ENVIRONMENTAL IMPACT OF SPACE ACTIVITIES AND MEASURES FOR INTERNATIONAL PROTECTION

*HE Qizhi**

The rapid development of space technology has created opportunities for enormous benefits to mankind. However, problems involving environmental impacts of space activities and concern for the protection of space environment are growing and will continue to grow in the space community.

Space law already recognizes the rights of states to explore and use outer space, including the moon and other celestial bodies. Since outer space activities are carried on from the earth's surface to outer space through the air space, they are a source of potential harm to the environment on earth's surface, in the air space and outer space. In approaching the subject of environmental protection, it must be remembered that the whole vertical space is indivisible, independent of disputes over the boundary between the air space and outer space.[1] Space activities have brought about different environmental impacts. In some cases the consequences are insignificant, while in others they may be serious. The existing space law though containing some general principles and certain specific rules regarding the prevention of environmental hazards, does not provide for adequate protection. It seems appropriate to make an overall examination in order to ascertain whether or what kind of measures should be taken to cope with the risks and harms brought by space activities.

Environmental Pollution

Since space activities must utilize existing elements in and release undesirable elements to the environment, they cause pollution-contamination in various degrees in different parts of the space environment. The term "pollution-contamination" here is used to denote an excessive presence of elements, substances and manmade events

* Member of Governing Board of the Chinese Society of International Law; Member of Board of Directors of the International Institute of Space Law; Corresponding Member of the International Academy of Astronautics.

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1. Gal, *Indivisibility of Environmental Protection in Vertical Space,* PROC. 27TH COLLOQ. L. OUTER SPACE 388-389 (1985).

resulting in adverse effects and detriment to space activities and the environment. Such adverse effects may be physical and tangible, or they may be nonphysical and intangible.

1. Chemical Pollution.

A spacecraft, while launching, produces a so-called "ground cloud" consisting of exhaust gases, cooling water, sand and dust, etc. At the present levels of launching, the resulting air and ground pollution pose no grave danger. But if launching activities increase greatly--for instance, if solar power satellite systems consisting of tens of satellites were developed--they would pollute the air and water around the launching site in a short period of time.[2]

The most affected part of space environment is the upper atmosphere where only very rarefied natural gas exists. It would be very difficult to mix up and dilute even a small amount of released exhaust gases and substances which could stay for a long time and spread horizontally over a large area. The chemical releases from spacecraft are mainly composed of nitrogen oxide, carbon dioxide, chlorine and hydrogen chloride, the latter two having a depleting effect on the ozone layer, which is situated about 16 to 48 km. above the earth. The ozone layer, by absorbing the sun's harmful ultraviolet rays, constitutes a very important protective ring around the earth. In an attempt to protect the ozone layer from depletion by the chlorine of chemical industries, the Vienna Convention for Protection of the Ozone Layer of March, 1985 by 20 countries[3] and the Montreal Agreement Protecting the Ozone Layer from Chlorofluorocarbons of September, 1987 by 46 countries[4] were successively concluded. As there are a number of natural and manmade events affecting the ozone layer, the issue must be studied further so as to determine to what extent the flight of spacecraft is an influencing factor.

The above mentioned chemicals and operational water releases may affect the ionosphere situated 80 km. above the earth. By reducing the density of the electrons therein, these elements may change the radiowave-reflecting properties of the ionosphere, thus distorting radio communications. As the atmosphere has a strong tendency to return to normal conditions after disturbances, it would be advisable to find a tolerable limit for each of the impacts on the environment.

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2. Impact of Space Activities on Earth and Space Environment, U.N. Doc. A/CONF.101/BP/4 (1981).

3. U.N. Information Service., Doc. UNIS/912 (1985).

4. *Ten Outstanding World News in the Scientific and Technological Field in 1987* People's Daily, December 17, 1987.

Satellites generally disintegrate upon re-entry due to the high temperature from air resistance. The resulting production of metal vapors can also influence ionospheric conditions affecting radio communication. But the present level of re-entry activities appears to be less than that of meteorites[5] and is not now of critical concern. In the future, if large numbers of satellites would be burned out on re-entry, the contamination of the upper atmosphere might be important. In this case, the introduction of reusable surface-space-surface vehicles would be helpful.

2. *Biological Pollution*

There are two kinds of biological contamination due to space activities:

(1) The risk that terrestrial micro-organisms carried by spacecraft might contaminate space, known as forward contamination.

(2) The risk that extraterrestrial micro-organisms might contaminate the earth. This is known as backward contamination.

In the beginning of the space age, these two kinds of biological contamination were matters of serious concern. Since it appears that the conditions for existence of micro-organisms do not exist on other planets, these dangers are of little immediate concern. NASA, after the Apollo Programme came to the conclusion that there are no infectious substances on objects recovered from the moon, decided to stop further disinfection and quarantine of the crew, spacecraft and lunar materials. However, Soviet space lawyers held the view that this decision should be made only after international consultation with other states possessing appropriate experience and adequate information on space exploration.[6] There is also the fear that biological researchers working with infectious diseases in space may be engaged in an activity which will result in forward contamination.[7] Biological pollution can not be completely excluded in the course of developing space activities.

3. *Radiological Pollution.*

Radiological pollution occurs from emissions of radioactive materials of electromagnetic waves. Since the 1978 incident of the Soviet

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5. The total meteoric mass entering the atmosphere is estimated at 10,000 kg./day. *See supra* note 2, at 8.

6. S.Vinogradov, *Space Activity and Environmental Protection,* in SPACE AND LAW 165-169 (1985).

7. McGarrigle, *Hazardous Biological Activities in Outer Space.* 18 AKRON L. REV. 103 (1984).

nuclear powered satellite, COSMOS-954, the issue of the use of nuclear power sources in outer space has raised worldwide concern. The launching failure or disintegration of nuclear power sources produces radiological pollution, and several such incidents have already occurred. To prevent or at least reduce the dangers brought about by such incidents, a set of legal control measures assuring security will be elaborated by the Legal Sub-Committee of COPUOS.[8]

Nuclear explosion in the upper atmosphere or outer space will play havoc with the space environment. The radioactive fallout will travel over long distances, not only changing the structure of the space environment, but also killing the electronic devices of operating satellites.

The electromagnetic waves produced by high-powered radio transmitters on earth or by satellites in space will generate electric and magnetic fields over large areas which disturb telecommunication of other satellites and adversely affect radio astronomy. Exhaust gas and chemical releases interfere with infra-red astronomy. All these issues are matters of great concern and are being dealt with by ITU.

Finally, laser beams generated from space or earth will also have great impact on the space environment and activities. With intensified militarization of outer space, the development of high energy laser and particle beam weapons will constitute serious threats to the peaceful uses of outer space.

Harms to Space Activities

The greatest threat to space activities has been recognized to be the hazards coming from man-made debris of spacecraft. As early as 1965, a space lawyer pointed out the potential danger of space debris.[9] Since then the space debris accumulated in earth orbits have greatly increased, presenting larger risks of collision between spacecraft and debris.

In space treaties, the term "debris" has not been defined. In general use, "debris" consists of spent space objects,[10] used rocket

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8. He, *Towards a New Legal Regime for the Use of Nuclear Power Sources in Outer Space,* 14 J. SPACE L. 195-212 (1986).

9. Hall, *Comments on Traffic Control,* 31 J . AIR L. & COMM. 1 (1965).

10. There is dispute over the issue whether "debris" covers spent objects. In terms of space law, the term "debris" may be safely assumed to cover spent space objects. But other experts, like Dr. L. Perek, hold that "debris" always implies "something broken up," or "only a part of the whole" and a complete satellite out of fuel and out of control should be called not a debris, but an inactive satellite. *See* Diederiks-Verschoor, *Harm Producing Events Caused by Fragments of Space Objects,* PROC. 25TH COLLOQ. L OUTER SPACE 10 (1983).

stages, separation devices, shrouds, clamps, and all large and small fragments, including the particles remaining after disintegration of a space object. These are man-made products of space activities which, in certain earth orbits, have already exceeded the flux of natural meteoroids which is relatively constant.[11] As a result, the probability of collision between satellites and orbital man-made debris would be greater than for natural meteoroids.[12]

According to figures by the North American Aerospace Defense Command (NORAD), there were 6,746 objects in space orbit, 5,108 of which were debris.[13] The capability of NORAD to track earth orbiting objects is limited. Objects orbiting at 400 km. must have diameters of about 5 cm. to be tracked, while at 1000 km. objects must be at least 10 cm. in diameter to be seen.[14] So the total number of debris, including small unobserved fragments, is much bigger and the issue much more serious than is being shown in the NORAD catalogue.

The main sources of space debris are explosions and collisions of space objects. Both can occur accidentally or by intentional action. Most debris comes from accidental explosions resulting from failures of propulsion systems. Some U.S. rocket explosions known to be the worst satellite explosions occurred shortly after launch, while others occurred years after launch due to explosions of residual self-igniting propellants. Intentional explosions of satellites have occurred through military space activities, particularly the Anti-Satellite Tests (ASATS). The Soviet Union is reported to have conducted 20 tests of an ASAT system, while the U.S. has been carrying on its own tests of airborne ASAT systems.

Another main source of space debris is collision between orbiting objects. Collision and explosion are closely related, as debris ejected from explosion can collide with other objects, thus creating additional debris. Collisions between two space objects can generate hundreds of trackable debris and probably millions of untrackable particles. Thus, the continued testing of space weapons by collision constitute further serious threat to the space environment.

The existence of space debris in earth orbit poses grave danger to operating satellites and space transportation systems. According to one estimate, with about 10,000 trackable objects in space, a large satellite at an altitude where debris is concentrated may have a probability of

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11. *See supra* note 5.

12. Kessler, *Orbital Debris Issues* in 5 ADVANCES IN SPACE RESEARCH 3-10 (2nd ed. 1985).

13. NORAD Catalogue, July 30 1987.

14. Johnson, *History and Consequences of in Orbit Break-Ups* in 5 ADVANCES IN SPACE RESEARCH 11-19 (2d ed. 1985).

collision of 10% over its lifetime and with predicted increase of trackable objects to 20,000 by 1995, the probability of collision could increase to 20%.[15] Satellites which suddenly stop functioning for unknown reasons may have suffered from collisions with untrackable debris. A notable example is Challenger's window being hit by a tiny paint chip during its seventh mission in 1983. The window had to be replaced at considerable costs.[16] Such accidents have repeatedly occurred. Unless proper measures are taken in time, it may be too late to correct the situation in the future.

Relevant Protection Provisions of Existing Treaties

During the past years of use and exploration of outer space, a number of international agreements have been concluded, containing relevant provisions on the protection of the earth and space environment. First among these is the 1963 Partial Test Ban Treaty which prohibits nuclear explosions in the atmosphere and beyond its limits, including outer space.[17] This can be marked as an attempt concerned with prevention of environmental effects of specific human activities in space. The People's Republic of China, though not a party to the Treaty, did solemnly declare that it "had not undertaken nuclear tests in the atmosphere for many years, and will never undertake any more nuclear tests in the future."[18] This statement represents China's positive attitude towards the aim of banning nuclear testing, and avoiding radioactive contamination in space.

The 1967 Outer Space Treaty and 1979 Moon Agreement are two chief documents relating to environment protection. These two treaties protect the moon and other celestial bodies from the environmental impact of military activities by essentially demilitarizing them.[19] But these treaties only partially demilitarize the whole outer space, particularly the near earth space by merely banning the placement of nuclear weapons and "any other kinds of weapons of mass destruction" in earth orbit.[20] Thus they leave the following loopholes: (1) no ban on testing and deploying other space weapons, including ASAT weapons; (2) no ban on warheads carried by strategic missiles on trajectories

15. Jasentuliyana, *Environmental Impact of Space Activities: An International Law Perspective,* PROC. 27TH COLLOQ. L. OUTER SPACE 390 (1985).

16. "Shuttle Hit by Man-Made Debris," Space World, March 1985.

17. For text of the Treaty, see 480 U.N. Treaty Ser. 43-49.

18. Statement by Chinese Premier Zhao Ziyang in *The Chinese People's Conference for Maintaining World Peace,* People's Daily, March 22, 1986.

19. Art. IV, para. 2 of the Outer Space Treaty; Art. III of the Moon Agreement.

20. Art. IV, para. 1 of the Outer Space Treaty.

travelling through outer space; (3) no definition of "weapons of mass destruction". In short, these treaties leave open the possibility of testing, deploying and utilizing space weapons other than nuclear weapons, enhancing the possibility of further worsening of the debris situation.

The 1976 Convention on the Prohibition of Military and Other Hostile Use of Environmental Modification Techniques also contributes to the protection of the environment, since such techniques include any means of modification of the motion, composition or structure of the earth or outer space, through intentional control of natural processes.[21]

After touching upon the military aspect, it is appropriate to focus on specific provisions of environmental protection. Article IX of the Outer Space Treaty obliges states parties to: (1) avoid harmful contamination of outer space or adverse changes in the environment of the earth resulting from the introduction of extraterrestrial matter and (2) enter international consultation if their activities would cause potential harmful interference with activities of other parties. It can be seen from the wording of the provision that it is of a rather limited character, since "harmful contamination" has to be related to outer space, whereas "adverse changes" only refer to effects on Earth's environment because of the introduction of extraterrestrial matter. With regard to consultation envisaged in the Article, this is a very important principle. However, there is a deficiency in that the consultation therein provided is not mandatory, nor is any procedure established or recommended. If the party concerned does not initiate consultation or refuses consultation demanded by other party, it does not constitute violation of the Treaty.

Article VII of the Moon Agreement makes an improvement on the general obligations contained in the Outer Space Treaty. It obliges states parties to: (1) take measures to prevent the disruption of the existing balance of the environment of the moon and other celestial bodies by introducing adverse changes, by harmful contamination or otherwise; (2) avoid harmful effects to the earth environment through the introduction of extraterrestrial matter or otherwise; (3) inform the United Nations of the measures being adopted to prevent the disruption of the existing balance of the environment of the moon and any plans to place any radioactive material on it. In this Article, the prevention of disruption of the existing balance of the environment of the moon is the key obligation of all states parties, and the insertion of "or otherwise" is intended to cover other sorts of contamination. As a whole, this provision of the Moon Agreement on environment protection makes up some of the deficiencies characteristic of the corresponding provision of the Outer Space Treaty.

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21. For text of the Convention, see G.A.Res. 31/72 of December 10, 1976.

The 1976 Registration Convention requires the registering of launchings with the United Nations, but it does not require notification of explosions or out-of-function space objects, nor registration of the type or amount of fuels or exhaust, chemical or radioactive substances, etc., which affect the space environment.

The ITU Convention and Radio Regulations prohibit harmful interferences of space communications and provide two procedures in this respect. The first is notification and registration of frequency assignment in the Master of Register, maintained by the International Frequency Registration Board (IFRB). The other is through coordination by various conferences.[22] But these procedures have been criticized for being inequitable and disadvantageous to developing countries.

The liability aspect of environmental protection had been partially dealt with by the 1972 Liability Convention, which established the launching state's absolute liability for all damages caused by its space object on earth or to aircraft in flight. It also covers damages caused by collision to another space object on condition that such collisions were caused by the fault or negligence of the launching state. According to the definition given in Article I of the Convention, "damage" could cover damage to the environment of the earth as far as this means the surface of the earth under jurisdiction of states. In dealing with the damage caused by the COSMOS-954 incident, Canada based its demands to the Soviet Union mainly on relevant provisions of the Liability Convention and it was settled accordingly by diplomatic negotiation between these two countries.[23] If damage consists of impairment of the environment of air space or outer space, or international public regions, such as high seas, Antarctica, etc., such damage does not seem to be covered by the Convention. This appears to be one of the lacunas which has to be filled by further elaboration.

Strengthening International Protection Measures

Space activities have brought with them impacts on the environment in various aspects, some of which should be more fully ascertained by further observation and study. It is now generally accepted that proper measures should be taken on the basis of a comprehensive and in-depth understanding of the situation. In recent

22. Art. 35 of the International Telecommunication Convention (Nairobi, 1982); Arts. 11 and 13 of the Radio Regulations (1982).

23. *Supra* note 8, at 108-109.

years, discussion on this issue has been brisk[24] and space law circles are going to demand that space legislative bodies direct their attention to this issue for gradual improvement and perfection of a legal framework for protection of the space environment.

As space activities involve the whole space environment, including earth surface, air space and outer space, protection measures have to deal with the whole indivisible vertical space. On the other hand, in view of the fact that impacts on various parts of the space environment are different, the main thrust should be directed to the issue of space debris--the most harmful pollution and which is growing in seriousness. The existing international treaties, though containing some general principles in this respect, are neither complete, nor adequate to cope with the developing situation. For filling this gap, many proposals have been made. Among them, the suggestion of elaboration of a comprehensive international instrument placing emphasis on the issue of space debris to be discussed by both the Scientific and Technical and Legal Sub-Committees is a possible approach. For the envisaged set of rules, the following recommendations might be worthy of consideration.

1. Definition of terminology. In space treaties, legal terminology relating to environmental harms has been "harmful contamination", "adverse changes in the environment", "harmful interferences", etc.[25] But no definition was given, nor any standard or criteria established, thus easily giving rise to dispute over whether a particular activity contravenes the general obligation under the treaty. So, it would be necessary to define the key terminology, such as pollution-contamination and other related terms. Among them, the term "debris" should be interpreted to cover spent space objects as generally understood. [26]

2. Ban on intentional destruction and fragmentation of space objects. The testing and deployment of space weapons, including ASAT and ABM weapons and the flight of strategic missiles on trajectories in outer space would cause explosions and collisions of such weapons leading to an increase on an unprecedented scale of space debris, thus bringing havoc to normal space activities. In view of the welcome signs in the arms talks between the two super-powers, it seems to be time to strengthen this trend and search for some interim agreement for a stop or

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24. Space environment was among the topics of discussion in the 23rd (1981), 25th (1983), 27th (1985) and 29th (1987) IISL Colloquiums on the Law of Outer Space where a number of papers were presented. More recently, the Institute of Air and Space Law of Cologne University held an International Colloquium in connection with the 600th anniversary of the University, entitled "Environmental Risks Arising from Activities in Outer Space - State of the Law and Measures of Protection," attended by space law experts the world over.

25. Art. IX. of the Outer Space Treaty; Art. 7 of the Moon Agreement.

26. *Supra* note 10.

moratorium on the development and testing of any kind of space weapons. Since this issue is of serious concern to all countries, bilateral negotiations between the two super space powers should be supplemented by multilateral negotiations which would encourage and support the bilateral negotiations for a greater achievement. The agreement reached would be the key to arrest the debris issue from becoming worse.

3. Adoption by agreement of practical measures to minimize the production of debris. These measures include: improved design of launch systems, thus limiting the number of loosely attached mechanisms; elimination of unspent fuels, thereby reducing the chance of self-explosion; controlled re-entry and total burn-up in the atmosphere of satellites after completing their function; the use of disposal orbits;[27] and possible "space salvage" or a "scavenging mission,"[28] etc. These measures could be helpful to alleviate the debris situation through concerted effort by space-faring countries and international space organizations.

4. International Expert Group. Such a Group will be composed of well qualified space scientists and technicians entrusted to review, assess and establish standards of environmental effects of space activities. The Group will be provided with necessary data and information before and after launch, concerning type and amount of fuels, radioactive payloads, exhaust gases and other chemicals released in all stages of flights of satellites, as well as explosions, collisions and other causes producing debris, so that after full examination, international standards and recommended practices may be established. The standards thus adopted can be mandatory and should be observed by all states except those having reservations, while recommended practices are intended for states to make best efforts to follow in the interest of protecting the space environment from contamination. Such standards and practices will be subject to review, amendment and updating, and will be annexed to the principal instrument.

5. Further norms of liability. In addition to liabilities as provided in the Liability Convention, the launching state should be held liable for damage to any part of the space environment, including earth surface, air space and outer space. Environmental damage should also cover damage to the common resources of mankind, such as Antarctica

27. As regards disposal orbits, agreement could be made to use specific belts to dispose of spent satellites. Two such belts have been suggested: one between low earth orbit and geostationary orbit, i.e. somewhere above 17,000 km. from earth which is rarely used; the other is beyond the geostationary orbit. *Cf.* Perek, *Traffic Rules for Outer Space,* PROC. 27TH COLLOQ. L. OUTER SPACE 40-41 (1985); Jasentuliyana, *supra* note 15, at 392.

28. Schwetje, *Current U.S Initiatives to Control Space Debris,* 29TH COLLOQ. L. OUTER SPACE 163 (1988).

and the high seas. Compensation thus paid may make it possible to restore the damaged environment to previously existing conditions.

6. *Establishing mandatory consultation regime.* The principle of holding consultation between states concerned before carrying on potentially dangerous activity must be regarded as an indispensable condition for environmental preservation from the harmful consequences of space activity. Article IX of the Outer Space Treaty provides such a principle but it is only of a very general nature. It is not mandatory, nor is any procedure established or recommended. Today, the obligation of holding consultation before carrying on an activity affecting the interests of other states, is in the formation stage in some branches of international law.[29] The envisaged instrument should incorporate the principle of consultation as mandatory. This would have important constraining influences though it might not lead to an agreement.

7. *Strengthening international cooperation.* Article IX of the Outer Space Treaty stipulates: "States Parties to the Treaty shall be guided by the principle of cooperation and mutual assistance, and shall conduct all their activities in outer space, including the moon and other celestial bodies, with due regard to the corresponding interests of all other States Parties to the Treaty." This means all states, particularly the major space powers, should exert their efforts by taking effective measures in the task of protecting the space environment from contamination by space activities. Further embodiment and specification of this principle is of vital importance.

The issue of protecting the environment from contamination from space activities has been put on the order of the day. Because of complicated political and other factors, it has not yet been on the agenda of the Legal Sub-Committee of COPUOS. But the trend in this direction is gaining ground. It has been increasingly recognized that only by taking concerted and effective measures in time will mankind have a reasonable chance to guarantee adequate protection against the hazards brought by space activities.

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29. For instance, Art. V. of the 1982 London Convention on Prevention of Marine Pollution by Dumping of Waste and other Matter, obliges a country, before special permit is issued for discharging certain harmful substances, to consult with both the affected countries and the appropriate international organizations..

LEGAL PROBLEMS POSED BY THE COMMERCIALIZATION OF DATA COLLECTED BY THE EUROPEAN REMOTE SENSING SATELLITE ERS-1

Michel Bourély *

Satellite remote sensing is one of the oldest and most widely used space applications. Like meteorology, it pertains to Earth observation activities which include the study of the globe (soil, subsoil, oceans) and its resources (ores, hydrocarbons, agriculture, forests, fishing). It calls forth several scientific disciplines (geodesy, geology, hydrology, climatology). It has very extensive spin-offs in every field (political, economic and military).

Like other space activities, satellite remote sensing ignores the natural and artificial frontiers of the different States. This entails consequences particularly important, because the States can be observed unknowingly and against their will. Furthermore, the so-collected information can be used or disseminated without their knowledge and thus benefit the observing State as well as third States without the observed States being able to benefit by this information. This situation is aggravated by the fact that the data collected by satellites can be used only after undergoing a complex processing on the ground which requires specialized equipment and technical training not easily accessible to all countries.

In legal terms, this means that satellite remote sensing is, like radio broadcast from space, an activity which poses the difficult problem of reconciling the principle of free exploration and use of outer space with the principle of the States' sovereignty over their territory and natural resources.

The problem is still more complicated by the tendency, which develops continuously in certain States, to give up performing satellite remote sensing activities by themselves and leave them, either as a whole or only in part, to the initiative of nongovernmental organizations or entities. This process is sometimes referred to as "commercialization".

Commercialization is already in existence in several countries:

- in the United States, the "Land Remote Sensing Commercialization Act" dated 17 July 1984 provided for the constitution of a private remote sensing system and the Eosat company was subsequently granted a license for operating Landsat satellites;

* Former Legal Adviser, European Space Agency

- in France, the Spot-Image company was established in late 1981 with a view to using the data collected by the Spot satellite and selling them to the public, an activity which it has pursued since 6 May 1986. A Spot-Image subsidiary was established in the United States under the name of Spot-Image Corp (SI Corp.);

- in the USSR, the Soyouzcarta Company broadcasts the products of Soviet satellites, to an area including select Western countries (Europe, Australia, United States).

Harsh competition opposes these various companies, particularly as regards the photograph definition. This varies from 30 m with the Americans, 10 m with the French, to 5 m with the Soviets. In order to take these differences into account, the United States has just decided to put satellite photographs of "military quality" at the disposal of the public - except where otherwise justified for national security reasons.

Lastly, we must also mention the existence of a project for an Earth observation satellite to be developed jointly by China and Brazil which must be viewed as a commercial rival of the above-mentioned satellites.

In an attempt to find a solution to this difficult and multi-faceted problem, the United Nations Organization has, for more than ten years, made considerable efforts which resulted, not without great difficulties, in the adoption in December 1986 of a Resolution on the principles which should henceforth govern satellite remote sensing activities.

As pointed out before, these activities were first performed by the different States in fulfilling objectives of their own, which were part of their mission to protect the interests of all their nationals.

At present time, remote sensing satellites are built, launched and used in orbit by the States themselves, but in some of these States the data collected by these satellites are processed and disseminated by nongovernmental organizations or entities. The development of "commercialization" will result in all such activities, whether in space or on ground, being performed by such organizations or entities.

It is within this framework that the Programme called "ERS-1" (European Remote Sensing Satellite N 1) must be placed. This Programme is the first in the field to be undertaken by several European countries (joined by Canada). The consequences of the association of several States for this undertaking increases the difficulty of the political and legal problems we have mentioned.

This is why it seems appropriate to study, from a legal viewpoint, the conditions for the consequences of the "commercialization" of data collected by the European Remote Sensing Satellite ERS-1.

To this end, it is advisable to discuss initially the general legal aspects of the problem, before describing those specific to the ERS-1 programme.

I. GENERAL LEGAL ASPECTS

The general legal aspects of the problem posed by the commercialization of data collected by the European satellite ERS-1 are, first of all, those applicable to every remote-sensing progamme, *i.e.* the compliance with the general principles which govern remote-sensing activities. It is also advisable to consider the principles applicable to the commercialization of space activities.

A. General principles of remote-sensing activities

The first principles governing the execution of remote sensing activities were laid down in international law by the agreement signed in Moscow on 19 May 1978 on the transfer and use of data resulting from Earth remote-observation from Outer Space.[1]

This agreement binds the members of Intercosmos, an agency for scientific co-operation among Eastern countries, the aim of which is, in particular "to study the natural environment (of the Earth) through the use of space objects." However, it binds only those who are parties and tends to settle only the situations created within the framework of co-operation organized among Intercosmos members.

The general problem concerning the activities of Earth remote observation from Outer Space could be solved only within the largest existing framework, namely that of the United Nations. As mentioned earlier, it took more than ten years of discussions within the Space Committee before the General Assembly of the United Nations could adopt on 4 December 1986, Resolution 441/65 which sets forth these principles.

In fact, the Resolution uses the term "remote-observation" only in its title while, in the text itself, it uses the term "remote-sensing" which is defined in Principle I(a) as "[t]he observation of the Earth surface from space, using the properties of electromagnetic waves emitted, reflected or diffracted by the observed bodies, for the purpose of improving the management of natural resources, parcelling out the territory and protecting the environment." Sub-paragraph (e) of the same Principle defines remote-sensing activities as "[t]he activities consisting in operating remote-sensing satellites, primary data receiving and filing stations as well as the data processing and processed data interpreting activities." These technical expressions "primary data", "processed data", as well as the term "analyzed information" are also defined in subparagraphs b, c and d of Principle I of the Resolution. This would

1. The following countries are parties to the Moscow Convention of 19 May 1978: the German Democratic Republic, Cuba, Mongolia, Poland, Rumania, Czechoslovakia and the USSR. Gál, *Legal Principles of Remote Sensing in the Moscow Convention of May 1978,* in PROC. 38TH COLL. L. OUTER SPACE 2 (1987).

indicate that the authors of the text were very anxious to set the Principles on a strong and realistic technical basis, not on theoretical considerations of a political or legal nature. On the other hand, it should be noted that the scope of the Resolution does not cover only the "outer space" part of remote-sensing activities, but also their "ground" part which, incidentally, seems to strengthen the point of view of those who are in favour of a "functional" instead of "physical" definition of outer space.

This article is not intended to comment on the fourteen other Principles included in the Resolution, the aim of which is, if not to resolve the conflict between the notion of freedom and that of sovereignty, at least to propose a compromise as regards their application.[2]

However, it must be kept in mind that a United Nations' Resolution cannot be considered as affording a final solution to this conflict since the legal value and the mandatory character of such texts are, at least, controverted.

Moreover, we know that recourse to the entry of "Principles" in a Resolution occurs only as a last resort where members of the UN Outer Space Committee have not been able to agree on the idea of preparing a Treaty.

However that may be, it is obvious that the Principles entered in the Resolution - which was adopted unanimously by the General Assembly - should be applied by every State, since they have become an integral part of the international law which Article III of the Treaty dated 27 January 1967 compels these States to observe. There must be no doubt about that as regards the States participating in the ESA, ERS-1 programme, which are all Parties to the Outer Space Treaty.

B. General principles on commercialization

One of the fundamental rules laid down by the Outer Space Treaty is the affirmation of the States' international responsibility for the fulfilment of space activities, whether these activities are undertaken "by governmental agencies or by non-governmental entities". Under Article VI of the Treaty, such activities must be authorized and continuously supervised by the appropriate State party to the Treaty. This article thus acknowledges the lawfulness of the space activities undertaken by non-governmental entities or organizations - activities usually referred to as

2. The United Nations' Resolution 41/65 of 4 December 1986 contains 15 Principles. Principle I gives a definition of Remote Sensing activities. Principles II, III and IV lay down the general principles of international law which must be used as a basis by the States which carry out Remote Sensing activities. Principles V to IX contain an incitement to international co-operation. Principles X and XI aim at protecting the environment and preventing natural disasters. Principles XII and XIII relate to the rights of the observed States. Principle XIV affirms the international responsibility of the States and Principle XV deals with the conciliatory settlement of disputes.

"commercial activities." But these activities are subject to the authorization and continuous supervision of the State to which the entity or organization in question is answerable. The State must ensure that "national activities are carried out in conformity with the provisions" of the Treaty, thus stating its international responsibility.

Last, it must be kept in mind that Article VI stipulates that in case of activities carried out by an international organization, the responsibility for compliance with the provisions of the Treaty will rest with this international organization and the States parties to the Treaty which belong to the aforesaid organization.

Thus, for the above-mentioned reasons, all remote-sensing activities which can be referred to as "commercial activities" must be fulfilled in compliance with the principles laid down in the United Nations Resolution dated 4 December 1986.

It should be noted that this is true whatever the nature of these activities, *i.e.* whether they take place in space or on earth. This is true whether these activities are carried out directly by a State or an intergovernmental organization, or by a nongovernmental organization or entity under responsibility of the appropriate State.

II. LEGAL BASES OF THE ERS-1 PROGRAMME

The ERS-1 is a European Space Agency programme which allows the satellite it intends to build and operate to be called a "European" satellite. But this term must not be given a strictly geographical meaning. It is used only because the programme is carried out under the conditions specified in the Convention providing for the establishment of a European Space Agency.[3]

One of the characteristics of this Convention is that it makes it possible for the Member States - which must mandatorily participate in a scientific programme - to carry out, jointly and within the framework of the Agency, optional programmes in the field of space applications. These optional programmes are carried out according to the rules laid down by the Convention itself in their main lines, but likely to be adapted to particular circumstances.[4]

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3. The Convention establishing a European Space Agency was signed on 30 May 1975. It came into force on 30 October 1980.

At the present time, the European Space Agency (ESA) includes 13 Member States: the Federal Republic of Germany, Austria, Belgium, Denmark, Spain, France, Ireland, Italy, Norway, the Netherlands, the United-Kingdom, Sweden and Switzerland, and well as an Associated State, Finland. Canada is bound to ESA by a co-operation agreement and participates in several optional programmes.

4. Article V.1 (b) and Annex III of the Convention establishing the European Space Agency. For more detailed information about the optional ESA programmes, see Bourély, *Institutional Arrangements for Space Cooperation in Europe,* in PROC. 24TH COLL. L. OUTER SPACE 159 (1981).

Such is the case with the development of the ERS-1 satellite. It is advisable to outline the technical aspect of this optional programme before discussing the legal rules with which it must comply. We will intially consider only the "R & D" aspect of the programme, since the use of data collected by the satellite falls under different rules which will be discussed in the third and fourth parts of this Article.

A. General framework for optional programmes of ESA

The system dealt with by the Convention is based on the fundamental idea that optional programmes are programmes specific to the Agency itself. Thus, the Agency supplies the framework in which they are implemented, using the necessary personnel and facilities (establishments and general-purpose installations). On the other hand, these programmes are financed only by those member States desirous of doing so. These are called the "Participants". Hence it follows that only the latter will have a say in the decision-making process concerning these programmes.

To implement this dual principle, the Convention provides for the involvement of three legal instruments:

(a) A *Resolution of the Council* (called "Empowering Resolution" by which the Board agrees that the planned optional programme will be implemented "within the framework of the Agency");

(b) A *Declaration* subscribed by the ESA member States desirous of undertaking the framework of an optional programme jointly and within the Agency. The draftsmen of the Convention proposed to encourage such programmes by stipulating that each member State is to participate in each optional programme, unless it has positively specified that it is not interested. Each Declaration contains a number of articles describing the Participants' commitments. It is complemented by two appendices, a technical one giving a more or less detailed description of the programme, its objectives, its timescale, its phases, *etc.*, and a financial one fixing a budget allocation for the implementation of the whole programme and determining the scale of contributions. In this respect, two important points must be made:

- the budget allocation is an estimation, but it is binding on the Participants. However, the Participants agree that it can be increased by 20% without the programme being questioned. If the possible overdraft is to be greater than 20%, each Participant will have a right to withdraw from the programme;

- on principle, contributions are calculated on the basis of the Participants' national income, but the Participants are entitled to agree to any other scale for the saving of expenses.

(c) *Implementing Rules* adopted by the Participants, containing the detailed methods agreed to by the Participants for implementing the programme. In particular, the necessary decision-making procedures

(appointment of the competent deliberative body, voting rules), as well as the application - subject to express exceptions - of ESA rules to contractual, financial and other matters. These Rules stipulate the conditions under which some non-member States may be allowed to join the Participants with a view to implementing the programme in question.

It should be pointed out that the Empowering Resolution is voted by the Council (by a simple majority of votes) *i.e.*, by all member States, whereas the Declaration - which is prepared and subscribed unanimously by all Participants - is submitted to the Council only for information. As regards the Implementing Rules, also prepared by the Participants, they must be submitted for approval to the Council whose decision is made by a simple majority of votes.

B. Technical aspect of the ERS-1 programme

Until quite recently, the European Space Agency had not had a remote-sensing satellite of its own and had merely been acquainted with this field by collecting and disseminating in Europe the data supplied by US satellites, particularly Landsats, through its "Earthnet" network.

In March 1982, ESA was authorized to initiate its first programme intended to develop and build remote-sensing satellites called "Earth Resources Satellites" (ERS). These will constitute the third generation of satellites of this kind in the Western World. They will complement Landsat (US) and Spot (France) satellites and will contribute to a better monitoring of the environment of the Earth and the exploitation of its resources. They will have an advantage over their predecessors in that they will be equipped with a system of ensuring a quick transmission of data whose processing and delivery will be guaranteed within three hours.

The objectives selected for ERS-1, the first satellite of a series, tend mainly to facilitate the exploitation of coastal oceanic areas (particularly the ice-packed areas), on the one hand, and the development of an improved meteorological information system at the earth scale, through the collection of data on weather conditions above the oceans, on the other. Lastly, ground objectives will be studied by means of an active VHF instrument (AMI) with two operating modes: either in the wind diffusion-metering mode or in the synthetic aperture radar (SAR) mode permitting to scan obliquely a 100-km wide strip of the satellite trace on the ground.

Two other instruments, provided by several participant States, will be added to those provided by the space agency: first, the most accurate scanning radiometer along the path (ATSR), presently available, providing sea surface temperatures, and measuring equipment for distance and speed (PRAREA). The States providing these instruments are financing the associated costs.

Owing to its remote-sensing systems, ERS-1 will enable scientists to follow the movement of oil slicks and icebergs, to study the effect of

acid rains on forests and lakes, the influence of ground erosion on farmlands and, also, to detect areas of geological faults in order to locate places at risk of earthquake. With the use of the data transmitted to the ground, it will be possible to locate continental - and to some extent submarine - ore deposits with accuracy. It will also be possible to locate spawning areas and to follow the growth of cultures.

The economic interest of these various applications is thus obvious and it will be increased to a great extent by the presence of quick data transmission systems on board the satellite.

ERS-1 is currently under construction by the European industry. Its launch by Ariane is scheduled to take place in early 1990 and it will have a two-year life expectancy. The construction of a second satellite, ERS-2, is envisioned and a launch in 1993 is planned.

Lastly, it is worth mentioning that the total cost upon completion of the ERS-1 programme (including launch costs) was estimated to be about 373 million European Currency Units (1 ECU =1 US dollar) in 1982.

C. Legal instruments constituting the ERS-1 programme

All ESA optional programmes comply with general rules laid down by the Convention and complemented by specific provisions. Thus, the ERS-1 programme fits quite naturally with this general framework, within which some adaptations have been made.

The adoption of the various legal instruments relating to the ERS-1 programme took place in successive steps.

At a meeting of the Agency Council, held at ministerial level in February 1977, a Resolution was adopted, placing emphasis on the interest of Europe to engage in a preparatory remote-sensing programme.

By a Resolution of 28 October 1981, the Council agreed to the implementation of a European remote-sensing satellite (ERS-1) programme with the Agency.

The Declaration relating to this programme was made out by the Participant States on 24 March 1982, updated on 16 June 1982 and amended on 19 July 1983. It was complemented by Implementing Rules established July 28, 1983, and approved on 27 May 1982 and amended in October 1983.

The following States have adopted the Declaration and are therefore Participants in the ERS.1 programme: the Federal Republic of Germany, Belgium, Denmark, Spain, France, Italy, Norway, the Netherlands, the United Kingdom, Sweden and Switzerland. Furthermore, Canada, although not an ESA member State, is a Participant in the programme.

The successive steps gone through by these legal instruments resulted from the fact that the Participants wished initially to commit themselves only for a definition phase (Phase B). An additional Declaration dated 11 July 1984, made by the Participants themselves

within the framework of a "Programme Board" allowed the next phases to be initiated (Phases C-D: system development and validation; phase E: preparation and execution of system operation).

Two annexes (A and B) are attached to this Declaration. They update the Technical and Financial Annexes of the initial Declaration. The additional Declaration contains also an Annex C which incorporates the principles agreed by the Participating States in respect to access to the ERS-1 System and of distribution of the resulting data and products. This additional Declaration was updated on 18 September 1985.

At a meeting held in Rome on 31 January 1985, the Ministers decided to "carry on ESA activities sturdily in the field of Earth observation," focusing them on the already-approved ERS-1 project and on future elements, namely, further missions of ERS-1 oceanographic and meteorological applications, a ground application project, the participation in the development of a second-generation meteorological satellite, and mission studies of solid globe physics, the atmosphere and climatology.

These directives were confirmed by the Ministers at a new meeting at The Hague on 9-10 November 1987. They affirmed the objective consisting of: "anticipating a substantial contribution of space and ground techniques to the Earth observation sciences and their applications and preparing, to the extent that it may be required, the setting-up of operational systems and organizations centered on the users for the operation of these systems. The Ministers have therefore stressed the interest for Europe of realizing a fair balance between infrastructure programmes (Ariane 5, Hermes, Columbus, Data Relay Satellite) and utilization programmes, in particular the observation of Earth resources. Moreover, the Ministers considered that the efforts currently made by Europe were: "a source of new possibilities for the private sector which should be encouraged to use the available potential, to participate in investments and assume responsibilities for the operation of such systems."

III. LEGAL ASPECTS OF THE OPERATIONAL PHASE OF THE ERS-1 PROGRAMME

Without elaborating any further on the characteristics of the ERS-1 programme as an optional development programme of the European Space Agency, it is now necessary to consider the legal problems posed by the operational phase of this satellite and to set forth the specific rules agreed to by the States participating in the programme. Additionally, the answer the States have given to the question of intellectual property is touched upon.

A. Specific rules laid down within the framework of the ERS-1 programme

As stated in the initial Declaration, the ERS-1 programme includes a so-called "operational" final phase (phase E) the nominal duration of which is two years. As a result, unlike other ESA programmes in which the developed equipment becomes the responsibility of a user organization once the programme is completed, the Agency itself will at least at the beginning, assume responsibility for the operation of the satellite and the dissemination of its data.[5]

Conscious of the problems that might be raised by this situation, the States participating in the programme have laid down special provisions for the operational phase (phase E). As in the other phases of the ERS-1 programme, the Declaration details the respective tasks and responsibilities of the Agency, and the participating States during this phase.

1. Role of the Agency during the operational phase

As regards the operational phase of the programme, Article 2 of the Implementing Rules stipulates that the Agency "fulfills or co-ordinates" the following tasks:

- raw data recording;
- data pre-processing and processing in quasi-real time, mainly for mission control and management purposes;
- data archiving, preparation and keeping of catalogues;
- elaboration of thematic products in real time;

5. The transmission of equipment developed by the European Space Agency to organizations in charge of its commercial use takes place at the present time in the following file:

- Launch vehicles for the benefit of Arianespace, a "commercial" company under the French law;

- Telecommunication satellites, for the benefit of Eutelsat, and inter-governmental organization;

- Meteorological satellites, for the benefit of Eumetsat, and inter-governmental organizations.

Moreover, in the field of Remote Sensing, the dissemination of data from American satellites (Landsat), connected as part of the Earthnet programme, has been entrusted since 1 January 1987 to a European group of manufacturers, in Eurimage. The establishment of these various organizations intended to assume responsibility for operational activities was agreed to jointly with ESA. However, the ESA Convention (Art. V.2(c)) enables ESA to perform "operational activities" itself such as the operation of the equipment developed by ESA, if the users ask it to do so, which is the case with the ERS.1 operational phase.

- data and product transmission and dissemination;
- mission control and management;
- demonstration of applications.

Moreover, "the Agency remains in contact with national Centres having a thorough knowledge in the field of remote sensing, particularly as regards the elaboration of thematic products in quasi-real time and the demonstration of applications."

Article 4 stipulates that the Agency:

- provides for the installation of the ground sector of the programme;
- determines the methods of data dissemination in quasi-real time to the main user centres of the participating States;
- coordinates the use of the Satellite by all acquisition stations which have access to the ERS satellite as well as the processing of acquired data;
- make necessary arrangements with the participating States as regards the use of their data processing facilities, on common bases ensuring similar conditions for all the participating States.

Lastly, Article 6 of the Regulation entrusts the Agency with the task of placing the contracts necessary for the implementation of the programme.

The institutional organization set up for the operational phase thus duplicates that of the development phase to the extent that the Agency is charged by the participating States to fulfill, on their behalf, a number of functions which would normally be incumbent on them.

As regards the operational phase of the ERS-1 programme, the Agency has designed the architecture of the data processing and the data archiving in a manner that will satisfy the exigencies of a vast community of users, from operators in real time to research groups.

The configuration kept for the ground sector revolves around a central installation set upon the ESA establishment in Italy (ESRIN) where the starting point of the Earthnet network is found. It includes, Processing and Archiving Facilities, or PAF, established in the Federal Republic of Germany, France, Italy and the U.K.

The principal functions of the PAF are:

- long-term arching and processing of raw data and some ERS-1 subsidiary information;
- the creation of geophysical products and autonomous precision, as well as their dissemination;
- the support for the evaluation of long term performances of remote sensors, the calibration and geophysical validation of remote sensors, the demonstration campaign, and pilot projects;
- the interface with the ERS-1 central installation of ERSIN which will be charged with the coordination of the ensemble of PAF installations.

2. The Role of Participating States in the Operational Phase

As a counterpart of the missions they ask the Agency to effect on their behalf, the Participating States take on the commitment to contribute to the financing of the different phases of the program and, in particular, of the operational phase, according to specific rules (Art. 5.2). They also agree to support the financial cost of all obligations that the Agency should incur as a consequence of its international responsibility (Art. 9.1).

However, the Participants reserve the right to exercise a number of prerogatives which are valid for the whole programme:

- the general rules of the Agency in terms of geographic return must be complied with (Art. 6);
- the rights of intellectual property, including access, communication and utilization rights deriving from inventions and technical data resulting from contracts and sub-contracts placed by the Agency for the implementation of the programme, are reserved for the benefit of the participating States and for the benefit of the Agency (Art. 7.1);
- the goods produced within the framework of the programme, as well as the facilities and equipment purchased for its implementation, are the property of the Participants, through the medium of the Agency (Art. 8).

B. Rules applicable to the intellectual property regime

1. General aspect of the problem

As we know, the regime of intellectual property applicable to the data collected by Remote-Sensing Satellites poses very specific problems. First of all, can we really say that the data collected by such satellites can be protected as being subject to the various intellectual property regimes existing throughout the world? If so, which system must be referred to? The regime of the State which launched the satellite, or that of the State where raw data is collected by a receiving station? But as raw data can be used only insofar as it has been processed more or less extensively, what sort of protection must be granted to it?

These questions, which are much discussed in the doctrine, find no answer in the United Nations' Resolution 41/654, the aim of which is only to lay down principles on how to carry out Remote-Sensing activities, and not to solve these kinds of difficulties.

International agreements on the protection of copyrights and the few national laws in existence do not enable us to meet fully and satisfactorily the necessity of properly protecting the legitimate interests of those who receive and process remote-sensing data with a view to