The Role of Space Domain Awareness

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Space Asset Resilience thru Protection

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Space … a Congested, Contested, and Competitive Domain

In 2018, NATO leaders recognized that Space is a highly dynamic and rapidly evolving environment.[1] As it has happened in other areas characterized by a rapid scientific development, Space technology has developed more quickly than the regulation of the use of Space. In fact, over the last sixty years approximately 9,600 satellites have been placed into Earth orbit[2] without any regulatory framework, and that number is expected to exponentially increase considering the tremendous advances in launch capabilities and spacecraft design. Moreover, the growing number of institutional and commercial actors capable of accessing Space and interested in using it makes Space the focus of increasing competition aimed at obtaining supremacy in the exploitation of this domain. NATO is heavily reliant on Space as it has a major impact on military operations and security activities.

All this led the Alliance to recognize Space as the fifth operational domain (after Air, Land, Sea, and Cyberspace). Since many of the most important activities supporting military operations planning and execution occur in this 'new' domain, it is fundamental to be aware of what happens in Space. Therefore, Space Domain Awareness becomes an essential enabling capacity.

Threats to Space Services and Operations

On 11 January 2007, China 'broke the balance' in Space warfare by firing an SC-19 ASAT missile at its own weather satellite Fengyun-1C. The Space Surveillance Network (SSN) has detected approximately 15,000 pieces of debris coming from that one event, but hundreds of thousands of debris particles (too small to be tracked, but still dangerous for human Space activities and Space operations) were released into Low Earth Orbit (LEO).

In 2009, the collision between the American Iridium 33 (active) and the Russian Kosmos 2251 (deactivated) communications satellites 789 kilometres over Siberia was the first publicly confirmed accident between two intact artificial satellites in Earth orbit.

Since 1957, more than 5,250 launches have resulted in some 42,000 tracked objects in orbit, of which about 23,000 remain in Space and are regularly tracked by the US SSN and maintained in their catalogue, which covers objects larger than about 5–10 cm in LEO and 30 cm to 1 m at Geostationary (GEO) altitudes. Only a small fraction – about 1200 – are intact, operational satellites today.[3] Moving at orbital velocities of thousands of miles per hour, any of these objects could represent a risk for manned and unmanned spacecraft.

The population of charged particles 'trapped' in the layers of the Earth's atmosphere (especially in the ionosphere) such as those coming from the upper atmosphere of the Sun can have impacts on electromagnetic signals and equipment (e. g., radar or radio transmissions problems, degradation in accuracy for positioning, navigation, and timing systems, local breakdowns or in the worst cases, complete loss of service). Solar activities can also disturb satellite orbits, forcing satellite operators to execute manoeuvres in order to recover the right trajectory.

Those just described are only some examples of threats, unintentional and intentional, natural or artificial, that could affect Space systems and operations.[4] It is self-evident how important it is to understand and accurately predict what happens in Space, with particular reference to military operations, where global security and people's lives are at stake.

Space Domain Awareness Capabilities

Given that there is no universally recognized definition, Space Domain Awareness (SDA) can be defined as the capability to detect, track, identify and characterize Space objects and the Space environment, aimed at supporting Space activities in terms of safety, security, and sustainability. We do need to identify risks and threats affecting Space systems in order to take appropriate countermeasures, thereby increasing Space systems resilience.

In practical terms, SDA can be considered the result of the integration of the following capabilities:

a. Space Surveillance and Tracking (SST): detects Space objects, catalogues them, determines and predicts their orbits. This capability itself is divided into three different services:
   - Conjunction Analysis: to deliver collision alerts (consisting of an estimated Probability of a Collision – PoC) between two objects. The

service is also called Collision Avoidance when a manoeuvre to reduce that PoC is suggested.

- Fragmentation: to survey and characterize new debris coming from a collision between Space objects or an explosion (e.g. of a rocket body), aimed at rapidly updating the Space object catalogue.
- Re-entry: to calculate and predict the probable area of impact of Space objects re-entering the atmosphere posing a risk to people and/or infrastructures on the Earth's surface.

b. Space Weather (SWx): studies solar activities and Space environmental effects that can influence performance and reliability of space-borne and ground-based technological systems.

c. Space Intelligence: collects data and information, conducts analysis and exploitation to identify unknown satellites, understand if they are operational and discover their capabilities (i.e., payload discrimination) and purposes (collaborative, hostile, and so on).

Therefore, it could be said that SDA is the same as SSA (Space Situational Awareness, keeping track of objects in orbit and predicting where they will be at any given time[5]) but it would not be correct. Both capabilities arise from the same scientific principles and can use same tools and same sensor networks; but their final goals are different. Specifically, Space Intelligence plays a fundamental role for SDA, whose ultimate goal is to coordinate, command and control Space effects in support of military commanders across the globe, ensuring the availability of a Space service at the right place and right time. Finally, SDA and SSA could be considered as two sides of the same coin; the former is mainly focused on military and operational aspects, the latter on civil/dual uses.

SDA Within NATO Nations

The leading Space actor in the Alliance is the US. They operate the largest fleet of satellites and SSN in the world, managing and maintaining a comprehensive catalogue of Space objects also for the benefit of other countries (Alliance members included). Although a lot of countries can boast some SST/SSA capacity, aside from the US, it is very difficult for a single nation to achieve a complete, effective, and autonomous capacity without cooperation. Some examples are the European Union programme for SST called EUSST (born in 2014) and the European Space Agency (ESA) SSA programme (started in 2009).

A similar reasoning can be made on the topic of SWx; in fact, the American National Oceanic and Atmospheric Administration (NOAA) is the reference agency while, in Europe, the ESA is the point of connection for the capacities of each participating member. NOAA and other cooperative agencies are mainly focused on scientific objectives. Within the Alliance, providing timely and accurate SWx information has been recognized as an important capability to acquire, and it is under discussion to establish a NATO Space Weather Centre (instead of the actual SWx capability as a branch of meteorology and oceanography).

Space Intel also deserves a separate discussion as it is still an undeveloped capability for everyone or, at least, it is probably too small for the task in front of it (as far as it is publicly known[6]). Traditionally, both the military and intelligence communities have seen Space only as a 'tool' for obtaining information. By viewing Space as a domain (potentially a warfighting domain), the need for intelligence about it has increased and includes knowledge on what objects are in Space, where they are, what capabilities they have and what threat they pose to friendly Space systems (ground and user segments included). The US Space Force is planning its first steps toward a new intelligence centre to make the great unknown a little less mysterious. The National Space Intelligence Centre (NSIC) will be an independent organization staffed by highly trained Space subject matter experts capable of providing quality intelligence support to Space warfighters, senior leadership, and policymakers through independent and collaborative work with the current National Air and Space Intelligence Centre (NASIC).[7]

The Present and Future Role of NATO

NATO neither has its own Space assets nor operates any. It relies on Space capabilities that Alliance nations provide on a voluntary basis. NATO operations strongly depend on Space services, so SDA also becomes a key resource for NATO and it needs more than just a 'donation' from Member States.

First of all, NATO could be the leading entity to promote the importance of SDA, encouraging the development and improvement of the current architectures and advocating for ideas ranging from the SSA concept of 'simple routine catalogue maintenance' to a tactical, predictive, and intelligence-driven capability integrated with Ballistic Missile Defence and Command and Control infrastructure. Moreover, without jeopardizing the independence of a single nation to use its assets as it prefers, NATO could play the role of coordinator for the various national capabilities, integrating them to have a clearer picture of Space and to be able to detect any change or potential threat on the Alliance, similarly to what happens in civil contexts (e.g., EUSST). Our nations' use of and dependence on Space requires the development of policies and doctrine, tools and resources to maintain the Alliance's superiority in Space. As mentioned before, no country can face this situation alone. The birth of the new NATO Space Centre at Allied Air Command in Ramstein, Germany,[8] could represent the first NATO step in that direction.

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Endnotes

1. Brussels Summit Declaration (Issued by the Heads of State and Government participating in the meeting of the North Atlantic Council in Brussels 11–12 Jul. 2018).
2. The latest figures related to space debris, provided by ESA's Space Debris Office at ESOC, Darmstadt, Germany. Available at: https://www.esa.int/Safety_Security/Space_Debris/Space_debris_by_the_numbers, accessed 1 Dec. 2020.
3. The European Space Agency, 'About Space Debris', https://www.esa.int/Safety_Security/Space_Debris/About_space_debris, accessed 23 Dec. 2020.
4. For further information: Space Threat Assessment 2019 – A Report of the Center for Strategic & International Studies (CSIS) Aerospace Security Project, Apr. 2019.
5. SSA definition made by Space Foundation. Available at: https://www.spacefoundation.org/space_brief/space-situational-awareness/, accessed 23 Feb. 2021.
6. 'What we really need most is elements of a warfighting domain and military service that have been lacking over the years. We need our own core intelligence capability,' said the new Space Force Vice Commander Lt. Gen David Thompson after his appointment, https://www.c4isrnet.com/battlefield-tech/space/2020/03/11/the-space-force-will-need-space-intelligence/, accessed 3 Mar. 2021.
7. Cohen, Rachel S., 'National Space Intelligence Centre Takes Shape', Air Force Magazine (published online 16 Nov. 2020), https://www.airforcemag.com/national-space-intelligence-center-takes-shape/, accessed 5 Jan. 2021.
8. NATO, NATO Agrees New Space Centre at Allied Air Command, 23 Oct. 2020, https://ac.nato.int/archive/2020/NATO_Space_Centre_at_AIRCOM, accessed 23 Mar. 2021.