INTERACTION BETWEEN SPACE TECHNOLOGY AND SPACE LAW

*Lubos Perek**

Introduction

Developments of space law were triggered, as a rule, by important developments of space technology. The effect, however, has not always been proportional to the cause. In some instances, a technical development, perhaps important but restricted in scale, was followed by a very fast development of space law. In other cases, vast amounts of technical data, achievements and established facts needed a very long time to be reflected in space law or had no effect at all. The reason is that there is a third ingredient in the cause-and-effect process. It is the political will of the international community or of one or more of the leading actors. If the political will was strong at the crucial moment, a solution was found speedily. If it was weak or absent, the question used to return to the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) year after year with the regularity of migrating birds.

A few examples will illustrate the above proposition. If applied to unsolved questions of space law, it could indicate in what cases the missing ingredient is insufficient facts and where a stronger political will could advance space law in the interest of a close and smooth cooperation among states.

The Emergence of Artificial Satellites

The first and the most decisive development of space technology was the launching of the first Sputnik in October 1957. In the course of 1957 and 1958 it was followed by nine other artificial satellites launched by the Soviet Union and the United States. Compared with the frequency of launchings today, it represents an average month's activity. All the first nine satellites were on scientific missions with promises, but not proofs, of feasible and useful applications. This rather meager factual basis was sufficient to initiate a very fast reaction by the international community. An *ad hoc* committee was created in the United Nations as early as December 1958 to deal with outer space matters. One year later, it was transformed into a U.N. General Assembly Committee on the Peaceful Uses

* Astronomical Institute, Czechoslovak Academy of Sciences, Prague; formerly, Chief: U.N. Outer Space Affairs Division; member: IAU, IAA, and IISL.

of Outer Space (COPUOS). Members of the Committee had a wide perspective foreseeing many of the developments that followed.

In April 1961, another event of paramount importance happened: the first flight of man in space. A few months later, a General Assembly Resolution[1] was passed and two years later was enlarged into the Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space.[2] The two documents contain many general legal principles which later appeared in the Outer Space Treaty.[3] They are of a high moral value and correspond to the global character of space activities by giving precedence to global points of view over partial views.

The work done in the law of outer space at that time deserves deep admiration. The power of thought was stronger than the power of facts and experience available. The political will was present. Within a few years, results had been achieved which needed centuries to attain in other fields of international law.

Another example of a fast reaction of the international community to an important step in space science and technology occurred after the landing on the Moon by the first man in 1969. One year later, Aldo Armando Cocca proposed an agreement on the principles governing activities in the use of the natural resources of the Moon and other celestial bodies. The political will, however, was declining at that time and it took more than ten years to conclude the Moon Treaty.[4] Even worse, only very few of the supporters of the Treaty in the COPUOS found their way to sign and ratify it.

The development of space activities and space technology has been spectacular in the last thirty years. Up to the end of October 1989 there were 3,180 launches carrying a total of 3,868 payloads.[5] Between 1,800 and 1,900 payloads were still in orbit at that date but only 200 to 350 of them still active.[6] The number of manned flights is equally impressive. There were 125 launchings with 365 flights by more than 200 astronauts

---

1. International Co-operation in the Peaceful Uses of Outer Space, G.A. Res. 1721 (XVI) (1961).
2. Declaration of Legal Principles Governing Activities of States in the Exploration and Use of Outer Space, G.A. Res. 1962 (XVIII)(1963).
3. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, Jan. 27, 1967, 18 U.S.T. 2410, T.I.A.S. No. 6347, 610 U.N.T.S. 205 (*entered into force for the United States* Oct. 10, 1967)[hereinafter "Outer Space Treaty"].
4. Agreement Governing the Activities of States on the Moon and Other Celestial Bodies - adopted by the U.N. Gen. Assembly on 5 December 1979, *opened for signature* 18 Dec. 1979, U.N. Doc. A/RES/34/68 (1979) (*entered into force* 11 July 1984) [herein "Moon Treaty"].
5. The figures given have been compiled from issues of SPACEWARN BULLETIN up to SPX-432 of October 25, 1989.
6. Kessler, *Orbital Debris Issues*, 5 ADVANCES SPACE RES. 3 (No. 2, 1985); Ducrocq, *Survie de SPOT 1*, AIR ET COSMOS 37 (Dec. 13, 1986).

and cosmonauts.[7] The total time spent by man in space was well over 20 years.[8]

Byproducts of space activities include many dead objects in orbit. These are payloads which had terminated their functions and debris. The total number of dead objects large enough to be detected is at present around 7,000, some decaying everyday and some being generated.[9] The number of debris which are too small to be detected has been estimated at about 8 times the number of trackable debris, *i.e.* at about 50,000 to 60,000 pieces.[10] Though small in size, they move so fast that they can damage an active satellite in case of a close encounter or destroy it in case of a collision.

Definition of Outer Space

This perennial item has been on the agenda of the COPUOS for many years, in recent times under a title counting 47 words. At the most recent session of COPUOS,[11] all the various views have been reiterated, from an opinion that a conventionally defined boundary between air and outer space is necessary or that any object launched into outer space be considered as being in outer space at all stages of its flight when its altitude exceeds 110 km, to the opinion that the need for a definition has not yet been established and that a prematurely adopted definition might complicate and impede progress in the exploration and use of outer space.

The fact is that all launching agencies know where outer space begins. Operators of satellites and authors of manuals, such as the manual for the space shuttle,[12] have used specific numerical values for the "entry surface" or similar concepts for a long time. Also, research workers engaged in the computation of orbits of space objects know where the lowest perigees of orbits lie and at what altitudes space objects can move in orbit around the Earth.

Another fact is that the reluctance of the international community to define the area of application of space law has already led to some difficulties; in the agenda of COPUOS, two entirely unrelated subjects have been linked together, namely the definition and/or delimitation of outer space and the status of the geostationary orbit. The result was a loss of

---

7. A. VITEK, KOSMONAUTIKA 1988, at 61 (Czechoslovak Press Agency, Prague, Apr. 1989).
8. *Id.*
9. NASA SATELLITE SITUATION REPORT (Goddard Space Flight Center).
10. TAFF, ET AL., *Low Altitudes, One Centimeter, Space Debris Search at Lincoln Laboratory's (MIT) Experimental Test System*, 5 ADVANCES SPACE RES. 35 (No. 2, 1985)
11. Report of the Committee on the Peaceful Uses of Outer Space, U.N. Doc. A/44/20 (1989).
12. K. M. JOELS & G. F. KENNEDY, THE SPACE SHUTTLE OPERATOR'S MANUAL (1982).

time and effort in the work of the relevant U.N. bodies and the inability to solve not one but two problems.

This is a case where no amount of reliable scientific data has been able to overcome the lack of political will to come to a solution.

Protection of Science

At the time the technology of rocket flight was developed to a degree allowing the reaching of space, the laws of motion of celestial bodies, and thus the ability to compute orbits of space objects, had been known for a long time. Workable methods of orbit determination go back to the 19th century when they were applied to planets, asteroids, and comets. Those methods had to be adapted to the flight of artificial space objects. In particular, the drag of the atmosphere at altitudes of a few hundred kilometers had to be taken into account. The theoretical basis for space flight, however, was available, thanks to theoretical astronomy.

Since the beginning of the space era, artificial satellites have been used for scientific research, providing opportunities of observation in the ultraviolet and infrared parts of the spectrum, inaccessible from ground-based astronomical observatories. At the same time, the many space objects and radio communications started to interfere with scientific research.

One such interference is radio pollution which poses a threat to radio astronomy. Ground-based radio telescopes can be built at remote sites to avoid interference from radio traffic between ground stations. But on the surface of the Earth there is no hiding from signals coming from a satellite when it passes over the horizon. Moreover, some satellite systems used for navigation purposes have several satellites distributed in the sky in such a way as to have at all times and at all places of the globe three or four satellites over the horizon. Frequency bands which are important for radio astronomy are protected within the framework of the ITU (International Telecommunication Union) system of allocating frequencies but there is overspill from strong sources in neighbouring bands and interference from other services sharing bands with radio astronomy. A more efficient protection of radio astronomy might require some legislative action.[13]

Astronomical observatories working in the visible light are facing the problem of light pollution. Street illumination is just as efficient in illuminating the night sky as the streets. About one half of the energy spent in street lights is lost in the atmosphere.

Space debris are another source of interference. Even a tiny object reflects sunlight and produces - under certain conditions - a point or a line on an astronomical photographic plate or affects measurement with a

13. Cohen, *The Threat to Radio Astronomy from Radio Pollution*, 5 SPACE POL'Y 91 (1989).

light detector. Such traces may lead to misinterpretation or to loss of unique observations. The scientific community expressed its concern on several occasions.[14] A speedy tackling of this problem by the legal community is highly desirable.

Satellite Communications

The first experiments with active communication satellites were performed in low earth orbit. They were very successful but the low orbit allowed only short times of transmission at each overflight. Therefore, in the 1960's, the proposal by Arthur C. Clarke[15] was followed. Clarke had suggested, as early as 1945, the placing of three satellites into the geostationary orbit at regular intervals in the equatorial plane. The satellites would form a system reaching ground stations on the entire globe with the exception of high-latitude regions. Under the present systems, sometimes more than three satellites are used for global networks, such as INTELSAT; sometimes one satellite is used for communications within a continent or across an ocean. There are close to 200 communication satellites in the geostationary orbit and their numbers are growing fast.[16] There are plans, notified to the International Frequency Registration Board, to launch over 500 satellites within the next five years.[17]

In addition to communications transmitted by satellites between points on the ground, communication links are vital for the operation of all satellites. Ground-to-satellite communication is used, *inter alia* for transmission of commands, while satellite-to-ground links are used for receiving information on the activities and state of the satellite.

Thus, satellite communications are indispensable for the correct function of any satellite. The regulation and coordination of this vast area has been taken up by the International Telecommunication Union because it had dealt with radio communications before. The problem of avoiding harmful interference between a newly introduced satellite system and all systems already in use has been successfully solved. The regulation appeared in the ITU Convention,[18] in the Final Acts of several World

14. *Environmental Effects of Space Activities Report by COSPAR and the IAF*, U.N. Doc. A/AC.105/420 (1988).
15. Clarke, *Extra-terrestrial Relays*, WIRELESS WORLD 305 (Oct. 1945).
16. This information was compiled by examining the sources listed earlier in notes 5 & 9, *supra*.
17. Data gathered from relevant tables in the 27TH REPORT BY THE INTERNATIONAL TELECOMMUNICATIONS UNION ON TELECOMMUNICATION AND THE PEACEFUL USES OF OUTER SPACE (Geneva 1988).
18. International Telecommunications Convention (Nairobi 1982) (*entered into force for the United States* Jan. 10, 1986).

Administrative Radio Conferences[19] and in the extensive Radio Regulations.[20] The ITU, however, declined to assume a wider role in regulating space traffic, although the technical expertise of its consultative body, the Comite Consultatif International des Radiocommunications (CCIR) was adequate for the purpose.

It is of interest to note that the ITU Radio Regulations contain definitions of several terms frequently used in papers on the law of outer space, such as "Satellite," "Spacecraft," "Orbit," "Geosynchronous Satellite," "Geostationary Satellite," "Deep Space," etc.[21] The definition of "Outer Space" does not appear in the list.

The United Nations was involved in a specific area of satellite communications pertaining to direct television broadcasting. The discussions were conducted for a number of years and led to the adoption of a set of principles[22] calling for consultations and agreements on international direct broadcasts. The impression arises that, at present, the attention is shifting to very practical questions of availability and cost of parabolic antennas and other receiving equipment.

Satellite Remote Sensing

Remote sensing satellites have been launched by the United States (LANDSAT), Soviet Union (in the COSMOS, METEOR and OKEAN series), France (SPOT), and India (IRS). Typical is the LANDSAT orbit at about 900 km altitude with orbital elements chosen so as to compensate the annual rotation of the Sun-Earth line with perturbations caused by the flattening of the Earth.[23] The essential characteristic of the orbit, called sunsynchronous, is the crossing of the equator always at about 9:30 local time.[24] Thus, advantage is taken of a better chance of clear skies in the morning hours and morning shadows can be used as an important indicator of ground features.

Remote sensing imagery has been successfully used for studying renewable as well as non-renewable natural resources in agriculture, forestry, land use, mapping, geology, management of water resources,

---

19. I.T.U., World Administrative Radio Conference (WARC) for the Planning of the Broadcasting-Satellite Service (Geneva 1977). *See also* I.T.U. WARC (Geneva 1979), WARC ORB-85 (Geneva 1985) and WARC ORB-88 (Geneva 1988).
20. International Telecommunications Union, Radio Regulations, (edition 1982, revised 1985, ITU Geneva)(hereinafter "ITU Radio Regs").
21. ITU RADIO REGS, *supra* note 20; Final Acts of WARC ORB-88, art. 1, para. 169 (Geneva 1988).
22. Principles Governing the Use by States of Artificial Earth Satellites for International Direct Television Broadcasting, G. A. Res. 37/92 (1982).
23. *E.g.* in W. GILG *et al.*, MISSION STUDY FOR AN OPERATIONAL REMOTE SENSING SATELLITE SYSTEM 61 (Dornier System GmbH, Friedrichshafen 1975).
24. *E.g.* in THE EROS (Earth Resources Observations Center) DATA CENTER 8 (1977).

oceanography, environment, etc. Such studies are of particular importance for developing countries where ground-based surveys are scarce or non-existent.

The discussions in the United Nations concentrated mainly on the problem of third countries getting possibly more information on the sensed country than the sensed country itself was capable of obtaining. A set of principles on remote sensing of the Earth from space has been adopted in 1986.[25] It encourages cooperation between sensing and sensed states and regional arrangements among sensed states. Recently, questions of availability and cost of remote sensing imagery to sensed states have become important.

Applications Without a Specific Legal Regulation

Developments in space technology have not been followed by developments in space law in all fields of application; in satellite meteorology, space technology has been incorporated into all major programs of the World Meteorolocial Organization,[26] research as well as meteorological and hydrological services, but no specific legal regulation followed. Evidently, the global usefulness of the system and the long tradition in freely exchanging meteorological data has made good cooperation possible.

Satellite navigation was discussed in the United Nations in the early years and a working group was created. In 1967, the working group presented a report and adjourned *sine die*. The work continued in the International Civil Aviation Organization and in the International Maritime Organization. The International Maritime Satellite Organization (INMARSAT) is a descendant of these efforts.

Another highly beneficial and efficient system in the field of position determination is the COSPAS/SARSAT system between the United States, the Soviet Union, Canada, and France for search and rescue in case of an accident. The system has already saved hundreds of lives.

Technically very promising is materials processing in space, making use of the very high vacuum and microgravity available on board of satellites. Relevant projects have been run within national or cooperative international programs making thus far no requirement on international regulation.

Large-scale applications such as satellite systems for collecting solar energy and transmitting it to ground stations, or building permanent space settlements, are still rather far in the future. When such projects will be nearing realization, their legal consequences, already discussed in

---

25. *Report of the Committee on the Peaceful Uses of Outer Space*, U.N. Doc. A/41/20, at 24 (1986).
26. Space Activities of the U.N. and International Organizations, U.N. Doc. A/AC.105/358, at 95 (1986).

many papers presented at the Colloquia of the International Institute of Space Law, will assume a more detailed form.

Large international crews on manned long-duration flights will undoubtedly require detailed legal regulation. Up to now, crews have been relatively small, between two to seven astronauts. Since their roles in flight have been well-defined and because close friendship bonds developed in the course of long training, no specific general regulation was required.

Military satellites are being used for many tasks, such as geodesy, meteorology, navigation, communications, early warning, surveillance, electronic and photographic reconnaissance, and antisatellite systems. Some of these systems play a positive role by strengthening confidence among states and verifying compliance with international agreements. Other systems play a negative role. These developments are reflected in international law, in particular, in treaties dealing with disarmament or arms control. They go far beyond what is generally understood by the law of outer space which mainly deals with peaceful uses of outer space. These questions are beyond the scope of these remarks.

Safety of Space Activities and Protection of Environment

As a consequence of the increasing density of space traffic, safety of space activities and the protection of space environment are emerging as important questions. At the 40th International Astronautical Congress of the International Astronautical Federation (IAF), held in Torremolinos, Spain, 7-13 October 1989, for the first time several speakers in the Colloquium on the Law of Outer Space advocated the elaboration of a treaty dealing with these subjects.[27]

The 7,000 trackable space debris and dead objects in orbit and the 50,000 to 60,000 debris which escape detection pose a hazard to active satellites and in particular to manned missions.[28] The hazard was recognized by the scientific community several years ago and has been widely reported in periodicals, monographs, COSPAR (Committee on Space Research) workshops on space debris, and the IAA (International Academy of Astronautics) symposia on safety and rescue. A position paper was published by the AIAA (American Institute for Aeronautics and Astronautics) in 1981.[29] Quite recently, studies have been published by

27. 29 PROC. COLLOQ. L. OUTER SPACE (1990).

28. *See infra* p. 23; *see also supra* notes 9 & 10.

29. SPACE DEBRIS: AN AIAA POSITION PAPER (July 1981) (PREPARED BY THE AIAA TECH. COMM. ON SPACE SYSTEMS).

the European Space Agency[30] and by a special working group for the USA National Security Council.[31]

In the United Nations, COPUOS requested the IAF and COSPAR to prepare a study on space debris which was before the 1989 session of the Scientific and Technical Sub-Committee. There was also a proposal by several states to put the issue of space debris on the agenda of the Sub-Committee. COPUOS considered it essential that more attention be paid by Member States to the problem of collision with space debris and other aspects of space debris. The Committee called for the continuation of national research on this question. Thus, in spite of the wealth of information, there has been no significant action by COPUOS. Let us recall the years 1959-1961 when rather meager data were sufficient to trigger the work on the Outer Space Treaty.[32] This time, the political will to deal with the problem of space debris has not yet emerged.

A similar reluctance had appeared earlier at the ITU World Administrative Radio Conference on the Use of the Geostationary-Satellite Orbit. At the first session, in 1985, a request was directed to the CCIR to prepare a report on the subject of space debris. The Report,[33] very brief and rather lukewarm,[34] was put before the second session of WARC ORB in 1988 but no action on the report appeared in the Final Acts of the Conference.[35]

The situation as regards space debris is typically ecological. The collision probabilities and the pollution of outer space are still fairly small and a legal instrument would not bring about many cases. However, the numbers of debris are steadily growing and the collision probabilities keep increasing. When the day comes that the risk will become unacceptable, it could be too late to do anything about it. The error in allowing the pollution of the world ocean to get out of control will quite possibly be repeated in the case of pollution of outer space by debris. It would be tragic, if we had to wait for an accident to make us aware of the problem. All the facts, all the studies and all the knowledge needed for tackling the problem are already before us.

In fact, one accident involving space debris has already happened and led to the introduction of an item dealing with space safety in COPUOS. It was the malfunction of COSMOS 954 and its subsequent disentegration over northern Canada in 1978. In the years that followed, the item on

---

30. SPACE DEBRIS: A REPORT FROM THE ESA SPACE DEBRIS WORKING GROUP ESA-SP-1109 (Nov. 1988).
31. REPORT ON ORBITAL DEBRIS BY INTERAGENCY GROUP (SPACE) FOR THE NATIONAL SECURITY COUNCIL (Washington, D.C. 1989).
32. Outer Space Treaty, *supra* note 3.
33. PHYSICAL INTERFERENCE AT THE GEOSTATIONARY SATELLITE ORBIT, 1986, CCIR Report 1004 of 1986 to WARC-88, paras. 2.15 & A.2.15 (Geneva 1988).
34. Perek, *Safety in the Geostationary Orbit After 1988*, Paper IAA-89-632, I.A.F. Congress (1989).
35. I.T.U. Final Acts, WARC ORB-88 (Geneva 1988).

nuclear power sources has been discussed in COPUOS. The progress achieved so far is encouraging and an agreement could be reached soon. There is, in addition, a shortcut to a most desirable solution: a ban on the use of nuclear reactors in the near-Earth outer space, as proposed by the Committee of Soviet Scientists Against the Nuclear Threat and by the Federation of American Scientists.[36] The proposal is based on the fact that nuclear reactors in Earth orbit are not used for peaceful purposes. The use of nuclear reactors could, however, be permitted in deep space where no alternative sources of energy are available.

The question of the use of nuclear power sources in space is just a part of the general question of safety of space activities and protection of space environment. It is unavoidable to deal with the general question, not with only a part of it. The following items, and possibly others, should be included:

- Coordination of satellite communications (already dealt with by the ITU),
- Collision avoidance through partial traffic separation,
- Removal of inactive satellites from low orbits by speeded up decay or by landing,
- Removal of inactive satellites from the geostationary orbit into disposal orbits,
- Minimizing the amount of debris,
- Avoiding unintentional explosions of space objects and prohibiting intentional explosions,
- Restricting human error and technical malfunction,
- Improving the information flow on motions of space objects, and
- Minimizing pollution of the atmosphere.[37]

A new international treaty on the subjects listed above would solve the matter. A less ambitious, but possibly equally effective, alternative has been proposed by N. Jasentuliyana.[38] A group of experts could agree on international standards and procedures as it is done in other fields. The Radio Regulations are a good example. The least that the international community could do is to adopt relevant recommendations in COPUOS. This modest step would go a long way toward increasing safety of space activities and reducing the danger posed by space debris. It can be

36. *Joint Proposal to Ban Nuclear Power in Earth Orbit*, 4 SPACE POL'Y 262 (1988); Aftergood, *Towards a Ban on Nuclear Power in Earth Orbit*, 5 SPACE POL'Y 25 (1989).

37. For details, see Perek, *Traffic Rules for Outer Space*, 25 PROC. COLLOQ. L. OUTER SPACE 37 (1983).

38. Jasentuliyana, *Environmental Impact of Space Activities: An International Law Perspective*, 27 PROC. COLLOQ. L. OUTER SPACE 395 (1985).

expected that launching agencies and operators of satellites, being in responsible hands of governments, would comply with measures of universal benefit, even without a strict obligation to do so. A minimum of political will of the international community is indispensable. Let us hope it will emerge soon.