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Space debris

National report on space debris research in the Russian Federation in 2002

1. In conducting its space operations, the Russian Federation attaches particular importance to experimental research on the problem of preventing the technogenic pollution of circumterrestrial space.

2. The principal operator and developer of space rocket systems in the Russian Federation is the Russian Aviation and Space Agency (Rosaviakosmos), which conducts its activities in the framework of the Russian federal space programme.

3. Rosaviakosmos considers that the most pressing problems are to ensure the safety of space flights, in the face of the technogenic pollution of circumterrestrial space, and to reduce the risk of the uncontrolled entry of space objects into the dense layers of the atmosphere and their falling to Earth. With a view to further promoting those research trends, Rosaviakosmos issues departmental papers to facilitate the progress of studies on the problems of reducing technogenic space pollution and improving the safety of existing space activities.

4. In order to resolve those problems, the Russian Federation is conducting scientific research and project design studies. Priority in such studies is given to:

(a) Environmental monitoring of circumterrestrial space, including the geostationary orbit (GSO) region;

(b) Development of models of circumterrestrial space pollution, including GSO;

(c) Creation of a single computer system (hardware-software) for the prompt data coverage of dangerous approaches of space objects, their uncontrolled entry into the dense layers of the atmosphere or their falling to Earth;

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(d) Development of ways and means to protect spacecraft and orbital stations from the effects of hypervelocity particles of space debris;

(e) Development and introduction of measures aimed at lowering space and GSO pollution.

5. The basic results of research by Russian organizations in these areas are given below.

6. As a result of radar measurements conducted by the Russian space monitoring system centres, a catalogue of observed objects exceeding 0.2-0.3 metres in size, at altitudes of up to several thousand kilometres, has been compiled and maintained. Currently containing information on almost 7,000 space objects, it enables collisions and falls to Earth of more substantial space objects to be predicted and a retrospective analysis of events in circumterrestrial space to be conducted. A catalogue of GSO space objects, containing over 600 entries, is also being compiled.

7. Organizations of the Russian Academy of Sciences are conducting optical and radar observations of space debris in the geostationary orbit and space object databases are being developed. Experimental radar trials of space debris in GSO and high-altitude elliptical orbits are being conducted, using the 70-metre antennas of the Evpatoriya Deep Space Centre. Utilization of the Centre's transmitter, with assistance from the receiving antennas of the low-frequency very-long baseline interferometry (VLBI) network (LFVN) project, has facilitated successful radar identification of objects in the GSO and in high-altitude elliptical and 12-hour orbits.

8. Considerable attention is given to the development and refinement of models showing the technogenic pollution of circumterrestrial space and GSO. On the basis of new experimental data on low-orbit space objects, the statistical model for medium- and long-term forecasts of the spatial distribution of technogenic objects exceeding 1 millimetre in size has been refined, which has led to the development of a computer model for space debris prediction and analysis (SDPA-E).

9. Research and experimental design projects are being conducted on creating an automated system for the collection and processing of information on technogenic or natural objects in circumterrestrial space with a view to assessing the current state of pollution and predicting dangerous or emergency situations in circumterrestrial space. A technical design, developed by the Central Engineering Research Institute (TsNIIMash) using the resources of the Mission Control Centre (TsUP), has produced valuable experimental data on computer tracking of the entry into the atmosphere of a variety of spacecraft and the space station Mir.

10. In shield protection research conducted on the Russian segment of the International Space Station various types of protective shields have been developed, including:

(a) Non-conformal protective shields from a basalt fibre-cloth assembly (so-called "collapsible wings");

(b) Conformal protective shields for the conical part of the docking module;

(c) Shield design success validated by calculation.

11. Universal multi-layer protection structures were proposed for the various spacecraft sections according to penetration hazard.

12. The results obtained can be used in the design of various types of spacecraft and orbital station.

13. Research on protective shielding is being undertaken by determining wall perforation by space debris particles under operational conditions and restoring a degree of hermeticity allowing relatively low mass flows (10-20 kilograms (kg)).

14. The problem of limiting technogenic pollution of circumterrestrial space is receiving considerable attention.

15. Currently the modernized carrier-rockets Soyuz-2 and Proton-M are viewed as the main basic carrier-rockets in the Russian launch vehicle system. In order to reduce the accumulation in orbit of carrier final stages, it is proposed to develop an experimental passive braking system on the Soyuz-2 third stage (I unit) in the hope of achieving a five- to sixfold reduction in the ballistic periods of the spent I units and almost entirely precluding their accumulation in orbit. In the operation of the other basic carrier-rocket, the Proton, the accumulation in orbit of spent final stages does not occur on account of their short flight in passive mode, the Proton being boosted to an orbit at a higher altitude of up to 200 kilometres (km).

16. Systems are being refined for separating the carrier-rocket stages from spacecraft and their components (trapping of explosive bolts inside devices designed to prevent fragments from their explosion from falling into the space environment, the replacement of pyrotechnical systems by closed mechanical devices and so on).

17. On the DM upper stage used on the Proton and the new commercial Zenit-3SL carrier-rocket (Sea Launch project), special measures are now in place for fuel-tank draining of fragments of propellant components and pressurization gases after separation from the spacecraft in order to ensure the safe removal of the upper stage and prevent its destruction during passive flight. In order to prevent explosions in a series of spacecraft launches, from 1996 onwards the release of both engine starting systems (SOZ motors) with simultaneous complete burn-up of their fuel in a negative stabilization regime has been eliminated (to date this has been performed for 21 carrier-rocket launches) and from 1997 a third powering of the main propulsion system of the carrier-rocket with residual propellant components has been foreseen in order to ensure accelerated removal from orbit and submersion (carried out in three carrier-rocket launches). Such measures are mainly implemented in commercial launches where there is surplus power.

18. A fully comprehensive range of measures to limit pollution of circumterrestrial space in connection with any launch is implemented on the modernized model of the DM carrier-rocket, on which the auxiliary SOZ motors fuelled by highly toxic hypergolic propellant components are scheduled to be replaced by reusable motors powered by the basic unit propellant components and closely integrated into its main propulsion system, as regards passivation and otherwise.

19. The design of the new Fregat, Briz-M and KVRB upper stages provides for their possible removal from working orbits with subsequent passivation.

20. Mitigating technogenic pollution of the GSO region is linked most specifically with the necessity of removing spent space objects after their operating lifetime into the graveyard region, the lower limit of which, in accordance with the recommendations of the Inter-Agency Space Debris Coordination Committee

(IADC) and the special requirements laid down in the technical documentation of spacecraft and carrier-rockets, must be higher than the GSO by at least 200 km.

21. In the case of spent space objects, this removal is implemented on the fragments of the rocket propellant (Ekran 31, Ekran M12 and so on). In the new space object designs, such as SESAT, Ekspress-A and others, in order to ensure removal of the spacecraft from GSO to the graveyard region it is planned to provide for special fuel reserves that must be depleted on instructions specifically for that purpose. Thus, with a spacecraft launch mass under 2,600 kg, the xenon consumption for removal to an altitude of 200 km is 84-124 kg, which constitutes between 1.3 and 1.6 per cent of the total fuel loading requirement.

22. With regard to upper stages, when spacecraft are launched into geostationary orbit, they are immediately put into the "storage" zone or orbits lower than the geostationary orbit. After a spacecraft is detached from the upper stage, it crosses into geostationary orbit with the help of its own propulsion system.

23. Particular attention is being paid to increasing the range of options for manoeuvring the removal of spacecraft from working orbits by means of electric rocket thrusters used as on-board corrective propulsion systems, which differ from liquid jet thrusters in that they are significantly more economical in terms of consumption of rocket propellant. Such electric thrusters are already being used in a number of Russian spacecraft and universal space platforms to correct spacecraft orbits and to propel spacecraft in the phase of inter-orbital transfer.

24. Particular attention is also being paid to the preparation of documentation on methods and technical standards:

(a) Rosaviakosmos departmental standards have been drawn up and introduced in the rocket and space commercial sector;

(b) "Space technology items: general requirements for limiting the technogenic pollution of circumterrestrial space" stipulates that such requirements must be taken into account in the technical work of developing space resources; all measures and technical solutions for their implementation are set out in a separate document on the design and use of the item;

(c) "Space technology items: general requirements for the protection of space resources from the impact of particles of natural and technogenic origin" (this standard is due to enter into force on 1 July 2003);

(d) The first draft of the state standard entitled "Model of the space-time density distribution of technogenic fluxes in circumterrestrial space" has been prepared;

(e) Assessments have been conducted of the possibility of taking more effective action to limit the technogenic pollution of circumterrestrial space, in particular the removal of geostationary spacecraft at end of mission into storage orbits and the removal of low-orbit spacecraft into orbits with a lifetime of no more than 25 years.

25. In 2003 the following Rosaviakosmos departmental standard was adopted: "Space technology items: general requirements for the protection of space resources from the impact of particles of natural and technogenic origin". Much work was

done on the preparation of the “Reference guidelines for protection from the impact of particulate space debris” (“Protection manual”).

26. Representatives of Rosaviakosmos, the Russian Ministry of Defence, the Russian Academy of Sciences and other Russian agencies and organizations participated actively in the preparation of a draft IADC document, “Guidelines for the organization of work to mitigate space pollution”, which may have a far-reaching impact on the development of space activities.

27. The draft document reflects the world community’s growing concern at the increased danger posed by space debris in circumterrestrial space, above all the danger to the International Space Station, and represents a first step towards the development of an international agreement stipulating sufficiently stringent standards for activities connected with the technogenic pollution of circumterrestrial space.

28. Adoption of the document requires prior resolution of a broad spectrum of technical, regulatory and legal problems on a consensual basis and a phased and balanced approach to implementing the principles contained in the document in the world’s space activities. In particular, it is necessary to prepare a single package of international documents establishing:

(a) The level of technogenic pollution of circumterrestrial space and the geostationary orbit;

(b) Principles for limiting the technogenic pollution of circumterrestrial space;

(c) Rules for using spacecraft in such a way as to avoid any increase in technogenic pollution of circumterrestrial space;

(d) Monitoring and procedures for sharing information about events connected with the technogenic pollution of circumterrestrial space, especially in the use of nano-, pico- and femtosatellites, which are practically invisible.

29. In that connection, the Russian Federation considers it premature to begin studying the legal aspects of the problems of limiting the technogenic pollution of circumterrestrial space in the Legal Subcommittee.

30. The annex to the present document contains an introduction in tabular form to new mitigation technologies.