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INTERNATIONAL LIABILITY FOR DAMAGES CAUSED BY PERSONS OR SPACE OBJECTS IN OUTER SPACE OR ON CELESTIAL BODIES TO PERSONS, PROPERTIES OR ENVIRONMENT IN OUTER SPACE OR CELESTIAL BODIES

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Abstract

Does the Liability Convention apply to damages caused to space buildings or bases not subjected to jurisdiction and control of any State because they have been built with local raw materials or to damages caused to space environment? The Convention refers to damages caused elsewhere than on the surface of the earth to a space object of one launching State or to persons or property on board such a space object by a space object of another launching State. No reference is made to damages caused by other means than space object. It does not mention the damage caused to the environment of a celestial body or space itself. Another aspect that must be defined is the referred to the period between the moment the damage is caused and the appearance of its consequences. The term for prescription of the right and caducity of the legal action when the damage is caused in outer space or on a celestial body, must be also established.

Liability on surface and in outer space

The Liability Convention establishes a substantial difference between damages caused in space and those caused on the surface or aircraft or ship navigating. In both cases liability derives in full compensation. But when the damage is caused elsewhere than on the surface of the Earth by and to somebody who has assumed space risks, liability is based upon fault. The Convention establishes the same framework to the damage caused in space as a consequence of a collision of two or more space objects causing damages to a space object of a third party.

When the damage is caused to somebody extraneous to space activities, it must be based upon risk, independently the existence of fortuitous case or act of God. In accordance to this guideline, the only possible exoneration is the victim fault, unless the activity performed by the agent was infringing the principles of the convention or international law, particularly the United Nations Charter.

Those space activities generating damages to the environment, are ruled by art. IX of

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the Outer Space Treaty, which establishes the duty for launching states of taking necessary measures to avoid harmful contamination and any change in the Earth's environment as a result of the introduction of extraterrestrial materials. This is, indeed, a clear provision but, there is no principle guiding the procedure when it is infringed. The same has happened with art. 7 of the Moon Agreement, similar in content and in results, and with the Declaration of Principles on Nuclear Power Sources [1] which principles 3 and 4 attempt to reduce the risk to environment.[2] As it has not been established been the procedure of legal reparation, the principle loses strength. We could say that the lane is drawn but a highway is needed.

Article IX of the Outer Space Treaty establishes not only the principle of preservation of outer space and earth's environment, but also the principles of cooperation and mutual assistance of the State Parties to the Treaty. Cooperation and mutual assistance are revealed through the procedure of international consultations which can be offered or requested by the States Parties, to avoid potentially harmful interference to their space activities. But these consultations are not obligatory.

Dr. Kopal remarks that the Moon Agreement in its art. 7 establishes the obligation for the State Parties to take measures to prevent the disruption of the existing balance of its environment, whether by introducing adverse changes in that environment, by its harmful contamination through the introduction of extra-environmental matter or otherwise. He says the word "otherwise" may include the pollution of the Moon environment or some of its areas by generation of space debris. Then he asks himself if such pollution be that big to be qualified as "disruption of the existing balance" of the Moon environment.[3]

Furthermore almost all damage due to space debris is caused in outer space, where liability is only imputable in case of fault. Can states be imputed of fault for generating space debris? I dare say they are, because they know that, with their technology, the risk of debris is unavoidable, and in spite this certainty of risk, they persist on their action, although they might reject the result. The measures of mitigation or de-orbiting do not prevent contamination or risk of collision in outer space, they only attempt to withdraw it.

Prof. Williams stated that it is very hard to determine the degree of fault, negligence or recklessness incurred by the space objects in an outer space collision. And, by other side, she recalls it is rather difficult to establish if the damage was caused by man-made debris, or by natural objects, particularly in highly populated orbits, as GEO.[4]

New concept of space object

Dr. Gál pointed out that space objects differ from other things by the specific feature that they are parts of the cosmic space. That is to say, things moving in the universe following astronomical rules. In this sense, he distinguishes between natural — planets, moons, asteroids, etc.— and artificial space objects. From the legal point of view he states that only the man-made can be qualified as space objects. Afterwards he defines the legal approach of space objects as *man-made objects launched into orbit round the Earth or other celestial bodies, or put on the surface of the celestial body other than Earth.*[5]

The nature of a space object is closely linked to the purpose borne in mind for its creation, thus, we can affirm that an object is spatial until it comes back to the Earth's surface and ceases its space functions. If it is no more appointed to accomplish its

natural purpose —space activities— it is no longer a space object from the legal point of view, in spite, that technically it may be still able.

The Liability Convention does not define the meaning of space object when establishing that it *includes component parts of a space object as well as its launch vehicle and parts thereof.* The denomination "object" could refer either to vehicle, satellite, device, tool or even a building. If a damage is caused by part of a space station built with raw material extracted from a celestial body (where no state can exercise its sovereignty), could we say the Liability Convention is applicable?

The Convention considers as a damage the loss of life or injuries to the persons on board a space object that has been collide by other space object. What happens if an astronaut, during an EVA mission, suffers a collision with a space object of another State Party, or if his/her suit is ripped by a space object wreck or space debris? I think the astronaut suit must be regarded as space object, because it is necessary for his/her survival in space, the Moon and other celestial bodies.

Space object could be defined in a future protocol as the *vehicle, launching vehicle and component parts, device, tool or structure or any object capable to perform space activities, to assure human conditions of life or allow the transit of persons throughout outer space or celestial bodies.*

Some damages, as those derived from satellite radiation, sound pollution during launch operations, and space debris, imply difficulties in determining the responsible subject. For these reasons the title of the Convention should be understood as ***Convention on International Liability for Damage Derived from Space Activities*** a protocol should also give the meaning of: space object, astronaut, person permanently settled in space or on celestial bodies and of state of launching.

Res derelictae

Sterns & Tennen express that the removal of a derelict object to a lower orbit for reentry and disintegration in the atmosphere poses a risk of contamination and damage to the Earth's environment. Furthermore, the boosting of a satellite to a disposal orbit may appear to be preferable to atmosphere disintegration, however it does not eliminate the problems of contamination and potential damage. Derelict craft in a disposal orbit above the geostationary ring could remain in space for thousands of years. Moreover, it is foreseeable that the placement of an object in orbit could directly result in a potential hazard to other objects, particularly where the launching authority has failed to make any provision to de-orbit or boost the object at the end of its useful life.[6]

Space debris

Prof. Gorove analyzed if space debris could be considered space objects in accordance to the Convention's definition: "component parts". In this sense, he concluded that it would appear unsound and unworkable within the context of the Liability Convention to regard any "part" of the launch vehicle as a space object and, at the same time, to assert that only a "component" part and not just any "part" of the spacecraft is to be taken as a space object. There is no indication that the drafters ever intended to make such distinction.[7]

I believe that, from the legal point of view, the question resides in establishing if a damage caused by debris could be imputed to the spacecraft from which it has been released. Therefore, it is necessary to determine if a damage caused not by the object itself or its component individual parts, but by a leftover or wreck, whatever its

size is, may be considered as done by the space object. The fleck of paint, metal shavings, or the glass splinter do not belong anymore to the space object, but they would not be there if the space object would not have been placed there before. Consequently, responsibility may be imputed to the state of launching.

The Committee on Peaceful Uses of Outer Space has agreed with the Scientific and Technical Subcommittee that international cooperation was needed to expand appropriate and affordable strategies to minimize the potential impact of space debris. The Committee also agreed that it was essential to pay more attention to the problem of collisions of space objects, including those with nuclear power sources, with space debris, and other aspects of space debris, in accordance with paragraph 32 of General Assembly resolution 51/123.[8]

There are some experiences in retrieval of space objects from their orbit: Debris removal options have been used on a few occasions to date. In the manned space program of the Russian Federation, debris removal has been used through the deorbiting of the Progress supply vehicles and aging orbital stations into oceanic areas (except Cosmos 557, Salyut 2 and the Salyut 7/Cosmos 1686 stations).[9]

Risk is best controlled by limiting the creation of debris through mitigation. Unfortunately, debris mitigation usually increases mission cost. Some debris mitigation procedures have only small impact on mission cost if they are specified early in the development phase. For example, deployment procedures can be designed to prevent ejection of objects.

To prevent explosions, satellite components that store energy can be passivated after end of useful life.[10] Passivation may entail moderate cost during the nonrecurring phase of the mission. Cost during operation should be small. NASA's guidelines for limiting orbital debris recommend that an object not remain in its mission orbit for more than 25 years. Satellites, upper stages, and deployed objects in low Earth orbit can take advantage of the Earth's atmosphere to reduce time spent on orbit. At sufficiently low altitudes, atmospheric drag on the object will cause the object's orbit to decay and result in reentry within 25 years. Vehicles at higher altitudes can perform post mission maneuvers to drop the perigee (orbital point closest to Earth) further down into the atmosphere. Propellant must be reserved for this maneuver. Hence, the cost to satellites is reduced mission life, and to upper stages it is reduced performance. If atmospheric decay is exploited to remove an object from orbit, then the risk posed to the ground by reentry of the object must be considered. At altitudes above 2,000 km, it is not feasible to force reentry within 25 years using currently developed space technology. At this time, it is generally recommended to place vehicles in disposal (often called "graveyard") orbits. Many spacecraft in geosynchronous orbit are already boosted into a higher disposal orbit at end of mission life. The number of objects in the geostationary transfer orbits (GTO) is increasing and is considered to be hazardous to future space activities because of their long orbital life.[11] Some missions may find it necessary to perform collision avoidance. The Space Shuttle has maneuvered to avoid collisions with other objects on several occasions. Regarding satellite constellations, if a potential collision will lead to the creation of a debris cloud that may result in damage to other constellation members, it may be worthwhile to perform a collision avoidance maneuver. In the more distant future, it may be necessary to completely remove all satellites and upper stages from orbit. This will not be possible until new technology is developed to make this feasible.[12]

Due to the laws of orbital motion and to physical processes involved in an explosion or collision, fragments are not spread uniformly throughout a debris cloud. At some locations, spatial density of fragments is much greater than at others. When spatial fragment density is high, the collision risk posed to satellites that fly through the cloud is greatly enhanced. [13]

A 4-mm-diameter crater on the windshield of the Space Shuttle Orbiter was made by a small bit of space debris determined to be a fleck of white paint approximately 0.2 mm in diameter. It was traveling at a relative velocity of 3 to 6 km/sec when it impacted. Debris particles less than 1 mm in size do not generally pose a hazard to spacecraft functionality. However, they can erode sensitive surfaces such as payload optics. Hence, while the spacecraft may survive, payload degradation can still result in mission loss. Debris fragments from 1 mm to 1 cm in size may or may not penetrate a spacecraft, depending on material selection and whether shielding is used. Penetration through a critical component, such as the flight computer or propellant tank, can result in loss of the spacecraft. Debris fragments from 1 to 10 cm in size will penetrate and damage most spacecraft. If the spacecraft bus is impacted, the satellite function will be terminated, and at the same time a significant amount of small debris will be created. In large satellite constellations, this can lead to amplification of the local smaller debris population and its associated erosional effect. If a 10 cm debris fragment weighing 1 kg collides with a typical 1,200- kg spacecraft bus, over one million fragments 1 mm in size and larger can be created. This results in the formation of a debris cloud which poses a magnified impact risk to any other spacecraft in the orbital vicinity, such as other constellation members. At geosynchronous altitude, average relative velocity at impact is much lower than in low Earth orbit, about 200 meters per second = 720 kilometers per hour = 432 mph. This is because most objects in the geosynchronous ring move along similar orbits. Nevertheless, fragments at this velocity can still cause considerable damage upon impact. A 10-cm fragment in geosynchronous orbit has roughly the same damage potential as a 1-cm fragment in low Earth orbit. A 1-cm geosynchronous fragment is about equivalent to a 1-mm low Earth orbit fragment.[14]

By other side, the Report of the Secretariat of Office of Outer Space Affairs (OOSA), states, that the National Aeronautics and Space Administration (NASA) of the United States of America established debris mitigation strategies in the early 1980's by conducting studies to determine how a requirement to de-orbit objects might be implemented in a cost-effective manner. In general, lowering the perigee of the orbit, so that the orbital life is 25 years or less, is adequate to protect the future environment. Such a manoeuvre is effective. France has developed future CNES debris mitigation policies include the following: The launcher may leave in orbit a maximum of one inert object (debris) per satellite launched. All objects left in orbit (whatever the orbit may be) must be made fully passive to prevent any further explosions after the end of the mission. Active elements such as batteries or tanks containing residual propellant must reach a fully inert state after delivering the satellites to orbit. Last stage separations must be clean and explosive bolts and clamps must be trapped to avoid operational debris. Solid propellant perigee kick motors that release aluminum particles are to be avoided. All other stages must naturally reenter the atmosphere or be de-orbited. A special release system has been developed for the upper stage of the Chinese Long

March 4 launcher. This system is designed to release, after separation of the satellite, the residual propellant from the tank and the residual gas from the high-pressure container in the booster, in order to avert the danger of in-orbit disintegration of the upper stage. The de-orbiting technology will be used on the improved Long March 2 launcher to make possible the earlier re-entry of its upper stage. According to a debris mitigation study conducted in China, no measures are required at the design stage for those parts and components of satellites and launcher stages that either do not enter into outer space orbit or are capable of returning to the atmosphere soon after their entry. For parts and components sent into an orbit with a longer orbital lifetime, it is necessary to take measures to tether them with the main object in order not to produce more debris. Whenever possible, China is using recoverable satellites for carrying out scientific experiments in outer space, thereby reducing the number of jettisoned satellites in orbit. The International Telecommunications Satellite Organization (INTELSAT) has adopted the following practices in the region of geostationary orbits (GSO): At the end of their operational lifetimes, INTELSAT will boost its communication satellites into an orbit at least 150 km above the geostationary arc. The intended increase in orbit will be 300 km for the INTELSAT-VI and all later satellite series; INTELSAT will discourage manufacturers of its spacecraft from using designs that jettison spacecraft parts, especially near GSO. For example, solid rocket motor casings and solar array cable wraps will stay attached to the spacecraft. The United Kingdom of Great Britain and Northern Ireland recognizes the unique nature of the geosynchronous altitude and the need to preserve this global resource for future development and exploitation. Consequently, the Skynet family of geosynchronous communications satellites controlled by the United Kingdom have the following operational requirements: For all satellites that are currently in orbit, a fuel budget is allocated that is capable of performing a tri- impulse manoeuvre to a circular orbit with a minimum altitude of 150 km above the geostationary ring at the end of operational life. Design requirements for future series of satellites specify a capability to achieve a minimum altitude of 500 km above the geostationary ring using a similar tri-impulse manoeuvre at the end of operational life. In all cases, in order to eliminate the potential for explosion, appropriate operational procedures will be established to make passive all energetic subsystems when the satellite has been placed in a graveyard orbit. [15]

New possible damages.

The Liability Convention establishes that "damage" means loss of life, personal injury or other impairment of health; or loss of or damage to property of States or of persons, natural or juridical, or property of international intergovernmental organizations. Nothing is said about the damage caused to the environment of a celestial body.

Many things have changed since 1972. When the Liability Convention was approved the only risk of collision in outer space was by means of meteorites. After 28 years "man-made" risks are matter of concern of decision-makers in space activities.

Space debris and nuclear power systems, radiation of satellital origin, and sound pollution derived from launchings, among other factors, cause damage as well, but in such a peculiar way that it is very difficult to establish the origin of the damage and the nature of the cause. Sometimes it is almost impossible to identify the state of launching from a very small debris.

The victim

The provisions of the Convention are not applied to damages caused by a space object of a launching State to nationals of that launching State; foreign nationals during such time as they are participating in the operation of that space object from the time of its launching or at any stage thereafter until its descent [16], or during such time as they are in the immediate vicinity of a planned launching or recovery area as the result of an invitation by that launching State.

The exception is due to the fact that the mentioned persons have assumed the risks of participating in such an activity, as well as the persons that are in the vicinity of a launching or recovery area. This same exception could be applied to the persons participating in a space activity o recovery in a large station or on a celestial body. But what legal framework should be applied to the case of space activities performed by persons born in a space station on another celestial body? Another issue that must be put in clear is if the persons born on a celestial body should be considered as foreigners in order to apply this provision.

When the victim is an astronaut colliding with a space object during an EVA mission, the corresponding principle should be the same as in collision among space objects.

The responsible subject.

The Liability Convention establishes the launching state as the international responsible subject for any damage caused in outer space or on surface or to a ship or aircraft navigating. It also brings about, the meaning of state of launching:

(i) A State which launches or procures the launching of a space object;

(ii) A State from whose territory or facility a space object is launched. This definition is comprehensive of any international organization participating or deciding a launching.

This implies that the launching state assumes international liability for any space undertaking promoted by nationals or residents.[17] To accomplish this principle and to balance state's responsibility and right to control, is important to create registries of operators and launchers.

In space settlements there may be not a state of launching –if we consider the possibility of utilities built with local raw materials where no state has jurisdiction and control. Who shall be liable then for the damages caused? Is it the moment to conceive the individuals liability? The settler not subjected to the jurisdiction and control of any state, shall be liable for the damages caused in the human space settlement? Which shall be the condition of those born in the celestial bodies? It seems that the Charter for Mankind in space may give some answers to this.[18]

The future shall bring new personal legal conditions in space law. The possibility for any person of abandoning Earth, with the mood of a definitive change, and establishing permanent residence at a human settlement on a celestial body or large space station will raise doubts about this person legal condition.

Amendment to the Convention on Registration of Space Objects

The tendency of abandoning space objects or their component parts could be counteracted by introducing the duty of creation of the local registry of space objects. At the present this is not a duty neither it is to notify the Secretary General of the United

Nations all the parameters related to the launched space object.

The suggested amendment could establish the loss of the jurisdiction and control over the space object not registered. or abandoned. This would allow any other state party to retrieve said object or to continue its operation with the same purpose or else. In connection to the liability it should remain in charge of the responsible state of launching, nevertheless, if any other state takes control of the object, the liability would become joint.

These principles may help to prevent the launching of space objects for unlawful purposes (black satellites, i.e.) increasing their costs and financial risks. But any regulation in this respect must be carefully planned to avoid any obstacle to future projects and to establish an adequate control, as well.

Claiming procedure for damages caused by non identifiable means

Whenever a damage is caused by means that turn hard or impossible to determine the state of launching, the procedure established in the Liability Convention for claiming, cannot be carried on. This situation must be solved in a future protocol, in order to give an adequate legal answer to space pollution (by debris, radiation, sound or else).

It has been pointed out that unidentifiable space debris imply a real problem for Law. The solution may be brought by the establishment of a worldwide monitory entity, making data available to all those interested; and an international guarantee fund financed by the active space-faring community through an obligatory contribution for every individual launch. [19]

This international fund would be assigned to compensate damages caused by these factors as well as those damages caused to the Earth's and outer space environments, and affecting undetermined individuals. When the victim is undetermined it has no state able to claim on his/her behalf. Therefore, it is necessary the creation of a special organ to investigate if the damage is due to natural reasons or derives from man-made origin. Once established the latter, a proper and full compensation, could be decided.

Time: relativity and equity.

Prescription and caducity of rights

Time is a factor conditioning the application of justice.[20] Whenever the compensation arrives late, justice disappears.

There may be a difference between time on Earth and in celestial bodies or large space stations. Therefore it is not convenient to establish rigid time parameters with reference to the rights of the victim so not to limit or even avoid a true reparation of his/her damage.

Since his birth, man is prisoner of time. The aim is to ensure prompt payment under the terms of the Convention: a full and equitable measure of compensation to victims of such damage.

The Convention establishes a term of a year to claim a reparation against the state of launching. This period is adequate thinking of a damage caused on the surface or in Earth's orbit. But, what happens with a claim that must be formulated from a Moon Station, a settlement on Mars or, furthermore, a claim for damages caused to a space probe and that have been informed from deep space as produced a year ago, or more?

A future protocol should modify this criterion establishing a period of a year since the damage was caused, the consequences were revealed or, either one or the another, are informed to Earth.

Conclusions

1. The denomination of the Liability Convention should be understood as *Convention on International Liability for Damage Derived from Space Activities.*
2. The concept of state of launching should be redefined and replaced by authority of launching, to comprehend situations where states cannot exercise their sovereignty.
3. The concept of space object should be broadened, to comprehend the astronaut's suit, and any other tool, device or building necessary for the development of space activities, preserving man's life in outer space or celestial bodies, allowing the movements of astronaut in outer space or to repair or reinforce spacecraft fuselage.
4. The concept of damage must be broadened, to encompass those caused by space debris, radiation released by satellites, nuclear contamination and injuries or loss of life of the astronaut during EVA missions.
5. It is convenient the creation of an international fund financed with contributions for launchers, and a Commission for monitoring space activities and the generation of debris.
6. It should be studied the establishment of an international commission for the investigation of space damages caused by undetermined reasons and to elucidate if those damages are due to natural or man-made objects or debris.
7. The Convention on Registration of Objects launched into Outer Space, should be complemented by a protocol, introducing the principle of loss of the jurisdiction and control rights for the state of launching that does not create its local registry, does not inform thoroughly the Secretary General of the United Nations of the space mission parameters, or leaves its space object abandoning its operation and exploitation.
8. In accordance with this last conclusion, The Protocol to the Convention on Registration should introduce the international recognition of jurisdiction and control over the derelicte space object to any state or international authority retrieving it to Earth, assuming its operation and exploitation or after spontaneous salvage, unless express opposition of the state of launching immediately followed by the accomplishment of the duties omitted.

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[2] Ali Akbar Golrounia and Mohsen Bahrami, The Draft of the International Law Association for a Convention on Space Debris (Buenos Aires) Can it Meet the Needs of 21st Century?, ***Proceedings of the 39th Colloquium on the Law of Outer Space,*** AIAA, 1997, p. 223 and ss.

[3] Dr. Vladimir Kopal, Space Debris: a Review of the Current Regulatory Structure, ***Proceedings of the 39th Colloquium on the Law of Outer Space***, AIAA, 1997, p. 343 and ss.

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[7] Stephen Gorove, Definitional Issues Pertaining to "Space Object", ***Proceedings of the 37th Colloquium on the Law of Outer Space***, AIAA, 1995, p. 87-98.

[8] B. Report of the Scientific and Technical Subcommittee on the work of its thirty-fourth session (agenda item 7) and implementation of the recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (agenda item 9 (a))

[9] OOSA Secretariat Report

[10] For example, propellant in upper stages and satellites can be eliminated by either venting or burning to depletion. Batteries can be designed to reduce risk of explosion.

[11] Space Debris ***OOSA HomePage***, UNOV HomePage.

[12] Copyright and Terms of Use, © 1995-1999 ***The Aerospace Corporation***. How Can Risk be Controlled?

[13] What are Debris Clouds? ***The Aerospace Corporation***, Internet site, Copyright and Terms of Use, © 1995-1999, All Rights Reserved.

[14] What Are the Risks Posed by Orbital Debris? Crater on the Windshield of the Space Shuttle; Internet page ***The Aerospace Corporation***,Copyright and Terms of Use, © 1995-1999 The Aerospace Corporation. All Rights Reserved.

[15] Steps Taken By Space Agencies For Reducing The Growth Or Damage Potential Of Space Debris, based on the United Nations document A/AC.105/620.

[16] Now we can ask: where? For the descent can be done on a celestial body or large space station.

[14] In this sense it states in art. II that: A launching State shall be absolutely liable to pay compensation for damage caused by its space object on the surface of the earth or to aircraft flight.

[18] M.M. Esquivel de Cocca, Human Society in Mars: New Legal Needs for a Different Mankind, ***Proceedings of the 35th Colloquium on the Law of Outer Space***, AIAA, 1993, p. 335.

[19] Frans G. Von der Dunk, The 1972 Liability Convention, ***Proceedings of the 41st Colloquium on the Law of Outer Space***, AIAA, 1999, p. 368 and ss.

[20] In this sense, art. XII refers to the principles of justice and equity. These imply a prompt compensation, for a delayed economical reparation would arrive after the original damage worsening due to the course of time, and so, it would never restore the person, natural or juridical, State or international organization to the condition which would have existed if the damage had not occurred.