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Research Article

International legal, technical and financial challenges for implementing the concept of space traffic management

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Abstract. Focuses on the concept of Space Traffic Management (STM), the matter which has been of high interest for many space actors in the last three decades. With the emergence of the NewSpace era, and flourishment of commercial and economic incentives for space activities, this topic has gained the attention of many space actors in the preceding decades, thus turning into a separate agenda item in the Legal Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space. However, establishing and implementing such regulations is a challenging task, especially for new space actors. This article aims to assess the existing challenges of STM and provide solutions to overcome them. Firstly, this article provides the necessity of establishing such a regulation: it is evaluated and discussed while describing the requirements for achieving this goal. Secondly, the paper studies definitions provided by governmental and non-governmental entities regarding this concept and the measures taken towards its realising. Finally, the research discusses the challenges that space actors face regarding implementing this concept, both legal and practical. In conclusion, the authors highlight the importance of promoting endeavours and coordination among all current and potential space actors with due considerations for their relevancy.

Key words: Space Law, Space Traffic Management, Space Debris, Space Safety, Sustainability, Situational Awareness, NewSpace

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Научная статья

Международные правовые проблемы реализации концепции управления космическим движением

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Аннотация. Детально анализируется концепция управления космическим движением, которая в последние три десятилетия вызвала большой интерес у всех государств и иных участников, вовлеченных в космическую деятельность. С наступлением «новой космической эры» («NewSpace», или «космос 2.0») и ростом экономических стимулов для космической деятельности эта тема привлекла много внимания общественности и стала важным пунктом повестки дня Юридического подкомитета Комитета Организации Объединенных Наций по использованию космического пространства в мирных целях. Однако разработка и внедрение международных правил космического движения является сложной задачей, особенно для новых частных участников космической деятельности. Эта статья призвана оценить существующие международно-правовые проблемы реализации концепции управления космическим движением и предложить некоторые решения для их преодоления. В рамках настоящей статьи, во-первых, будет оценена и обсуждена необходимость установления регулирования управления космическим движением, а также перечислены требования, которые необходимо решить для достижения этой цели. Во-вторых, будут проанализированы определения, предоставленные государственными и негосударственными организациями в отношении этой концепции, и меры, принятые для ее реализации. В конечном итоге будут обсуждены теоретические и практические международно-правовые проблемы, с которыми сталкиваются участники космической деятельности при реализации этой концепции. В заключение подчеркивается важность поощрения усилий и координации между всеми действующими и потенциальными участниками космической деятельности с должным учетом потребностей последних.

Ключевые слова: международное космическое право, управление космическим движением, космический мусор, космическая безопасность, устойчивость, ситуационная осведомленность, новая космическая эра, NewSpace

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Introduction

In recent decades, all space actors and non-actors have accepted outer space as one of the most important spheres in the economic, political, cultural, and technological aspects. At the outset of the space age, this territory was exclusively in the hands of governments leaving no room for the private sector. Besides there were no prospects for private businesses to be involved in the hindsight. In fact, the primary purpose of outer space activities was to strengthen the military status of the powers. With the emergence of NewSpace, the military paradigm shifted towards facilitating commercial companies' entry into this field. Evidence of this statement is the rise of ambitious private actors such as SpaceX Starlink, OneWeb, Amazon, and so forth with the prospect of maximising economic benefit through cutting edge technologies. Safety and sustainability are considered the most crucial economic development parameters. Currently, there are thousands of satellites in earth orbit, congesting the environment and increasing the risks of collisions. Accordingly, the need for a comprehensive regime to address these issues seems more necessary than ever.

The concept of Space Traffic Management (STM) was first proposed by the American Institute of Aeronautics and Astronautics at the beginning of the 1990s (Takeuchi, 2014). Afterwards, The International Academy of Astronautics in 2006 formalised this concept (Contant-Jorgenson, Lála, Schrogl, 2006). The most important measure taken by a State regarding STM regulation was the U.S. Space Policy Directive-3[1], stipulating the government's position on this issue. European States have also contributed to sorting things out by establishing regulatory frameworks and taking various measures which, directly or indirectly, correlate with STM. However, the unspecified status of developing countries must be taken into account; it reflects these countries' economic and technological constraints. As a result, there is no guarantee for realising such a concept as all the efforts and initiatives are generally the non-binding instruments that act as incentives to promote the importance of a multilateral and uniform system of regulations to address space congestion. Under international space law, no country has sovereignty over outer space, and it is accessible to every Nation for peaceful purposes (Mirzaee, 2017). On the contrary, airspace is regulated, and air traffic management within this location is an obligation upon States. Yet, no obligation to develop STM regimes has been reached because States cannot enforce territorial sovereignty in outer space. This issue ties in with the matter of outer space demarcation. One of the most critical aspects of STM is undoubtedly the mitigation of space debris, which was not brought to the global community's attention until the

[1] White House (2018) Space Policy Directive-3, National Space Traffic Management Policy. US Government, 18(06).

mid-1980s. Since then, many national and international space agencies have enacted various protocols and other initiatives to tackle this challenge. Although there is understanding that such goal can be reached by concerted and joined efforts on behalf of the international community certain policies and/or technological advancements so far have yet to overcome plenty of technical and regulatory obstacles. Of those two, technological barriers seem to be easier to overcome as rapidly advancing developments allow to tackle space debris mitigation issues thus ensuring the space infrastructure security, but regulatory issues are holding the process back. One of them is the delimitation of outer space; an important legal issue debated ineffectually over the last few decades (Syed Tamjeed, 2020).

The authors discuss the necessity of establishing the STM and evaluate the existing definitions to propose their understanding of this concept. Further parts are focused on the review of the measures taken at national and international levels and analysis of challenges that developing countries face in terms of STM implementation.

The Necessity and Requirements of Implementing Space Traffic Management

Regarding the increment trend of placing space objects in the earth orbits and the orbit of other celestial bodies, working out a regulated, integrated, and accessible regime to promote safety and prevent orbital events in space operations seems not just necessary but urgent. To reach the aim the following requirements must be met:

- to increase the safety and sustainability of space operations,
- to enhance coordination among space actors, and
- to facilitate the entry of developing countries into outer space.

By considering the necessities mentioned above, experts in this field conducted one of the most significant endeavours in establishing a comprehensive concept known as STM.

Coordination among States requires a strengthened sense of accountability, supported by obligations of States regarding space activities; this suggests sharing data for traffic control. One must consider that it is necessary to establish unified and comprehensive basic rules that facilitate the free flow of data on space objects' movement in outer space to ensure space operations' safety and effectiveness. Formulating STM rules plays a vital role in shaping the concept, gradually building up foundation for mutual consensus among States and international organisations. Concrete rules of responsibility are also necessary for improving States' legal control over space activities in terms of broader compliance with international law.

So far, traffic in space as a concept has never been adequately addressed, which resulted in many operational problems of space activities. Although the lack of traffic management in outer space is not the primary catalyst behind these issues, it is one of the main roadblocks that States face in their space operations. Air and sea law are helpful as a benchmark and example. But these branches, will not prove sufficient for the complexities and constant technological and legal challenges that States face due to the ever-growing nature of space activities.

In this part, it seems necessary to address the STM concept in the current issues of outer space, including space debris, small satellites, and satellite mega-constellations, and assess the positive effect in tackling such matters.

Space Debris. One of the reasons for the emergence of the STM concept is the control of space debris production. With the increasing trend of space activities and emergence of new space actors in recent years, it is clear that space debris is becoming a serious hazard; it contributes to greater satellite operational costs. A single piece of space debris as big as 1cm travels at a rather high speed and carries enough force to destroy or completely destabilise a satellite. In case of collision with a satellite, its replacement will require hundreds of millions of dollars. In 2019 it was estimated that 129 million debris pieces from less than a centimetre to more than ten centimetres in size floated around the earth orbit. Accordingly, the matter of utmost priority in this situation is not only removing the existing space junk from the orbit but preventing creation of more debris under a comprehensive regime of traffic management. To this end, the STM standards to improve satellite technical and design quality and conjunction assessment technologies can help avoid disasters such as explosion and collision of space objects upon launching and re-entry.

Small Satellites. With the activities of new space actors, especially developing States, small satellites have become of prime importance. In recent years, the number of small satellites launched from the Earth saw a significant increase, bringing to light the necessity of taking technical and regulatory measures to control situation in space and ensure the long-term sustainability of outer space activities. Since 2012, small satellites have gained a lot of attention from the global community, especially in developing countries. The reason behind it is that such countries, due to technological and economic obstacles, often lack the independent capacity to utilise and launch larger satellites. States and private operators successfully launched more than 1700 small satellites between 2012 and 2019[2]. Their number has increased drastically in the last decade because of lower financial and technological burdens as well as easy launching.

Based on these statistics, one can infer the importance of organising small satellites in low Earth orbit (LEO) to prevent space objects condensation, avoid collision and control the scope of litter abandoned after the end of a satellite's operational life.

Satellite Mega-Constellations. One of significant achievements in the NewSpace era is the emergence of satellite mega-constellations in the low Earth orbit as a result of space activities of States and industries. Satellite mega-constellations comprise a collection of small satellites that can cover a vast area on Earth's surface through interoperability and synchronous operation. These constellations will undoubtedly affect the management of outer space, especially the management of space traffic. A significant characteristic of such constellations is their placement at an altitude of less than 2000 km. Such low orbit, in turn, means that satellites' sheer volume might become a severe threat to other space objects if poorly managed due to the high number of satellites in a constellation. For example, as of 2020, SpaceX Starlink has proposed placing 4400 satellites between 540 and 570 km with a +/–30 km station-keeping variance, which seems to be close to appropriating 500—600 km of earth orbit for their use[3].

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[2] Bryce Space and Technology (2020) Smallsats by the Numbers. Available at: https://brycetech.com/reports/report-documents/Bryce_Smallsats_2020.pdf [Accessed 14th October 2020].

[3] Cao, S. (2020) The Race Between SpaceX's Starlink and Amazon Is Heating Up. Available at: https://observer.com/2020/11/spacex-starlink-amazon-kuiper-fcc-orbit-altitude-rights/ [Accessed 18th October 2020].

Another critical issue worthy of notice is the destruction of satellites that have reached the end of their operation. Some satellite constellations carry hundreds of small satellites. Each launch of such bunch of satellites into the low Earth orbit are a risk that will enhance the necessary technical and legal measures required to implement a comprehensive and harmonious regime for managing objects in outer space.

Definition of the Concept of Space Traffic Management

In recent years, many definitions provided, both by public entities and experts, emphasised either technical-regulatory aspects or were solely limited to technical issues. The first official definition was presented by the International Academy of Astronautics, highlighting the technical and regulatory elements:

"Space traffic management means the set of technical and regulatory provisions for promoting safe access into outer space, operations in outer space and return from outer space to Earth free from physical or radio-frequency interference (Contant-Jorgenson, Lála, Schrogl, 2006)".

The United States, in the preamble of its Space Policy Directive-3, introduced the second definition, which indicates the technical and practical aspects of this concept:

"Space traffic management shall mean the planning, coordination, and on-orbit synchronisation of activities to enhance the safety, stability, and sustainability of operations in the space environment"[4].

Other definitions, generally provided by experts in this field, often underline the technical and practical characteristics of STM, paying less attention to the regulatory and legal dimensions. However, evaluating and comparing the remaining definitions by authors and experts helps create a more in-depth understanding of the STM concept.

William Ailor from the Aerospace Corporation underscores the organisational aspect, the purpose of which is to assure the long-term sustainability of space activities free from any harmful interference (Ailor, 2015). Being one of the former chiefs of the ITU Department of Space Services, he describes the concept as an approach to secure entry into space, operation in and re-entry to the Earth. He focuses on the functional aspect of STM and provides a general definition of the concept through a purpose-oriented approach (Henri, 2015).

Those descriptions are considered to be rather general and abstract compared to recent definitions. Currently experts have adopted a more precise, operational, and technical approach towards this concept. Some of them believe that creating the process of collision avoidance with regard to identifying high-risk cases and communicating conjunction assessment data to clients is a vital STM aspect. Such process gives credence to its role in reducing the conjunction between space systems (Peterson, 2018). On the other hand, some have adopted a functional approach in defining STM thus highlighting the importance of control, authority, and responsibility. From their perspective, STM is the control of the orbital environment by the appropriate authority that is responsible for preventing collision between operational satellites and any

[4] White House (2018) Space Policy Directive-3, National Space Traffic Management Policy. US Government, 18 (06).

natural or man-made objects (Stillwell, 2019). Irrespective of the approach to the phenomenon both have delved into the specifics of goals, elements and/or functions of management. From their point of view, STM comprises four aspects: data collection, notification, consolidating firm space traffic regulations, and control. In other words, assuring Space Situational Awareness (SSA) is a prerequisite for setting out rules and regulations on the launch from and return of space objects to the Earth.

Anyway, the efficient functioning of the regime in terms of safety, sustainability and coordination of actions both in technical-practical and legal-regulatory aspects, requires unified efforts on a global scale.

Based on the above the following definition is suggested:

“Space traffic management (STM) means a universal system of regulations, consisting of a set of technical and regulatory standards to promote safety, sustainability, and coordination among space actors, which encompasses the entire process of space operation from pre-launch to the end of orbital life”.

Measures Taken Regarding the Development of Space Traffic Management

American Institute of Aeronautics and Astronautics (AIAA). The concept of STM has come to light in recent years through a series of workshops held by the AIAA alongside other international organisations on cooperation, which also dealt with the subject. In light of the 5th and 6th AIAA workshops, held from 1999 to 2001, it gave way to important insight and recommendation regarding STM. However, such activities were unfruitful and did not yield any noticeable results compared to Lubos Perek’s studies in the early 1980s. With this in mind, the 2001 session of the AIAA workshop suggested that the International Academy of Astronautics (IAA) should conduct a study regarding the issue mentioned above. The IAA accepted the suggestion, and it was included into the IAA’s agenda in late 2001 (Benkö, Schrogl, Digrell, Jolley, 2005).

International Academy of Astronautics (IAA). The most important action taken by any non-governmental entity regarding this concept’s development is the studies conducted and published by the IAA in 2006 and 2018. In the initial study, the IAA assessed the current status of outer space and its relevant activities and analysed the STM concept in each of the aforementioned topics. Afterwards, the phases of launch, in-orbit operation, and re-entry were considered the key elements for developing the said concept. Eventually, the Academy proposed a general framework for such a system. In the second study in 2018, it updated the previous survey’s enumerated topics to facilitate States’ decision-making regarding this concept. This entity also investigated the relevant actions taken by stakeholders in the last twelve years.

Long-term Sustainability of Outer Space Activities (LTS). One of the most significant issues put on the agenda of the United Nations Committee of Peaceful Uses of Outer Space’s Scientific and Technical Subcommittee by French representative in 2010 was the process of formulating guidelines for the Long-term Sustainability of Outer Space; the preamble and twenty-one guidelines of LTS were agreed upon by States Members of UN-COPUOS in 2016 and 2018 and the other topics will be discussed in the near future. This set of guidelines consists of a preamble and four sections, which are as follows: A. Policy and Regulatory Framework for Space Activities, B. Safety of Space Operation, C. International Cooperation, Capacity-Building, and Awareness, D. Scientific and Technical Research and Development.

By looking at each of the guidelines under the above-mentioned sections, one can see the connection and even the overlap of some of those guidelines and the concept of STM's related issues. The section most relevant to STM is the safety of outer space activities. The most pertinent clauses passed under this section are the following: to provide updated contact information and share information on space objects and orbital events, to improve the accuracy of orbital data on space objects and enhance practice and utility of sharing orbital information on space objects, to perform conjunction assessment during all orbital phases of controlled flight, and to develop practical approaches for pre-launch conjunction assessment.

One could argue that the successful implementation of the LTS guidelines for outer space activities, due to the vast range of topics included, and agreement on the remaining guidelines can fulfil the goals set up by the supporters of the STM concept.

The United States Space Policy Directive-3. In line with the adoption of policies for commercialisation of outer space activities and altering the cooperation approach towards space operators from military to commercial applications, the president of the United States, on 18th June 2018, issued the executive order titled the "National Space Traffic Management Policy"; he put the matter under the supervision of the Department of Commerce. The U.S. government, through this policy, seeks to establish a transparent regime of STM and provide precise, open data and modelling for all; acting as a leader in this field the U.S. offer other States to use the data provided by them to maintain the States' space activities (Blount, 2019).

Moreover, The United States Senate has recently taken steps to implement the goals set out in the Space Policy Directive-3 regarding establishing an STM regime and maintaining U.S. leadership in this domain (Wicker, 2020). The Space Preservation and Conjunction Emergency Act (SPACE Act) is introduced to codify the SPD-3. It transfers responsibility for Space Situational Awareness data (SSA data) and conjunction analysis to non-military space operators from the Department of Defense to the Department of Commerce, marking another measure to emphasise the commerce sector's role in civil space exploration. Such a transfer leaves more room for the Department of Defense to focus solely on the military aspects and requirements of collision avoidance while providing more leeway for the Department of Commerce to interact with the commercial and international satellite operators. This act is taken as the bill on transferring authority from the military to the U.S. government's commercial section for the STM commercial sector.

At first sight, this approach can be beneficial to other countries, especially developing, as it provides access to data on their space objects without enduring the staggering costs. The U.S. has taken numerous steps in the last couple of years to create both the technical and legal basis necessary to realise the STM regime. However, this approach and the benefits derived from it for both the U.S. and partnering States will result in leadership in any services related to STM and SSA. This approach can be problematic in the long term, as developing countries may be affected by any sudden change of policy regarding the provision of these services, i.e., the providing State can make its decisions at will. With this in mind, it must also be noted that other Space powers have not shown any active response to the trend that is set in motion.

The European States. None of the European States has demonstrated a uniform and comprehensive approach regarding STM similar to the United States government's executive order, even though some public and private entities have taken individual steps towards formulating this concept. The issuance of the executive order and, recognition of the importance of security in Europe's space policy agenda, has stimulated European public and private stakeholders' attention towards this subject (Moranta, Hrozensky, Dvoracek, 2020). Hence, in its proposal for establishing the European Union's space programme, the European Commission has declared that "the increase in space activities may have an implication on the international initiatives in the area of the space traffic management. The Union should monitor those developments and may take them into consideration in the context of the mid-term review of the current multiannual financial framework"[5].

The 2018 report of the European Space Policy Institute highlighted the implications of the US executive order on European countries' future space activities and envisaged the future challenges of Europe to maintain its position in the field of space activities. Also, given the necessity of establishing a new STM regime, the report recognized the Europe's needs to set forth its specific approach with regards to this issue, bearing in mind its priorities and in accordance with the existing systems (Aliberti, Sarret, Hrozensky, Perrichon, Rowley, 2018).

Challenges of Adherence to Space Traffic Management Regulations

A. Legal Challenges. In space law, despite decades of norm-making, there are still challenging issues facing the establishment of any new legal regime in the space domain. Although such issues have been on the agenda of the legal sub-committee of the UN-COPUOS, there has been no consensus so far. Accordingly, this section will enumerate the most relative STM challenges. It is worth noting that overcoming these challenges will significantly facilitate the establishment of the STM regime.

Legal Frontier between Airspace and Outer Space. One of the most important and determinant variables that play a vital role in regulating outer space activities is the delimitation of outer space. Creating a regime for STM will ensure safety and sustainability of operations in outer space. However, it may seem that without a boundary to differentiate between air and outer space, this matter proves more challenging (Jakhu, Sgobba, Dempsey, 2011). Establishing a frontier between the two territories has been an issue of a long discussion in the legal sub-committee of UN-COPUOS. However, despite the matter being an agenda item in the legal sub-committee for more than five decades, States have been unable or unwilling to provide a specific and precise definition of outer space delimitation. Most of the space

[5] European Commission (2018) Proposal for a Regulation of the European Parliament and of the Council: Establishing the Space Programme of the Union and the European Union Agency for the Space Programme and repealing Regulations (EU) No 912/2010, (EU) No 1285/2013, (EU) No 377/2014 and Decision 541/2014/EU.

powers have currently adopted neither the functionalist nor the spatialist approach regarding this issue, their priority being a "wait-and-see" approach at the moment (Cheng, 1983).

However, some States have adopted a specific and clear altitude regarding where airspace ends and outer space begins. For example, the Australian Space Activities Act of 1998 indirectly defines a boundary between airspace and outer space by instituting a 100 km altitude as the standard measure for launching objects into outer space[6]. Furthermore, the Danish Outer Space Act, in Part 2, defines outer space as space above the 100 km altitude from the sea level, hence giving a straight and direct answer to the question of air and space boundary[7]. Therefore, the above-mentioned States have, in a sense, adopted the Von Karman Line method, according to which "a vehicle at this point (which can be between 53—60 mi depending on air density) would have to fly faster than orbital velocity to derive sufficient aerodynamic lift from the atmosphere to support itself. At this point, air density is about 1/2,200,000 the density on the surface of the Earth." (Lal, Nightingale, 2014). Such approach can be used as the standard for resolving the outer space delimitation issue in their respective national laws.

The main problem of ambiguity in finding a boundary between airspace and outer space is regulating space activities, especially regarding UN treaties' scope governing space activities (Takeuchi, 2014). Outer space activities have undergone many changes and include various activities across all the orbits surrounding the Earth, giving weight to delimitation more than ever. It is understandable to say that outer space might be a combination of both spatialist and functionalist approaches, given States' practices (Davarzani, 2018:127).

The first step to identifying the proper approach suitable for the STM regime is to evaluate each approach's benefits. The spatialist approach is favourable in that it provides for a clear-cut standard for identifying the scope of activities and objects under space law by using the location. On the contrary, the functionalist approach necessitates close observation of the actual function, proving somewhat problematic in practice. In terms of traffic management, it is beneficial to have an identifiable external form of activity to associate an object with the relevant rules of air or space law (Davarzani, 2018:58).

In summary, a spatialist approach is a more straightforward method to determine the domain of STM rules and regulations. However, States can apply a mixture of the two approaches mentioned above within this domain.

States Liability. An ambiguous aspect of outer space treaties is the responsibility of States other than the launching States. This issue creates several ambiguities concerning the definition of liability. Article 1 (a) of the Convention on the Registration of Space Objects is limited to the following situations: (1) A State which launches or procures the launching of a space object; (2) A State from whose territory or facility a space object is launched.

Based on the above-mentioned description, there can only be four situations in which a State exercises jurisdiction and control over a space object. The problem arises

[6] Australia. Australian Space Activities Act (1998) Part 2, Definitions.
[7] Denmark. The Danish Outer Space Act (2016) Act No. 409.

with the transfer of such an object to a third State. Given this article's ambiguity, a damaged State cannot refer to the actual operating State for damages. However, some scholars (Hobe, 2013) believe that the registering State will act as a quasi-guarantor for any damages caused by a space object at an international level. Nevertheless, the registering State can refer to the operating State afterwards. Solving such ambiguities can pave the way for establishing the STM regime. Also, the focal point of such a regime is the ability to directly contacting the satellites actual operating States.

Legal Definition of Space Debris. Space debris is another important and critical factor that must be taken into consideration when trying to establish a regime for STM. It is a serious impediment that has the potential to halt any progress whatsoever.

A typical dictionary definition of debris is "the remains of something broken down or destroyed"[8]. This definition seems to be relevant for natural litter collected in the vast void of space. Artificial and human-made debris includes, but is not limited to, the fragments of objects created as a result of the collision between objects; numerous satellites and other objects are orbiting the Earth after the end of their operational life.

Unfortunately, there is currently no unified and unanimously accepted definition of the nature and extent of space debris among States and other relevant stakeholders. One of the suggested definitions is that space debris comprises any human-made object that is either: (1) Earth-orbiting and non-functional with no reasonable expectation of assuming or resuming its intended function; or (2) Re-entering the Earth atmosphere (Wheeler, 2014).

B. Technical Challenges. Implementing the concept of STM by space actors faces technical challenges. The first challenges are related to access to data and data sharing, which are the main elements of such a regime. The next challenge is infrastructure, such as Conjunction Assessment & Orbital Maneuver Hardware.

Challenges of Data Access and Sharing. Data access and sharing is the first step in implementing the STM concept. These data include *which object is deployed on orbit, where it is at a given time,* and *which operator controls it.* The data are collected by various space actors, while the Space Situational Network (SSN) of the United States is collecting the most comprehensive and accessible information known as Space Situational Awareness (SSA). The primary aims for setting the SSN were protecting space assets and ensuring military access to outer space. However, the universal access to the most basic information on an object's location, including Two-Line Elements (TLE) in orbit, was authorised by the government. At the same time, the U.S. reserved more detailed information for the domestic entities and allied States (Blount, 2019).

One can deduce that implementing the STM concept based on the information shared by one or a few States cannot be considered reliable and in the interests of other nations, especially developing ones. It seems to be more essential to conduct such activities under the aegis of an international body.

Lack of Relevant Infrastructure. Another critical factor for implementing STM is developing the necessary infrastructures, including conjunction assessment software and orbital manoeuvre hardware.

[8] Australian Space Academy (2007) Guide to Space Debris. Available at: http://www.spaceacademy.net.au/watch/debris/debris.htm [Accessed 18th October 2020].

Launch Conjunction Assessment (CA)[9] software is the process of identifying close approaches between the planned trajectory(s) of a launch vehicle and other human-made objects in orbit. CA includes active and inactive satellites, rocket bodies, debris, and analyst objects that are not in the public catalogue. Although conducting such an assessment is crucial for implementing this concept not all the nations can manage it.

Orbital manoeuvre hardware is another key technical issue; it enables satellites to reposition in the case of emergency or when it is necessary to avert collision risk or change orbit. Being exclusive to the advanced space powers, this technology is one of the most vital requirements of implementing the STM regime. It requires a great amount of fuel and reduces the operational life of satellites. This factor has led operators to embrace collision risk rather than refer to a manoeuvre.

C. Financial Challenges. Developing countries are economically weaker than developed ones so that even normal satellite launches put them under a lot of financial burdens. Given the high costs of access to the aforementioned software and hardware, these nations might face further financial strains while trying to implement the STM standards; this might inhibit their space industries and widen the existing gap evermore. Besides, any further development of technology related to STM standards laid down by developed countries are both money and time-consuming. Thus, one of the key factors to ensure the growth of the space industry in developing countries is time, or more precisely, the speed at which they achieve certain milestones in space flight.

Conclusion

In recent years, space activities' sustainability has become the concern of all participating States, including space powers and new actors in multilateral international discussions, especially on the UN-COPUOS platform. This concern indicates a common demand by the international community to establish a mechanism to address this issue. States' responses to such necessity have reflected two opposite approaches. Some States have been looking forward to dealing with this challenge through an international multilateral entity such as UN-COPUOS, whereas others endeavoured to assume a leading role by utilising the national legislation approach. Both methods have their advantages and disadvantages. On the one hand, regulating space activities through an international entity is undoubtedly time-consuming, although it enjoys more international support from the majority of States. On the other hand, regulating through national legislation, despite the fact that it is a faster and more comprehensive method, generally implies putting one's interests above other States' interests.

Obviously, realization of STM regime requires international cooperation and coordination of existing and potential actors in space activities. Accordingly, international multilateral discussions and negotiations regarding the establishment of a comprehensive and efficient regime for STM shall take into account the special needs and interests of all countries, especially developing, to implement it correctly. Such approach may pave the way for sustainability of space activities and help solve other issues, such as space debris, exploration and use of outer space resources, etc.

[9] 18th Space Control Squadron (2018) Launch Conjunction Assessment Handbook. Available at: https://www.space-track.org/documents/LCA_Handbook.pdf [Accessed 9th October 2020].

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