THE RUSSIAN FEDERATION SPACE PLAN 2006-2015 AND ACTIVITIES IN SPACE DEBRIS PROBLEMS

Dr. Sergey Kulik

Roskosmos 41, Pionerskaya Str., Moscow 129857, Russia

ABSTRACT

Space activity is an essential part of overall mankind activity. Since the first space flights the great number of useless objects had occupied near-Earth space thus forming space debris population. Risk of damage for functioning and future space systems, as well as to people and property on the ground is being increased consistently from year to year. Current practice of space vehicles designing and operation is needed to be adapted in order to protect near-Earth space environment. The Russian Federation shares space community concerns about space debris problem, first of all, with respect to the International Space Station and manned space flights safety. The Russian Federation adheres to the UN COPUOS activities on space debris problem and participates in the Inter-Agency Space Debris Coordination Committee (IADC) activities.

GENERAL REMARKS

The Russian Federation keeps leading positions in space activity on launches that is why it has special concern about avoiding an irreversible degradation of near-Earth space environment. In Fig. 1 there is depicted the dynamics of launches in Russia and the others space faring states and organizations. As it follows from the presented data about 40% from overall number of launches in 2004 were made by Russian Federation.

The prospects of Russian space activity are determined by a number of official documents such as:

- Law of the Russian Federation on Space Activities;
- The Basic Directions of Policy of Russian Federation in Science and Technology Development up to 2010 and in Further Perspective;
- Decrees of the President of the Russian Federation;
- Resolutions and Orders of the Government of the Russian Federation.



Figure 1. The dynamics of launches in Russia and others space faring states and organizations

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RUSSIAN FEDERAL SPACE PROGRAM

Russian Federal Space Program is being worked out on the basis of the said documents. It determines the ways of space systems development. The last Program covered period since 2001 up to 2005. The new Russian Federal Space Program is under development. This Program covers the period 2006-2015 years and is directed to strengthening of orbital back-up, to improvement of spacecraft characteristics, widening possibilities of launchers and launcher sites. Special attention is paid to manned space flights, that are:

- crew selection, training, vital activity and medical support system in long duration (over one year) space flight;
- advanced transportation system for manned space missions and orbital infrastructure development;
- development of interplanetary manned flights scenario, definition of piloted complexes technical requirements;
- development of key technologies: propulsion sets, energy systems, robotics and its demonstration;
- space flights to the Moon and to the Mars.

Russian space transportation system roadmap is prepared as it presented at Fig 2.

A number of international projects are under development. Russian – European concept of integration "Arian 5" + "Bykal"- type RFBB is studied. The work is done by CNES, EADS, TsNIIMASH and Khrunichev Space Center using the following integration scenario:

- European-Russian small scale research team-work;
- development of joint advanced technologies and projects, ground and flight tests;
- long term partnership for joint large scale R&D;
- manufacturing and operation of commercial STS.

Another project is RLV technology demonstrators flight tests using launch vehicles generated from ICBM and SLBM (see Fig. 3).

In frame of Russian Federal Space Program considerable efforts will be concentrated on earth remote sensing, gidrometeorology, environment monitoring and emergencies control (see Fig. 4).



Figure 2. Russian space transportation system roadmap





Figure 3. Launch vehicles generated from ICBM and SLBM



Figure 4. Earth remote sensing, gidrometeorology, environment monitoring and emergencies control systems (2006 - 2015).

SPACE DEBRIS ACTIVITY

The Russian Federal Space Agency organizes the work on space debris problem in cooperation with Branch industry enterprises, Russian Academy of Sciences and other entities. Russian Federal Space Agency approved the SPACE DEBRIS MITIGATION STANDARD that is OST 134-1023-2000 "Space Technology Items. General Requirements for Mitigation of Space Debris Population" (July, 2000). The Standard provisions are basically similar to the recommendations of appropriate Standards and Guidelines of the other states and organizations - IADC members. The field of application of the present Standard extends to launch vehicles and spacecrafts capabilities, reusable space systems, interplanetary stations and vehicles exploring outer space, space vehicles of scientific, socio-economic and commercial designations to include manned space vehicles, excluding military space vehicles. A national Standard on space debris mitigation is under development. The work on space debris problem is organized in all directions concerned: observation, modeling, shielding, mitigation etc.

OBSERVATION

The Russian Federation disposes of wide civil network of on-ground observational means that may be used for the purposes of space debris investigation:

- arranging of optical sensor network (of Russia and CIS) for the regular survey of accessible part of GEO using the large field telescopes { Zvenigorod (50cm), Simeiz (53cm), Almaty (50cm), Nikolaev (43cm), Kourovka (42cm), Goloseevo (40cm), Ujgorod (43cm) };
- the regular searching of medium-size GEO objects
 {
 Riga (80-cm), Simeiz (1-m), Odessa (60-cm), Zelenchuk (60-cm), Mondy (60-cm), Zvenigorod (60-cm), Shamakhi (1-m), Almaty (1-m) };
- optical observation of low size GEO-fragments { *Terscol (2-m), Shamakhi (2-m), Mondy (1.7 m),*

Pulkovo (1.15 m) };

• the regular radar observation of low size fragments at GEO and GTO { *Evpatoria* (*RT-70*)=>*Bear Lakes* (*COBALT-RT-64*); the same may be used at *LEO: Evpatoria* (*RT-70*)=>*Simeiz* (*RT-22*) }.

MODELLING

The new "SPDA-GEO" model of space debris in GEO region has been developed in Russia (author – prof. Andrey Nazarenko). Model is based on the assumption of GEO objects probability break-ups is about the same as in other space regions. The developed software evaluates the explosions of GEO objects and calculates the orbits of fragments caused by these explosions and evolution of explosion volume shape as a function of time. In according with "SPDA-GEO" model the number of GEO explosions may be greater than the two known events in the "Catalog of break-ups": Ekran (77092A) in June 25, 1978; Transtage 5 (68081E) in February 21, 1992.

SHIELDING

Hypervelocity impact of a projectile on the mesh barrier was investigated. There was developed a 2-D numerical code which is based on a molecular dynamics approach. This code simulates fragmentation of the projectile on the mesh barrier. As an example at Fig. 5 there is shown the time dependency of total kinetic energy of the system "projectile-target" with respect to a laboratory frame of reference (in units of initial kinetic energy).

New calculation capabilities to determine shields structure were developed in COLLO code including nonlinear optimization method. Now there is used graphical method, Monte-Carlo method and finite element method. The finite element method allows to solve the optimization problem quite quickly for spacecraft of complicated shape even in case of multielement protection.



Figure 5. Total kinetic energy of the system "projectile-target" with respect to a laboratory frame of reference.

MITIGATION

In according with the Russian Space Debris Mitigation Standard - OST 134-1023-2000 the mitigation measures are introduced for Russian launchers and spacecraft:

- the reduction of pressure and venting the remaining propellant components from fuel tanks after engines shut down at the end of mission;
- for all commercial missions the jettisoning of SOZ engines of the "DM" Apogee Motors was prohibited;
- the propellant components remainders in SOZ engine tanks are burnt out in the regime of "negative stabilization" after the end of mission;
- separation of operational elements is excluded or minimized;
- on-board batteries are discharged;
- self-destruction systems are not introduced;
- the flywheels and momentum wheels stop rotating due to self- deceleration;
- separation of operational elements is excluded.

RE-ENTRY

The 5-th IADC Re-entry test campaign 2003 was the third one regarding to real large test object, which was the spacecraft Cosmos-389. The essential peculiarities of this test campaign due to unexpected peaks of the solar and geomagnetic activity that caused strong perturbations in the atmospheric parameters. Russian re-entry predictions were exact and had a good stability (see Fig. 6).

The Russian Federal Space Agency is interested in future activity on space debris problem and international cooperation in frame of UN COPUOS, IADC, ISO. We confirm the priority of international activities in preparing of STSC Space Debris Mitigation Guidelines that should be focused on:

- minimization of the potential for on-orbit breakups;
- post-mission disposal;
- minimization of the operational elements;
- prevention of on-orbit collisions.

The Main Problems of Future Activity may be:

- implementation of Internationally Approved Mitigation Guidelines;
- international Monitoring of Mitigation Guidelines Fulfillment;
- international agreements about the "Rules on space roads".

CONCLUSION

- The Russian Federation is devoted to the international efforts on space debris problem resolution and it is already implementing practical steps on space debris mitigation on a voluntary basis within its own national mechanisms.
- Russian Federal Space Program up to period 2006-2015 is elaborated and it is now under approval. The work on space debris problem is included in the appropriate provisions of Program.
- A Russian national standard on space debris mitigation is under development.
- The Russian Federation is convinced that the most appropriate place for developing of an internationally approved measures to protect near-Earth space environment is UN Committee on the Peaceful Uses of Outer Space.



Figure 6. Russian re-entry predictions of the 5-th IADC Re-entry test campaign