

The need to improve registration practices in the context of space traffic management

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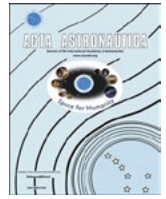


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The need to improve registration practices in the context of space traffic management

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ABSTRACT

This paper examines the legal basis and framework for the United Nations registration process for space objects. UN registration processes are compared against and contrasted with national and regional registration processes to highlight potential adjustments in light of the need for a space traffic management system. While there are shortfalls in compliance and monitoring of States' responsibility to adhere to UN registration requirements, the growing importance of space traffic management is providing a catalyst for reform and recommitment to the ideals upon which the 1975 UN Registration Convention was based. Since the data provided to national registries and the UN register is not detailed enough and is not sufficient for creating a space traffic management regime, it is recommended that (1) the recommendations concerning the registration of space objects belonging to a large constellation that were agreed by the UNCOPUOS Working Group on the Status and Application of the Five United Nations Treaties on Outer Space in 2023 are implemented to ensure uniformity of registration practice regarding large constellations; (2) States incentivize good registration practices by other States, for instance by requiring that satellites of commercial actors are registered by the relevant launching State as a condition for market access; (3) the importance of furnishing additional information on the subsequent activity and status of objects, as required by the Registration Convention, UN General Assembly resolutions 1721 (XVI) B and 62/101 and Guideline A.5 para 2 of the UNCOPUOS Guidelines on the Long-Term Sustainability of Space Activities, be underlined.

1. Introduction

The importance of registering space objects has been appreciated since the early days of the space age. The principle that States should

register space objects was first formulated in United Nations (UN) General Assembly (GA) Resolution 1721 (XVI) of December 20, 1961. Initially, the idea was to establish one central worldwide register of space objects maintained by the UN. This was turned into a national

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registry by UNGA Resolution 1962 (XVIII) of December 13, 1963, which serves as a criterion to allocate jurisdiction and control. This 1963 resolution was the basis for Art. VIII of the Treaty on Principles Governing the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (OST) of 1967. In the subsequent Convention on Registration of Objects Launched into Outer Space (REG) of 1975, the concept of national registration, as presupposed by the OST, was elaborated [1].

Registration is also important for the implementation of the Convention on International Liability for Damage Caused by Space Objects (LIAB) of 1972, which deals with liability for damages caused by space objects in outer space (in which case liability is fault-based) and damages to aircraft in flight or on the surface of the Earth, with “damage” being defined by the LIAB as “loss of life, personal injury or other impairment of health; or loss of or damage to property of States or of persons, natural or juridical, or property of international intergovernmental organizations.” [1].

With a few exceptions to be discussed later, registration of space objects occurs at the national and international level in a two-step process. States establish national registries for their space objects and notify the UN Secretary-General about entries in their respective national registries. The UN Office for Outer Space Affairs (UNOOSA), acting on behalf of the UN Secretary-General, maintains a register to record the national submissions, as well as an Online Index of Objects Launched into Outer Space [2,3].

Registration is linked to the launching State of a space object and no double registration is admissible. Although there may be more than one launching State for a given space object, only one State can register it. According to Art. II para. 2 of the REG, the choice of the State which will be the State of Registry shall be negotiated among the various launching States.

Registration practice has evolved over time in response to technical developments and legal challenges. The privatization of some major international satellite organizations raised a number of registration questions that had to be addressed. In 2007, the UN adopted GA Resolution A/RES/62/101 titled “Recommendations on enhancing the practice of States and international intergovernmental organizations in registering space objects” [1]. However, the continual emergence of new kinds of space activities, such as the manufacture of new space objects in space or the launch of sub-satellites in space, continues to present new challenges in applying the REG. In addition, the advent of very large satellite constellations is a challenge of a practical nature, simply because of the sheer number of registrations to be processed.

In the context of space traffic management, registration information is useful for identification purposes, but not for real-time space traffic management and/or coordination. This is because the basic orbital parameters recorded in the registration system are not sufficient for precise orbital calculations, nor are these parameters updated on a regular basis.

In this article, the current status of registration practice is reviewed and some of the challenges posed by the much greater number of satellites being launched into space and the increase of private actors are identified, especially with the advent of large satellite constellations. The article also addresses some possible ways to address these challenges and indicates how the registration system may be enhanced to support effective space traffic management.

2. Overview of the current international legal basis and framework for the registration of space objects

In 1967, when the UN adopted the OST, there were only a few nations launching space objects into space. However, the drafters recognized that keeping track of these objects, their basic orbital parameters, launching States, and other important information would be critical for transparency and safety in the future. That future is now. As of May 2024, there were more than 9.900 operational satellites in space, from many different countries and other non-State actors, often including

multinational projects. With many new entrants into space from all over the world and new types of space objects being launched, the questions surrounding the registration of these objects are of the utmost importance. To begin thinking about solutions, it is necessary to understand the current international legal basis and framework for the registration of space objects.

2.1. Hard law

Two UN treaties address registration requirements. The first is the OST, adopted nearly sixty years ago, at a time when some of the technology we have today seemed like science fiction. However, its basic principles still apply to the multitude and evolution of current and future space activities. As of June 2024, 115 States are parties to the OST and 21 are signatories [4]. Given the large number of State Parties and signatories and the amount of time the OST has existed, the treaty is now arguably customary international law and binding on all States in the world.

The importance of the OST in the registration context is found primarily in Art. VIII:

“A State Party to the Treaty on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, and over any personnel thereof, while in outer space or on a celestial body. [...] Such objects or component parts found beyond the limits of the State Party to the Treaty on whose registry they are carried shall be returned to that State Party [...].”

Art. VIII is part of a concept elaborated in Arts. VI through VIII OST, which address State responsibility, State liability and jurisdiction and control, respectively. State responsibility, also for non-governmental activities, is attributed for ‘national activities’, liability rests with the ‘launching State’ and jurisdiction and control over a space object and its personnel are linked to its national registration. While the OST presupposes registration, the REG expands upon that concept. It relies on the criterion of ‘launching State’, defined in Art. VII OST, to determine the State of registry. The term ‘national activity’ lacks a definition and is not directly linked to ‘launching State’ or ‘State of registry’ but it may be advisable for States to register space objects if they are responsible for the corresponding activity. Finally, Art. XI of the OST encourages States to make their space activities public, including apprising the UN, with the objective of increasing international cooperation.

The Preamble of the REG states the need for national registries of space objects and for the UN to create and maintain an international register. Importantly, it obligates launching States to register space objects and includes what data to publish, as well as providing a system to determine the State of registry in cases where more than one launching State exists. This is critical in today’s space environment of multinational space projects where several States are usually involved. Art. II of the Convention provides.

1. When a space object is launched into Earth orbit or beyond, the launching State shall register the space object by means of an entry in an appropriate registry which it shall maintain. Each launching State shall inform the Secretary-General of the United Nations of the establishment of such a registry.
2. Where there are two or more launching States in respect of any such space object, they shall jointly determine which one of them shall register the object in accordance with paragraph 1 of this article, bearing in mind the provisions of Art. VIII of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, and without prejudice to appropriate agreements concluded or to be concluded among the launching States on jurisdiction and control over the space object and over any personnel thereof.
3. The contents of each registry and the conditions under which it is maintained shall be determined by the State of registry concerned.

The specific information that States are required to furnish is indicated in Art. IV and includes.

- Launching State(s);
- Appropriate designator or its registration number;
- Date and territory or location of launch;
- Basic orbital parameters, including:
 - o Nodal period
 - o Inclination
 - o Apogee
 - o Perigee
- General function of the space object.

While supplying the information to the UN is required, the Convention only goes so far as stating that the State is obligated to provide this information “to the greatest extent feasible” and “as soon as practicable.” Once a State provides the information, UNOOSA, on behalf of the Secretary-General, enters it into the UN’s register, which is open and accessible to all.

Problems arise when States provide differing information, or the information is too vague. Additionally, States may submit their information pursuant to different instruments (i.e. Art. XI of the OST, REG, or Resolution 1721B, discussed in the next section). To add to these issues, some States do not provide all the required information, more than one State registers, or no State registers.

2.2. Soft law

In addition to these two legally binding treaties, there are also several “soft law” instruments that address the registration of objects launched into outer space. The first is UN GA resolution 1721B (XVI) on International Co-operation in the Peaceful Uses of Outer Space, adopted on December 21, 1961. This resolution is still used today by States which have not ratified the REG. It calls upon States that launch objects into orbit or beyond to furnish information promptly to the UN Secretary-General, who should enter that information into a public registry.

The second is the Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space, adopted on December 13, 1963 and thus predates the OST. Its Principle 7 is nearly the same as Art. VIII of the OST.

Thirdly, UN resolution 62/101 of December 17, 2007 with Recommendations on enhancing the practice of States and international intergovernmental organizations in registering space objects must also be mentioned. It contains recommendations to States and requests UNOOSA to facilitate registration, *inter alia* by providing a model registration form. States are encouraged to ratify the REG and to provide information and contact details for their national registries. The resolution tries to remedy the issue of non-registration or dual registration by asking States involved in a launch to reach prior agreements on which State will register the object. They are also encouraged to ask launch service providers under their jurisdiction and control to advise the owner and/or operator of the space object to address the appropriate States on the registration of that space object. In case of transfer of ownership, the resolution requests States to provide additional information to the UN.

Lastly, UN resolution 68/74, adopted on December 11, 2013 is relevant. The resolution contains eight Recommendations on national legislation relevant to the peaceful exploration and use of outer space, and one of these concerns registration. It mainly reiterates the instruments mentioned above and emphasizes the importance of registration once again.

These four instruments are relevant for the subject of this paper, because, even though not legally binding, they were adopted by consensus in COPUOS and reflect the political will and commitment of its member States, which include all the major spacefaring nations. Moreover, with sufficient State practice and *opinio iuris*, they may reflect

customary international law, which is binding on all States.

3. Overview of current national and regional registration practices

In this section, the registration practices of a few major space actors, namely the USA, Russia, China and the European Space Agency (ESA), are outlined, along with information on the status of their notifications to the UN about objects launched into outer space, and how many of these are still in orbit. Furthermore, an overview of the practice of the UN in collecting and disseminating registration information is given. The information provided also indicates current and expected developments.

3.1. Registration practice in the USA

The USA has ratified both the OST and REG. Presently, three different entities conduct and/or oversee launches in the USA (and launches by US persons from locations outside the USA): the US Department of Defense (DoD) for national security space launches, the National Aeronautics and Space Administration (NASA) for civil science and exploration missions, and the Department of Transportation (DOT) Office of Commercial Space Transportation (AST) for commercial space launches. After launch, each entity (DoD, NASA, and DOT AST) forwards to the Office of Space Affairs in the US Department of State’s Bureau of Oceans and International Environment and Scientific Affairs (OES/SA) relevant information on space objects from launches in their purview for registration with UNOOSA. The Department of State, in turn, collates and coordinates the received information, and passes a harmonized list via a *note verbale* to UNOOSA (e.g., ST/SG/SER.E/1079).

Another State Department office, the Office of Emerging Security Challenges in the Bureau of Arms Control, Verification & Compliance, supports the OES/SA effort with regard to ensuring full compliance of the US Government with the REG and related US international obligations.

The DoD, via the 18th Space Defense Squadron (18th SDS), creates and maintains a catalogue of all space objects they are aware of, with a current minimum space object physical size of 6–10 cm. The catalogue is curated and available to the public at the [Space-Track.org](https://www.space-track.org) website [5]. The DoD is responsible for maintaining this catalogue of space objects, which goes back to Sputnik. The launch vehicle that carried the Sputnik satellite to orbit is object #1 in the Space-Track catalogue. The 18th SDS is the keeper and provider of the numbering system [CAM1], i.e., the catalogue or Space Surveillance Network (SSN) number. For instance, the Sputnik booster is #1, Sputnik is #2, etc. It should be noted that this catalogue is not the official US registry, which has been maintained by the State Department since its creation in 1977.

There can be delays of days to weeks, or longer, from when an object is launched into space and when it is registered with UNOOSA. The 18th SDS, among other organizations, does not wait for UN registration of space objects before entering them into the Space-Track catalogue.

Given the recent increase in launch cadence, the State Department’s OES/SA is working to update their technology for both the registry they maintain, as well as how they receive and process launch information from the DoD, NASA, and DOT AST.

As of June 2024, the USA had registered 9621 objects with the UN, of which 7363 are still in orbit [3].

3.2. Registration practice in the Russian Federation

Russia has ratified both the OST and REG. According to the Russian Law on Space Activities [6], all space objects which were launched into outer space and orbited the Earth at least once, or launched further into outer space, and which fall under the jurisdiction and control of the Russian Federation, are subject to registration and marking. The relevant procedure, timelines, and the list of required information is set

forth by the Russian space agency Roscosmos [7]. With regard to the timeline, operators must submit the registration information within five days after launch and after verification, and Roscosmos registers the object not later than seven days after receiving the application. The procedure largely reiterates Art. VIII of the OST and applicable provisions of the REG. The national registry is maintained in paper and electronic form. Registration of space objects in Russia is free of charge.

Roscosmos is responsible for the registration of civil, dual-use and military space objects in the national registry and the UN Register of Objects Launched into Outer Space, in coordination with the Ministry of Foreign Affairs and the Ministry of Defense.

Since 2017, the Russian regulations on the registration of space objects have been undergoing revision [8]. The new draft does not require an object to orbit the Earth at least once to qualify for national registration (para. 8). Another novelty is that any space object is subject to registration irrespective of their mass, size, and functional condition (para. 3). In addition, Roscosmos undertakes to inform the UN Secretary-General of space objects launched by Russia in the interests of foreign customers (para. 25).

As of June 2024, the USSR and Russia had registered 3706 objects with the UN, of which 1613 are still in orbit [3].

3.3. Registration practice in China

China has ratified both the OST and REG. As a State Party to the latter, China has registered its space objects domestically and has provided relevant registration information to the UN. In 2001, China formulated the “Measures for the Administration of Registration of Space Objects” (hereafter Registration Measures) and established a national registry [9]. The Registration Measures contain fifteen articles, divided into eight topics.

Art. 1 sets out the purpose of the measures as regulating space activities, establishing the national registration system, protecting the legitimate rights and interests of China and fulfilling its obligations as a State Party of the REG.

As to jurisdiction, Art. 3 stipulates that “These measures shall apply to all space objects launched from the territory of China and space objects launched by China as a joint launching State.” Thus, on the one hand it acknowledges territorial jurisdiction, while on the other, space objects launched overseas must also be registered in China’s national registry if China is a joint launching State. Thus, jurisdiction refers to a combination of territorial links and launching State links.

According to Art. 5, the Commission for Science, Technology, and Industry for National Defense (COSTIND) oversees the administration of national registration. After the regulatory reform in 2007, the State Administration of Science, Technology and Industry for National Defense (SASTIND) took over this function. In addition, “concerning the national registration involving other joint launching States, COSTIND, if necessary, determines the registrant after consultation with the Ministry of Foreign Affairs.” The provision further stipulates that “the space object shall be registered by its owner in the national registry, whilst in case of multiple owners, the space object shall be registered by the main owner on behalf of all owners.” The exception is that “under the circumstance of the owner of a space object being a foreign government, juridical person, other organization or natural person, the space object shall be nationally registered by the corporation which provides the international commercial launching service.”

As stated in Art. 12, international registration of space objects shall be transmitted by the National Defense Science and Industry Commission to the UN Secretariat through the Ministry of Foreign Affairs, within sixty days after the domestic registration of space objects.

In Art. 2, a space object is defined as “artificial Earth satellite, manned spacecraft, space probe, space station, launch vehicles and parts thereof, and other man-made objects launched into outer space.” Small satellites, if they fall within the category of artificial earth satellites, must also be registered.

The Measures also provide requirements for the timing of registration and for the modification of registration: “When the conditions of the space object registered in accordance with these Measures have changed substantially (e.g. change of orbit, break-up, non-operating, return and re-entry into the atmosphere), the registrant of the space object shall make an amendment to the registration within sixty days after the conditions of the space object changed.”

A Notice on Promoting the Orderly Development of Microsatellites and Strengthening Safety Management was issued in May 2021 by the China National Space Administration (CNSA). Its Art. 13 states that: “(w)hen a microsatellite is launched into orbit or its in-orbit state changes, the owner shall submit the registration materials to the Bureau of Science and Technology for National Defense in accordance with the relevant provisions of the Measures for the Administration of Registration of Space Objects, and perform the registration or change procedures of space objects.”

China submitted registration information of space objects to the UN for the first time in 1990, and submitted a total of around thirty registration submissions under Article IV of the REG. The latest of these is document ST/SG/SER.E/1123 of June 2023. The registration information provided by China meets the requirements of the REG, including the launching State, name and code of the satellite, launch date, launch location, basic orbital parameters and functions of the space object. Sometimes the model of the launch vehicle is also provided. Most owners or operators of space objects only indicate “China”, and a few directly indicate specific owners or operators, such as Tsinghua University or the Meteorological Bureau and Oceanic Administration. Sometimes, space objects launched by foreign customers are registered. In these cases, the information submitted clearly indicates that the foreign country is also the launching country. China uses the model form of UNOOSA. In addition, the general sharing of registered space objects and basic data such as launch time, place and orbit parameters are registered, and some unregistered orbit parameters or some orbit parameters are launched. China does not provide information about satellite failure and re-entry to the UN.

As of June 2024, China had registered 733 objects with the UN, of which 643 are still in orbit [3].

3.4. Registration practice of the European Space Agency

ESA declared acceptance of the rights and obligations provided for in the REG in 1978, becoming the first international intergovernmental organisation to respond to the registration requirements.

At the end of 2013, after more than thirty years of space object registration, ESA’s Director General decided to formalise this practice and to issue a space object registration policy applicable to all future ESA missions to guarantee up-to-date and centralised information about all ESA space objects.

ESA’s Space Object Registration Policy entered into force on March 28, 2014: it applies to all ESA missions and establishes the principles for the registration and notification of ESA space objects. The content of the policy and some examples of its applications are summarised below [10]. In particular, the policy states that.

- (a) all ESA space objects shall be registered in an ESA-internal register maintained by the ESA department in charge of legal affairs;
- (b) registration-relevant information is to be provided for that purpose by the respective programme/project/mission manager in accordance with a structured process detailed in a technical annex;
- (c) ESA will continue to notify the UN Secretary-General of ESA space objects in conformity with the Agency’s international obligations;
- (d) such notification shall be furnished to the UN in reasonable time after the launch or status change of an ESA space object, but not later than one month after the launch or status change.

The last point contains significant novelties with respect to the agency's previous registration and notification practice. First, it explicitly lays down that the policy does not only apply to the launch of space objects but also to status changes of space objects that already are in Earth orbit or beyond. Second, it introduces a timeframe for the notification to the UN Secretary-General (i.e. one month), which represents a rare example of a binding commitment to effectuate space object notifications in a timely manner.

Similarly, the technical annex of the ESA Registration Policy sets out the implementation requirements. It obliges the responsible managers to provide.

- (a) six months before a scheduled launch: the notification of the upcoming launch including planned dates and orbital parameters;
- (b) immediately upon launch and orbit injection: the name and international designator (also known as the COSPAR ID) of the space object; all launch details, the main orbital parameters to be notified to the UN, as well as additional information as deemed appropriate or necessary;
- (c) at any later point, without delay: information on the change in the status of an ESA space object;
- (d) six months before a foreseen space object re-entry, whether controlled or uncontrolled: the notification of the re-entry including information such as the calculated re-entry time window or information about the expected object fragmentation;
- (e) immediately after re-entry: the confirmation of the re-entry.

To allow for an accurate implementation of the REG, the ESA Registration Policy establishes several working definitions. The term 'ESA space object' includes the following.

- (a) ESA assets embarked on an ESA or non-ESA launch, entering an orbit around Earth;
- (b) launcher stages for launches under an ESA development programme, entering an orbit around Earth;
- (c) adaptors, fairings and other elements associated with (a) or (b).

ESA space objects being launched beyond Earth orbit are also registered and notified accordingly.

The term 'status change' of an ESA space object comprises.

- (a) significant, permanent changes of orbital parameters of a space object and
- (b) permanent changes of the space object's status and functionality.

Finally, all registration information is stored in ESA's Database and Information System Characterising Objects in Space (DISCOS) [11] to allow for reporting capability for the automated, scheduled or on-demand generation of a print-ready report on the complete registration status of all ESA space objects, with a similar engine as the one used for the preparation of ESA's Space Environment Report [12].

As of June 2024, ESA had registered 77 objects with the UN, of which 65 are still in orbit [3].

3.5. UN practice in collecting and disseminating registration information

With the entry into force of the REG on September 15, 1976, the UN Secretary-General established a register to record information furnished under the convention. The Secretary-General delegated responsibility for the maintenance of the register to UNOOSA. The register also contains information furnished under UN GA resolution 1721B (XVI) of December 1961, pursuant to which the original register was established in 1962. The original hardcopy version of the Register of Objects Launched into Outer Space comprises the A/AC.105/INF & ST/SG/SER.E/UN document series. These documents are publicly available on the

UNOOSA website.

UNOOSA also maintains an Online Index of Objects Launched into Outer Space, a searchable database as an open source of information for space objects worldwide [3]. The Online Index is not an online version of the Register of Objects Launched into Outer Space. Rather, it is a reference tool intended to assist States in searching for registration documents associated with a space object as well as identifying which functional space objects remain unregistered. As such, while the Online Index contains "unofficial" information, the register itself contains the "official" information that was submitted by States of registry and disseminated under the A/AC.105/INF and ST/SG/SER.E/document series. UNOOSA only adds administrative information to the Register.

The Online Index is searchable by State, international designator and object name. It contains information on satellites launched from 1957 to the present. Space debris and other non-functional space objects are presently not included. The Index also contains information on objects not yet registered with the UN. Unregistered objects are identified through primary and secondary open sources. Examples of primary sources are [Space-Track.org](https://www.space-track.org), ESA's DISCOS, notifications on foreign objects provided by governments, and online national space registries of States. In addition, secondary resources such as media reports, blog posts and operator websites are used. The Office uses a colour code for objects to allow distinguishing between objects that have been registered by States and those that have not been.

As of June 2024, the online index contained around 16,500 objects registered with the UN by more than 100 States and organizations. In addition, there were around 2000 objects in the database that were not registered with the UN, bringing the total to around 18,500 objects listed in the Online Index. This means that approximately 90 % of all satellites, probes, landers, crewed spacecraft, and space station flight elements launched into Earth orbit or beyond have been registered. States are also required to inform the Secretary-General as soon as practicable concerning previously registered objects that are no longer in orbit.

In terms of the REG, States Parties are required to establish their national registries and provide information on their space objects to the Secretary-General for inclusion in the UN Register. States are also required to inform the Secretary-General of the establishment of such a registry. To date, over forty States and three international intergovernmental organizations have notified the UN about their national registry [13].

4. Enhancing registration practices and processes to support space traffic management

The current registration system was designed decades ago, and it can be difficult for States to register objects in a timely fashion, especially if they have multiple objects per launch (e.g., a CubeSat Transporter mission that releases ~100 CubeSats in addition to other objects). Asking for additional information to enhance what is provided when registering only compounds the timeliness problem. Part of 'enhanced registration' should be an 'enhancement of the registration process', to make it easier for States to gather, collate, and forward the necessary registration information to UNOOSA. The problem with operators of especially small satellites and CubeSats is that they need weeks or even months to provide the actual orbital parameters because it is unclear which of the objects in the "swarm" is theirs.

Although, as noted above, UNOOSA is proactive in gathering information in advance of getting formal notifications from States regarding launches, the Office is also planning to enhance the registration process and will switch from collecting "notes verbales" and typing them into its database to a new online platform. This online database version of the Register started development in 2024.

This section addresses several other initiatives that are relevant in the context of enhancing registration practices and processes in light of space traffic management, such as "the Registration project" of UNOOSA, the UNCOPIOS Guidelines on the Long-Term Sustainability

of Space Activities, and the recommendations on registration of large constellations of satellites of the UNCOPUOS Working Group on the Status and Application of the Five United Nations Treaties on Outer Space.

4.1. The UNOOSA registration project

In 2022, UNOOSA launched a stakeholder study titled “The Registration Project: Supporting Implementation of Treaty Obligations related to the Registration of Objects Launched into Outer Space” to collect and discuss current practices and raise awareness about registration [14]. A total of forty-six Member States and one international intergovernmental organisation responded to questionnaires and/or participated in interviews. UNOOSA interviewed over seventy-five registration focal points, representatives and experts from all geographic regions. They were asked to share their approaches to implementing their international commitments related to the registration of objects launched into outer space. An Expert Event was held in May 2023. The final report of December 2023, concluding the first part of the project, highlighted that the increasingly complex nature of present and future space activities led States to take varying approaches to determine a ‘State of registry’, identifying the various coordination channels within and among actors, such as the UN, States, launch service providers, industry and academia, as well as the interlinkages between licensing, authorization, and the registration process. Among emerging trends that require consideration, the report addressed spaceports, large constellations and lunar operations.

4.2. The UNCOPUOS guidelines on the long-term sustainability of space activities

The Guidelines for the Long-term Sustainability of Outer Space Activities (LTS Guidelines) have been negotiated within UNCOPUOS in a Working Group of its Scientific and Technical Subcommittee (STSC) from 2010 on and were adopted in 2019 [15]. They recall the existing framework of international space law consisting of the UN Treaties on Outer Space, with the OST as its fundament, and the principles subsequently developed by UNCOPUOS and adopted in UNGA resolutions. Compliance with LTS Guidelines is voluntary as they are non-binding, but States are requested to implement them at the national level and report back to the Committee about this process.

The LTS Guidelines are structured in four parts, one of which addresses policy and regulatory issues. Guideline A.5 explicitly calls upon States and international intergovernmental organizations to “enhance the practice of registering space objects”. It reiterates existing obligations and recommendations regarding the registration of space objects and calls upon States to implement them uniformly.

The guideline addresses.

- a) ensuring the development and/or implementation of effective and comprehensive registration practices,
- b) adoption of appropriate national or other relevant policies and regulations to harmonize and sustain over the long term such registration practices on the widest possible international basis,
- c) the need to provide timely detailed information,
- d) pre-launch agreements,
- e) the role of UNOOSA and support of its activities and
- f) information about space objects that will be separated later during a mission.

The LTS Guidelines consider proper registration “a key factor in the safety and long-term sustainability of space activities.” While registration is important to allocate jurisdiction and control according to Art. VIII OST and the identification of space objects for purposes of salvage as well as liability is recalled in the preamble of the REG, the data submitted does not suffice to calculate possible close conjunctions and

collision risks, as relevant for STM.

4.3. The UNCOPUOS Working Group on the Status and Application of the five United Nations Treaties on Outer Space

In 2023, the UNCOPUOS Working Group on the Status and Application of the Five United Nations Treaties on Outer Space issued a report with recommendations on several topics, including registration [16]. The Working Group outlined various steps taken by States of registry to accommodate the increased number of registrations, such as increasing the frequency of submissions, using a spreadsheet format, and consulting the secretariat about how best to provide the information and refining those practices. In the case of large constellations, it recognized that consideration could be given to furnishing additional information through the model registration form made available by UNOOSA, including information on and contact details of the owner and operator, web links to national space object registries, and contact details of designated registration focal points. The Working Group also suggested to make registration information concerning satellite constellations available by means of public websites linked to national space object registries during the time between the submission of information to the UN and its distribution by UNOOSA.

Appendix I to the report outlines questions provided by the Chair of the Working Group on several topics, including registration. They covered (1) whether there is a legal basis in the existing international legal framework which would allow in orbit transfer of registration of a space object between States; (2) how a transfer of activities or ownership of a space object during in-orbit operations from a company of the State of registry to a company of a foreign State could be handled in compliance with the existing international legal framework; (3) what jurisdiction and control are exercised over a space object registered by an international organization in accordance with REG; (4) whether the concept of large constellations raises legal and/or practical questions, and whether there a need for an adapted form of registration; and (5) whether there a possibility, in compliance with the existing international legal framework, based on the existing registration practices, of introducing a registration “on behalf” of a State of a launch service customer, based on its prior consent, and whether this would be an alternative tool to react to large constellations and other challenges in registration. Appendix II of the report contains a questionnaire on small-satellite activities, asking States whether they have a practice of registering small satellites, and if so, whether they have a practice of updating their status and whether there is any legislation or regulation that requires non-governmental entities to submit information for the purpose of registration, including updating of the status of small satellites they operate.

4.4. The case of large constellations of satellites

As seen above, several new developments pose challenges to the current registration system and require the enhancement of registration practices and possibly the adoption of additional international instruments. Especially large constellations of satellites pose such challenges, due to the sheer number of objects being launched.

Large constellations do not affect the general design and characteristics of the current registration system, but they do affect the capacity of States and UNOOSA to process the data in a timely manner. Multiple objects with very similar orbital data are launched simultaneously and, in the future, outdated, defective or decaying elements of constellations will be replaced with new satellites on an ongoing basis.

Although from an engineering and operations perspective, a constellation could be considered as an interdependent system of systems rather than as a collection of separate space objects, registering them as such would not be in line with the single object-based approach of the REG. Giving up this approach is not advisable in view of the identification of objects for liability and salvage reasons.

5. Conclusions and recommendations

The system of registration of space objects has functioned well so far, but new technological advances and other developments require new measures to further enhance the registration system in support of the development of a space traffic management regime.

First, the recommendations concerning the registration of space objects belonging to a large constellation that were agreed by the UNCOPUOS Working Group on the Status and Application of the Five United Nations Treaties on Outer Space in 2023 must be implemented to ensure uniformity of registration practice regarding large constellations.

Second, States must incentivize good registration practices by other States and one lever that could be used in this context is market access, i. e., for a commercial actor to have market access, the relevant State would require registration by the relevant launching State.

Third, the importance of furnishing additional information on the subsequent activity and status of objects, as required by several instruments, must be underlined. UN GA resolution 1721 (XVI) B and Art. IV para 3 of the REG require States Parties to inform the UN Secretary-General as soon as practicable when their registered objects are no longer in orbit. UN GA Resolution 62/101 elaborates on this requirement, and LTS Guideline A.5 para 2 further specifies it by asking States and intergovernmental organizations to “consider providing information on any change of status in operations (*inter alia*, when a space object is no longer functional) and, following the change in supervision of a space object in orbit, information about changes in the orbital position”. It reminds them of the importance of achieving and sustaining a practicable degree of coherence and uniformity in applying the provisions of this paragraph.

Through these recommendations, registration information, processes and practices can be improved in support of space traffic management.

CRedit authorship contribution statement

Tanja Masson-Zwaan: Writing – original draft, Writing – review & editing. **Peter Martinez:** Writing – original draft, Writing – review & editing. **Francesca Letizia:** Writing – original draft. **Catrina Melograna:** Writing – original draft. **Martin Reynders:** Writing – original draft, Writing – review & editing. **Robert Rovetto:** Writing – original draft. **Mark A. Skinner:** Writing – original draft. **Marius Stanciu-Manolescu:** Conceptualization. **Maruska Strah:** Conceptualization. **Olga Volynskaya:** Writing – original draft. **Guoyu Wang:** Conceptualization, Writing – original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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