

SPACE DEBRIS - A FUNCTIONAL APPROACH

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Abstract.

So called "space debris" has increasingly been recognized as danger for manned and unmanned operations.

The real danger of space debris is the fact that it moves and therefore functions.

According to its location and locomotion we should distinguish the following:

a) Space debris in orbit (which is the most important location.)

b) Space debris coming down to earth regardless the question whether it was formerly in orbit or not.

c) Space debris moving with more than orbital velocity and therefore leaving the surrounding (and orbit) of our planet outward bound.

All regulations regarding Space debris ought to distinguish between

a) Space debris existing;

b) future debris coming out of a space object already not moving in Outer Space;

c) debris to be caused by a space object not yet launched into Outer Space or even not yet constructed.

If space objects presently operating or yet to be started

can not conceptually be safely returned to earth, such objects might have to be provided with a booster. Such booster would have to accelerate the objects in space to escape velocity before they become inoperable and thus more Space debris.

I. Introduction:

The problems of Space debris have been a topic of many recent discussions. Scientific and legal definition has been tried, and the legal validity of the term "debris" was questioned. It was clearly seen that Space debris caused danger of damages which have not been sufficiently anticipated when the Outer Space Treaty and/or the Liability Convention were drafted (1).

It seems to be in order to examine:

1. What is Space debris; does it have special functions?

2. What are the dangers caused by Space debris?

3. When these dangers consist in possible damages, what can be done

a) to avoid such damages and/or

b) to compensate for them?

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With this an examination of some related legal problems and the attempt of a new approach seems to be justified.

II. What and where and when is Space debris?

1. The definition(s) of Space debris:

a) It has been said that "debris" is a popular rather than a legal term. This is not quite exact. As early as 1963 the "Treaty banning nuclear weapon tests in the Atmosphere, in Outer Space and Under Water" prohibited nuclear explosions, "in any other environment if such explosions cause radioactive debris to be present outside the territorial limits of the state...." (2). (My emphasis).

Although one could possibly substitute the term of "debris" with "junk", "pollutant", "contaminant", "flotsam", "refuse" etc., one should stick to the term "debris" as the most widely used.

Detailed investigations have been made in numerous studies and books like Tanscione & Strother (3), Camboni (4), Baker (5), Reijnen and De Graaf (6), International Bar Association (Thomas ed.) (7), ESA Space Debris Working Group (8), Christol (9), IAA Ad Hoc Space Debris Group, chaired by Mc Knight and Flury (10), the UN (10), Johnson and Mc Knight (12), Schonberg and Walker (13), Schneider, Kitta, Stilp (14), Singer (15), Perek (16), Diederiks-Verschoor (17), Von Traa - Engelmann (18), Sterns and Tennen (19), Frantzen (20), Jasentuliyana (21), Wirin (22), Tennyson (23), Hawk and Grey (24), Gorove (25), Boeckstiegel et. al. (26), Kopal (27), Hintz (28), etc., etc., to mention somewhat arbitrarily only a few

of the important publishings of the last decade, and there exists even a quarterly newsletter regarding Space Debris (29).

b) Space debris might be defined as all artificial objects which move in Outer Space due to the natural laws of motion and which are not under control, thus except active satellites.

Thus, this debris comes out of former Space objects.

c) Although (as mentioned above) radioactive debris has been dealt with nearly thirty years ago, regarding all other possible characteristics of Space debris no great differentiation has been made. This seemed justified to a certain extent because up to now damage by Space debris seems to have been done only through the impact of small particles on a moving space object.

On the other hand, a piece of Space debris may be as big as a whole stage of a rocket and thus be really a huge "component part" of a space object (30).

Furthermore it has not to be legally decided whether (and if not, why not) a roaming particle is in its origin "a space object or a component part of it" (31).

A nut or a screw or a bolt within the constructive framework of a space object obviously seems to be a (component) part of this object. If however due to some misfortune such a bolt etc. is loosened and starts to move in an independent orbit, it might be considered as a particle of "Space debris", although a few moments ago it was a component part of space object. If we apply Pereks

definition (32), it has become Space debris because it is not longer part of an active satellite. By the same reasoning, a whole inactive satellite which still moves in orbit would be a Space debris, although rather large one.

We may have to distinguish between an already existing "blanket contamination" which consists of about " 30 million small particles resulting even from one hit".

On the other hand, there is some "point contamination" by larger pieces of matter (such as the rocket stages, quotes above) (33).

And some point contamination has even acknowledged as "catalogue objects" (34).

I would agree with this reasoning.

2. The Functions of Space debris.

Any object in Space moves. Movement is a basic physical criterion of all three dimensional things in Outer Space. Would its circulating movement be stopped, this would only mean that the said object would fall down, i.e. move from Outer Space towards the planetary surface (or burn up beforehand) (35).

Debris therefore is Space debris as long as it moves in Outer Space. However, regarding its location and its movement important distinctions will have to be made. We might distinguish the following categories of such location and motion.

a) Space debris in orbit. It would move with orbital velocity (36).

b) Space debris coming down to Earth regardless the question whether it was in orbit or not. Such debris would show less than orbital velocity.

c) Space debris moving faster than orbital velocity ie. with escape velocity and therefore leaving the surrounding (and orbit) of our planet outward bound. Such Space debris moving outward might be of less and less danger and thus of less and less importance. For many centuries to come it is probably not necessary to deal with debris which results par exemple from the explosion and/or deterioration of a Space probe flying by outer planets of the solar system and into interstellar space.

d) Furthermore, the direction of a movement in orbit is an important parameter to be considered.

If a space object and a particle of debris do move in the same direction (for instance in geostationary orbit), they still may have different velocities, but only within the width of the spectrum which permits movement in orbit at all. The faster object will rise a little bit, the slower one might decrease its altitude. The difference between the two velocities is of course (physically speaking) small in relation to orbital velocity itself.

If for instance a spacecraft moves with exactly 36.000 kilometers per hour (km/h) and from behind (and a little bit below) comes a particle moving at 36.500 km/h then the velocity of possible impact would be 500 km/h only.

If, on the other hand, one Space object moves in geostationary orbit and a particle has a circumpolar orbit, then the velocity of impact will be orbital velocity itself multiplied by the factor of $\sqrt{2}$ (and about 108 times more than in our first example).

If, finally, a particle of Space debris and a space object move in reverse direction, we would have to add up both orbital velocities and have an impact with 72.000 km/h, being 144 times higher (and therefore more damaging) than in our first example.

One more parameter to be considered is time:

Practically all Space debris has formerly been active satellites and other space objects or component parts of those. Thus we have to distinguish between

- a) Space debris presently existing;
- b) Future debris coming out of a Space object already now moving in Outer Space;
- c) Future debris out of Space object not yet launched into Outer Space or not yet even constructed.

III. The Present Legal Situation (Lex lata).

1. Space debris is a legal issue (as well as a scientific one) because it constitutes a danger in Space (by way of collision or otherwise) for (operating) Space objects and, above all, Astronauts.

It has been suggested that existing Space Law does not deal with the problems of Space debris in particular, and with the damage which it could cause. But that is not so.

2. One of the general principles of recognized international law, one of the principles of customary law as well is the principle "to act in a way that does not harm the interests of other legal subjects" (sic *utere tuo ut alienum non laedas*). There can be no doubt that this principle applies in Outer Space as well (37).

3. Regarding Space Law proper we must realize that the notion of damaging Space debris was not a special topic of the related UN Treaties, Agreements and Resolutions, etc. But a short review of those might be commented as follows (38):

Treaty of Outer Space of Oct. 10, 1967:

Art. I. provides the freedom of access (for exploration and use) to Outer Space by all states.

Comment: This access might be impaired by Space debris.

Art. VI., as often discussed, states the international responsibility of State Parties to the Treaty for national activities in Outer Space.

Comment: If such activities cause Space debris, States are responsible.

Art. VII. writes down the international liability for damage to another state party to the treaty by a launching state.

Comment: This might include damage by Space debris.

Art. VIII. is basis for the retention of jurisdiction and control over Space objects and requests the return of those or their component parts to the state of registry.

Comment: The possibility of derelicting Space objects by the ownerstate is not mentioned. It was obviously presumed that each state wants to maintain such ownership.

Art. IX. requests consultations in case of potentially harmful interference with activities on other State parties.

Comment: Now that we know that Space objects tend to turn into debris and might therefore cause rather soon harmful interference with activities of other States, such consultations might be necessary before any future start of a Space object.

b) The Liability Convention of Oct. 9, 1973, defines in its Article I the term "damage", although (of course) only "for the purposes of this convention". It defines "damage" to mean loss of life, personal injury or other impairment of health; or loss of or damage to property of states and persons.....

The same Article states that the term "Space Object" includes "component parts" of Space objects as well as its launch-vehicle and parts thereof.

Art. III. states such liability regarding Outer Space only in case of fault.

The Comments to the Space Treaty seem applicable.

c) The "Registration Convention" of Sept. 9, 1976 repeats in its Article I. that a Space object includes the component parts of it, etc., and that a Space object which is to be launched into orbit or beyond has to be registered with the UN Secretary General.

Comment: Space debris thus comes out of formerly registered Space objects.

d) The Agreement regarding "Space Station Freedom" of Sept. 29, 1988, states in its Art. 5 (2) that "each partner shall retain iurisdiction and control over the elements it registers according to the annex of this agreement."

The said annex lists "elements like habitation module payload accomodation equipment, module for a manned base, outfittings, maintainance depot and special purpose dexterous manipulator.

Comment: There can be no doubt that such elements are component parts of Space Station Freedom which in itself is a Space object.

e) The Intelsat - Agreement of Feb. 12, 1973, gives in its Art. IV. (a) (iii) the right to "....dispose of property.... "

Comment: No mention is made whether such disposal may comprise abandonment in Outer Space and thus creating Space Debris.

f) Finally, regarding the Agreement between USA, NASA and US Airforce Of Feb. 1, 1983, we find under Art. IV, b.1. that "damage" shall include such damage caused by a release of or exposure to a hazardous substance..."; and lit. c.2. expressedly mentions environmental incidence".

Comment: The drafters of this agreement were obvioulsy aware of the danger, caused by Space debris.

Generally, it is, therefore, not so much the existence of Space debris in itself which

would be prohibited by international law (especially Space Law) but its damaging potential.

But once we have realized that Space debris may cause damage, and as we know that such causing is prohibited by law, we are obliged to redeem this situation.

We have got already the obligation of Debris - avoidance.

Obviously this obligation rests with the launching State. And this will have to take into account the function (and functioning) of the debris particles.

IV. The Functional Approach:

Space debris, as we have seen, is not simply "refuse" like (noncontaminating) refuse on Earth, it is not merely "in the way" and therefore to be disposed of. It takes not merely up room, where it lies around. On the contrary: It moves as we have seen at very high velocities. It cannot be compared to a spent bullet lying on the ground, but it is like a bullet flying astray in the woods, shot by a bad marksman. Space debris is therefore something that functions, and functions in a most dangerous way.

1. The function of velocity:

Space debris may - as we have seen - either

a) move at less than orbital velocity; then it is prone to burn up or to fall down to Earth. This has to be avoided if it constitutes danger of damage to human life and/or property on the planetary surface (39).

b) It might be objects or particles moving with more than orbital speed, i.e. with escape velocity. Such Space debris

finally will either fall into the sun or (with higher improbability) be caught by another celestial body of our solar system, or escape the solar system at all and move into interstellar space.

Obviously such Space debris constitutes practically no danger.

c) The real danger of damage lies in the function of Space debris which moves - as indicated above - with orbital velocity around the Earth. And it continues to move there indefinitely.

The function of this Space debris as potentially harmful is it which demands prohibition and/or protection in a scientific sense of this word as well as in a legal sense.

2. The function of time.

As we also have seen Space debris is either

a) already a particle or particles moving in orbit without any useful function;

b) a component part of a Space Object still operable which therefore in all probability will later on become Space debris;

c) a Space object and/or component part of it which has not yet left the surface of the Earth and possibly has not yet been built or even designed.

3. Legal regulations, therefore, need different approaches. Those might be the following:

a) It may be necessary to either clear Earth orbits from Space debris and/or find other ways - be it shielding - to protect national and inter-

national space activities from such debris. In practice, both measures ought to be applied: Against "blanket contamination" shielding may be necessary; "point contamination" could be removed (40).

b) It may be necessary to legally agree on measures to avoid that existing Space objects and/or their component parts become Space debris in orbit. An additional booster might be added in Space now to such an object and it would accelerate the objects velocity immediatly before that Space object becomes inoperable. Or that booster might decelerate the object and bring it back to Earth without being lost at all.

c) The most urgent regulation, however, is regarding Space objects to be launched into orbit. I propose that they would have to be provided with a device which would bring them safely back to Earth or would boost them into escape velocity or towards a kind of "Debris orbit" before they become unoperable.

And I propose furthermore: This device would have to be specified to the UN Secretary General upon registration according to Art. IV of the Registration Convention by the Launching State. To fail to do this should result in a reversal of the burden of evidences in relation to Art. III of the Liability Convention. A state to violate this obligation would be presumed guilty of fault unless otherwise proved (41).

A stiff sanction? Probably yes. But any *lex imperfecta* would not be enough to prevent that "Titanic Desaster" Judge Lachs spoke about in his introductory remarks.

V. Conclusion:

As we have seen Space debris is causing danger and will increasingly continue to do so. And each newly started Space object will at first be endangered itself by Space debris and finally will become itself such debris, endangering other Space objects.

When we know this, and as we do not want to abandon Space flight altogether, and as we even want to continue manned Space operations, legal regulations must be found for our problems. Space flights do need security. And such security will have to be a legal one as well.

Notes and References:

- (1) i.e. 1967 and 1972;
- (2) Treaty Banning Nuclear Weapon Tests in the Atmosphere in Outer Space, and Under Water of Oct. 10, 1963;
- (3) Space Environmental Hazards, Krieger Publishing Company, announced for 1993;
- (4) Orbital Debris, Scientific Report, Allen Press, Ohio, State University, Research Foundation, 1990;
- (5) Space Debris, Legal and Policy Implications, Nijhoff, 1989;
- (6) Pollution of Outer Space, in particular of the Geostationary Orbit, Nijhoff, 1989;
- (7) Environmental Liability, Graham & Trotman, 1991;
- (8) Space Debris, Report SP-1109, 1988; ESA Publications Division.
- (9) Protection of Space from Environmental Harms, Annals of Air and Space Law, Vol. IV. (1979) p. 434;
- (10) Formulation of an International Position Paper on Orbital Debris, 42nd Congress of the IAF, Montreal, 1991;
- (11) UN Doc. A/AC.105/420 (1988); A/AC 105/409 (1988); A/AC 105/L. 179 (1989); A/AC 105/456 (1990); A/AC 105/420 (1990).
- (12) Artificial Space Debris, Krieger Publ. 1987 and 1991.
- (13) Composite Material Debris shielding for Long-Term Space Structures, IAF Paper 91-282, Montreal;
- (14) Micrometeorites /Debris Protection of the Columbus Specialized Module, IAF Paper 91-280, Montreal;
- (15) LDEF Interplanetary Dust Experiment: IAF Paper 91-285, Montreal;
- (16) Traffic Rules for Outer Space, Proceedings of the 25th Colloquium on the Law of Outer Space, 37, 1983; furthermore Intervention at the 1991 Meeting of the IAA Scientific Legal Liaison Committee;
- (17) Harm Producing Events Caused by Fragments of Space Objects (Debris), Proceedings of the 25th Colloquium of the Law of Outer Space 1 (1983);
- (18) Environmental Hazards from Space Activities: Status and Prospects of International Control, Proceedings of the 25th Colloquium on the Law of Outer Space 55 (1983);
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- (20) Umweltbelastungen durch Weltraumaktivitäten in Boeckstiegel, (ed.) Handbuch des Weltraumrechts, Cologne, 1991, 611 ff.);

- (21) Environmental Impact of Space Activities and International Law Prospective, Proceedings of the 27th Colloquium on the Law of Outer Space, 390, 1984;
- (22) Space Debris and Space Objects, 42nd Congress of the International Astronautical Federation, Montreal, Canada, IISL 91-030;
- (23) Composite Material in Space - Results from the LDEF Satellite, Canadian Aeronautics and Space Journal, Vol. 37, No. 3, Sept. 1991;
- (24) Report of the AIAA, News Conference Oct. 10, 1991: What are the Real Effects of Space - Launch Rockets on the Environment;
- (25) Contamination and the Outer Space Treaty, p. 63, 14th Colloquium on the Law of Outer Space, 1971;
- (26) Environmental Aspects of Activities in Outer Space - State of the Law and Measures of Protection, Institut für Luft- und Weltraumrecht, Köln, 1988;
- (27) Issues Concerning Space Debris, Report of the Chairman IAA/IISL, Scientific Legal Liaison Committee (Topic of "Special Damages"), 1991;
- (28) Weltraumgegenstände in supra (20) p. 176 f.;
- (29) Orbital Debris Monitor, International Newsletter; Fairfax, VA22033, USA;
- (30) Lachs, The Law of Outer Space; Sijthoff, Leyden, 1972, makes clear that jurisdiction of (and responsibility for) Space Objects also covers those parts of the Space Objects which are severed from the main body by unforeseen circumstances (70 f.);
- (31) von der Dunk, Liability versus Responsibility in Space Law, Misconception or Misconstruction? AIAA Paper with permission of author, 33, see also literature quoted under supra (3) to (29);
- (32) See supra (16);
- (33) Satellite Debris Experiment produces surprising results, Space News, Feb. 24; March 15, 1992;
- (34) See supra (10);
- (35) This physical fact might hint towards a solution regarding "Orbit cleaning"
- (36) The Lowest Possible Velocity for a Space Object moving in Orbit is 7900 m/sec. (meter per second). Escape velocity is 12.620 m/sec. and, of course, all higher velocities (I have dealt with the characteristics of velocities problems in Weltraumrecht, Mainz, 1965, based on Saenger, Raumfahrt, technische Überwindung des Krieges, Rohwolt, Hamburg, 1958;
- (37) See supra (32) and literature, quoted there including often cited Trail Smelter Case; the 1972 "Stockholm principles" of the UN

Conference on the Human Environment, etc.;

- (38) The texts quoted are provided in "Space Law and related documents", 101 Congress 2nd Session of the United States Senate, June, 1990;
- (39) See (36);
- (40) See Kopal supra (27); with regard to "shielding", see Session 14 of the 42nd Congress of the IAF, Montreal, 1991 under Chairmanship of Messrs. Klug and Lambert; IAF Papers 91-280 to 91-285, see furthermore supra (34).
- (41) This might be a stiff sanction. But unless we would like to have a lex imperfecta, such a reversal of the burden of evidences might be necessary.