

SPACE JUNK: DEBRIS OF A DIFFERENT LEVEL

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INTRODUCTION

Those of us who study and analyze environmental problems are now faced with the need to stop looking downwards (soil, water) or around us (air, noise...) in order to raise our gaze towards (literally) higher objectives. Once and for all, we must become aware of a different need: we should no longer restrict ourselves to focus our attention on the near or relatively near damaging effects of human activity to find, without compromising economic profit, solutions to new hazards that come from well above and may seriously affect the lives of future generations: Environmental damage also comes from outer space. In this article we will try to give a brief overview of the legal consequences of launching, monitoring and subsequently abandoning space objects.

1. Definition of Space Object

We can define Space Object as *“any man made device or creation placed in outer space or in celestial bodies for the purpose of performing a space function or activity”*.

It should be noted that neither the Space Treaty, nor the Convention on Liability for Damage Caused by Space Objects or the so-called Registration Convention (see Regulatory Legal Framework below) define the nature of a space object, just stating that its component parts are also included in the concept. That's why we know who launches something into space, but not what is being launched. Undoubtedly, this inconsistency is clear evidence of the paradoxes arising when legal texts have to be negotiated between States and of how much must be given up to allow for the approval of a norm.

It is clear however, that when we speak of space objects, we refer to artifacts of human production aimed at developing a space activity; component parts included; “Components” are different from “fragments” that are pieces or parts of the whole or part of it whose existence assumes that the object has been ruptured.

2. Definition of Space Junk

We can describe the concept of “Junk, Scrap or Space Debris” as *“any object or part of an artificial object, either abandoned or rendered unusable and remaining in the Earth's orbit, in space or in a celestial body”*.

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A report of the [United Nations Inter-Agency Coordinating Committee on Space Debris \(IADC\)](#) defines space debris as all "*non-operational man-made objects, including fragments and elements thereof, in Earth orbit or re-entering the atmosphere*".³ However, this is an incomplete definition, since it does not take into account space debris that is not in Earth's orbit or re-entering the atmosphere. (For example, the remains of moon landings).

This report says that approximately 60 percent of the registered debris is generated by disintegration of space vehicles or rockets. Fragmentation often occurs as a result of remnant fuel explosions or other chemical reactants contained in rocket machinery ⁴

3. Saturation of outer space. Locations. Recent Facts

In order to understand the nature and magnitude of the problem, it is necessary to have a basic idea of the different satellite orbits that exist, depending on their purpose. For reasons of brevity we will refer only to the four (4) kinds of orbits that are useful for the purposes of this article.

Geostationary Orbit

Commonly called **GEO**, it is the orbit where satellites maintain a fixed position with respect to the Earth's surface, at a constant altitude of 36,000 km. Satellites on this orbit appear to be stationary in the sky, making it ideal for telecommunication satellites, as they provide a "repeater" of signal that is always visible from the same terrestrial locations.

The main problem with this orbit derives from the high cost of placing a satellite therein. The GEO orbital positions are allocated to countries through the International Telecommunication Union (ITU, part of the UN) and cost a lot of money, so operators are responsible for leaving fuel to take care of "deceased satellites", which normally implies that they are sent to the so-called "graveyard orbit" (see below), located even further away. But these concerns do not stem from the wish of preventing possible future damages but from commercial considerations: the abandoned slot makes room for a new satellite.

A solution that does nothing but "*kicking the problem forward*", by accumulating in this orbit cemetery a "scrap estate" that our future generations will have to assume in approximately 100 years' time, which is supposed to be the moment from which orbital deterioration would become a problem.

Low Earth Orbit

The Low Earth Orbit (**LEO**) is located between 200 and 2,000 km above sea level and can be as low as 160 km above sea level.

³ A/AC.105/C.1/2011/CRP.14, p. 11.

⁴ A/AC.105/C.1/2011/CRP.14, p. 12.

Seventy per cent of the debris is housed precisely in this strip of space, which also houses the International Space Station, some 350 km high.

Middle Earth Orbit

Satellites in **MEO** (Middle Earth Orbit) are at an altitude above LEO and below GEO. These are orbits suitable for positioning several satellites in constellation form, at the same height, for communications or navigation purposes.

Graveyard Orbit

This is an orbit almost 200 miles farther away from Earth than the farthest active satellites, at an astonishing 22,400 miles above Earth, where "dying" satellites are "buried".

It is estimated that only 7% of the orbiting objects are useful satellites. The remainder are objects left on their own, out of which only around 20,000 orbits have been located and identified.⁵

The biggest problem is posed by space debris scattered in the GEO orbit. Junk not only damages communications satellites by colliding with them, but also interferes with communication signals launched from the surface.

In LEO orbits, scrap metal moves at eight km per seconds, that is, seven times faster than a bullet, making evasive actions difficult.

In 2015, the International Space Station (ISS) suffered an incident of precisely this nature, and in the face of this threat, it was necessary to seal the Station and take measures to eventually abandon it for fear of a collision with an out-of-control former Russian satellite.

Officially, NASA has recorded an average of one piece fall to earth each day, totaling between 50 and 100 tons per year. Fortunately, most of the incidents occur at sea, which occupies 71% of the earth's surface, or in scarcely populated areas such as the Canadian tundra, the Australian desert or Siberia.

But the amounts of fragments of less than 1 m² (size limit of the US catalogue) present in the GEO orbit is unknown. For this reason, several space nations, including Spain, have begun optical observation of the orbital ring (see below).

Relatively small fragments normally disintegrate as they enter the atmosphere, but larger pieces fall at cosmic speed, multiplying their mass weight as a result of acceleration. It is clear that the risks of damage are not only limited to outer space, but also represent a serious danger to the Earth's surface in general. An increased frequency of these falls also increases the likelihood of damage to urban areas.

Numerous incidents caused by the fall of space debris have been registered in countries such as Canada, Australia, Argentina, the United States, the Pacific Islands, and other. With exceptions, most of them fortunately had no consequences, although the seriousness

⁵ https://elpais.com/elpais/2016/06/02/ciencia/1464865448_335730.html

of any of these even small pieces of debris falling on urban areas, nuclear power plants, hospitals, schools, telecommunications facilities, etc., should not be overlooked.

Spain has also been no stranger to this type of incident.

For a two-week period in November 2015, the Spanish sky began to release metal spheres. First in Pozorubio de Santiago, (Cuenca), then in Elda, in Alicante and a few days later, three spheres fell in different parts of the Murcia region. The origin of those fragments, which ranged in size from a few centimeters to four meters in diameter, was clear: they were space debris of unidentified origin.

Even now, as we write this article, we read the news of the forthcoming fall to earth – in early April 2018 - of a Chinese space station (Tiangong-1), which is out of control and may fall on a still not identified point on a significant international geographical strip, but calculations indicate that it is most likely it may fall somewhere in the south of the Argentine Republic,

3. Action Plan: Forecast, Prevention, Mitigation and Removal.

a. The Forecast can only be worrying, mainly because the rate of production of space objects (and, consequently, of future space junk) is not expected to decline in the immediate future.

Due to their obvious value, the LEO and GEO orbits, as well as other regions of space, are under UN protection. But, given the non-mandatory nature of international regulations, its future depends on the measures that each country - and each space agency – may decide to take. Experts urge political intervention in this regard, specially, in the light of the fact that giants such as Boeing or SpaceX have announced the launch of "mega-constellations" of thousands of telecommunications satellites that will be placed in EO orbit (where the signal travels faster), estimating that this army of "mini-satellites" would increase the risk of collision and fall by up to 50%.

b. According to the demands of the United Nations, operators must withdraw their satellites from low orbits in less than 25 years by having them re-enter Earth, but the only measure envisaged so far is to move them into the so-called "graveyard orbit", located at least 300 kilometers above GEO orbit, where the force of earth's attraction is lower. But there are no guidelines for the junk that has been orbiting for decades, which is why complex negotiations are foreseen in the coming years. However, this would require the consensus of all the members of the "[Committee for Peaceful Uses of Outer Space,](#)" *to which 84 countries belong.*

c. Some countries such as France and Ukraine, among others, and the European Space Agency (ESA) have already started to adopt mechanisms to make these requirements mandatory. Warnings of collision hazards are now part of the daily routine of satellite operators. ESA's satellites are moved between once and twice a year. And the International Space Station, one.

d. Junk removal projects.

Switzerland, Spain and the United States as well as ESA (through its [Clean Space Project](#)) have developed various alternatives for removal of about 16.000 objects that interfere with spacecraft or artificial satellites by, for example, in the case of Switzerland, resorting to "de-orbiting satellites" which (estimated to be operational as of this same 2018) could catch debris that may cause problems to other satellites or spacecraft and send them back to Earth or precipitate together with them into the atmosphere, where they will both disintegrate.

Spain has two ongoing projects. On the one hand, it has created its own system for debris removal in the framework of a research project developed at the ETSI of Aeronautics of the Polytechnic University of Madrid and financed by the European Space Agency called "[Ion Beam Shepherd for Contactless Space Debris Removal](#)" through the Advanced Concepts Team, within the [ARIADNA Project](#) program.

At the same time, Spain is also developing a project ([Deimos Sky Survey](#)) to observe and track space objects by means of a network of three telescopes located at the Sierra Madrona Natural Park and Valle de Alcudia (Ciudad Real) that track the sky in search of objects (natural or artificial) that move on the apparently fixed background of stars; they track specific objects that have already been identified or suspected and, finally, they focus on objects of space debris located in or on the LEO orbit.

All these projects coexist with other similar national projects (i.e. the NEE- 01 Pegasus project of the Republic of Ecuador). A unification of efforts seems imperative to achieve greater efficiency in the removal of space debris.

NASA has also developed protocols for reducing and eliminating space debris⁶.

3. International Regulatory Legal Framework

The most relevant legal instrument to date in this area is the [Convention on International Liability for Damage Caused by Space Objects](#) - 1972, (the Liability Convention) derived from the 1967 [Outer Space Treaty](#) (Outer Space Treaty of 1967) that entered into force in September 1972.

This Convention walks together with the [Convention on Registration of Objects Launched into Outer Space](#) (known as the Registration Convention) (adopted by the United Nations General Assembly in 1974 and into effect since 1976. As of December 2017, it has been ratified by 64 states, including the main "launching" States.

Elaborating on the contents of Article 7 of the Outer Space Treaty, the Liability Convention provides that a launching State shall be absolutely liable to pay compensation for damage caused by its space objects on the surface of the Earth or to aircraft, Space and Celestial bodies as well. The Convention also provides for procedures for the settlement of claims for damages.

The set of these rules gives rise to different legal considerations:⁷

⁶ NASA Procedural Requirements for Limiting Orbital Debris (w/ Change 1 - 5/14/09); NASA-STD-8719.14 (with Change 4), U.S. Government Orbital Debris Mitigation Standard Practices

⁷ A/AC.105/C.1/2011/CRP.14, p. 22 y ss.

a. The illegality of generating space debris: in fact, nobody can deny that for the so-called "space nations", space debris is not only an absolutely foreseeable result of their activity, but that they also have the technical possibility of knowing in advance when a space object will become useless junk. Therefore, the fact of abandoning objects at the end of their useful life only aggravates a behavior that we understand is ethically and legally reprehensible. Its predictability makes it punishable as inexcusable (or even objective - see below) gross negligence, the consequences of which can even affect the very State that generates the waste.

This possibility could conflict with the lack of compulsory jurisdiction, the Achilles' heel of public international law. This makes those rules that are not complied with by States that are Parties to a given international convention to actually become "dead letter". However, taking into account the requirements of Article XII of the 1967 Space Treaty, whereby States waived their right to exercise sovereign rights over outer space and celestial bodies, it could be interpreted that disputes arising in outer space matters would make it possible to bring the offending State to trial before special tribunals (not yet created). For this reason, this international agreement grants the State of Registration jurisdiction and control over its objects, mission and crew to assign them the tools that make their liability for damage caused by their objects viable. Such same States waived to enforce the sovereignty that they exercise on Earth, thus validating the principle of congruence: no State can rely on a right it has previously waived. It could therefore be argued that, in space matters, States are subject to mandatory jurisdiction.

b. Obligations to reduce scrap and remedy the environment in which it is located.

On January 24, 1978, a secret Soviet Union spacecraft, Cosmos 954, came out of control. As it contained a small nuclear reactor to power radar antennas and 50 kg of enriched uranium. After identifying itself and following the procedures established in the Liability Convention, the launching State compensated the injured State. Fortunately, there was no loss of radioactivity. But for the moment, this case is an exception.

c. Obligations to participate in collision avoidance and exchange of information;

d. The obligation to participate in the process of active removal and possible recycling of waste; and

e. The need to identify and share the financial burden and technology transfer, pursuant to the principle of necessary international cooperation provided for in the Space Treaty. The latter raises the issues of the responsibility and charging for abandoning space debris and failing to identify and afford protection against risks.

The Liability Agreement provides for the **absolute international liability**⁸ of the launching State for damage caused by space objects to space, celestial bodies, air and water environments and the Earth's surface. What is not clear from this agreement, as

⁸ "Absolute Liability" is understood to include reparation "as if the damage had never occurred *plus* compensating events or developments foreseen or implemented by the damaged party that were frustrated by the damaging event". Conversely, the "Strict (Integral) liability" just looks at providing reparation as if the damage had not occurred"

well as from the Space Object Registration Convention, is the legal nature of those parts of space objects that are unidentifiable by fragmentation.

While space liability is absolute, damage no longer occurs only in outer space. It should therefore be borne in mind when approaching this issue that, at present, the Liability Convention makes the launching State responsible only when there has been fault. In any case, it should be borne in mind that the extent of liability for damages occurring in space or to celestial bodies is subjective, whereas damage occurring in air, water or terrestrial space is objective. But liability will always be absolute.

If the launching State cannot be identified (e. g. because of the small size of fragments that reach the surface of the earth) the damage will, in the current state of legislation, remain unrecoverable.

It was Aldo Armando Cocca, an Argentinean pioneer in Space Law, who provided the possible legal solution to the situation we raise in this article. Cocca suggested that the only thing that could be done in this case would be to create a Fund to be nourished with amounts to be contributed by space nations in proportion to their respective levels of activity; amounts which could be used to compensate damages. In this way, if the launching State cannot be identified, at least those who have suffered damage can be financially compensated. In any event, such fund would come into play only when the spatial nature of the objects causing the damage is clear.

Such solution resembles the contents and goals of the United States of America's [*Comprehensive Environmental Response, Compensation and Liability Act*](#) (CERCLA) in 1980, (known worldwide as the "Superfund") that empowers the Environmental Protection Agency (EPA) to assume the costs of regenerating contaminated soils in those cases where the responsible parties cannot be identified. The European experience stems from from [*Directive 2004/35/CE of the European Parliament and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage*](#) (*The Environmental Liability Directive*). This Directive has already been received into European national legislations and applies strict liability principles to damage caused by Operators of inherently dangerous listed activities (defined as "activities of actual or potential concern" to air water and soil; Operators carrying out dangerous activities listed in Annex III of the Directive fall under strict liability (no need to proof fault). Operators carrying out other occupational activities than those listed in Annex III are liable for fault-based damage to protected species or natural habitats. The establishment of a causal link between the activity and the damage is always required. Affected natural or legal persons and environmental NGOs have the right to request the competent authority to take remedial action if they deem it necessary. For further information, please [*follow this link*](#)

However, we consider that this regime opens the door to the imposition of a strict and unlimited liability for space activity, that can be clearly defined as being "inherently dangerous".

Within the current European regulatory framework, it might even be possible to consider the possibility that those affected by the fall of a space object (for example, the fall of objects witnessed in Murcia, if they had fallen in residential areas) could bring action against the Spanish State on the basis of its own national law, as Spain is a party to the

conventions regulating the launching and registration of space objects or, even, because the country cooperates with third countries in developing space programs, while under the obligation to protect its airspace.

Having said this, we must state that based on Article I of the 1967 Space Treaty (which recognizes all States' right to access, peacefully use and explore outer space), the production of space debris cannot be considered per se illegal. But the production of space debris **can** be considered illegal in some cases; for example, when causing serious or extreme environmental damage or alterations or interfering with the peaceful exploration and use of outer space.

As to whether there is a legal obligation to mitigate the risks associated with space debris, it should be borne in mind that there is no explicit obligation, but there is a principle (set forth in article IX of the Space Treaty) mandating that the environment must be protected, as reflected in which prohibits States from carrying out space activities that may cause harmful pollution of outer space and requires the implementation of appropriate international consultations where there is reason to believe that the planned activity may potentially cause harmful interference to another State. While the standard is primarily aimed at the protection of "outer space", it is clear that space nations have an obligation to take appropriate measures to prevent harm to other States and to areas beyond their jurisdiction and control, or at least, to minimize that risk.

In short, we are referring to the need for due diligence in cases where the risk is obvious.

Assuming environmental damage resulting from the fall of an unnatural space object (e. g. by causing a forest fire), identification of the launching State is equally essential in determining responsibilities.

Applying the "polluter pays" principle in an extensive, strict and comprehensive manner, the international liability regime of launching States should be extended, in order to specifically condemn those States that generate and abandon waste, since this attitude pollutes an environment that belongs to present mankind and will affect future generations to an extent that cannot yet be fully appreciated. We advocate for the creation of a joint spatial and environmental liability system that, in addition to obliging to the total and complete compensation of the damage caused (including but not limited to the obligation to restore the affected system or systems to their natural state) shall prevent the States responsible for abandoning or generating the remains in space, from making future launches for a period of time that could fluctuate between six months and a year. And insofar as technological developments would allow, also consider the passing of regulations sanctioning abandonment as a prohibited practice.

Probably, unless abandonment is regulated as in current maritime or aeronautical law (with the result that another State could appropriate an object that has been abandoned by its State of Registration), such developments would require four essential amendments to the Liability Convention of 1972:

1. Firstly, to include a broad definition of "Victim" or "Damaged Party" specifically stating that liability would also encompass the environment as a subject "capable of suffering from spatial damage"; a definition we understand is not sufficiently clear

(although we believe it would be implicit) in the current wording, which refers exclusively to the damaged "State".

2. Second, to amend the wording of Article 10.1. of the Convention to extend the current limitation period of one (1) year from the time when the facts giving rise to the damage occurred; or from the moment when the injured State could have been "reasonably" aware of the damage, that may become evident long after the harmful event may have occurred, thus giving rise to controversy over what is "reasonable" (regarding soil pollution, fetal damage, etc.).

3. Finally, given the absolute predictability of the future damage to the environment (whether terrestrial, marine or of any other nature) that would stem from an activity that creates or aggravates a probable risk, the legal system should be clarified to focus on the principle of "*absolute and objective liability*", which should take precedence over the principle of fault as a requirement of punishability. Along such guidelines, even the placing of an out-of-use space object in a "graveyard" orbit should qualify as an objectively prohibited practice.

We consider that the above legal structure would be in line with Art. 12 of the Liability Convention, stating that absolute liability requires leaving the victim (or the natural environment in this case) "*in the same condition as if the damage had not occurred*".

This principle would be similar to the one of "full and complete (integral) liability", but has a different subjective nuance when applied to human victims, since the concept has a static meaning (taking things back to the state prior to the harmful event), while absolute liability adds an essential dynamic aspect by also providing for indemnification of actions or events that the victim could have planned or had in mind for the future, which must be effectively respected and carried out, thus allowing the victim (or his or her successors in title) to have access and enjoy such situations throughout their lives⁹. As we can see, the responsibility of the Launching State would extend beyond the scope of strict liability, where indemnification normally takes the form of a single payment.

These proposals are based on the failure of the economic system of sanctions or fines in place to date. A perverse understanding has arisen that replaces environmental prudence or due diligence, for a fee to be paid in consideration of the damaging conduct. The "*polluter-pays*" principle should not be implemented through the simple payment of a fine or a limited repair of damage caused (thus transmitting the perverse message that polluting pays off) but extending over time and in economic terms allowing for the total and absolute reparation of the damage caused.

4. Liability for Damage Caused by Space Objects

The Liability Convention provides that liability will always be international and absolute, by implementing liability principles that are different from those applied in other areas of law, but close to that of the environmental "strict liability".

⁹ A challenging approach that was discussed at the Conference of the International Institute of Space Law held in Tokio. If a shepherd would die because of the fall of a space object, the Launching State should be bound to provide what the shepherd should have provided to his family, such as housing, food, garments, education up to University level, thus extending in time and economic content the liability of the Launching State.

In space law, the launching State must repair (i) damage to or loss of life, (ii) all damage to public or private health; and (iii) loss or damage to property and physical elements belonging to States, international organizations, individuals or legal entities alike. Environmental damage must be clearly included.

6. Conclusions

* Space debris is produced mainly because objects that have been abandoned in space collide with other objects or meteorites. Each collision increases the number of fragments in geometric form.

* Spatial States must take an absolutely preventive approach. They can readily foresee that each object launched will - at some point in time – become space debris capable of causing damage; and must assume the risk and take action to prevent such predictable damage. The measures taken so far are clearly insufficient. It is necessary to pass legislation sanctioning the abandonment of space objects (even in graveyard orbits) and prioritizing their rescue.

* The principles set out in existing treaties whereby the exploration and exploitation of outer space and celestial bodies should be “non polluting” have not been observed.

* The existing legal rules to date do not adequately guarantee the right of victims or damaged parties to an absolute reparation of the damage that could be caused by the fall of space debris of unidentified origin. It is also necessary to create a solidarity fund to respond for damages of any kind caused by particles or unidentifiable fragments. /////