LONG-TERM SUSTAINABILITY OF SPACE ACTIVITIES

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INTRODUCTION*

For 50 years, space systems have contributed enormously to maintaining peace and economic development.

First and foremost, they contributed greatly to stabilizing the political situation between the two major nuclear powers during the Cold War, thanks to early warning and reconnaissance satellites. Since the end of the Cold War, space systems dedicated to security have been deployed by several states besides the two superpowers, thus contributing to an increase of transparency and a more secure world.

The contribution of satellite systems to the modern information society as we know it today has also been significant, if only because satellite communication and broadcasting abolish borders and open access to global news and content. Satellites also came to play the major role in establishing a global positioning and navigation systems, which have gradually replaced most, if not all, ground-based navigation and positioning infrastructures.

Similarly, Earth satellites and deep-space probes allowed a quantum leap in our ability to peer through the history of the universe and of the solar system, including a major contribution to a better understanding of the mechanisms affecting our own planet, whether its atmosphere, its oceans and land masses—its biosphere.

Space systems and the services derived from them have become an indispensable factor in development programmes in many less advanced regions of the world, whether to facilitate educational programmes and health services, improve food security and water resource or forestry management, and so forth. In a more long-term vision, space-based systems

* The views expressed here are the personal views of the author and do not necessarily reflect the views of the UN COPUOS, nor of the UN Secretariat.

Published in *Security in Space: The Next Generation—Conference Report, 31 March–1 April 2008*, United Nations Institute for Disarmament Research (UNIDIR), 2008.

could play a role in lowering our dependency on fossil fuels for energy generation, whether by collecting and redirecting solar energy to the Earth's surface or by helping us getting rid of long-lived nuclear waste.

IS LONG-TERM USE OF OUTER SPACE SUSTAINABLE?

However, our ability to continue to use outer space in the long term is not guaranteed: one is indeed faced with two factors which may hinder the long-term, sustainable use of outer space:

- There is a significant increase in the number of government and private space operators;
  - At the present time, there are eight states who operate launching systems (launch base and launcher),[1] and South Korea might join this very select club during the course of the year;
  - Beyond the few states mastering the capability to launch satellites into outer space, there are more than 50 states and regional organizations that operate satellites in orbit;
  - In parallel, a rapidly increasing number of both large and small private companies operate commercial satellite systems; and
- This increasing number of actors in outer space will to continue to grow over the years and will inevitably lead to a continuous increase of the number of objects orbiting the Earth.

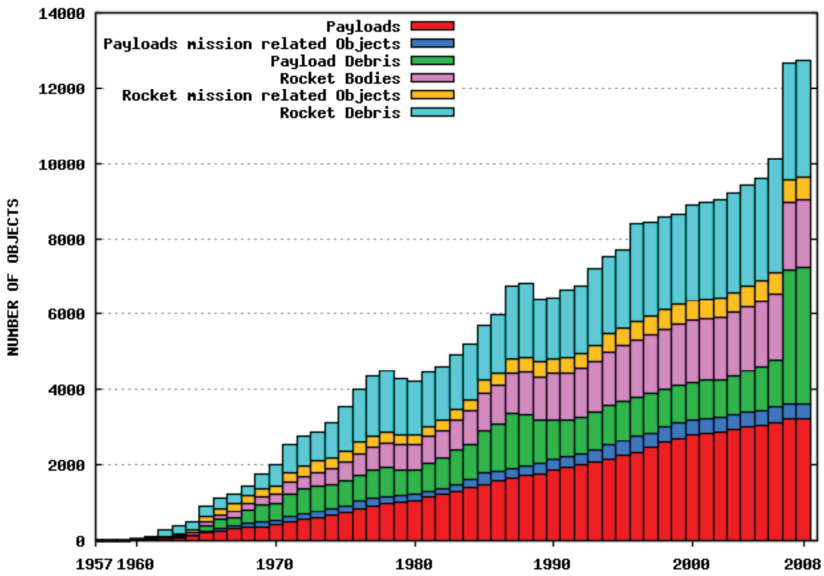
Let us review some numbers which reflect the first half-century of space activities:

There were 4,547 recorded launches of spacecraft from 4 October 1957 (the date of the launch of Sputnik 1) to the end of 2007. Today (the beginning of 2008), there are 660 operational satellites in orbit and 12,500 identified objects larger than about 10cm (that is, tracked by the US Space Surveillance Network), of which 40% are satellites no longer in operation or spent rocket upper stages and 55% are fragments and other objects. In addition, there are at least 300,000 objects between 1cm and 10cm and it is estimated that there are several million objects below 1cm.

Chart 1, taken from a presentation by Heiner Klinkrad of the European Space Agency to the Scientific and Technical Subcommittee of the UN Committee for the Peaceful Uses of Outer Space (COPUOS) in February

2008, illustrates the increasing number of catalogued space objects from 1957 to the end of 2007, most of them space debris. Note in particular the significant increase of payload debris in 2007, which for the most part resulted from the voluntary destruction and break-up of the Chinese satellite Fengyun-1C by a Chinese ballistic missile on 11 January 2007.

Chart 1. The number of space objects catalogued by the US Space Surveillance Network during each six-month period from October 1957 to January 2008



The figures above and the long-term trend of catalogued space objects in orbit shown in Chart 1 illustrates how the proliferation of space debris is a real concern for the future utilization of outer space. Although the actual deployment of weapons in outer space has not happened, ground-based weapons can be used against low-Earth-orbit spacecraft and aggravate the situation. If such weapons were activated in a conflict situation, the huge amount of space debris that they would generate and the feeling of insecurity that it would create would jeopardize the future use of near-Earth outer space.

In other word, space security is fragile and not guaranteed, particularly if one takes a long-term view.

It is therefore clear that maintaining safe and secure access to outer space will require a lot more attention. It will become necessary to develop rules of behaviour and instil a higher degree of discipline in all actors to be able to manage orbital traffic, orbital positions and facilitate space operations.

SOME REASONS TO BE OPTIMISTIC

Space security is not guaranteed but there are some reasons to believe that there are ways to improve the safe and secure use of outer space. First of all, the excellent work done over the last 10 years on the space debris issue by the Inter-Agency Space Debris Coordination Committee (IADC), which gathers 10 major space agencies,[2] and the unanimous adoption in 2007 by the 67 member states of COPUOS of the UN Space Debris Mitigation Guidelines,[3] which were later endorsed by the UN General Assembly,[4] provide a good model of how the international community can make some progress towards a regime of sustainable space operations.

Based on the model of the work on space debris mitigation, and as a follow-up to an idea that I first proposed at the George Washington University/Space Policy Institute workshop on space security held in Paris in May 2006,[5] I proposed to the COPUOS delegations in June 2007[6] that they should tackle the issue of long-term sustainability of space activities with a bottom-up approach comparable to the space debris mitigations guidelines. COPUOS has not yet taken a formal decision on this proposal but delegations are gradually becoming more conscious of the need to address this issue.

A FIRST STEP TOWARDS THE LONG-TERM SUSTAINABLE USE OF OUTER SPACE

However, without waiting for a formal decision by COPUOS, which will require the unanimous consent of 67 delegations, a first implementation step took place recently at the initiative of France. On 7–8 February 2008, France hosted in Paris an informal working meeting of spacefaring nations to address the topic of long-term sustainability of space activities. The purpose of this informal meeting was to discuss the possibility of setting up an ad hoc working group to develop information exchange mechanisms and consensus-based rules of behaviour which would contribute to a safer and more secure space environment.

Participation at the meeting reflected a widely shared interest by many delegations: there were representatives from 20 countries, including all the major spacefaring nations and some developing countries, as well as from the European Space Agency and the European Union; there were observers from the UN Office for Outer Space Affairs, the International Space Environment Service and the World Meteorological Organization; and commercial telecommunication satellite operators (Intelsat, Eutelsat and SES) were invited to participate in the second day of the meeting and share their views with the government and international organization representatives.

The informal working group meeting heard detailed presentations on the work of the IADC and on the long-term outlook for space debris. It also noted the need for establishing a mechanism to facilitate and ensure safe operations in the geosynchronous orbits and took note of the initiatives already taken in this area by commercial telecommunication satellite operators.

In the area of space weather, the informal working group also noted the mechanism set up by the International Space Environment Service to collect and distribute timely information and forecasts on solar activity, flares and coronal mass ejections.

The main conclusions of the meeting and plans to move forward can be summarized as follows:

- long-term sustainability of space activities is an issue that needs to be addressed by all nations interested in the future utilization of outer space. It is essential to brief the delegations of COPUOS on this initiative;
- it would be desirable to prepare a draft outline document on the topic of long-term sustainability of space activities to be circulated to participants, with a target date of late summer 2008. For this purpose, a drafting group was set up and will meet in conjunction with the plenary session of COPUOS in June 2008;

- a second meeting of the informal working group should take place during the later part of 2008, dedicated to discuss and, if possible, to finalize the outline document, with a view to submit it at the next session of COPUOS Scientific and Technical Subcommittee in February 2009;
- it is essential to organize communication channels with delegations involved in the discussions on the prevention of an arms race in outer space at the Conference on Disarmament; and
- finally, it would be good to brief non-government organizations actively involved in space security issues and activities on the safety of space systems and obtain their support and contributions.

Note that the fourth recommendation above is implemented by this presentation to the UNIDIR conference participants.

LOOKING FORWARD TO A SET OF BEST PRACTICE GUIDELINES IN SPACE ACTIVITIES

Hopefully, the approach taken via the informal working group approach described above will be fruitful and will produce a useful background document on the long-term sustainability of space activities, on the basis of which a set of best practice guidelines for space activities may be developed during the next year or so.

The outcome of the informal working group will then be introduced formally to COPUOS, either directly to its plenary session or via its subcommittees. The next step would be, if a consensus can be found, to develop them as recommended best practices for space operations for eventual endorsement by the UN General Assembly.

CONCLUSION

Ensuring secured and sustainable access to and use of outer space is a major issue for all nations, including those nations that do not have yet any space activities.

The benefits from the uses of space systems are shared by all stakeholders—commercial, research, civilian and military communities.

Because they share the same environment around our planet and beyond, states, international and regional organizations, and private commercial operators must find a common approach to use outer space in a sustainable way.

The ad hoc, bottom-up approach recommended here is a non-political, pragmatic way forward to reach consensus on how to keep outer space safe and secure for the long term.

ANNEX

SPACE DEBRIS MITIGATION GUIDELINES OF THE COMMITTEE ON THE PEACEFUL USES OF OUTER SPACE[7]

Background

Since the Committee on the Peaceful Uses of Outer Space published its Technical Report on Space Debris in 1999, it has been a common understanding that the current space debris environment poses a risk to spacecraft in Earth orbit. For the purpose of this document, space debris is defined as all man-made objects, including fragments and elements thereof, in Earth orbit or re-entering the atmosphere, that are non-functional. As the population of debris continues to grow, the probability of collisions that could lead to potential damage will consequently increase. In addition, there is also the risk of damage on the ground, if debris survives Earth's atmospheric re-entry. The prompt implementation of appropriate debris mitigation measures is therefore considered a prudent and necessary step towards preserving the outer space environment for future generations.

Historically, the primary sources of space debris in Earth orbits have been (a) accidental and intentional break-ups which produce long-lived debris and (b) debris released intentionally during the operation of launch vehicle orbital stages and spacecraft. In the future, fragments generated by collisions are expected to be a significant source of space debris.

Space debris mitigation measures can be divided into two broad categories: those that curtail the generation of potentially harmful space debris in the near term; and those that limit their generation over the longer term. The former involves the curtailment of the production of mission-related space debris and the avoidance of break-ups. The latter concerns end-of-life procedures that remove decommissioned spacecraft and launch vehicle orbital stages from regions populated by operational spacecraft.

Rationale

The implementation of space debris mitigation measures is recommended since some space debris has the potential to damage spacecraft, leading to loss of mission, or loss of life in the case of manned spacecraft. For manned flight orbits, space debris mitigation measures are highly relevant due to crew safety implications.

A set of mitigation guidelines has been developed by the Inter-Agency Space Debris Coordination Committee (IADC), reflecting the fundamental mitigation elements of a series of existing practices, standards, codes and handbooks developed by a number of national and international organizations. The Committee on the Peaceful Uses of Outer Space acknowledges the benefit of a set of high-level qualitative guidelines, having wider acceptance among the global space community. The Working Group on Space Debris was therefore established (by the Scientific and Technical Subcommittee of the Committee) to develop a set of recommended guidelines based on the technical content and the basic definitions of the IADC space debris mitigation guidelines, taking into consideration the United Nations treaties and principles on outer space.

Application

Member States and international organizations should voluntarily take measures, through national mechanisms or through their own applicable mechanisms, to ensure that these guidelines are implemented, to the greatest extent feasible, through space debris mitigation practices and procedures.

These guidelines are applicable to mission planning and operation of newly designed spacecraft and orbital stages and, if possible, to existing ones. They are not legally binding under international law.

It is also recognized that exceptions to the implementation of individual guidelines or elements thereof may be justified, for example, by the provisions of the United Nations treaties and principles on outer space.

Space debris mitigation guidelines

The following guidelines should be considered for the mission planning, design, manufacture and operational (launch, mission and disposal) phases of spacecraft and launch vehicle orbital stages:

Guideline 1: Limit debris released during normal operations

Space systems should be designed not to release debris during normal operations. If this is not feasible, the effect of any release of debris on the outer space environment should be minimized.

During the early decades of the space age, launch vehicle and spacecraft designers permitted the intentional release of numerous mission-related objects into Earth orbit, including, among other things, sensor covers, separation mechanisms and deployment articles. Dedicated design efforts, prompted by the recognition of the threat posed by such objects, have proved effective in reducing this source of space debris.

Guideline 2: Minimize the potential for break-ups during operational phases

Spacecraft and launch vehicle orbital stages should be designed to avoid failure modes which may lead to accidental break-ups. In cases where a condition leading to such a failure is detected, disposal and passivation measures should be planned and executed to avoid break-ups.

Historically, some break-ups have been caused by space system malfunctions, such as catastrophic failures of propulsion and power systems. By incorporating potential break-up scenarios in failure mode analysis, the probability of these catastrophic events can be reduced.

Guideline 3: Limit the probability of accidental collision in orbit

In developing the design and mission profile of spacecraft and launch vehicle stages, the probability of accidental collision with known objects during the system's launch phase and orbital lifetime should be estimated and limited. If available orbital data indicate a potential collision, adjustment of the launch time or an on-orbit avoidance manoeuvre should be considered.

Some accidental collisions have already been identified. Numerous studies indicate that, as the number and mass of space debris increase, the primary source of new space debris is likely to be from collisions. Collision avoidance procedures have already been adopted by some Member States and international organizations.

Guideline 4: Avoid intentional destruction and other harmful activities

Recognizing that an increased risk of collision could pose a threat to space operations, the intentional destruction of any on-orbit spacecraft and launch vehicle orbital stages or other harmful activities that generate long-lived debris should be avoided.

When intentional break-ups are necessary, they should be conducted at sufficiently low altitudes to limit the orbital lifetime of resulting fragments.

Guideline 5: Minimize potential for post-mission break-ups resulting from stored energy

In order to limit the risk to other spacecraft and launch vehicle orbital stages from accidental break-ups, all on-board sources of stored energy should be depleted or made safe when they are no longer required for mission operations or post-mission disposal.

By far the largest percentage of the catalogued space debris population originated from the fragmentation of spacecraft and launch vehicle orbital stages. The majority of those break-ups were unintentional, many arising from the abandonment of spacecraft and launch vehicle orbital stages with significant amounts of stored energy. The most effective mitigation measures have been the passivation of spacecraft and launch vehicle orbital stages at the end of their mission. Passivation requires the removal of all forms of stored energy, including residual propellants and compressed fluids and the discharge of electrical storage devices.

Guideline 6: Limit the long-term presence of spacecraft and launch vehicle orbital stages in the low-Earth orbit (LEO) region after the end of their mission

Spacecraft and launch vehicle orbital stages that have terminated their operational phases in orbits that pass through the LEO region should be removed from orbit in a controlled fashion. If this is not possible, they should be disposed of in orbits that avoid their long-term presence in the LEO region.

When making determinations regarding potential solutions for removing objects from LEO, due consideration should be given to ensure that debris that survives to reach the surface of the Earth does not pose an undue risk to people or property, including through environmental pollution caused by hazardous substances.

Guideline 7: Limit the long-term interference of spacecraft and launch vehicle orbital stages with the geosynchronous Earth orbit (GEO) region after the end of their mission

Spacecraft and launch vehicle orbital stages that have terminated their operational phases in orbits that pass through the GEO region should be left in orbits that avoid their long-term interference with the GEO region.

For space objects in or near the GEO region, the potential for future collisions can be reduced by leaving objects at the end of their mission in an orbit above the GEO region such that they will not interfere with, or return to, the GEO region.

Updates

Research by Member States and international organizations in the area of space debris should continue in a spirit of international cooperation to maximize the benefits of space debris mitigation initiatives. This document will be reviewed and may be revised, as warranted, in the light of new findings.

Reference

The reference version of the IADC space debris mitigation guidelines at the time of the publication of this document is contained in the annex to document A/AC.105/C.1/L.260.

For more in-depth descriptions and recommendations pertaining to space debris mitigation measures, Member States and international organizations may refer to the latest version of the IADC space debris mitigation guidelines and other supporting documents, which can be found on the IADC website (www.iadc-online.org).

Notes

1 Thirty-seven satellite launches were performed in 2007.
2 The Agenzia Spaziale Italiana, the British National Space Centre, the Centre National d'Etudes Spatiales (France), the China National Space Administration, the Deutsches Zentrum für Luft- und Raumfahrt, the European Space Agency, the Indian Space Research Organisation, the Japan Aerospace Exploration Agency, the National Aeronautics and Space Administration (United States), the National Space Agency of Ukraine and Roskosmos (Russia).
3 The COPUOS space debris mitigation guidelines are reproduced in the Annex.
4 UNGA Resolution A/RES/62/217 of 10 January 2008, paragraph 26.
5 "Collective Security in Space, European Perspectives", Space Policy Institute, The George Washington University, Washingon, DC, January 2007.
6 General Assembly, *Future role and activities of the Committee on the Peaceful Uses of Outer Space*, UN document A/AC.105/L.268, 10 May 2007, § D.
7 General Assembly, *Report of the Committee on the Peaceful Uses of Outer Space*, UN document A/62/20, supplement no. 20, 26 June 2007, annex.