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SPACE TRAFFIC MANAGEMENT IAA COSMIC STUDY

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I. Scope of the Study

Space traffic already takes place. It seems, however, minuscule with regard to the dimension of near-Earth outer space. Around 13.000 man-made objects larger than about 10 cm are currently tracked out of which only 650 are operational spacecraft. On the surface, the management of space traffic does not appear to be a pressing problem. Investigated further, this judgement has to be challenged. A high level or even growing number of launches from more and more launch sites and space ports, the entering of non-governmental entities, the positioning of satellite constellations, an increase in space debris and the advent of reusable launch vehicles supports this judgement. Considering this scenario, conceptualizing space traffic management will turn out to become a relevant task during the next two decades. Space traffic management will, however, limit the freedom of use of outer space. Therefore an international consensus on internationally binding regulations will only be achieved, if States identify a certain urgency and expect a specific as well as collective benefit from this.

II. Definition of Space Traffic Management

The dimension of this task can be assessed, when the following 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 set up for the purpose of this study. Through this definition, the purpose of space traffic management becomes clear: it is to provide appropriate means so that space activities can be conducted without harmful interference. By that 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 this purpose of achieving a common good, actors have to follow specific rules, which is also in their self-interest.

III. Dimensions and Phases of Space Traffic

Space traffic touches two dimensions: the scientific and technical area, and the regulatory field that are analyzed in this study. Then, those two dimensions of space traffic are applied to analyzing the three phases of space traffic: the launch phase, the in-orbit operation phase, and the re-entry phase. Below are the findings.

IV. Findings

Space Traffic: Current Status and Prospects for 2010 and 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 precisely.
- The large majority of active satellites have no maneuver capability and most others have only a limited capacity to change their trajectory.
- There is a slow but steady decline of launch activities since 1980.
- There is a rise in the number of launch vehicles (today 18). There is also a rise in the number of launch centers (today 11).
- The prospects for the introduction of full/partly RLV are still open. In any case, by 2020 they would probably still be limited to supporting missions below 1000 km.
- Human spaceflight has been accounting for 13% of launches during the past 20 years. It might rise with the emergence of new actors in this field but dramatically only beyond 2020.
- Technologies like tethers, stratospheric platforms or space elevators, which might be introduced in the future, will have to be taken into account when rules in particular for the launch and re-entry phase are developed.
- The population of space debris is continuously growing in number (today around 100,000 objects larger than 1 cm, most of them not catalogued).

- The number of catalogued objects is steadily rising (today 13,000 objects larger than approximately 10 cm).
- The number of active satellites remains at 6-7% of total catalogued objects.
- Capabilities for space surveillance rest with the US (and to a smaller extent to Russia and some singular capabilities in Europe); the US 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 and provide for orbital avoidance service for all space assets.
- There are two major catalogues of space population, which is a far cry from the needed unified system of monitoring space traffic.
- Information on space weather is still limited but important for the operation of space objects as well as the prediction of the debris environment.
- The constant monitoring and information of space weather would be a useful tool for implementing a space traffic management system.

The Current Legal and Regulatory Framework

- The general principles of space law provide for a basis and rationale to establish a space traffic management regime.
- There exist some singular rules in international space law as well as in international telecommunication law, which constitute elements for a space traffic management system (especially for the GEO through the ITU). They are, however neither complete nor are they 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 IADC space debris mitigation guidelines of 2002 (non-binding soft law) encompass elements of space traffic management (use of disposal orbits, notification in case of controlled re-entry; but so far no provisions on the environment, i.e. avoidance of polluting the atmosphere/troposphere).
- Space law is, however, lacking numerous provisions, which are essential for a comprehensive traffic management regime (i.e. pre-launch notification). Of particular importance is a legal recognition of a difference between space objects considered as valuable assets by their owners, and space debris which have no value at all.
- A space traffic management regime has to touch also the question of harmonizing national space legislation (mostly to be established) and its consequential licensing standards and procedures, since they provide the building blocks for assuring technical safety.
- In the context of arms control/disarmament negotiations notification practices (prior to launch) are currently discussed, thus surpassing the status of civilian space law and negotiations in UNCOPUOS.
- The implementation of a comprehensive space traffic management regime would require additional regulation (with regard to information and the execution of

space missions), which would further limit the freedom of use of outer space; in order to achieve a consensus on this, States have to perceive a certain urgency and have to expect a specific as well as collective benefit (as they receive from existing regulation).
- There are interfering factors, in particular military doctrines, which might hinder the establishment and working of a space traffic management regime.

Comparable Traffic Regimes

In international spaces such as high sea—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 in the high sea, the exclusivity of the flag State is due to be overruled by an extension of the territorial jurisdiction of one or some States. This solution is not acceptable for space activities as there is no territorial jurisdiction involved. The solution of the port State is not usable as, for the time being a satellite does not fly back to Earth, the solution of extension of "coastal" jurisdiction is also impossible for obvious technical reasons. These difficulties should be taken into consideration if and when Space Traffic Management will be set in force.

The Launch Phase

- There is a rise in the number of launch vehicles (today 18).
- There is also a rise in the number of launch centers (today 11).
- The prospects for the inauguration of full/partly RLV are still open. In any case, by 2020 they would still be limited to supporting missions below 1000 km.
- Human space flight might only change dramatically beyond 2020.
- 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 the "launching State" has to be clarified.
- A pre-launch notification is necessary.
- Obligatory information in cases of damage is relevant.
- An international level playing field for transport services should be aimed for with a balance of public and private/economic interest.

The In-Orbit Operation Phase

- Maneuvering and in-orbit collision avoidance (with regard to other operational space objects as well as with regard to space debris) is growing in number and importance.
- Maneuvering in the GEO is intensely applied 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 no prioritization with regard to maneuvers.
- There is no prioritization of certain space activities, no “right-of-way-rules”, nor is any kind of utilization

of space ruled out (except it is against the peaceful uses).
- There is no traffic separation ("one-way-traffic").
- There are no "zoning" rules (restriction of certain activities in certain areas).
- There are no communication rules (advance notification and communication if orbits of other operators are passed).
- The ITU system of nominal orbital positions finds application only to satellites in the GEO.
- Private/commercial actors have started (i.e. through SUIRG and ITU) coordinating against radio-frequency interference.

The Re-Entry Phase

- Intentional (RLVs as well as active debris mitigation) and un-intentional 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.
- Responsibilities and liabilities for damages caused by space objects or its components ensue not only from international space law but also from the general provisions of national (tort) civil and administrative law.
- The generally shared wish to reduce space debris raises the question, whether regulation should also set a standard under which conditions a re-entry activity is in general 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 solve the open issue of passage of space objects through airspace (the Chicago Convention does not apply to space objects in air space).
- The question is posed to introduce certain internationally recognized descent corridors and possibly even impact areas which are not frequently used by other traffic and which might be dedicated to space traffic.

IV. Conclusions

Framework

In the following, a model is provided on how a comprehensive space traffic management regime for 2020 could look like. There could be drafting of an international inter-governmental agreement building on and not replacing the existing treaties. It would include provisions for liability and the basic principle that States are the primary actors but that provisions of the agreement are applicable for private activities as well through national licensing regimes (certain issues will be clarified in the agreement).
This international inter-governmental agreement would:
- Comprise a legal text, which cannot be changed easily and technical annexes, which can be adapted more easily (modeled from ICAO or IMO)
- Contain three parts:

1. Securing the 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 data (format of the database, access to data on request, collision warning as a service)
- Establishes an information service on space weather

2. Notification System

- Sets pre-launch notification with better parameters than Registration Convention as well as other provisions (e.g. ITU and proposed UNIDROIT Protocol)
- Provides information on the end of active/operational lifetime of space objects
- Provides pre-notification of orbital maneuvers and active de-orbiting (communication rules and cooperation provisions)

3. Traffic Management

- Clarifies "space objects", including legal distinction between valuable objects and valueless space debris
- Clarifies "fault" in case of damage caused in outer space
- Sets delimitation for the launch phase and clarifying the concept of the "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)
  - Right of way rules for in-orbit phase
  - Prioritization with regard to maneuver
  - Specific provisions for GEO (in harmonization with ITU rules)
  - Specific rules for LEO satellite constellations
  - Debris mitigation mechanisms
  - Safety provisions for re-entries
  - Environment provisions (pollution of the atmosphere/troposphere, etc.)
- Clarifies "space objects", including legal distinction between valuable objects and valueless space debris
- Gives a framework and main features for national licensing regimes, which implement the provisions of the agreement
- Sets out an enforcement mechanism (e.g. renouncement of access to information) and dispute settlement
- Clarifies institutionalized interlinks with ICAO and ITU

4. Organization

- The provisions of the three agreements are in a first step monitored by UNCOPUOS and handled by UNOOSA
- In a second step, post 2020:
  - The new agreement may be (together with the existing space treaties) replaced by a comprehensive Outer Space Convention;
  - ICAO's mandate may be enlarged to cover both the aviation and space traffic management legal frameworks;
  - UNCOPUOS as well as UNOOSA functions could be integrated into new ICAO;
  - Space activities by private actors will develop into the same legal status as in air traffic.

<u>Possible first steps in improving the situation in space traffic</u>

- Space debris guidelines

Currently developed Inter-Agency Space Debris Coordinating Committee (IADC) guidelines for mitigating space debris are an important, positive step toward space traffic management. They should be endorsed by the UNCOPUOS as a UN legal document with a view to make their acceptance and implementation universal.

- Collision avoidance

Cataloguing activities (U.S. Strategic Command, European Space Agency, Russian Space Agency, and private companies) should be improved and coordinated. Improvements could include development and deploying new sensors, improving analytical techniques, and incorporating data from sensors not primarily intended for tracking orbiting space objects. Improvements to the GSO catalogue would be considered a priority and should be treated as such by the IADC Subgroup on Measurement.

- Enforcement and checking mechanisms

Neither the UN nor the ITU has any enforcement or checking mechanisms. These are within the power of sovereign states. The ITU list of radio space stations as well as the UN Register of objects launched into outer space reflect governmental announcements only. This situation should be changed, resulting in obligatory registration and provision of unified sets of relevant data.

- Distinction between valuable spacecraft and worthless space debris

The UNCOPUOS or its Subcommittees should start discussing whether or not space debris are space objects in the sense used in space law treaties. If it is decided that space debris are space objects, an additional protocol should be elaborated stating what provisions of the treaties apply to valuable spacecraft and which provisions apply to space debris. If it is decided that space debris are not space objects, the protocol should determine under what conditions space debris can be removed or re-orbited in order to prevent collisions or close encounters with valuable spacecraft.