Security in Space

Luciano Anselmo
Space Flight Dynamics Laboratory
ISTI/CNR – Pisa – Italy

INTERNATIONAL WORKSHOP ON PAOLO FARINELLA (1953-2000): THE SCIENTIST AND THE MAN

Dipartimento di Matematica, Università di Pisa, 14-16 June 2010

Introduction

- Paolo Farinella devoted a considerable amount of his time and energies to the political, military and social implications of space activities and research.
- Most of these interests may be collectively included under the expression "security in space".
- The aim of this presentation is roughly reviewing some of the Paolo's contributions in the field (in cooperation with Bruno Bertotti and myself).
- Paolo shared our view of the growing strategic importance of space assets and recognized the positive and stabilizing role, in the context of the arms race between the two superpowers, of the so-called "national technical means of verification", i.e. "spy satellites".
- But he was also a staunch defender of the outer space preservation for future generations, endorsing the ban of destabilizing orbital arms systems, as space-based bombardment vehicles, anti-satellite weapons and the "star wars" anti-missile battle stations envisaged in the US in the 1980's.
- He recognized that space activities, both in the military and in the civilian areas, might become dangerous.

The danger of space activities

- There are several circumstances in which space activities may cause significant threats to the security of both nations and people.
- Well known examples are anti-satellite weapons, space vehicles carrying radioactive material on board, uncontrolled reentering space objects, and explosions or collisions in space generating swarms of orbiting debris.
- If dangerous activities were to be carried out by a nation in a region which is "common property of mankind", the adoption of constraints, regulations and monitoring appeared necessary to safeguard the interests of other parties.
- Paolo shared the view that, in this area, an internationally agreed regime would be by far superior to purely unilateral moves.
- He was also convinced that establishing an international system for space surveillance and verification would present significant advantages with respect to the proliferation of "national technical means".

Outer space surveillance

- The monitoring of space activities is today carried out effectively and systematically only by the US and Russia (plus a more limited capability by France).
- In 1991 we proposed *(Space Policy*, August 1991, pp. 184-198) to remediate this situation by developing international means of surveillance of space activities.
- Different scenarios for the establishment of an International Agency for Space Surveillance (IASS) were considered and an attempt was made to assess the main political hindrances to its effective functioning.
- We also discussed a minimum set of requirements for the IASS, assuming that only current technology was used and that no attempt was made to systematically track all low-orbiting objects.
- The components of the agency, the required tracking systems and their performance were analyzed.
- The achievable accuracy of orbit determination from tracking data was estimated by performing a suitable set of computer simulations.

Recent developments 1

- France deployed its own space surveillance system (GRAVES).
- Other countries acquired limited space surveillance capabilities.
- ESA funded some studies of a European space surveillance system.
- ESA launched the Space Situational Awareness (SSA) program to protect Europe's citizens and satellite-based services by detecting space hazards.
- At the 52nd session of UN COPUOS, the Member States of the Inter-Agency Space Debris Coordination Committee (IADC) were invited to prompt IADC to advise the Scientific and Technical Subcommittee on a proposal by the delegations of Germany and Italy.
- The task was "to develop first ideas on concrete measures with the purpose of making available already existing sources of information as well as data and information on objects in outer space for the promotion of a safe and sustainable development of the peaceful uses of outer space".
- The stated objective of the joint proposal was "to avoid collisions in outer space between operational spacecraft and space debris and other operational spacecraft respectively, as well as to protect the Earth's population in case of reentering debris".

Recent developments II

- After two decades of international moratorium, in January 2007 China carried out a successful ASAT test, producing about 3,000 cataloged debris in the most crowded region of the circumterrestrial space.
- In February 2008, the US destroyed an uncontrolled and potentially hazardous satellite a couple of weeks before reentry (no cataloged debris left in orbit after a few months).
- In February 2009, two satellites collided in low and nearly polar orbits, generating about 2,000 cataloged debris.
- The Chinese ASAT test and the satellite collision, combined, have increased the number of trackable objects in low Earth orbit by over 60%.
- Following the satellite crash, the Joint Space Operations Center (JSpOC) of the US Strategic Command now conducts conjunction assessments for all operational spacecraft in Earth orbit, regardless of ownership or nationality.
- In May 2010, General James Cartwright, vice chairman of the Joint Chiefs of Staff, said it was no longer possible for the US and other countries to keep vast numbers of orbiting satellites a secret.

Nuclear power in space

- Concerning specifically the use of nuclear power in space, widespread concerns prompted the UN General Assembly, in 1992, to approve a resolution establishing criteria for a safe use of such capability.
- However, these criteria were restricted to non-propulsive systems and to current types of technologies and missions.
- We believed that while a comprehensive ban on space nuclear systems in general appeared neither feasible nor desirable, additional "rules of the road" were needed to address current and future safety concerns.
- In such a context, it appeared important to make a clear distinction between nuclear systems operating permanently in low Earth orbit and systems launched from, or assembled near, the Earth, but intended to operate in deep interplanetary space.
- While the former systems should be forbidden, up to a maximum height taking into account the collision hazard with orbital debris, the latter ones might be allowed, provided suitable safety measures or devices were put in place.

The regulation of nuclear systems

- We addressed the question in a series of initiatives and papers during the 1990's.
- Several reasons have been put forward supporting a ban on the operation of nuclear power systems in Earth orbit:
  - No near-term civilian applications are envisaged;
  - The highly radioactive core of activated nuclear reactors, as well as the toxicity of the plutonium used in the radioisotope thermoelectric generators, represent a potential hazard for the Earth environment in case of accidental reentry into the atmosphere;
  - The collision of a small piece of artificial debris with a space nuclear power system could generate a cloud of radioactive fragments, soon dispersed by the perturbations over a large volume of space;
  - The radiation (gamma rays and positrons) emitted by unshielded nuclear reactors in Earth orbit may "blind" the instruments of space observatories devoted to research in gamma-ray astronomy, disrupting the study of this unique window over the most violent phenomena occurring in the universe;
  - The possible military use of nuclear power systems in Earth orbit could stimulate an arms race.

The 1992 UN Resolution

- On 1992, the General Assembly of the United Nations approved a Resolution ("Principles Relevant to the Use of Nuclear Power Sources in Outer Space") establishing guidelines and criteria for a safer use of nuclear power sources in space.
- The set of principles endorsed "applies to nuclear power sources in outer space devoted to the generation of electric power on board space objects for non-propulsive purposes".
- This Resolution was important, because filled a gap in the international law on a critical topic.
- It addressed nuclear power sources having "characteristics generally comparable to those of systems used and mission performed at the time of the adoption of the Principles."
- However, much more capable systems could be developed in the future and the use of nuclear devices for propulsion is recommended for some new space missions.

The additional rules proposed

- Some additional rules could be needed to lessen the safety concerns while taking into account the difference between a nuclear power system operating in a low Earth orbit and a system launched or assembled near the Earth to operate in interplanetary space or far enough from the Earth.
- In our opinion possible measures to be considered included the following:
  - No nuclear power system should be operated in low Earth orbit (maximum height to be defined): in this region of space only the transit of spacecraft carrying nuclear systems will be permitted;
  - Spacecraft carrying on board nuclear power systems could be assembled in low Earth orbit, provided that their final destinations lie outside the forbidden region and an accidental release of radioactive material in the Earth environment could be prevented by safety mechanisms or procedures;
  - The orbits available for an extended stay and operation of space nuclear systems should lie at such altitudes that the interference with experiments dealing with gamma-ray astronomy would be reduced below a threshold to be fixed;
  - Nuclear devices used for propulsion might be activated in low Earth orbit, only provided that the transit time is maintained below a given ceiling and safety devices are in place to avoid the accidental contamination of the environment.

The situation

- We presented *The Regulation of Nuclear Power Systems in Near-Earth Space as a CBM Aimed at Strengthening International Security*, Intervention in the ad hoc Committee on the Prevention of an Arms Race in Outer Space, Geneva Conference on Disarmament, 8 June 1993.
- The last launch of a nuclear reactor in Earth orbit occurred in 1988, the year of the *Cosmos 1900* emergency (there is a *de facto* moratorium).
- In the early morning of 18 November 1996, due to a malfunctioning upper stage, the Russian Mars 96 probe reentered over the Pacific Ocean, carrying on board 6 radioisotope generators to produce electricity plus 10 for thermal control, corresponding to a total of about 300 g of plutonium 238 dioxide.
- No pollution of the environment by radioactive material took place.
- On 15 October 1997, the *Cassini* probe, equipped with radioisotope thermoelectric generators, was successfully launched towards Saturn with about 33 kg of plutonium 238 dioxide.
- At present only the launch of a few planetary probes equipped with radioisotope generators is planned or seriously considered.
- The debate concerning nuclear power systems in space is likely to continue in the future, being just another instance of many such dilemmas arising in assessing the risk/benefit ratio from complex technological and scientific endeavors.

« Siamo venuti a conoscenza del Workshop che si terrà a Pisa in onore del nostro comune amico Paolo Farinella. Grande, importante, doveroso riconoscimento per Paolo! Siamo fieri e contenti di questa iniziativa.

Non passa occasione per noi del Gruppo Astronomico, di ricordarlo con affetto e con un grande groppo che ci attanaglia la gola. Simpatia, disponibilità, sono le prime parole che mi tornano alla mente pensando a lui. Questo, senza considerare l'assoluto prestigio e competenza da lui raggiunti in campo scientifico.

Le sarei grato se, ricordando la figura di Paolo, mettesse in rilievo l'importanza che dava alla divulgazione e in particolare i consigli e suggerimenti che dispensava a noi astrofili, nel tentativo di indirizzare la nostra passione alla ricerca scientifica, nel termine reale di queste parole. Cioè non una semplice attività ludico/ammirativa del cielo.

Tutti noi ricordiamo con nostalgia le cenette/conferenze che ci riservava dopo le iniziative pubbliche, in cui era capace di farci sognare ad occhi aperti la dinamica asteroidale, di farci *vedere* con la mente la dinamica degli impatti. Con parole semplici, tra un boccone e l'altro, ci spiegava cose per noi irraggiungibili, anche a causa dei nostri limiti culturali, con una chiarezza semplicemente... illuminante!

Quando una persona se ne va così, lasciando un vuoto tangibile e persistente, credo sia il segno della sua grandezza.

Grande Paolo! Un plauso commosso da tutti i soci del Gruppo Astronomico Viareggio! »

Roberto Beltramini

Presidente del Gruppo Astronomico Viareggio

15 Aprile 2010