to NATO Ops Course N3-01 Briefing given by LtCol Christopher Ritter at the 15th Meeting of the NATO BiSCSWG in Ramstein, Oct. 2018.
2. NATO ACT (2019) Discipline Alignment Plan (DAP) for the Space Support in Operations discipline – 2019.
3. NATO ACT (2019) NATO Electronic Education and Training Opportunities Catalogue (ETOC). (online) Norfolk: NATO Allied Command Transformation. Available from: https://e-itep.act.nato.int/Guest/ETOCindex.aspx?sEncCrit=KTfmWLxPHci%2BxBaQEhKu2jFxxoJ67NQZ2FdWv%2FF3Y54W%2B9LqrZq9J2nt1PiLEYlsqXprdug2U2eNetZF%2FSWDQViaaH9Rsxd89XxanwjbZGNgZGEm%2BFk5BQJBBq7KIUXTbzcBLvJKzniEloCqYoFcGPYrkq3xCCiANiXvwORLsnjeKrzcVEpR%2BAm4TCz30Xk5KdESLzKYPE7rW9istSTbjg%2Bbe1C35u6UmAC%2FNn%2FCenk1Vb8bRKjIPP4trTespp%2BIg4YbMNOwhps8XVfYrPIGAPAUzxuEC%2BygiqMGMcOT15T5%2BU5PJh8DWs4o84E88iI0bSdoKQLs84Y8CHR6i%2BGIGw%3D%3D (accessed 14 Feb. 2020).

ANNEX A

Definitions and Acronyms

Apogee Apogee describes the point of an orbit around the Earth where the satellite has the highest altitude over the Earth surface.

ACO Allied Command Operations. Strategic level authority of NATO, located at SHAPE.

ACT Allied Command Transformation. Allied command focussed on all kinds of further development within NATO, located in Norfolk (US).

AIRCOM located in Ramstein (GE)

AJP Allied Joint Publication

AUS Australia

BeiDou-III GNSS operated by the Chinese military. Augmented from the RNSS BeidDou-II which came operational in 2014. BeiDou-III was claimed operational in July 2020 (http://en.beidou.gov.cn/).

BE Belgium

BICES a secured NATO network

NBiSCSWG NATO Bi Strategic Commands Space Working Group is currently the highest entity in NATO for Space support developments. It is chaired by ACO and co-chaired by ACT on the Lt Col (OF-4) level. Members are NATO entities and commands as well as NATO- and NATO-cooperating nations. All members are invited and participate if possible. The group meets twice a year.

CA Canada

CHN People's Republic of China

CoE Centre of Excellence. NATO accredited entities outside the NCS that support NATO.

Constellation A constellation is a number of satellites that interacts to gain a wider coverage or a better revisit rate.

COTS Commercial-off-the-shelf. Technology and products that are commercially available to anybody.

CSpOC Combined Space Operations Centre. Multinational US-led Military Space Operations Centre, located in the Vandenberg Air Force Base, California (US).

CZ Czech Republic.

DAP Discipline Alignment Plan. Overview on courses offered by NATO nations or NATO entities on a specific topic and who can attend them.

DE Denmark

DEW Directed Energy Weapon. A powerful energy system that can cause irreversible damage in this case to a satellite in Space. The most advanced worldwide developments use laser or microwave emitters.

DIRLAUTH Direct Liaison Authorized. This a 'by-pass' like coordination authorized to minimize the coordination time. For Space support in NATO it has to be negotiated and defined prior to an operation, most likely within the force generation process.

ETEE	Education, Training, Exercises and Evaluation
EHF	Extremely High Frequency. Frequency Band between 30 GHz and 300 GHz. It offers the most protected communication service even in hostile environments, but with relatively low data rates to fixed and mobile users.
ESA	European Space Agency
ES	Spain
EU	European Union. Political and economic alliance of 27 European nations. Except Austria, Cyprus, Finland, Ireland, Malta and Sweden all nations are members of NATO as well.
EUSST	European Union Space Surveillance and Tracking initiative. Established in 2014 and currently conducted by the five Spacefaring nations of the EU (FR, GE, IT, SP and UK104) on monthly bases. It was enlarged in 2018 by three other nations (PL, PO and RO) who will be fully included in the service provision once their SpOCs are certified. (https://www.eusst.eu/)
ETOC	Electronic Education and Training Opportunities Catalogue
Five-Eyes	Common term to describe the nations AUS, CA, NZL, UK and US in their military and security cooperation.
FR	France
Galileo	is a civilian GNSS operated by the EU. It consists of a minimum of 24 satellites on three orbital planes. There is at least one spare satellite per orbital plane planned. The inclination is 56°. GALILEO offers a militarily usable service with the Public Regulated Service (PRS). (https://www.gsa.europa.eu/)
GE	Germany
GEO	Geostationary Earth Orbit or Geosynchronous Earth Orbit. This orbit has an altitude of roughly 36,000 km above the equator. Satellites in this kind of orbit circle around the Earth with the speed of the Earth's rotation rate, which means that they can always be seen at the same position in the sky. The orbital period is around 24 hours.
GLONASS	Globalnaja Nawigazionnaja Sputnikowaja Sistema, GNSS system operated by the Russian Space Agency Roscosmos, financed by the military. (https://www.glonass-iac.ru/en/)
GNSS	Global Navigation Satellite System. The generic term for global satellite based navigation systems like GPS or GLONASS.
GPS	Global Positioning System. Also called NavStar GPS, is a military GNSS system, operated by the US military. It consists of a minimum of 24 satellites on six orbital planes. There are several spare satellites to create a robustness in case of technical issues. The inclination is 55°. (https://www.gps.gov/)
GR	Greece
HEO	High Elliptical Orbit. An orbit with a very low Perigee over the southern hemisphere (usually 200 to 1,000 km) and a very high Apogee over the

	northern hemisphere (usually 40,000 up to 60,000 km). Orbits like this have an orbital period of roughly 12 hours and allow a visibility of roughly 10 hours over the northern hemisphere. They are often used for SATCOM and OPIR. A minimum constellation of three satellites offers a 24/7 coverage of the northern hemisphere. A special HEO used by Russia is the Molniya orbit.
HU	Hungary
Hyperspectral image	A coloured image based on multiple, usually more than hundred spectral bands.
IMS	International Military Staff. The highest international military staff element in NATO, located at the NATO Headquarter in Brussels working for the MC.
INTELFS	a secured NATO network
ISR	Intelligence, Surveillance and Reconnaissance.
IT	Italy
JFC	Joint Forces Command, NATO has currently two JFCs operational, one is located in Brunssum (NE) and the other in Naples (IT). A third one is currently in the build-up phase at Norfolk (US).
LANDCOM	located in Izmir (TU)
LEO	Low Earth Orbit. Satellites in these orbits have usually an altitude between 200 and 1,500 km above the Earth surface. The orbital period is between 90 and 100 minutes.
LU	Luxembourg
MARCOM	located in Northwood (UK)
MC	Military Committee. Senior military authority in NATO and the oldest permanent body in NATO.
MEO	Medium Earth Orbit. Satellites in these orbits usually have an altitude between 15,000 and 25,000 km above the Earth surface. The orbital period is around 12 hours.
METOC	Meteorological and Oceanographic. Generic term for all kinds of weather-related support in operations.
MoU	Memorandum of Understanding
Multispectral image	A coloured image based on multiple, usually three to fifteen, spectral bands.
NAVIC	RNSS operated by the Indian Space Agency, also known as Indian Regional Navigation Satellite System (IRNSS), officially claimed as a civilian system. (https://www.isro.gov.in/irnss-programme)
NAVWAR	Navigation Warfare
NATO STO	NATO Science and Technology Organization
NCIA	NATO Communication and Information Agency. NCIA is responsible in NATO's approach to Space for commercially-provided SATCOM, initial NAVWAR capabilities as well as remote sensing service for mapping and infrastructure information. The NCIA HQ is located in the Hague (NE).
NCS	NATO Command Structure

NDPP NATO Defence Planning Process. Five year planning cycle for NATO requirements that can be fulfilled by the member nations. It could include development of new capabilities or the acquisition of existing technology.

NE Netherlands

NIFC NATO Intelligence Fusion Centre, located in Molesworth (UK)

NO Norway

NSB NATO Signal Battalion. NATO currently operates two multinational Signal Battalions that ensure SATCOM connections.

NZL New Zealand

OPIR Overhead Persistent Infrared

Panchromatic image A black and white image based on multiple shades of grey.

Perigee Perigee describes the point of an orbit around the Earth where the satellite has the lowest altitude over the Earth surface.

PL Poland

PNT Positioning, Navigation and Timing

PO Portugal

Polar Orbit A polar orbit is a special LEO that has an inclination of roughly 97° and covers nearly the whole earth surface.

Revisit time The time between two overflights of a single satellite or a satellite out of the same constellation over a specific point on the Earth's surface. Usually revisit times of single satellites differ between 3 to 7 days, in a synchronized constellation it can be decreased down to several hours or even several minutes if you use large scale constellations that consists of more than 100 satellites.

RNSS Regional Navigation Satellites System. Generic term for regional satellites based navigation systems like NAVIC or BeiDou-II.

RO Romania

RUS Russian Federation

SACEUR Supreme Allied Commander Europe. Highest ranking NATO military commander in Europe. He is in personal union also Commander ACO.

SAR Synthetic Aperture Radar. An imaging Radar sensor.

SATCOM Satellite Communications

SATRAN Satellite Reconnaissance Advance Notification. An SSA product that gives information of a specific area about overflights of foreign satellites, depending on the requirement. This service is also often described as 'overflight warning'.

SC Strategic Command

SDA Space Domain Awareness

SEW Shared Early Warning

SHAPE Supreme Headquarters Allied Powers Europe, located in Mons (BEL)

SHF Super High Frequency. Frequency Band between 3 GHz and 30 GHz. It is often also called Wideband. It offers secure voice radio and relatively high data transmission, but requires larger antennas that are more suitable for fixed than for mobile use.

SpOC	Space Operations Centre
SpSCE	Space Support Coordination Element
SSA	Space Situational Awareness
SSR	Space Support Request. Formalized request for a specific Space support that is used within the NATO Space support coordination functionality.
STANAG	Standardization Agreement
UHF	Ultra High Frequency. Frequency band between 300 MHz and 3 GHz. This band usually offers secure voice radio and relatively low data rate transmission to mobile users
UK	United Kingdom
US	United States of America
TU	Turkey
WX	Space Weather. Space weather describes the impact of charged particles in the wider atmosphere of the earth. Most WX effects are caused by solar activity like corona mass ejections etc.

ANNEX B

Questionnaire

This JAPCC initiated questionnaire sent to all NATO member nations and the NATO entities NCIA and NIFC. The questionnaire also includes questions for the JAPCC project to find: 'Specifications of Requirements for a national military Space Operations Centre (SpOC) with regard to potential NATO need for information'. The questionnaire was developed by the JAPCC Space personnel to collect the needed basic information, nation's needs and nation's views. The data is then used for further analysis on these two studies. The aim of every question is briefly described in 'bold'.

1. **Does your nation operate a national Space Operations Centre (SpOC)? If yes, please give some details to structure / tasks / workflow / further development.**
   Aim is to find criteria for military Spacefaring nations. Aim is to identify nations that operate a SpOC.

2. **What Space products and Space support services to potential operations does your nation produce?**
   Aim is to find Space support that can be used for NATO.

3. **Do you share these products / services or parts of it with NATO or are you willing to do so in the future?**
   Aim is to find potential limiting factors.

4. **Are official agreements / contracts / MoUs established between your nation and NATO in effect? Please list them in detail.**
   Aim is to get an overview about already existing cooperation.

5. **From your point of view, is there a need for additional agreements / contracts / MoUs between NATO and your nations, as well as organizations and commercial entities?**
   Aim is to get recommendations from the nations for further development.

6. **From the NATO point of view: are there existing and desired redundancies in Space support data, products and services; do we need these?**
   Aim is get an overview about nation's understanding of NATO Space support.

7. **Do you cooperate with other nations (bilateral, multilateral), if yes in which areas?**
   Aim is to get an overview out existing cooperation.

8. **What are the requirements to guarantee the provision of Space support data, products and services? Please list detailed NATO's requirements for information for Space support in operations.**
   Aim is get an understanding of nation's needs.

9. **Please provide recommendations for the possible future role of NATO to improve Space resiliency.**
   Aim is to collect further ideas by the nations.

10. **Do you know NATO requirements for special products and services? Please list them and explain the procedures for their implementation.**
    Aim is to get an overview about nation's knowledge of NATO Space support.

11. **What are the requirements for a mutual support arrangement between national SpOCs and NATO HQ with regard to information flow and exchange?**
    Aim is to collect further ideas by the nations.

12. **Do you have some recommendations for a potential structure of a typical national SpOC for a support arrangement with NATO?**
Aim is to collect ideas by the nations in respect to national needs.

13. **What do you think is the best way / the realistic way of exchanging data and services?**
Aim is to collect certain ideas by the nations.

14. **Highlight technical and security restrictions / issues and special legal aspects regarding support from your national SpOCs to NATO.**
Aim is to find limiting factors for potential future developments.

15. **Do you have technical comments for a potential data transferring systems for Space support in operations data and Space products?**
Aim is to collect ideas from the nations.

16. **Does your nation use Space support services in operations in training, exercises or national operations? If yes which ones?**
Aim is to get an overview about the nation's current status.

17. **For potential requests for Space support, what national entities in your country (civilian as well as military) are responsible for that?**
Aim is to understand the nation's structure.

18. **What kind of Education and Training (E&T) for the military personal responsible for Space support are mandatory in your nation? Do you offer courses in your nation and are these open for other NATO members? Do you use E&T support from other nations?**
Aim is to understand and analyze the national training and education structure as well as finding potential courses for NATO training and education.

19. **Are there potential Space training support requirements in your nation?**
Aim is to understand then national needs.

The nation's responses to the questionnaire are listed in the table below. The table contains only the NATO member nations which have responded the questionnaire. A given answer which was usable for analyzing the topic and got integrated in the study is marked ('X') or if it is in experimental or development status ('(X)'). Only question number 1 marks an existing SpOC as 'X'.

HU and RO responded to the questionnaire, but stated that they do not have any involvement in Space Support in Operations yet, but are interested to follow the development of that topic.

NCIA as well as NIFC personnel were interviewed based on the questionnaire.

	BE	CA	CZ	GE	DE	FR	UK	GR	HU	IT	NE	NO	PL	PO	RO	TU
1 nation operates a SpOC		X		X		X	X			(X)						X
2 offer products / services	X	X		X	(X)	X	X	X		X	X		X			X
3 sharing of stated in 2		X		X	X	X	X			X	X					X
4 MoUs agreements to NATO	X	X		X		X				X						
5 need for additional MoU			X	X	X	X	X			X				X		X
6 existing redundancies in NATO	X				X	X	X						X			
7 bi- / multilateral cooperation	X	X		X	X	X	X	X		X	X	X	X	X		
8 requirements for Space support		X			X	X	X			X	X	X				X
9 future role of NATO to improve Space resiliency	X	X		X	X	X	X			X	X	X	X			X
10 requirements for special Space products						X				X		X				
	BE	CA	CZ	GE	DE	FR	UK	GR	HU	IT	NE	NO	PL	PO	RO	TU

	BE	CA	CZ	GE	DE	FR	UK	GR	HU	IT	NE	NO	PL	PO	RO	TU
11 arrangements between national SpOC and NATO HQ					X	X	X									X
12 potential structure of a SpOC				X			X					X				X
13 way of data exchange	X	X		X	X	X	X				X	X	X			X
14 restrictions between SpOC and NATO	X	X		X		X	X	X								X
15 technical comments on data transfer	X			X	X	X							X			X
16 national use of Space products/ services in exercises	X	X		X	X	X	X			X	X	X		X		X
17 POC for Space support	X	X		X	X	X	X	X		X		X	X	X		X
18 Education and training options	X	X		X	X	X	X	X		X	X		X			X
19 Space training support require- ments		X	X	X		X	X				X		X			X
	BE	CA	CZ	GE	DE	FR	UK	GR	HU	IT	NE	NO	PL	PO	RO	TU

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ANNEX C

About the Author

Lieutenant Colonel, DipEng, MSc. Tim Vasen, German Air Force

Lieutenant Colonel Tim Vasen began his military career in July 1994 as a conscript. On gaining his commission, he served for several years in command and staff positions within the artillery branch of the German Army, including a deployment to KFOR as Company Commander of the DEU ISTAR-company.

In 2008 he became a career intelligence staff officer where he took over responsibility in several intelligence functions and was primarily responsible for IMINT planning and technical assessments including positions in the Office of Military Studies as Senior Analyst for Space Systems, and from 2013 to 2017, as the Head of Space intelligence in part of the German Space Situational Awareness Centre (GSSAC).

Since October 2017 Lieutenant Colonel Vasen has served as a Space SME at the JAPCC. In this function, among others, he provides active technical assessment support to the NATO Science and Technology Organization and is the responsible OPFOR Space Planner for major NATO exercises TRJN17, TRJE18, TRJU19 and SFJU/JA20.

In July 2020 he made an inter-service transition to the German Air Force, to further be able to be assigned in Space and intelligence positions.

Lieutenant Colonel Tim Vasen has an Engineering Diploma degree in civil engineering from the German Armed Forces University in Munich and a Master of Science degree in Innovation and ISR from the Lincoln University, UK.

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