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Space Traffic Management (STM) – Legal Aspects[1]

Abstract: Space Traffic Management (STM) is a new concept referring to space activities. The highest priority is the safety and security of outer space and all conducted operations. There is no definition of STM. There is an urgent need to regulate STM providing safety and security regulations at the international, regional, and national levels. Because there is no STM definition, the regulator might use the example of existing regulations of the International Civil Aviation Organization on Air Traffic Management (ATM). European EUSST is a good example of being a "precursor" of STM. However, many questions are still open regarding specific regulations needed to create an STM system, such as at which level they should be made: globally, regionally, or nationally.

Keywords: *space management, space debris, code of conduct, national legislation, SSA, space policy*

Introduction

Space Traffic Management (STM) is one of the newer concepts related to space activities. The highest priority here is the safety and security of outer space and all operations performed in it. So far, no definition of STM has been developed. There seems to be an urgent need to regulate space navigation at international, regional, and national levels due to the increasing space overcrowding. A question arises here about the type of regulations and the scope of their application. So far, no comprehensive and unified set of rules for Space Traffic Management (STM) has been developed. It is unclear how or based on what powers an entity (organization) could manage space traffic. The STM concept is currently enjoying much interest, mainly due to the increase in the number of entities operating in space (both

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states and enterprises). Both the LEO (Low Earth Orbit) and the GEO (Geostationary Orbit) orbital systems constantly risk a collision. Mitigating this risk requires satellite operators to track space objects and their dynamics to be constantly vigilant and alert to ensure the safe and efficient use of space for present and future generations.

There are different phases of flight in space (e.g., launch, orbital, and return). Hence an STM system would include all of them. Such traffic should be orderly and transparent to each operator. It is worth remembering that spacecraft cannot reach outer space and return to Earth without crossing the airspace used by aircraft. Therefore, an effective traffic management system must not endanger the safety of both aircraft and space objects. In addition, there is a high risk of collision of active and inactive objects in orbit and the creation of an increasing amount of space debris. There is a need to guarantee the security of outer space.

Research on STM was reflected in a 2006 report entitled "The Space Study of Space Traffic Management" prepared by the International Academy of Astronautics (IAA). The report defines STM as a "set of technical and regulatory rules designed to promote safe access to space, outer space operations and return from space to Earth free from physical or radio frequency interference". Another proposed definition of STM is: "Outer space traffic management covers activities related to the oversight, coordination, regulation, and promotion of outer space activities (including the protection of the space environment) during several distinct mission phases – such as launch, outer space operations and return from outer space" (Oltrogge, 2018). Another definition is that STM means "planning and coordination with activities that enhance sustainability of operations in the space environment..." (Zaidi, 2020).

STM should be aware of the safety and security of all space activities. That is the reason why space debris cause risks for operators. Space debris is created due to collisions in space (the collision of the Kosmos 2251 and Iridium 33 satellites in 2009 created over 1,600 pieces). "Space garbage" is a threat to the security of states. International regulations include the guidelines developed by UN COPUOS (UN resolution (62/217 in 2008) (UNOOSA) or the provisions of the Interagency Coordination Committee for Space Debris – IADC. The main objective of the IADC is to exchange information on research activities in the field of space debris among members of space agencies, facilitating collaboration in space debris research, reviewing progress in ongoing joint operations against space debris IADC promotes the coordination of national space debris research and, above all, its reduction. IADC guidelines are non-binding legislation aimed at reducing waste generation space activities in connection with the space activities of states and their operators (Ailor, 2020, pp. 231-255).

STM in National Legislation

Due to the non-binding nature of international regulations, there is a need for national legislation relating to outer space activities. National law is generally easier to adopt and amend than international law. Moreover, definitions that are missing in international law may be introduced into national legal orders. The European Court of Justice (ECJ) case-law is also characteristic, as in one of its documents on the interpretation of Art. According to Articles 1, 2, and 4 of Council Regulation No 3577/1992 of 7 December 1992 (EEC, 1992), the possibility of applying restrictive national law exists only if urgent needs in the general interest justify it. This judgment can be a basis for opening the way for national space legislation in the absence of such legislation at the international level, or, on the contrary, for the assumption that, in the absence of Treaty provisions, the space activities of operators are not restricted in any way (Rapp, 2009, p. 90).

Some authors point to the urgent need for national space legislation, especially in the privatization of the telecommunications sector. The following factors can be taken into account when legislating: private space licensing system; general requirements concerning, on the one hand, the facilitation of obtaining private licenses and, on the other hand, the observance of the principle of state interest (domestic and international), the question of liability and the necessity of insurance (von der Dunk, 2005, pp. 139-145; Koster, 2002, pp. 454-457).

In 2001, the so-called Cologne project on national space legislation (Project 2001 Working Group on National Space Legislation) demonstrated the need to harmonize space legislation and a level playing field for actors operating in space. National laws and regulations vary from country to country depending on the country's policy, wealth, and access to technology, geography, security, and environmental protection. The draft, pointing to the need to harmonize the provisions of international law, including in terms of liability rules, attaches greater importance to national law in this area (Hobe & Hettling, 2002; Koster, 2002).

International treaties do not guide states on how they should implement laws. If the provisions are directly applicable, the country concerned may extend the scope of the provision and clarify it in its national legislation. States should establish a legal framework for space activities, including activities carried out by private actors; national legislation should contain standards for registration and licensing rules.

Many authors point out that the existing space conventions do not contain adequate provisions tailored to the current needs of space activities. It is due to the reluctance of richer countries, whose practice has accustomed them to doing what they want. The proposals are different: do nothing and rely on natural mechanisms or set specific standards and an international regime. The only way out of the lack of international rules is through national legislation. A stable legal environment will help recover economic costs and increase the confidence of potential investors. National legislation may liberalize rules to maximize the benefits of space exploration (Brisibe & Davis, 2001).

It is worth noting the European Space Agency (ESA) activities and the European Union (EU), whose extensive space legislation, especially in telecommunications and data protection, unites the European market. Undoubtedly, in most of the presented legal acts relating to outer space (usually in the form of laws, constitutions, decrees, etc.), various space organizations were created. Some agencies have more or less developed competences. Comparing the world legislation with the European one, liberalization tendencies can be noticed (most visible in the telecommunications sector); in defense matters, states always retain their sovereignty.

The state's commercial activity in space has also evolved, which is why many internal legal acts increasingly encourage the private sector (domestic and foreign) to invest in space activities. Therefore, as the United States has done, states are trying to enable space operators to operate without unnecessary administrative barriers. However, despite these activities, in most countries (including Poland), space activities are still not covered by a separate space regulation. It is related to the scale of the use of airspace and space. Although there are no special regulations related to STM, all regulations may also be useful in space traffic management.

STM Policy and Strategy

As seen above, special STM provisions are still missing. It also calls for a globally accepted Space Traffic Management (STM) system. There is currently no overarching international space management system that seamlessly covers launch, orbital re-launch, and orbital activities, as well as security activities. It has also raised questions whether private space operators worldwide are subject to ongoing oversight in line with international treaty obligations, particularly Art. VI of the 1967 Outer Space Treaty (UNOOSA, 1966).

Given the world's growing dependence on space for critical national security, economic and social services, and infrastructure (and the resulting growing vulnerability to any disruption), there is a growing concern worldwide about ensuring that space capabilities operate as planned. In addition, the ability to track objects in space has not increased at the same rate as the increased use of space. Accurate and precise knowledge of the location of satellites and spacecraft and the surrounding environment and ensuring radio-frequency interference-free operation are key elements of this interest. There is also a growing consensus within the SSA community that simple sharing data between countries and organizations is not enough and that there is a need for cooperation to ensure the safety and sustainability of space activities (for example, ensuring that satellites do not interfere with radio frequency or that objects will move with each other if there is a risk of collision), which is coordinated both nationally and internationally.

SMT may also be regulated at the national level. The only example is in the USA. There is national legislation on STM (e.g., the US concept of space and air traffic management system (SATMS). It represents, in line with the "space concept", an environment in which space and air operations are smooth and fully integrated into a modernized, efficient national system. In June 2018, US President Donald Trump signed the Third Space Policy Directive to monitor orbit objects and share information to help spacecraft avoid collisions. Space Policy Directive – 3 (Gleason, 2020) provides guidelines and guidance to ensure that the

United States remains a leader in providing a safe environment as commercial and civil space traffic increases. As space becomes more and more threatened, so does the need for the Department of Defense to focus on protecting US space capabilities and interests (security). At the same time, the rapid commercialization of space requires a traffic management framework that protects US interests and considers the needs (security) of the private sector. The new directive aims to reduce the increasing threat of orbital debris for the common interest of all nations.

In line with this directive, the US should continue to provide basic Space Situational Awareness (SSA) data and basic STM services without charging users directly (Jah, 2020, pp. 1-24). According to the directive, STM means planning, coordination, and synchronization of activities in orbit to increase the safety, stability, and durability of activities in the space environment. The United States recognizes that spaceflight safety is a global challenge and will continue to encourage safe and responsible behavior in space while stressing the need for international transparency and sharing of STM data. Through this national policy on STM and other national space strategies and policies, the United States will enhance security and provide continued leadership, priority, and freedom to operate in space.

US STM policy aims to address many of the security challenges associated with the expected revival of space movement, particularly related to the deployment of mega-constellations and unmanageable spacecraft, such as cubes. STM can be characterized by developing a normative approach using best practices, technical standards, pre-commissioning risk assessment, and in-orbit collision avoidance services. STM involves overseeing a complex chain of information/ data to support the operational decision-making process. STM development relates to issues such as SSA data refinement, SSA data policy, and specification of STM best practices and standards (Daily Journal of the US, 2018; Buenneke, 2018).

There seems to be a need to strengthen US-EU cooperation on SST and STM. There is a need to recognize the seriousness of the issues at stake and the urgent need to establish a framework for preventing and mitigating threats to space security. The number of space operations will certainly increase in the future; the same will be true of the number of space objects. Therefore, it is certain that the current and limited activities in the field of traffic management and architecture will become insufficient. The task should aim to develop a new approach to space traffic management, considering current and future operational threats.

It can only be done when there is a clear political will to step up action through commitment at the national level. The challenges are limited progress at the international level, and policies do not necessarily undermine the importance of multilateral space security efforts. As mentioned earlier, the Space Policy Directive 3 calls for a reorganization of responsibilities in the military and civil sectors, SSA data sharing, SSA data quality improvement (to achieve the appropriate accuracy required to securely plan, coordinate, and synchronize in-orbit activities and mitigate risk collisions), SSA data policy (to establish appropriate information management structures (collection, aggregation, distribution) to safeguard data integrity, reliability and confidentiality, and to define STM best practices and standards (to increase security, stability and sustainability of activities in the space environment for various stakeholders- military, civil, or commercial.

The STM appears to be moving from informational to normative STM (Specification of Standards of Behavior covering preventive, operational, and curative measures throughout the life cycle of space systems (best practices, standards, regulations). There is an urgent need for international coordination of many, possibly divergent, regional/national approaches to STM. As some observers have pointed out, there is a need to prepare a European approach to space traffic management by creating a dedicated forum that would coordinate the views, needs, and possible input of European stakeholders. Transatlantic cooperation between the US and the EU can bring many benefits (ESPI, 2020, pp. 14-17).

Data sharing is a priority in the next generation of STM systems and capabilities. Created in 2009, the Space Data Association (SDA) is a formal, non-profit association of civil, commercial, and military spacecraft operators that supports controlled, reliable, and effective data sharing, critical to the security and integrity of satellite operations. The SDA objectives are as follows: promoting responsible operator behavior in all orbital domains to ensure the protection of key resources and the space environment, providing system members (SDC) to increase flight safety, improving the accuracy of collision avoidance predictions, using other data exchange opportunities. The SDA is uniquely positioned to contribute to discussions about the future STM. SDA members study the requirements for next-generation STM systems. The stressed limitation indicates the need for new capabilities to ensure long-term protection of the space environment and ensure efficient operational products. Collaboration with all stakeholders: governments, agencies, operators, and industry is crucial (Dickinson, 2018).

Code of Conduct in Outer Space

The American Stimson Center initiated the Code of Conduct. It was called "Rules of the Road", and it concerned internationally agreed space operations. The most important elements of the code are the following principles: collision avoidance, space debris prevention, information exchange and consultation on debris-generating activities in space, coordination of spectrum use and orbital allocation, as well as STM (Space Traffic Management) (EEAS, 2014, pp. 1-13). The US's opposition to the treaty solutions has made the idea of the code more and more important. The Code was intended to be a non-binding legal instrument – where acceding States voluntarily agreed to certain rules of conduct. Moreover, as soft law, the code is easier to agree with and avoids lengthy discussions about the definition and sends an important signal to political processes, both at home and abroad. However, there is also a risk that such codes will distract from efforts to conclude international agreements.

In December 2008, the Council of the EU officially presented the draft space code. The Code, which was created on the initiative of the European Union, is an international instrument that is binding on the states acceding to it voluntarily (except for standards that are unified and customary – they are applied even by states that are not signatories to the Code). The Code was open to states only and applied to their activities within intergovernmental organizations. The code applied to both the military and the civilian aspects of security and safety operations. The Code could have practical benefits for space security and affect civil space operations. Regulatory issues in the code, including defense issues, were an integral part of the European space policy. The purpose of the Code was to keep future space states accountable for its implementation and application in their operations. The Code did not give the EU any particular role or responsibility.

The aims of the code were twofold. On the one hand, it helped strengthen existing treaties, rules, and other arrangements, encouraged states to join these initiatives, implement their provisions and promote their universality. On the other hand, it complemented the UN treaty system by codifying good practices in space operations, including notification and consultation. It might strengthen trust and transparency between states and contribute to the development of space activities. The idea of the Code collapsed due to diplomatic failure in 2015. The last activity of UNCOPUOS (UN Committee of Peaceful Uses of Outer Space) and its success were achieved in 2019 with Long Term Sustainability (LTS) idea as "Code of the road". The international space community accepted 21 guidelines about common responsibilities in space and its use in peaceful manner. However, some of them were not accepted by the states (Plattard, 2020).

The primary purpose of the guidelines is to assist States and international intergovernmental organizations, both individually and collectively, to mitigate the risks associated with the conduct of outer space activities so that present benefits can be sustained and future opportunities realized. Consequently, implementing the guidelines for the long-term sustainability for outer space activities should promote international cooperation in the peaceful use and exploration of outer space (A/AC.105/L.318/Add.4, 19th June 2019; V.19-04973). Let us hope that this idea of a common understanding of space safety and security use will reach international consensus in practice (Polkowska, 2019, p. 275).

STM in Europe

STM is important for the Single European Sky. Europe is very interested in satellite communications and therefore invests a lot for governments and institutions. Europe has a strong interest in ensuring safe and reliable satellite communications at significantly lower prices than military satellites. One of the key areas of concern is resilience and reliability. Therefore, space traffic management is very important. There is an urgent need for a code of conduct establishing common standards of behavior, primarily based on empirical data and evidence, to help satellite operators avoid confusion, adapt to safety constraints, and anticipate and implement in practice routines to deal with regular and emergency situations.

The establishment of a body or organization responsible for monitoring, oversight, coordination, and enforcement (including incident management) will benefit the design and operation of an effective and sustainable space management system. The authority must address the concerns of stakeholders while balancing the need for effective control as policies and procedures are developed. Many agencies, companies, universities, and technologies can participate in a space traffic management program. Effective and secure information exchange between this group will be essential for managing traffic in congested space. Consequently, a communication strategy will be needed with policies and procedures on whom to contact, when and how to initiate, how to format, how to evaluate and assign urgent tasks and expected responses. In addition, communication must be secure and reliable.

With STM, state situational awareness is important. SSA in Europe consists of three separate segments: SST (Space Surveillance Tracking), particularly in space debris, space weather, and near-earth orbit (NEO) observations. Nineteen participating countries participate in the SSA programs of the European Space Agency (ESA). The European SSA (Space Situational Awareness) system has a dual-purpose civil and military application. Additional components for the SSA system may be added shortly. They are built based on military requirements and developed by the European Defense Agency (EDA). Significant progress in developing the SSA system in Europe in which many actors participate: Member States, ESA, EU can be observed. There are still some challenges in developing and operating a European SSA system. Ensuring security in space requires many measures to monitor the space environment, mitigate threats to space infrastructure, and reduce the vulnerability of space infrastructure. According to the 2018 ESPI Report, the SSA covers all measures and activities to monitor, detect, predict and inform about man-made and natural, deliberate, and unintended threats to outer space activities (i.e., threats from the space environment).

"Precursor" of a European STM system is EUSST (European SST). Space Surveillance and Tracking (SST) Support Framework was established by the European Union in 2014, foreseeing the creation of an SST Consortium of, initially five EU Member States (France, Germany, Italy, Spain, and the UK), and currently eight (also Poland (Polkowska & Chimicz, 2020), Portugal, Romania), as enlarged in 2018. "Space Surveillance and Tracking" refers to the capacity to detect, catalog, and predict the movements of space objects orbiting the Earth. Since 2016 the SST Consortium and the European Union Satellite Centre have been working together to develop a European SST capability in a series of EU-funded projects, known as "EUSST". The EU Member States of the SST Consortium have designated national Operational Centres to provide operational SST services to SST Users via the EUSST Service Provision Portal to implement the SST Support Framework (European Parliament, 2014, pp. 227-234). Three types of services are provided to users: Collision Avoidance – provides risk assessment of collision between spacecraft or between spacecraft and space debris, Re-Entry Analysis – provides risk assessment of uncontrolled re-entry of man-made space objects into the Earth's atmosphere and Fragmentation Analysis – provides detection and characterization of in-orbit fragmentations, break-ups or collisions.

SST services are provided to registered users on the EUSST Service Provision Portal operated by the EU SatCen as Front Desk and compliant with the Service Portfolio. The Front Desk allows users to register for SST services, transmits service-related information and products through the Service Provision Portal, and provides user support through a dedicated Helpdesk. The users of the SST services set out in the SST Decision are public and private spacecraft operators, public authorities concerned with civil protection, as well as European Union Member States, the European Council and Commission, and the EEAS (Becker & Faucher, 2020).

The Future of the STM System

Based on the above experiences, the STM problem should be treated in a "holistic" way, as a system of systems that includes the contribution and participation of all states, entities (government, commercial, academia, etc.), vehicle types (satellites, orbital launch, hypersonic, suborbital). The basic principles of a better framework are: No organization has the best data on everything; the STM system needs to collect and process reliable data to get the best results. The collected data must be "normalized" and quality controlled internally. The STM system should be compatible with both internal data and data collected from other sources. Bias in tracking observations and satellite operations should be identified and removed. The STM must cover all phases of flight, including orbital operations, sub-orbital flight, hypersonic, take-off/return, and end-of-life deorbit/return/descent.

Recognizing that classified operators cannot participate directly, the ideal STM candidate should provide all eye and SSA data to classified communities hoping that this data will be used for due diligence and prevent collisions with classified objects (Oltrogge, 2018).

Conclusions

With the increase in the number of active satellites and space debris in space, especially in high orbits and altitudes, physical congestion has become an increasing problem. So far, there have been several confirmed, unintentional collisions between a functional satellite and another space object, either damaging the satellite or destroying both objects and creating thousands of new space debris, potentially endangering aircraft safety. STM aims to eliminate future collisions and other incidents in space that could create additional debris or other threats to the safety of outer space operations and increase the safety and efficiency of outer space operations. Space Situational Awareness (SSA) is an important component of the STM. SSA relates to the capability to characterize the space environment and outer space activities. A key element of an SSA is the use of terrestrial or space sensors, such as radar or optical telescopes, to track space objects. Data from multiple sensors are combined to estimate the orbits of space objects and predict their future trajectories. EUSST is an excellent example of being a "precursor" of STM.

There is a need on by the government to consider national laws that could legally define where outer space begins, in the absence of an international definition. Likewise, space launchers should be aware of the different aviation and space law systems and the lack of international legal certainty between them. While some countries currently apply practices that could be considered part of the STM, there is currently no common state practice or an established international system. There have also been international policy initiatives to discuss voluntary guidelines or standards for improving the safety and sustainability of outer space activities and research to investigate the interactions between space and air traffic and possible safety issues. There is an ongoing debate whether the international STM system should start internally or internationally (as a multilateral treaty). There is still hope that Long Term Sustainability guidelines prepared by UNCOPUOS will be a good start in establishing STM rules. One is sure: safety and security of space activities are priorities for all actors in space.

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