AN ANALYSIS ON THE LEGAL OBLIGATION OF SPACEFARING STATES FOR SPACE DEBRIS REMEDIATION AND MITIGATION*

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Abstract

Over the last few decades, mankind has constantly striven to understand and grasp the world around it. Some of the most profound breakthroughs in recent years are found in the course of the space exploration. Space venture is no longer only the domain of the most developed States. However, increased human activity in outer space has contributed to greater environmental threats. An increasing amount of space debris is being introduced into our cosmos. Varying in size yet deadly given its speed and possible radioactivity, debris contaminates the outer space environment and will eventual hamper further exploration.

This paper provides an analysis of the integral element of environmental law upon space law. Using elements of public space law and customary international law, it examines the *res communis* nature of outer space and the function of law in determining the extent of the obligation of space-faring states to preserve the spatial environment. An assessment of the present *corpus juris spatialis* highlights that definite implementation of such obligation remains wanting. The author concludes this paper by identifying the shortcomings of the present regulations on space debris, and provides recommendations to fill the legal void in space debris regulation.

Intisari

Beberapa dekade terakhir ini, umat manusia senantiasa berusaha untuk memahami dan menyelami dunia sekitarnya. Beberapa penemuan terbesar dalam beberapa tahun terakhir ditemukan dalam eksplorasi ruang angkasa. Penjelajahan ruang angkasa ini tidak lagi menjadi domein dari sebagian besar negara maju. Akan tetapi, peningkatan aktivitas manusia di luar angkasa telah mengakibatkan ancaman lingkungan yang lebih besar. Peningkatan jumlah puing-puing ruang sedang diperkenalkan ke kosmos kita. Benda tersebut memiliki berbagai ukuran namun mematikan, mengingat kecepatannya, dan mungkin radioaktivitas, puing-puingnya mencemarkan lingkungan luar angkasa dan pada akhirnya akan menghambat eksplorasi selanjutnya.

Makalah ini menjelaskan analisis unsur integral hukum lingkungan pada hukum ruang angkasa. Unsur-unsur hukum publik dan kebiasaan hukum internasional, digunakan untuk mengkaji res communis luar angkasa dan fungsi hukum dalam menentukan tingkat kewajiban negara berkapasitas antariksa dalam melestarikan lingkungan ruang angkasa. Penilaian corpus juris spatialis ini menyoroti kurangnya pelaksanaan yang pasti dari kewajiban tersebut. Penulis menyimpulkan makalah ini dengan mengindentifikasi kekurangan dari peraturan sekarang mengenai puing-puing ruang dan memberikan rekomendasi untuk mengisi kekosongan hukum dalam peraturan puing-puing ruang angkasa.

Keywords: Spacefaring States, Space Debris Remediation, Space Law.
Kata Kunci: Negara Berkapasitas Antariksa, Remidiasi Puing-puing Ruang Angkasa, Hukum Ruang Angkasa

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A. Introduction

It has been said that it is man's nature to explore, to seek out new frontiers to expand its world. It is then of little wonder, that since the beginning of civilization, space has been a constant fascination. Our ancestors revered the great unknown that is the cosmos, and intellects of old have always sought means to decipher the mysteries in our stars. The importance of space exploration extends beyond mere humane curiosity; it is a sign of development and national prowess. It holds such big importance that the space race—culminating in the sending of the first men to the moon—is one of the biggest hallmarks of the Cold War (Collins, 1999).

Satellites, the first objects launched into space, are employed to ease life on earth, voyages to distant planets are arranged, and scientists are enabled to be stationed at orbit to directly observe space. However, these achievements do not mean that the interest in space activities will wane anytime soon. To the contrary, states, which have started, early on the space race is preparing to undergo bolder and more ambitious missions. Small and temporary space structures have evolved into larger and more permanent space stations, and plans for space tourism are even drafted. The effort to explore space is not only *intensified,* but also expanded. States which were previously silent are beginning to play larger roles in exploring the universe. Indonesia, for example, has begun plans to test its nationally made RX-550 rocket with the range of 100-900 km in 2013 (AntaraNews.com, 2012).

B. The Environmental Element of Space Law

Environmental legal principles have been affirmed and have gained effect in the international context, as *inter alia* seen in the International Court of Justice *Fisheries Jurisdiction* case on how States arrange for the conservation of shared natural resources. To assess whether States have obligations towards preserving the spatial environment of the cosmos, determination must firstly be made as to whether the principles of environmental law can be applied to outer space. Such assessment shall be made with a three-tiered approach; by assessing space in itself, its relation to living environment on earth, and the future possibility of space in sustaining life.

First, environmental law, as defined by the United Nations Environment Program, encompasses the body of law, which seeks to protect the natural environment, which may be affected, impacted or endangered by human activities (United Nations Environment Programme). Natural environment encompasses all parts of the environment, living or otherwise, which came to be naturally (Johnson et al., 1997). Therefore, despite the heretofore-apparent absence in biotic life form, outer space is considered as forming this natural environment and worthy of protection under environmental law (Menezes).

Secondly, the need to identify the environmental element in space law is necessary given space's undeniable impact upon life on Earth. Space debris has constituted an environmental hazard as it increases the risk of collision and consequential damage, as further addressed *infra*.

Finally, aside from being a natural environment in itself, current, and present developments to mankind's exploration in space further render support to the protection of the space environment. With the launch of the Skylab in 1973—which has accommodated astronauts and researchers for 40 years—space stations have enabled

humans to live for prolonged periods of time in space. The increasingly intensive and permanent use of space structures are feared to eventually cause damage to the environment in which they are placed (Galloway, 1989).

Therefore, it can be concluded that it "would be wrong to consider the law of the space environment as something separate, distinct, and different from the concepts of terrestrial environmental law (Lyall & Larsen, 2009). It is evident that environmental space law is a specialized area of environmental law (Lyall and Larsen, 2009) hence development in this area should not be held separate from the technological development of space ventures.

C. Definition and Nature of Space Debris

There are numerous objects currently orbiting the Earth, yet not all are considered as space debris. Some space objects are naturally formed, such as meteorites, and other are man-made structures. Space debris merely forms a percentage of man-made structures in space. Although there is currently no formal agreement on the definition of space debris, it is the general consensus that it encompasses structures, which are no longer operational and are uncontrollable. The United Nation has further endorsed the definition of space debris as

> "all manmade objects, including their fragments and parts, whether their owners can be identified or not, in Earth orbit or re-entering the dense layers of the atmosphere that are non-functional with no reasonable expectation of their being able to assume or resume their intended functions or any other functions for which they are or can be authorized" (Technical Report on Space Debris, 1999).

Space debris can originate from a myriad of sources. A satellite may have exhausted its operational period and is no longer in use, payloads are deteriorated, and rocket thrusters are spent. Aside from intact structures, fragments also make up the number of space debris encircling our Earth.

Based upon their form, the scholar Howard Baker divides space debris into four classes; inactive payloads, operational debris, fragmentation debris, and micro-particulate matter. Inactive objects are primarily made up of satellites that have run out of fuel or have malfunctioned, and hence are no longer able to maneuver. Operational debris is an object, which have been released to space in normal operations, whether intact or in its component form. Parts of a space object, which have broken apart through explosion, collision, or deterioration, or any other means, are classified into the third group of fragmentation debris. Micro-particulate matters are the smallest form of debris. Made up of shed coatings or surfaces, this form of debris is released to space due to surface degradation (*inter alia* due to radiation, micrometeoroids, or atomic oxygen) (Senechal, 2007).

It is the realization of spacefaring states that, in the interest of ensuring spatial safety, space debris should be properly monitored. Although an international database is currently under discussion in the Inter-Agency Space Debris Coordination Committee (IADC), as of 2013 it has yet to exist. Reliance must then be made to national sources, as several States operate space debris catalogues of their own.

The two most prominent national catalogues are the United Sates Space Command catalogue and the space object catalogue of the Russian Federation. Other national catalogues rely on the data of

either one or both of these two catalogues; examples are the Database and Information System Characterizing Objects in Space (DISCOS) of ESA, and the National Space Development Agency (NASDA). Such institutions do not merely aim to identify space object, but also to monitor them to ensure safe space voyage, which can include analysis on the trajectory prediction analysis for re-entering objects and collision avoidance analysis.

Given the absence of a centralized database to track and monitor space debris, the number of tracked space debris may vary from catalogue to catalogue. However, it is generally estimated that by 2011, space debris comprise approximately 7,000 debris larger than ten centimeters, 17,500 between one and ten centimeters, and 3,500,000 under one centimeter (Roberts, 1992).

D. The Threat Posed by Space Debris upon the Environment and Mankind

1. The Dangerous Properties of Space Debris

Despite the vastness of space, space debris scattered above our atmosphere still poses an imminent danger upon the environment. This phenomenon is due to the fact that most human activity is concentrated in a specific area of space; namely the Low Earth Orbit (LEO) and the Geosynchronous Earth Orbit (GEO). Of the currently operational space structure, an estimated 45% are located in LEO and GEO (Bruenner & Soucek, 2011). This tendency to accumulate creates a problem of overcrowding in areas most used for exploration, which renders further human activities dangerous.

The three characteristics of debris render it a potential high-level risk to the environment. Firstly, space debris decay slowly, and can become a semi-permanent problem for future years and even centuries. When space debris collides with a functioning space structure, this would in turn produce more debris fragments; creating a so-called snowball effect (Bruenner & Soucek, 2011). In fact, the fragmentation of spacecraft constitute an approximately 43 percent of the current debris population—for debris larger than 5 cm, this number even rises to 85% ("Technical Report on Space Debris, 1999). Left unchecked over the years, where space launches becomes more frequent, this would slowly create a self-sustained polluted area dense with debris, which would eventually bar further commercial and exploration activities (Senechal, 2007).

Secondly, being defunct, the very nature of such objects renders it uncontrollable and difficult to track. Debris come in many sizes. Collision with a large debris piece, defined generally as objects larger than 10 cm in size, can severely damage equipment and even put lives at risk. The European Remote Sensing Satellite (ERS-1) had to perform collision-avoidance maneuvers to avoid large debris in 1997 and 1998, and the French SPOT-2 also had to do so in 1997.

Thirdly, it is not only sizeable debris, which can pose danger; high speeds provides for high-velocity impact. The current database is merely capable of tracking debris as small as 10-30 cm in diameter ("Technical Report on Space Debris", 1999). This means that there are countless of smaller debris, which is unaccounted for.

Smaller debris is not at all harmless. The velocity of the objects traveling in orbit—11,000 km per hour for debris in Geosynchronous Orbit (GSO) and 35,900 km per hour in LEO—would render even small objects dangerous (Roberts, 1992). Even object smaller than a few millimeters in diameter can cause damage to operational space systems, damaging shuttle windows or

antenna. Human space operations are also at risk, and measures must be taken to secure extravehicular activity (EVAs) crews to be shielded from debris by the orbiter. To illustrate, travelling at approximately 35 thousand km per hour, a 0.5 chip of paint could puncture a standard spacesuit, killing an astronaut or disabling an expensive satellite (Bruenner & Soucek, 2011).

2. Impact of Space Debris to the Environment

The damage caused by space debris to the environment can take on several forms. Even in the early days of space faring, the dangers of space debris did not entirely go unnoticed. Triggered with the launch of Sputnik 1 in 1957, the Scientific and Technical Sub-Committee of the UN Committee on the Peaceful Uses of Outer Space concluded that pollution in outer space can take form through "[changing] the space environment or adversely affect other experiments in space" (Diederiks-Verschoor & Kopal, 2008). This paper will first address the effects of space debris to the space environment, and then assess the effect this has upon man's activities in space. Additionally, assessment will also be made on how activities in space can affect the quality life on earth.

i. Damage to the Space Environment

The first identified issue arises with respect to changes to the space environment. Outer space is considered as a pristine environment, and it has become the consensus of States to not taint it with its byproducts (Ferguson & Wilson, 2010).

Contamination of outer space is caused by the introduction of harmful matter into outer space. Although there is no direct definition of the notion 'harmful contamination' of outer space, the general term 'pollution' enjoys common usage and is defined as 'a modification of the environment through human agency by the introduction on undesirable elements or by the undesirable use of elements' (Diederiks-Verschoor & Kopal, 2008). Scrap metal, fuel, structural components, and waste and garbage produced by manned satellites would contaminate space if they were allowed to be jettisoned to space. Nuclear, the testing of which for military purposes in outer space has been widely condemned, would also taint the existing environment (Jasani, 1987).

ii. Adverse effects to Space Exploration

The second tier of damage is the adverse effect to further space exploration. Space debris put other active structures at risk for a collision, or it can interfere with telecommunications and remote sensing, which will put human life and active payloads at risk. Danger is amplified by the fact that at high velocity even minuscule objects can be dangerous. An incident involving the Shuttle Challenger occurred as it was hit by a tiny piece of paint measuring only 0.2 mm in diameter.

iii. Impact on Earth

Not only outer space is subject to harmful contamination; space debris can also impose the risk of environmental pollution on Earth. Should debris fall down to Earth, the force of impact may create severe destruction where it lands. Given that most are nuclear charged, debris can also contaminate the area even when it comes down in an unpopulated area.

In January 1978, the Cosmos 954 satellite disintegrated and fell over North Canada. Although inflicting no direct loss of life, the debris was radioactive and contaminated an area of over 600 km. Two subsequent incidents further raised awareness on the environmental hazards of space debris, namely the reentry of COSMOS 1402 in 1983 and COSMOS 1960 in 1988 (Benkoe & Schrogl, 1993).

These incidents also underscore the fact that the primary pollutant in activities related to nuclear power sources in outer space is radioactivity caused by nuclear waste, which is released both in outer space and in Earth (Abeyratne, 1997).

E. The Need for an International Legal Regime Regulating Space Debris

1. Function of Law in Anticipating Further Developments

The current population of debris is growing, and that the probabilities of potentially damaging collisions are increasing ("Technical Report on Space Debris", 1999). Given the past and present development of space ventures and the plethora of environmental issues it presents, an immediate response in the form of a unifying regulatory standard of conduct is required (Williamson, 2006).

Even when one disagrees that the *status quo* merits the creation of a separate regime governing space debris—that the present danger is at minimum and such matters shall be shelved to a later date—law does not merely seek to resolve an issue, which is currently present. Law as useful a tool in resolving present conflicts *ex-post* as anticipating problems and regulating their possible occurrence *ex-ante* (Bruenner & Soucek, 2011).

The Brundland Report emphasizes that safeguarding future environmental conditions should not fall behind present developments; that development must "meets the needs of the present without compromising the ability of future generations to meet their own needs" ("Report of the World Commission on Environment and Development", 1987).

2. The Shared Responsibility of States

One of the unique aspects of laws governing space law is that it must inherently be of an international character. The contamination of space affects the interest of all states, and hence it must be treated through global measures and "cannot be resolved by any country independently" (Diederiks-Verschoor & Kopal, 2008). The chief reason thereto is that the legal status of outer space is that of *res communis*; a common property of mankind (Brownlie, 2003). No particular state or individual may subjugate space as its sovereignty, make claims with its regard, and most relevantly, refrain from any acts, which would adversely affect its use.

This would imply that despite the fact that although individual claims upon space cannot be made, the obligation to care for space is one burdened upon all states. It is a general rule in international customary law, as enshrined in Principle 21 of the Declaration of the United Nations Conference on Human Environment (1972) that States are obliged to abstain from causing damage to the environment outside of their national jurisdiction, even when *controlling* their own resources (Koneva, 2004). States should "avoid engaging in the harm-producing activity or weigh the benefits against the potential environmental damage and take appropriate steps to mitigate the anticipated environmental harm (Mirmina & Den Herder, 2005).

Under the General Assembly Resolution 61/36 on the Principles on the Allocation of Loss in the Case of Trans boundary Harm, 'damage' is interpreted to encompass loss of life or injury to persons, loss or damage to property, or loss of damage by impairment of the environment. Therefore, liability for damage would appear to arise irrespective of whether the damage occurred outside of the sending state's territory. This notion is affirmed further by the International Law Association in the Buenos Aires International Instrument on the Protection of the Environment from Damage Caused by Space Debris in 1994. Environmental damage encompasses "the

hostile changes in the environment within the territory under the jurisdiction of any state or any other place not under the jurisdiction of any new state" (Bockstiegel, 2000).

3. Current Legal Regime and Shortcomings

The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space Including the Moon and Other Celestial Bodies (Vladimir, 1966) was conceived to balance the development of space exploration with a sense of obligation to ensure propriety. Although the Outer Space Treaty makes no direct reference to space debris, it generally regulates activities conducted in space.

Under the Treaty, each State Party which launches an object into outer space, or from which a launch is conducted, is held liable for damage for such objects *or its component parts* in outer space. Article 1 prescribes that the exploration and use of outer space shall be carried out in the interest of all countries. Space debris would evidently contradict such an aim, as they would render space exploration and use dangerous due to crowding.

Article 9 follows in the vein of Article 1 by mandating signatory states to "avoid harmful contamination" and to consult other States prior to conducting an activity, which can lead to "harmful interference." However, the Convention is unclear on whether the obligation of regulating impact or to control would encompass space debris, as one of its most distinguished identifier is the lack of ability to control it. Further questions are also raise on whether floating debris can be designated as a "national activity" or merely its unintentional by-product. The harmful contamination and adverse changes in the environment of the earth, resulting from the introduction of extra-territorial matter'; geared towards protection of human beings rather than the environment as an end in itself (Sands & Peel, 2012).

The 1972 Space Liability Convention furthers the obligation of states whose space object cause damage by mandating compensation. However, there are several caveats in this Convention, which do not render it fully suitable for the protection against space debris. Liability will only be invoked under the Convention in cases the existence of a physical damage, and not in cases where space debris 'merely' pollutes space.

Additionally, an ongoing debate still exists on whether the term 'space object' encompasses the broad spectrum of space debris, small fragments and all. There are two main veins of interpretation to such terms. It is argued on one hand that a reading of "component parts" shall be inclusive to fragments, notwithstanding their functionality, size, or origin (Bruenner & Soucek, 2011). In contrast, it can also be argued that practically, the definition of space objects, "does not include all space refuse." This unresolved issue is of utmost importance, as liability cannot be invoked for non-space object debris.

As compensation cannot be invoked without the identification of the State which to bear it, the 1974 Convention on Registration of Objects Launched into Outer Space also plays an important role in the space debris regime. However, the same impediment as found within the Space Liability Convention arises; registration obligations merely arise with respect to space objects, and if certain forms of debris were not covered under the definition of a space object, the Convention would not apply. Additionally, further uncertainties arise with respect to the method of registration. The issue on whether fragments of the main body of must be registered separately is an example of a practical

issue, which is yet clearly regulated (Diedericks-Verschoor & Kopal, 2008).

F. Recommendation

Through an assessment of the present body of space law—*corpus juris spatialis*—it is apparent that a comprehensive and specialized regime on space debris remains wanting. In terms of the interest of legal certainty, existing laws do not clearly enumerate on whether space debris mitigation qualifies as a legal obligation of spacefaring states. In a more technical sense, given that the laws were not specifically made with space debris in mind, with are of different characters than functional space structures, regulations in place may not accommodate the full need.

A more poignant case for the need of change is that present regulations were adopted before environmental considerations had become an important international legal issue, and do not reflect some of the legal innovations which have occurred in the past decade. Therefore, the introduction of a separate international scheme to tackle space debris is highly recommended.

Such scheme, if introduced, should provide clarity on both the issue of the extent of the obligation of states, as well as contain specific technical code of conduct on the remediation of the space debris problem. If, as the *status quo* allows, a State sending objects into orbit is allowed to do so without being subject to repercussions or control in their treatment of space debris, the problem of space debris would be perpetual one. Each state sending space objects must be held liable for its own debris, inventorize them and take measures to slowly remove it (Gordon, 1982).

Measures to mitigate and to remediate space debris are urgently needed. Debris mitigation and remediation are differing yet interrelated concepts. The former is concerned with the reduction of future space debris, while the latter are measures to actively lessen the impact and danger of current debris (Mineiro, 2011).

There are currently two main ways in which space debris is removed from orbit; either through entry to the Earth's atmosphere, or the maneuvering of controllable structures to a safe orbit prior to becoming defunct. However, these fixes are at best temporary, and still do not eliminate the risk of collision—both in space and on Earth. To truly reduce the amount of waste encircling the Earth, measures for manual removal of debris, a mechanism for space debris extraction, must be considered.

However, preventive measures would be and more practical and economical than remedying existing problems; not only must existing debris problem be dealt with, remediation measures must be taken to prevent said issue to recur or be amplified. Standards on better (essentially, ecofriendly) designing of spacecraft must be introduced to ensure that not only spacefaring State do not become overly eager in joining the space craze without taking sufficient measures to prevent environmental degradation (Leinberg, 1989).

Finally, it is recognized that there is currently very little information shared between States, which would aid a joint resolution to the space debris problem. The United Nations has made calls to Member States to provide information on practices that they have adopted and that proven effective in minimizing the creation of space debris, and the time is high that an international platform for this purpose is created. The Inter-Agency Space Debris Coordination Committee (IADC) attempts to achieve such and end since its establishment in 1993, but its membership is limited to several states. To date, only the European

Union, Japan, USA, Russia, China, British, France, India, Germany, and Italy are counted as members of the IADC, and to truly achieve its aim, the Committee should be opened to virtually all States.

G. Conclusion

It is to be concluded that the present need for an international regime regulating the remediation and mitigation of space debris is an urgent one. Not only do debris physically provide barriers to the inhabitance of the certain orbital area; their radioactivity would taint and adversely affect the space environment. Should spacefaring states fail to mitigate the present problem, the contamination of the environment by space debris would continue, endangering lives on Earth and also the environment as a whole.

There is an undeniable aspect of environmental law to space law. Even when space may not necessarily house living biotas of its own, environmental law includes all aspects of the natural world, both living and otherwise. The condition of the outer space is also inevitably interconnected with life on Earth; impacts and re-entry would pose serious harm to the biosphere, and it can also be foreseen that human activities in space would only intensify. Hence, despite the fact that environmental law was conceived generally and not necessarily with space law in mind, environmental conservation principles are to be applied to the issue of space debris.

However, these principles merely provide general guidance and reference. Present laws, although providing general principles on mankind's activities in space, have yet sufficed to fulfill the demand for adequate protection of the space environment. The problem with the *status quo* can be surmised to be threefold; certain areas are silent on the treatment of space debris, the existing law is too vague to be applied concretely, or that existing laws do not take into account the particular nature of space debris—barring effective resolution of the problem.

To truly resolve the issue of debris, the two major steps of remediation and mitigation must be undergone. Mitigation is necessary to reduce the impact of vessels from further contributing to the present problem, while remediation is called for to actively resolve existing problem. These measures must be undertaken through a global cooperation mechanism, as burdening such role to individual states would be unrealistic and contrary to the shared nature of outer space.

In utilizing outer space, it is imperative to note that every State is entitled to strive towards the stars, and explore it for its own interest. However, in doing so, it must be made clear that such rights do not come without restriction, and the right of humanity to still enjoy space from years to come should not be foiled by the carelessness of the present generation.

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