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Committee on the Peaceful Uses of Outer Space

Long-term sustainability of activities in outer space

Working paper submitted by the Russian Federation*

I. Safety in space, in the context of the theme of the long-term sustainability of outer space activities

1. In 2011, the Committee on the Peaceful Uses of Outer Space decided how the work of the Working Group on the Long-term Sustainability of Outer Space Activities of the Scientific and Technical Subcommittee should proceed. An important result was attained as part of that decision-making process: it proved possible to focus on many aspects of the issue of the long-term sustainability of outer space activities and delimit issues chosen for detailed consideration according to their functional attributes. Even though the positions of the various States could not always be reconciled, the adoption by the members of the Committee of a decision to consider a number of different aspects was enough in itself to strengthen the perception of outer space as a strategic resource belonging to all of humanity and made it possible to identify and consolidate new common interests with a view to increasing opportunities for cooperation, both in ensuring safety in space and in applying it to other areas.

2. Nonetheless, for a number of reasons, particularly the nature of the theme, it is not possible to foresee all the specific results of the analytical survey approach, which means that the Committee must act pragmatically and with the appropriate degree of caution.

3. Space safety and the safety of space activities are important concepts within space diplomacy. However, the context for considering such concepts varies from one platform for international negotiations to another, whether it is the Committee on the Peaceful Uses of Outer Space, the group of governmental experts on outer

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space transparency and confidence-building measures (expected to start work in July 2012), the groups involved in the consultations on drafting a code of conduct on space activities or the Conference on Disarmament. In the context of the Committee, the issue of the safety of space activities is linked primarily with the issues of the pollution of near-Earth space and the tracking of non-operational objects and fragments of space debris.

4. At the same time, the question of raising verifiability and information levels while simultaneously considering and resolving the problems of ensuring the safety and predictability of space activities should be seen in the wider political context: the safety of space activities is, after all, inextricably linked with their predictability and with States' intentions with regard to the use of space. Those issues are closely connected.

5. Successfully ensuring safety in space and in space activities requires the exchange of reliable, accurate and sufficiently complete information in an agreed format; the development of verification codes; and mutual understanding concerning policies, legitimate methods and technical procedures to facilitate the fair and effective implementation of measures to do away with non-operational space objects and fragments of space debris. In the long term, it is important to establish strong and clear prospects for cooperation in this regard. The creation of an institutional basis for international practice in this area, in the form of guiding principles and the corresponding implementation mechanisms, requires the development of specific systemic approaches at both the national and the international levels. Collective progress along this path and the adoption of considered and authoritative decisions would be substantially facilitated by ensuring that work in the international forums mentioned above on ensuring the safety of space activities is successful.

II. Regulatory frameworks

6. The policies and measures adopted by the Russian Federation with regard to preventing and lowering the level of space pollution and ensuring the safety of space activities at every stage of the life cycle of space equipment are developed in such a way as to fully meet the national requirements and technical standards in force and the internationally accepted guiding principles and regulations.

7. The Russian Federation has established a legal basis whereby work can be conducted on resolving the problem of space debris. The basic instruments, apart from the Space Activities Act of the Russian Federation of 20 August 1993, as amended by Act No. 331-FZ of 21 November 2011, are as follows:

(a) A guideline document entitled "Basis of the space activities policy of the Russian Federation for the period 2012-2020 and the long-term prospects", approved by the President of the Russian Federation in 2008, which defines one of the main issues as ensuring the safety of space activities and introducing technology and construction that minimize the formation of space debris when spaceships and space stations are launched and used;

(b) The existing system of standards governing activities to lower or prevent the pollution of space, including:

(i) Specialized space industry standard (OST) 134-1023-2000, entitled "Space technology items: general requirements for the mitigation of space debris" (came into force in 2000);

(ii) Specialized OST standard 134-1031-2003, entitled "Space technology items: general requirements for the protection of space facilities from the mechanical effect of fragments of natural or man-made origin" (entered into force in 2003);

(iii) State standard of the Russian Federation GOST P 25645.167-2005, entitled "Space environment (natural and artificial): model of the space-time distribution of the flux density of man-made substances in space" (entered into force in 2005);

(iv) State standard of the Russian Federation GOST P 25952-2008, entitled "Space technology items: general requirements for space facilities to mitigate the creation of space debris" (entered into force in 2009). The requirements of this standard extend to all new or modernized space complexes of a scientific, social, economic, commercial or military nature and cover every stage of the life cycle of space complexes, in line with the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space.

III. Current situation regarding application, utilization methods, technical standards and methodology

8. Implementation measures taken by the Russian Federation in response to the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space are as follows:

(a) Limit debris released during normal operations:

(i) Measures taken: full elimination of the possibility of structural components, parts and fragments from Fregat, Breeze-M, DM-SLB and stage-3 Soyuz-2 carrier rockets being discarded in space;

(ii) Measures planned: full elimination of the possibility of structural components, parts and fragments of satellites under development being discarded in space;

(b) Minimize the potential for break-ups during operational phases:

(i) Measures taken: selection of justified design features for the construction of spacecraft and the installation of meteorite shields on the high-pressure units of the Elektro-L spacecraft and the Breeze-M and Fregat boosters in order to prevent their rupture and destruction, and the use on the Ekspress-AM spacecraft of nickel hydrogen accumulator batteries instead of batteries using silver-cadmium accumulators, which are vulnerable to destruction resulting from the explosion gases that they produce;

(ii) Measures planned: selection of justified design features for the construction of future spacecraft and installation of meteorite shields on high-pressure units in order to prevent their rupture and destruction;

(c) Limit the probability of accidental collision in orbit:

(i) Measures taken: a regular assessment is undertaken of the probability of a collision between the International Space Station and large fragments of space debris, and avoidance manoeuvres are envisaged (since 2007, there has been an agreed exchange of orbital parameters to ensure that the Russian Ekspress-AM 3 and the Japanese MTSAT satellites keep position; and since 2012, dangerous convergence on the geostationary satellite orbit (GEO) for the Elektro-L and Luch-5A satellites has been monitored);

(ii) Measures planned: practical implementation of measures aimed at preventing accidental collisions between spacecraft of the Russian orbital constellation and other space objects;

(d) Avoid intentional destruction and other harmful activities:

(i) Measures taken: elimination of intentional destruction on all carrier rockets, boosters and spacecraft;

(ii) Measures planned: development of current practice;

(e) Minimize potential for post-mission break-ups resulting from stored energy:

(i) Measures taken: depressurization of booster fuel tanks following their transfer to a disposal orbit; draining of fuel remnants from the propulsion unit of DM-type boosters; burning of fuel remnants from the main engine; burning of fuel remnants from the propulsion unit of the launch system following separation of the space object; discharging of on-board accumulator batteries and stopping of fly wheels, gyroscopes and other mechanical devices; purging of fuel remnants under high pressure; and discharging of chemical power sources on Ekspress-AM satellites;

(ii) Measures planned: for future spacecraft, there will be afterburning of the engine propellant following the conclusion of the active mission lifetime, discharging of on-board accumulator batteries and disconnection of on-board accumulator batteries, stopping of fly wheels, gyroscopes and other mechanical devices, venting of pressure gas ranks and ensuring that the temperature regulation pipework is kept hermetically pressurized;

(f) Limit the long-term presence of spacecraft and launch vehicle orbital stages in the low-Earth orbit region after the end of their mission:

(i) Measures taken: the controlled re-entry of the orbital space station Mir, which had a mass exceeding 120 tons in 2001; the controlled deorbiting and re-entry of the Progress cargo vehicles (up to four or five times in the course of a year); the controlled deorbiting and re-entry of the Ekspress-AM 4 spacecraft in order to prevent an accidental collision and the creation of a greater quantity of fragments of space debris; and the deorbiting and re-entry of Fregat boosters following launches to low-Earth orbits;

(ii) Measures planned: planning for a re-entry manoeuvre for the spacecraft Resurs-DK1, Resurs-P and Maksat-R in a non-navigational area of the Pacific following the completion of the flight mission or, in the absence of fuel supplies sufficient for re-entry, a manoeuvre to transfer satellites to limited lifetime orbits, the parameters of the orbits being determined by the fuel remnants;

(g) Limit the long-term interference of spacecraft and launch vehicle orbital stages with the geosynchronous Earth orbit region after the end of their mission:

(i) Measures taken: successful re-orbiting in 2006 of the damaged geostationary spacecraft Ekspress-AM 11 to the disposal orbit using altitude control and stabilization system engines;

(ii) Measures planned: planning for operations to reorbit more recently designed geostationary satellites to the disposal orbit after their mission lifetime.

IV. Automated detection and warning system for hazardous situations in near-Earth space

9. To supplement existing means of controlling the areas of space available to the Russian Federation, work is continuing under the supervision of the Russian Federal Space Agency (Roscosmos) to create and use, initially on an experimental basis, an automated detection and warning system for hazardous situations in near-Earth space, the operations of which are to be conducted in the interest of, among others, international cooperation.

10. The main activities to be undertaken using the system are:

(a) Monitoring space objects presenting a potential risk for manned or unmanned spacecraft;

(b) Monitoring the development of dangerous situations in near-Earth space, particularly the dangerous convergence of space debris objects with operational spacecraft and the deorbiting of high-risk space objects;

(c) Overseeing the implementation of measures to dispose of carrier rockets, boosters and spacecraft whose stages have been spent in disposal orbits or limited lifetime orbits.

11. The following measures have been implemented to date:

(a) The basic structure of the system has been created, including the main information analysis centre (central core) and the information-gathering segments;

(b) Joint action has been set up between Roscosmos, the Ministry of Defence of the Russian Federation and the Russian Academy of Sciences with regard to resolving issues of observation, analysis and forecasting of the man-made environment in near-Earth space;

(c) Organizational and technical procedures are being worked out for joint action with the operators of spacecraft in the Russian orbital network as regards the identification and prevention of dangerous convergences with other orbital objects;

(d) Special funds are being established for Roscosmos in the interests of providing the required number of experimental optical stations to observe space objects.

12. The system is facilitating the participation of Roscosmos in international test campaigns to track dangerous space objects and restrict their presence in the orbit.

13. In the period 2011-2012, four avoidance manoeuvres of the International Space Station were carried out using the system. Over 1,500 convergences of space debris fragments with spacecraft of the Russian orbital network were identified. Over the same period, a ballistic and information operation was conducted to track the deorbiting of more than 50 space objects, the timing and area of descent of which were planned.

14. The system is used by the Space Control Centre of the Space Control System of the Ministry of Defence of the Russian Federation and also the Keldysh Institute of Applied Mathematics of the Russian Academy of Sciences, the Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation of the Russian Academy of Sciences and the Institute of Solar-Terrestrial Physics of the Siberian branch of the Russian Academy of Sciences to carry out the above-mentioned tasks. The system is also used to address safety issues relating to the International Space Station.

15. One of the main features of the development of the system in the future will be to extend international cooperation with regard to identifying and preventing dangerous situations. Such cooperation will include:

(a) Developing and implementing organizational and technical procedures for joint action with facilities engaged in resolving similar problems in Europe, as well as in the United States of America and other countries;

(b) Extending the range of information provided by the system on dangerous events for both Russian and foreign users;

(c) Developing and using additional ways of observing space objects;

(d) Analysing complex space situations in near-Earth space.

V. Aspects of the problem of space debris removal

16. The application of technology to the removal of fragments of space debris raises, inter alia, legal issues relating to the status of space objects that have ceased operating, and to property rights and issues relating to licensing and the obtaining of authorization.

17. Operations to remove space objects require the fulfilment of certain prerequisites: the establishment of an international legislative basis and mechanisms for making decisions on a legally valid basis (based on the principles and standards of international law), for sharing information and for the duly regulated, transparent and trust-based conduct of removal operations.

Jurisdiction in relation to orbiting objects that have ceased to operate

18. In the context of the discussion of issues relating to space debris removal, the question arises as to whether non-functional space objects, including fragments of space debris, fall within the jurisdiction of States.

19. At present, not all States register every object that appears or is formed in orbit as a result of various events (including launches, technological operations, experiments and break-ups). Most States enter in their national registers and submit to the Secretary-General information relating only to payloads. That practice is recognized as legally acceptable and in keeping with the objectives of the Convention on Registration of Objects Launched into Outer Space. The following thematic areas should therefore be considered:

(a) *The submission of information on all objects formed in orbit as a result of routine operations (the separation of hardware fragments and major structural components of the stages of carrier rockets, upper stages and space objects during the launching and testing of space objects, the conduct of experiments in space, the break-up or use of space objects etc.)*. Does the jurisdiction of the State extend to such objects if that State submits such information but does not enter the objects in its national register or in the Register of Objects Launched into Outer Space? How should the principle of the exercise by a State of jurisdiction and control over a space object be approached if that object ceases to exist in its original form, that is, if it breaks up entirely or in part? What is the legal status of fragments formed as a result of the break-up of a space object? Does continued jurisdiction in relation to such fragments provide a legal basis for liability in the event that such fragments cause damage to a space object that is under the jurisdiction of another State?

(b) *Submission of information in order to analyse possible dangerous situations in orbit and to issue warnings of dangerous approaches*. What is the legal basis on which a State under whose jurisdiction a non-functional space object falls might provide other States with information on the approach of that object to functional space objects belonging to those other States or with information regarding space objects that have ceased to operate and the likelihood of the descent of intact structural components to Earth? How is it possible to ensure that such a procedure is carried out in the event that the State has insufficient or no technical capability to track such objects? Should that State seek the assistance of States that have the necessary capacity, in order to obtain the necessary information? Should it develop relevant tracking technologies (or invest in their development within the framework of international projects) in order to ensure that it fulfils its obligations under international space law?

(c) *Analysis of the legal consequences of collisions*. If a non-functional object that is under the jurisdiction of one State collides with a functional space object that is under the jurisdiction of another State, how should it be determined which State is the party at fault? Can action be brought against a third State that has provided information on the parameters of the orbital movement of the objects that have collided if, on the basis of that information, decisions have been taken regarding the necessity or inadvisability of carrying out collision avoidance manoeuvres?

(d) *Taking of decisions relating to the deorbiting of a non-functional orbiting object*. Is there a need, in connection with the examination of the technical aspects of removing non-functional space objects and fragments of space debris from orbit, to analyse the ways and means of drawing a functional and legal distinction between space objects, as defined in the Convention on Registration of Objects Launched into Outer Space, and fragments of space debris? Would the distinction of such fragments from space objects as defined in the Convention be a justified and logical step? Would it be necessary to proceed from the understanding that, in the event that a physically intact space object ceased to exist in orbit, the launching State or the State of registry, in implementing the relevant procedures provided for in the Convention, could ascertain that the space object had disintegrated into fragments and confirm that it had ceased to exercise jurisdiction and control over those fragments? What might be the legal basis for, and consequences of, operations to remove non-functional space objects if the issue of exercise of jurisdiction in relation to such objects is not regulated?

Identification of orbiting objects

20. In order to identify orbiting objects, the following information needs to be collected:

(a) Orbital information indicating a correlation between newly obtained measurements and previously detected objects and the detection of new, previously unmonitored objects (trajectory identification and detection of new objects);

(b) Information on monitored objects where such identification indicates a correlation between the monitored object (as a physical body) and the event that has led to its appearance or formation in orbit and, consequently, the determination of the State (or international organization) under whose jurisdiction the object is most likely to fall (identification of the origin of the object).

21. With regard to trajectory identification and detection of new objects, a key aspect is the detection in orbit of the greatest possible number of objects and the definition and continuous refinement of the parameters of their orbital movement with sufficient precision to make it possible to correlate, to an acceptable degree of reliability, newly obtained results of observations with specific individual trajectories. A prerequisite for the achievement of those objectives is the availability of:

(a) The necessary technical resources (radiolocators, optical stations, equipment for passive radiotechnical monitoring etc.) to ensure trajectory measurements of sufficiently high precision;

(b) Sophisticated software systems that perform the mathematical procedures and algorithms needed to process hundreds of thousands (and, in the future, millions) of trajectory measurements per day for several tens of thousands (and, in the future, hundreds of thousands) of objects.

22. As far as identification of the origin of the object is concerned, it is extremely important that there should be virtually constant global monitoring of the whole of near-Earth space in order to provide an opportunity for identifying objects as they appear and identifying their operational correlation with events (launches,

technological operations, experiments and controlled destructions) as they happen. In order to ensure that such monitoring can be undertaken more effectively and that its results can be made more accurate, it is essential to have an additional flow of information from various sources on planned operations, such as launches, manoeuvres or disconnection of technological components and additional useful loads, in near-Earth space. The identification of objects that have been tracked in orbit for a lengthy period largely depends on the completeness of the record of accumulated orbital information, the record of information on events in near-Earth space and the record of information on the characteristics of space objects.

23. To date, no efforts have been made to collect the necessary information. The opportunities for various Governments to create and add to records of orbital information on the basis of the results of trajectory measurements have been very limited.

24. In relation to operational satellites, it is possible, in the overwhelming majority of cases, to conduct an independent analysis on the basis of data from various sources, including operators and manufacturers; however, where fragments of space debris are concerned, especially fragments from controlled destructions, it is not possible for a State to conduct such an analysis if it does not have its own technical monitoring equipment or a record of information on objects and events in near-Earth space that has been kept updated over many years.

25. The Russian Federation, like the majority of launching and other States, has currently not institutionalized a procedure for the public dissemination of regularly updated orbital information relating to space debris and operational satellites. Such information, which is openly available from several sources, does not cover all objects that are tracked: a considerable amount of information relates to the category of an object and is not suitable for disclosure or is not released for public dissemination on account of the fact that:

(a) An orbital object, whether operational or non-operational, such as a carrier rocket stage, an apogee or perigee motor unit, a technological fragment or a fragment from a controlled destruction, is connected with the launch of spacecraft for military purposes and their subsequent use and disposal;

(b) It is not possible to precisely define the origin of the object owing to incompleteness (for different reasons) of the telemetric, orbital and other data;

(c) The physical characteristics of an object (small size, high coefficient of radiotransparency or low surface reflection coefficient in the visible spectrum, for example), the impossibility of observing it on a sufficiently regular basis and, consequently, the periodic "loss" of the object mean that it is not always possible to establish whether a newly discovered object is the same as a previously observed but "lost" object;

(d) Orbital information may be classified as a trade secret.

26. Accordingly, there will be a need to consider ways and means of developing an agreed approach to the identification of orbital objects. This will, incidentally, make it possible to distinguish small satellites from objects of space debris.

VI. Joint processing of data on orbital objects obtained from various sources

27. From the point of view of ensuring the safety of space activities, it is important that:

(a) Orbital data used for making decisions on avoiding a possible collision of an operational satellite with another orbital object are reliable, meet the requisite level of precision and correspond in form and content to specific standards;

(b) Procedures for obtaining orbital data and the methods for assessing accuracy are agreed between the participants in information exchanges with regard to the transparency of the models used, the attitude to the assessment of accuracy and so on.

28. There are two comparable systems for monitoring near-Earth space: that of the Russian Federation and that of the United States. A number of States have the technical means, or a range of means, to monitor space.

29. There are currently no unified standards applying to the calculation and presentation of assessments of the accuracy of orbital information. However, assessments of the accuracy of orbital information make a decisive contribution to assessing the degree of risk of a convergence in space. It is impossible to compare such assessments that are received on the basis of the independent processing of a basic mass of primary (trajectory) information without carrying out a careful additional analysis and exchanging additional information between processing centres.

30. It is possible to envisage a range of States and other legal entities joining forces on a multilateral and/or bilateral basis to analyse and exchange specific information. Any of the possible scenarios involves a particular level of technical or political feasibility. Hypothetically, the most feasible idea seems to be the creation of a single monitoring centre working on the basis of obtaining the results of the processing of primary information from various sources in the form of the parameters of the orbital movement of potentially dangerous objects and assessments of the accuracy of such orbital parameters. Providing an institutional basis for international action on producing the best assessments of the parameters of orbital movement, including deciding on the procedure for reporting such assessments when decisions are taken on the need to carry out avoidance manoeuvres or other operations, and also procedures for conducting subsequent analysis of dangerous incidents that have occurred, will require a considerable focusing of minds.