

STUDY ON SPACE TRAFFIC MANAGEMENT BY THE INTERNATIONAL ACADEMY OF ASTRONAUTICS

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SCOPE AND TARGET USERS OF THE STUDY¹

There is already a great deal of space traffic. It seems, however, minuscule with regard to the extent of near-Earth outer space. Around 9,000 man-made objects larger than about 10cm are currently catalogued, out of which only 650 are operational spacecraft. At first glance, the management of space traffic does not appear to be a pressing problem. On closer examination, this judgement has to be challenged. This view is supported by a high and ever growing number of launches from more and more launch sites and spaceports, the participation of non-governmental entities, the positioning of satellite constellations, an increase in space debris and the advent of reusable launch vehicles.

Considering this scenario, conceptualizing space traffic management will turn out to become a relevant task during the next two decades. Space traffic management, however, will limit the freedom of use of outer space. Therefore an international consensus on internationally binding regulations will only be achieved if states recognize the urgency and expect a specific as well as collective benefit—including an economic benefit—from this.

Due to its long-term approach, the study does not provide a specific plan of action to any single target user. In sketching out first steps, however, it addresses or directs decision makers in the UN Committee on the Peaceful Uses of Outer Space (COPUOS), International Telecommunication Union (ITU) and International Civil Aviation Organization—organizations which are building blocks for a future space traffic management regime—to approach specific problems. In addition to that, further questions to be studied have been identified, which might be tasks for the respective committees of the International Academy of Astronautics and the International Institute of Space Law.

DEFINITION OF SPACE TRAFFIC MANAGEMENT

The scale of this task can be assessed when the following working definition of space traffic management is taken as a starting point: 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.

Since an authoritative definition of space traffic management does not yet exist, this definition has been created for the purpose of this study. Through this definition, the purpose of space traffic management becomes clear: it is to provide appropriate means for conducting space activities without harmful interference. It supports the universal freedom to use outer space as laid down in the Outer Space Treaty of 1967. It should also be clear that for the purpose of achieving a common good, actors have to follow specific rules, which are also in their self-interest.

DIMENSIONS AND PHASES OF SPACE TRAFFIC

Two dimensions of space traffic are analysed in this study: the scientific and technical, and the regulatory. Then, those two dimensions of space traffic are applied to analyzing the three phases of space traffic: launch, in-orbit operations and re-entry. Below are the findings.

FINDINGS

Space traffic: current status and prospects for 2020

- The motion of space objects is influenced by different forces, which cannot be accounted for precisely. Errors in predictions of space object motion are primarily caused by variations of atmospheric density, and the error in predicted position in orbit increases with the square of elapsed time. For this reason, positions of all objects should be monitored systematically and with high accuracy.
- The large majority of active satellites have no manoeuvring capability and most others have only a limited capacity to change their trajectory.
- There has been a slow but steady decline of launch activities since 1980, but there is a rise in the number of launch vehicles available

(currently 18). There is also a growing number of launch centres (currently 11).

- The prospects for the introduction of fully or partly reusable launch vehicles are still open. In any case, by 2020 they will probably still be limited to supporting missions below 1,000km.
- Manned spaceflight has accounted for 13% of launches during the past 20 years. It might increase with the emergence of new actors in this field, but is likely to increase dramatically only after 2020.
- Following the successful flight of SpaceShipOne, there might be—if safety is guaranteed—a growing number of suborbital manned flights, including with tourists as passengers.
- Technologies such as tethers, stratospheric platforms or space elevators, which might be introduced in the future, will have to be taken into account in particular when rules for the launch and re-entry phases are developed. New concepts for satellites (for example “autonomous nanotechnology swarms”) will raise requirements for in-orbit operations.
- Space debris is continuously growing in quantity (currently there are about 100,000 objects larger than 1cm, most of them not catalogued).
- The number of catalogued objects is steadily rising (currently there are about 9,000 catalogued objects larger than approximately 10cm).
- The number of active satellites remains at 6–7% of total catalogued objects.
- The United States’ space surveillance capabilities dominate, followed by Russia and Europe. The United States provides data and processed information on a voluntary basis.
- The capacity and accuracy of current space monitoring systems is not sufficient to cover small objects or to provide for orbital avoidance service for all space assets.
- There are two major catalogues of space objects, which is far from the comprehensive system of space traffic monitoring that is required.
- Information on space weather is still limited but is important for the operation of space objects as well as for the prediction of the debris environment.
- The constant monitoring and information on space weather would be a useful tool in implementing a space traffic management system.

The current legal and regulatory framework

- The general principles of space law provide a basis and rationale to establish a space traffic management regime.
- Some unique rules exist in international space law as well as in international telecommunications law, which can be considered as basic elements of a space traffic management system (especially for use of geosynchronous Earth orbit, following ITU rules and regulations). These rules however are neither complete nor harmonized. ITU rules, aiming at the avoidance of radio-frequency interference, are far more advanced than rules aiming at the avoidance of physical interference.
- In this context, the Inter-Agency Space Debris Coordination Committee guidelines of 2002 (not a legally binding agreement) encompass elements of space traffic management (for example use of disposal orbits and notification in case of controlled re-entry) but so far they do not include provisions on the environment, such as the avoidance of pollution of the atmosphere/troposphere.
- Space law, however, lacks many provisions which would be essential for a comprehensive traffic management regime (pre-launch notification, for example). Of particular importance is a legal recognition of the difference between space objects considered as valuable assets by their owners, and space debris that has no value.
- A space traffic management regime has to consider the question of harmonizing national space legislation (much of which has yet to be established), and national licensing standards and procedures, since they may provide the building blocks for assuring technical safety.
- In regard to arms control/disarmament negotiations, notification practices (prior to launch) have been developed through the Hague Code of Conduct against Ballistic Missile Proliferation, thus superseding the status of civilian space law and negotiations in COPUOS.
- The implementation of a comprehensive space traffic management regime would require additional regulation (with regard to the execution of space missions), which could be perceived as limiting the freedom of use of outer space guaranteed by the Outer Space Treaty.

- There are interfering factors, in particular national military and security policies and practices, which might hinder the establishment and operational effectiveness of a space traffic management regime.

Comparable traffic regimes

In international common spaces, such as the high seas—and outer space—no territorial jurisdiction applies. Only personal jurisdiction does. When rules such as traffic management are concerned, this system is far from being efficient. It is the reason why on the high seas, the exclusivity of the flag state is likely to be overruled by an extension of the territorial jurisdiction of one or several states. This solution is not acceptable for space activities as there is no territorial jurisdiction involved. The solution of the port state is not workable, since at present a satellite does not fly back to Earth. The extension of “coastal” jurisdiction is also an impossible solution for obvious technical reasons. These difficulties should be taken into consideration if and when a space traffic management regime enters into force. Nevertheless, there are many interesting elements from the Law of the Sea which could be studied further, in particular as the development of international law for oceans and outer space do have the common basic elements of extra-territorial applications.

The launch phase

- Safety certifications should be introduced.
- A clarification of the term “space object” is needed.
- The question of delimitation of air space and outer space should be revisited.
- The concept of “launching state” has to be clarified.
- A pre-launch notification system is necessary, although the Hague Code of Conduct includes non-legally binding provisions for such notifications of space launch vehicle launches.
- Obligatory information in cases of damage is relevant.
- An international level playing field for transport services should be aimed for, with a balance between public and private/economic interest.

The in-orbit operation phase

- Manoeuvring and in-orbit collision avoidance (with regard to other operational space objects as well as with regard to space debris) is growing in importance.
- Manoeuvring in the geosynchronous orbit is utilized but with little consideration of possible collisions.
- Reliable collision probabilities can be estimated only when reliable information exists, which currently is not guaranteed.
- There is already one-way traffic in geosynchronous orbit, as all satellites there are orbiting eastward in the equatorial plane.
- No systematic zoning (restriction of certain activities in certain regions) of outer space is applied.
- The ITU system of nominal orbital positions is applicable only to satellites in geosynchronous orbit.
- Private/commercial actors have started coordinating (through the Satellite Users Interference Reduction Group and the International Telecommunication Union) to prevent radio-frequency interference.
- Matching spacecraft with radio transmitters on-board could make the problem of “paper satellites” transparent and better understood.

The re-entry phase

- Intentional (reusable launch vehicles, as well as active debris mitigation) and unintentional de-orbiting (natural debris mitigation through decay) is now more frequent but care should be taken that large debris structures will be de-orbited in fragments.
- Responsibility and liability for damages caused by space objects or their components ensue not only from international space law but also from the general provisions in national legislation.
- The generally shared aspiration to reduce space debris raises the question of whether regulation should also set a standard clarifying under which conditions a re-entry activity is considered legitimate, and under which conditions it is not.
- Notification of, and coordination with, local and downrange air traffic, maritime authorities and local government officials are already considered a best practice in coordinating launch activities.

- Space Law and Air Law have to resolve the open issue of passage of space objects through airspace (the Chicago Convention does not apply to space objects in airspace).
- The question arises of whether to introduce certain internationally recognized descent corridors and possibly even impact areas which are not frequently used by other traffic and which could be dedicated to space traffic.

CONCLUSIONS

Framework

In the following section, a model is provided for what a comprehensive space traffic management regime for 2020 could look like. An international intergovernmental agreement could be drafted, building on but not replacing the principles incorporated in the existing space treaties. It could include provisions for liability and the basic principle that, while states are the primary actors, provisions of the agreement are applicable to private activities as well through national licensing regimes (certain issues will need to be clarified in the agreement).

This international intergovernmental agreement would comprise a legal text, which could be changed easily, and technical annexes, which could be adapted more easily. The international intergovernmental agreement envisioned would contain three parts:

Securing information needs

- Defines necessary data (on trajectories as well as radio frequencies).
- Sets provision for the data (sources, governmental as well as private, including financing).
- Establishes a database and distribution mechanisms for the data (format of the database, access to data on request, collision warning as a service).
- Establishes an information service on space weather.

Notification system

- Sets pre-launch notification with better parameters than the Registration Convention, as well as other provisions (e.g. ITU and proposed International Institute for Unification of Private Law (UNIDROIT) Protocol)
- Provides information on the end of active/operational life of space objects.
- Provides pre-notification of orbital manoeuvres and active de-orbiting (communication rules and cooperation provisions).

Traffic management

- Clarifies “fault” or liability in case of damage caused in outer space.
- Sets delimitation for the launch phase and clarifies the concept of “launching state”.
- Provides traffic management rules based on the use of the database for the purpose of collision avoidance, including safety provisions for launches; zoning (selection of orbits), priority of manoeuvres; specific provisions for geosynchronous orbits (harmonized with ITU rules); specific rules for low Earth orbit satellite constellations; debris mitigation mechanisms; safety provisions for re-entries; and environmental provisions (pollution of the atmosphere/troposphere and so forth).
- Clarifies “space objects”, including a legal distinction between valuable objects and valueless space debris.
- Provides a framework and main features for national licensing regimes, which implement the provisions of the agreement.
- Sets forth an enforcement mechanism (for example, the renouncement of access to information) and dispute settlement.
- Clarifies institutionalized links with the International Civil Aviation Organization, ITU and other relevant organizations.

Organization

- The provisions of the three agreements initially would be monitored by COPUOS and handled by the United Nations Office for Outer Space Affairs.

Subsequently, post-2020 the new agreement, together with the existing space treaties, could be superseded or replaced by a comprehensive Outer Space Convention. The operative oversight, that being the task of space traffic management, could be taken up by an already existing forum or organization (such as COPUOS or the International Civil Aviation Organization), which would evolve into a body designed for that purpose. Looking 20 years ahead, the job could also be handled by a non-governmental entity tasked by the states parties to an Outer Space Convention. In the end, space activities by private actors will come to have the same legal status as air traffic.

Notes

- ¹ The study has been prepared by a group of 16 international experts and coordinated by Kai-Uwe Schrogl (regulatory part) and Petr Lála (scientific and technical part). The Rapporteur of the group is Corinne Contant. For more information, see *Cosmic Study on Space Traffic Management*, International Academy of Astronautics, 2006.