Preserving the Outer Space Environment: The "Precautionary Principle" Approach to Space Debris

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The amount of space debris in Earth's orbit increases in alarming speed. Since the dawn of the "Space Age", tons of manmade, useless objects have been left around our planet, including abandoned stages of launching rockets and uncontrolled artificial satellites. The current scenario urges the international community to discuss effective legal measures to mitigate the production of space debris, due to the risks they represent to functioning space objects, to astronauts during extra vehicular activities and, in the event of their reentry, because of the harm they may inflict to aircraft in flight as well as property and people on the ground.

In the interest of preserving the outer space environment, reference is contemplated to a fundamental tenet of International Environmental Law, *i.e.*, the "precautionary principle". According to the Rio Declaration on Development and Environment of 1992, "*in order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation*" (article XV).

The present paper proposes a study of the "precautionary principle" as applied to Space Law, relating it to the present space debris situation, as means to support efficient and cost-effective regulation safeguarding the peaceful exploration and use of outer space, for the benefit and in the interests of all countries.

I. The Space Debris Situation

Nowadays, it is easy to take for granted the vast number of manmade artifacts circulating in Earth's orbit. Used for diverse purposes, including telecommunications, remote sensing or global positioning, artificial satellites produce data and services essential for our modern society. Such technological wonders currently compose a factual, ever increasing "constellation" of space objects. The

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quandary faced by the international community is that, irrespective of their size or velocity, most of those satellites, as well as parts of their launching vehicles, have been recklessly forgotten around our planet after their lifespan, presenting relevant risks to the outer space environment and to space activities in general.[1]

The problematic of space debris, in accordance with Antony MILNE, represents a consequence, to a large extent, of astonishing scientific, commercial and military achievements experienced after the Second World War.[2] Nevertheless, it may be reasonable to state that, nowadays, abandoned and uncontrolled space objects do characterize an increasing danger to space activities in general, both from a technical and political standpoint, due to their potential hazardous nature.[3]

One should bear in mind, as provided by I. H. Ph. DIEDERIKS-VERSCHOOR, that space debris might originate from various sources: "*these may be explosions creating fragments (e.g., deliberate explosions of satellites as part of space weapons testing), deterioration of active and inactive payloads, spent rocket thrusters, and other materials produced by the operation of spacecraft.*"[4]

Vis-à-vis liability for harm produced by space debris, special reference shall be made to the "Convention on International Liability for Damage Caused by Space Objects" (the "Liability Convention"), opened for signature on March 29, 1972. This instrument identifies the international liability, regarding damage inflicted to third parties, by a State that launches or procures the launching of a space object, or from whose territory or facility a space object is launched, considered therein as a "Launching State" (Article 1, "c").

The Liability Convention provides a double system of liability, depending on the place of damage: if caused on the surface of Earth or to an aircraft in flight, there shall be absolute liability (Article 2); on the other hand, if produced else-

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1 "*Depuis le début de l'exploration du cosmos, vingt-trois mille objets spatiaux ont été lancés de la Terre, mais seulement seize mille ont été détruits, soit par l'effet de frottement au moment de leur rentrée dans l'atmosphère, soit lors de leur retombée sur Terre, enfins, certains ont pu êntre ramenés sur la planète. Les sept mille autre sont désagrégés, soit progressivement, au gré des collisions avec d'autre débris, soit brutalement, à l'occasion de leur propre explosion.*" (Jean-Paul Pancracio. *Droit international des espaces*. Paris: Armand Colin, 1997. p. 247.) See also: Lakshya Vaibhav Datta. *Introduction to Space Debris: Challenges and Removal Techniques: Fundamentals of Space Debris Removal from Low Earth Orbit and Middle Earth Orbit*. Saarbrücken: LAP Lambert, 2013.

2 Antony Milne. *Sky Static: the Space Debris Crisis*. Westport: Greenwood, 2002. p. 12.

3 Paulo Borba Casella. *Direito Internacional dos Espaços*. São Paulo: Atlas, 2009. p. 619. José Monserrat Filho. *Direito e Política na Era Espacial*. Rio de Janeiro: Vieira & Lent, 2007. p. 93/102.

4 I. J. Ph. Diederiks-Verschoor. *An Introduction to Space Law*. The Hague: Kluwer Law International, 1999. 2nd Ed. p. 132.

where than on the surface of Earth to another space object, liability can only be effective in case of fault (Article 3).[5]

The Liability Convention is therefore applicable to damage produced by space debris, since they constitute, as a matter of fact, examples of space objects, irrespective of their control or functionality. Indeed, Armel KERREST defined space debris as "*a useless man-launched object in outer space*".[6] Such particular situation, by itself, justifies precaution by Launching States in relation to any space debris under their responsibility.[7]

Collisions between space objects in orbit frequently produce clouds of debris, proportional to their speed and size.[8] In fact, it shall be seriously considered the current development of the "kessler syndrome", conceived by the American scientist Donald KESSLER, according to which orbital collisions produce a cascade effect, incrementing the potential of future accidents.[9]

The first orbital collision between two intact artificial satellites was registered in 2009, between the Russian COSMOS 2251 and the American IRIDIUM 33, producing around 100.000 debris of more than 1 centimeter of diameter in the increasingly crowded low Earth orbit. As observed by Ram S. JAKHU, the accident denounced how real the dangers represented by space debris are, requiring widespread attention.[10]

As far as uncontrolled reentries of space objects are concerned, they also create a significant peril to people and property on the surface of our planet, as well as aircraft in flight. While most space debris may eventually be consumed during the time they cross Earth's atmospheric layers, some, of considerable size,

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5 Olavo de O. Bittencourt Neto. *Direito Espacial Contemporâneo: Responsabilidade Internacional.* Curitiba: Juruá, 2011. p. 80/89.

6 Armel Kerrest. "Space Debris, Remarks on Current Legal Issues". *ESA SP*, n. 473, v. 2, Oct.-2001, p. 869.

7 Bruce A. Hurwitz. *State Liability for Outer Space Activities: in Accordance with the 1972 Convention on International Liability for Damage Caused by Space Objects*. Dordrecht: Kluwer Academic Publishers, 1992. p. 33.

8 Joseph N. Pelton. *Space Debris and Other Threats from Outer Space*. New York: Springer, 2013. p. 17/24.

9 "*In 1990 Donald Kessler investigated the problem further in a publication on 'Collision Cascading: the Limits of Population Growth in Low-Earth Orbits', which describes the consequences of self-sustained growth of the space debris population, initially triggered by collisions between intact objects and ultimately sustained by collisions between collision fragments (this was later known as the 'Kessler Syndrome'). Such a cascading process, which cannot be stopped in its advanced stage, could render certain altitudes shells in the LEO region unsafe for a long time.*" (Heiner Klinkrad. *Space Debris: Models and Risk Analysis*. New York: Springer, 2006. p. 2.)

10 Ram S. Jakhu. "Iridium-Cosmos Collision and its Implications to Space Operations", *In:* Kai-Uwe Shrogl, Wolfgang Rathgeber, Blandina Baranes and Christoph Venet. *Yearbook on Space Policy – 2008/2009: Setting New Trends*. New York: Springer, 2010. p. 254.

do in fact survive the reentry, as records show.[11] Bearing in mind the difficulty in calculating their exact falling trajectory, many States may, at the same time, be required to stand alert, eventually undertaking emergency measures, such as closing their airspaces to commercial aircraft or dislocating population from dangerous areas.

The threat represented by uncontrolled reentries of space debris became quite evident in 2011, when, in a matter of weeks, two falling space objects of considerable size claimed the attention of the international community as a whole. Both the American UARS ("Upper Atmosphere Research Satellite") and the German ROSAT ("Roentgen Satellite") had dimensions equivalent to a small truck and, due to that, not only survived their reentry but also effectively "surfed" through atmospheric layers before reaching the ground, preventing an accurate estimate of their final landing destinations.

The UARS, prior to its final collision into the Pacific Ocean on September 23, 2011, experienced several ever-changing calculations, as far as its landing site was concerned.[12] The same happened to the ROSAT, which almost caused a calamity, diving on October 23 into the Bay of Bengal, minutes before reaching the densely populated territories of India and Bangladesh.[13]

In 2012, objects preliminarily identified as parts of launching rockets were found at the Brazilian city of Anapurus. The largest of them, apparently a fuel tank weighting around 30 kg, fell in a populated area and was inadvertently handled by locals, unaware of the inherent dangers.[14]

Those examples must be put into perspective: several other space objects of considerable sizes are expected to survive reentry in the near future, deserving proper consideration by the international community.

In accordance with data provided by the *Space Surveillance Center* of NASA in its latest report, the "Orbital Debris Quarterly News" of July 2013, a total of 16.602 objects bigger than 10 cm of diameter have been tracked around our planet, of which 12.990 are rocket bodies and debris.[15] It must be stressed that a relevant number of space debris, due to its diminute dimensions, cannot be properly identified from ground stations and therefore were not included in the refereed study, although constituting endangerment to space activities.

Gérardine M. Goh ESCOLAR acutely addressed such perilous state of affairs:

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11 For instance, reference is made to the famous 1978 Cosmos 954 incident, thoroughly analyzed by Bruce A. Hurwitz. *State Liability for Outer Space Activities: in Accordance with the 1972 Convention on International Liability for Damage Caused by Space Objects*. Dordrecht: Kluwer Academic Publishers, 1992. p. 113/140.

12 Available online at <www.nasa.gov/mission_pages/uars/index.html>, last accessed 01 September 2013.

13 Available online at <www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10081/151_read-1779/>, last accessed 01 September 2013.

14 Available online at <www.aeb.gov.br/indexx.php?secao=noticias&id=828>, last accessed 01 September 2013.

15 Available online at <http://orbitaldebris.jsc.nasa.gov/newsletter/pdfs/ODQNv15i4.pdf>, last accessed 01 September 2013.

> "Humanity has created one of the greatest obstacles to its own exploration of outer space. Artificial space debris in Earth orbit, left by past and present missions, comprises one of the greatest risks to operations in space. As the quantity of orbital debris in Earth orbit increases, the safety and success of both manned and unmanned space missions is increasingly compromised."[16]

At the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPOUS), questions regarding space debris, including mitigation, even though not effectively prospering at the Legal Subcommittee, have already been addressed by the Technical and Scientific Subcommittee, which adopted the "Space Debris Mitigation Guidelines" in 2007.[17] Through such document, not binding *per se*, space debris were defined as "*all man-made objects, including fragments and elements thereof, in Earth orbit or reentering the atmosphere, that are non-functional.*"[18]
The referred instrument, highly technical by nature, identified general best practices in relation to mitigation of space debris. However, it has not yet been translated into a legal norm, requiring relevant conducts on that regard, due to conflicting opinions involving this sensitive topic at the UNCOPUOS Legal Subcommittee.

II. Environmental Law and Space Law

Even though the amount of space debris keeps on growing, without sufficient alleviation by Launching States, the current treaty framework remains largely absent on that regard.[19] Therefore, since only non-binding international instruments offered measures to limit the production of space debris, arguably space faring nations still hold the prerogative to deal with this situation based only on their own, personal perspectives, whenever required by circumstances.

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16 Gérardine M. Goh Escolar. "The View from Oriels of the Stars: The Legal Obligation to Mitigate and Remediate Space Debris in Earth Orbit", *In:* Sagar S. P. Singamsetty, Gérardine M. Goh Escolar, Romeo F. Kadir and Sara M. Langston (editors). *Contemporary Issues and Future Challenges in Air and Space Law*. Utrecht: Air and Space Law Books, 2011. p. 352.

17 A/AC.105/890.

18 Regarding legal definition of space debris, reference is made to the following works: Vladimir Kopal. "Issues Involved in Defining Outer Space, Space Objects and Space Debris". *Proceedings 34th Colloquium On the Law of Outer Space*, Montreal, 1991. Armel Kerrest. "Space Debris, Remarks on Current Legal Issues". *ESA SP*, n. 473, v. 2, Oct.-2001, p. 869.

19 C. M. Reijnen. "Aspectes Juridiques de la Pollution dans l'Espace Extra-Atmosphèrique – Le Problème des Debris Spatiaux". *Annales de l'Université des Sciences Sociales de Toulouse*, Toulouse, France, n. 37, 1989.

As observed by Lawrence D. ROBERTS, the outer space agreements "*raised environmental concerns only in the context of efficient use of space resources or research opportunities. They did not attempt to provide broader protection of the space environment. These factors, as well as the complexities of the space environment, make it difficult for the agreements to provide a solution to the continuing degradation of the space environment.*"[20]

However, such legal lacunae may be just conjectural. To properly address such a intricate issue, one needs to look beyond the current Space Law treaties. Indeed, this procedure is authorized by the "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies" of 1967 (the "Space Treaty"), commonly regarded as the "Magna Carta" of Space Law, which, in its Article III, provides that the use and exploration of outer space shall be carried in accordance with International Law, "*in the interest of maintaining international peace and security and promoting international cooperation and understanding.*"

Additionally, Article IX of the referred treaty do provide that "*State Parties to the Treaty shall pursue studies of outer space, including the Moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment.*"

Ergo, relevant principles of International Law are applicable to space activities, including important tenets of International Environmental Law. The "precautionary principle", conceived upon a prospective approach, as far as pollution is concerned, seeks the protection of the environment from specific human activities involving grave risks, even when scientific knowledge on that regard may seem insufficient to fully comprehend the particularities of the resulting threat to nature.

Precaution is justified in Environmental Law, since there is often too much at stake, as far as natural resources are concerned. An abstract danger, even though not fully realized, nonetheless demands attention, at least in relation to some global commons, deemed too important for the well being of our planet and of mankind to be left unattended. Any real threat of irreversibility must be carefully dealt with, whether it involves the imperilment to flora, fauna, global commons or even the climate.

In relation to policy, the precautionary approach requires legislators to think ahead, figuring out solutions while there is still time to do something about an imminent menace to the environment. The rationale is quite simple: it is better to be safe than sorry.

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20 Lawrence D. Roberts. "Addressing the Problem of Orbital Space Debris: Combining International Regulatory and Liability Regimes", 15 B.C. Int'l & Comp. L. Rev. 51, 1992.

III. Precaution towards Space Debris

In accordance with Dirk HANSCHEL, the origins of the precautionary principle may be found in Germany, where it has been imbedded in national environmental legislation since the 1970s.[21] Progressively, the *Vorsorgeprinzip* would be adopted in the North Sea conferences, especially since the second one, of London, 1987,[22] providing that the most dangerous substances to such a critical environment required proactive attention from European States and, therefore, should be thoroughly controlled.
In 1992, at the United Nations Conference on Environment and Development (UNCED), the precautionary principle was included in the "Rio Declaration", a *soft law*, non-binding document which nevertheless listed several fundamental principles of the International Environmental Law.[23] Even though arguably tentative, due to political pressure offered by countries concerned about its application to scientifically debated issues, Article 15 of the Rio Declaration establishes that:

> "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

As indicated by David FREESTONE and Ellen HEY, the precautionary principle was contemplated by "*virtually every recent treaty and policy document related to the protection and preservation of the environment*",[24] including

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21 "*In Germany, which is considered its country of origin, the precautionary principle was mentioned for the first time in an environmental program of 1971 and in a definition of environmental policy provided by the Federal Governmental in 1976 – a long time before this principle came to life in the international agenda. This approach was further developed and refined in the subsequent years.*" Dirk Hanschel. "Progress and the Precautionary Principle in Administrative Law – Country Report on Germany", *In:* Eibe Riedel and Rüdiger Wolfrum (eds.). *Recent Trends in German and European Constitutional Law*. Berlim: Springer, 2006. p. 180/181.

22 The first North-Sea Conference was held at Bremen, 1984, followed by London, 1987, The Hague, 1990, Esbjerg, 1995, Bergen 2002 and Gothenburg 2006. They involved coastal States in a joint effort to protect the North-Sea environment, comprising delegations from Belgium, Denmark, France, Germany, the Netherlands, Norway, Sweden, Switzerland and the United Kingdom. See: Lothar Gündling. "The Status in International Law of the Precautionary Action", *In:* David Freestone and Ton Ijistra (eds.) *The North Sea: Perspectives on Regional Environmental Cooperation*. London: Graham & Trotman, 1990. p. 23/30.

23 Guido Fernando Silva Soares. *A Proteção Internacional do Meio Ambiente*. Barueri: Manole, 2003. p. 62/64.

24 David Freestone and Ellen Hay (ed.). *The Precautionary Principle and International Law: the Challenge of Implementation*. The Hague: Kluwer Law International, 1996. p. 3.

the "Draft Agreement on Straddling and Highly Migratory Fish Stocks" (New York, 1995), the "Black Sea Declaration" (Odessa, 1993), the "Climate Change Convention" (New York, 1992), the "Convention on Biological Diversity" (Rio de Janeiro, 1992), the "Baltic Sea Convention" (Helsinki, 1992), the "Convention on the Protection and Use of Transboundary Watercourses and International Lakes" (Helsinki, 1992) and the "Convention for the Protection of the Marine Environment of the North-East Atlantic" (Paris, 1992).

Although the influence of the Rio Declaration over the refereed treaties may be deemed undeniable, one should recall that the precautionary principle had already been considered in treaty law prior to the UNCED 1992, as indicated by the "Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa" (Bamako, 1991).[25]

Notwithstanding their particularities, the referred international instruments do provide a clear statement against inaction in face of significant threats to the environment. Therefore, any political procrastination, based on the lack of definitive scientific proof that a certain activity or substance is dangerous to man or the environment, shall be ultimately rejected, whenever the risks are deemed unjustified.

Alexander KISS thus explained:

> "In general, the precautionary principle can be considered as the most developed form of prevention that remains the general basis for environmental law. Precaution means preparing for potential, uncertain, or even hypothetical threats, when there is no irrefutable proof that damage will occur."[26]

The referred form of anticipatory environmental protection, first and foremost, contemplates a policy oriented to the protection of nature. Consequently, the burden of proof is often shifted: any party intending to develop a certain potentially dangerous activity or produce a realistically hazardous substance must prove that such deed does not endanger the environment.[27]

In a detailed study, Nicolas DE SADELEER shed light on how the precautionary principle operates:

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25 Geraldo Eulálio do Nascimento e Silva. *Direito Ambiental Internacional*. 2nd ed. Rio de Janeiro: Thex Editora, 2002. p. 55.

26 Alexander Kiss and Dinah Shelton. *Guide to Environmental Law*. Leiden: Martinus Nijhoff, 2007. p. 95.

27 "*The precautionary principle is based on the premise that actions on environmental matters should be taken even if there is a lack of total scientific certainty, often reversing the burden of proof and placing it on those who claim that an activity is not damaging.*" Elli Louka. *International Environmental Law: Fairness, Effectiveness and World Order*. Cambridge: Cambridge University Press, 2006. p. 50.

> "The precautionary principle may henceforth be applied if there are 'reasonable grounds' for concern even when irrefutable proof is lacking. That is to say, the threshold shall be set neither too high nor too low. If it is too high, the principle would be devoid of substance; if too low, the principle would become inoperable. A middle course should thus require public authorities to demonstrate that a risk is considered scientific likely (reasonable scientific plausibility'). That condition would be fulfilled when empirical scientific data (as opposed to simple hypothesis, speculation or intuition) make it reasonable to envisage a scenario, even if it does not enjoy unanimous scientific support."[28]

Regarding this trend of precautionary approach, as far as International Law is concerned, Timothy O'RIORDAN and James CAMERON affirmed that "*international agreements covering global or regional environmental protection are increasingly based on proactive or preventive measures which encompass collective action and burden sharing.*"[29]

Due to the overwhelming reception of the precautionary principle by International Environmental Law documents, the relevant references in international jurisprudence as well as national and regional assimilation, one may submit that such canon has achieved a position not only of a general principle of law but, more conspicuously, of a customary rule of international law.

In accordance with the Statute of the International Court of Justice, customs represent an "*evidence of a general practice accepted as law*" (Article 38, 1, b). This source of International Law has two compulsory elements: first, the *consuetudo,* that is, a material fact of behavior, reflecting a consistent and general practice; and second, the *opinio iuris*, *i.e.*, the subjective belief that such practice is required by law.[30]

As explained by Malcolm N. SHAW, "*custom does mirror the characteristics of the decentralized international system.*" Indeed, "*it reflects the consensus approach to decision-making with the ability of the majority to create new law binding upon all, while the very participation of states encourages their compliance with customary rules*".[31]

Although some publicists deny that the precautionary principle, because of its shortcomings or indetermination, has already achieved the status of international custom,[32] Philippe SANDS understands that its legal status is certainly moving in that direction:

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28 Nicolas de Sadeleer. *Environmental Principles: from Political Slogans to Legal Rules.* Oxford: Oxford University Press, 2002. p. 160.

29 Timothy O'Riordan and James Cameron. *Interpreting the Precautionary Principle.* London: Earthscan, 1994. p. 175.

30 Ian Brownlie. *Principles of International Law.* Oxford: Oxford University Press, 2003. 6th Ed. p. 6/12.

31 Malcolm N. Shaw. *International Law.* 5th Ed. Cambridge: Cambridge University Press, 2003. p. 70.

32 For instance, Lakshman Guruswamy. *International Environmental Law in a Nutshell.* 4th Ed. St. Paul: West, 2011. p. 7553.

> "There is certainly sufficient state practice to support the conclusion that the principle, as elaborated in Article 15 of the Rio Declaration and various international conventions, has now received sufficient broad support to allow a strong argument to be made that it reflects a principle of customary law, and that within the European Union it has now achieved customary status, without prejudice to the precise consequences of its application in any given case."[33]

In view of the relevance of the precautionary principle to International Environmental Law, even described by Malgosia FITZMAURICE as one of its founding principles,[34] the consequences of applicability of a precautionary approach to the current situation of space debris mitigation must be properly acknowledged.

IV. Concluding Remarks

Undeniably, there remains to be provided a binding treaty rule contemplating a clear obligation to mitigate the production of space debris, indeed a term yet to be properly defined by International Law. Until now, only "*soft law*", non-binding instruments addressed the space debris situation, carefully avoiding the constitution of any direct and strict duty on that regard. As stated by Armel KERREST, "*it should be necessary to precise the law applicable to space debris. (…) At the international level, the principle of an obligation to mitigate debris should be clearly accepted.*"[35]

Nevertheless, irrespective of any shortcomings in the current legal framework, one should seriously wonder if an international obligation to mitigate space debris does not already exist, of a consuetudinary nature.

Considering, as stated above, that the precaution principle, at least since the 1990's, has received enough general international support to be regarded as a general principle of law or, even more, as a customary rule of International Law, it seems quite reasonable to support its applicability to the current space debris situation.

As such, it is hereby submitted that there is no lacuna in Space Law, as far as the legal requirement to mitigate the production of space debris is concerned. In accordance with the precautionary principle, Launching States shall endure cost effective measures to contain the growing production of space debris, for protection of the outer space environment.

From a technical and scientific standpoint, H. KLINKRAD, C. MARTIN, R. WALKER and R. JEHN distinguished certain categories of measures avail-

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33 Philippe Sands. *Principles of International Environmental Law*. 2nd Ed. Cambridge: Cambridge University Press, 2003. p. 279.

34 Malgosia Fitzmaurice. *Contemporary Issues in International Environmental Law*. Northampton: EE, 2009. p. 1.

35 Armel Kerrest. "Space Debris, Remarks on Current Legal Issues". *ESA SP*, n. 473, v. 2, Oct.-2001, p. 869.

able for proper space debris mitigation: reduction of mission related objects; prevention of on-orbit explosions; prevention of non-explosive release events; collision avoidance between trackable objects; post-mission disposal of space systems and removal of passive on-orbit objects.[36]

Those alternatives must be seriously considered not only by space-faring nations,[37] but by the international community as a whole, since, in accordance with the precautionary principle, which is suggested to be applicable to Space Law, the mitigation of space debris represents in actual fact a legal obligation, as far as International Law is concerned.

Poul HARREMOËS sensibly noted that "*the challenges that the precautionary principle heralds involve more than simply new decision rules and technical instruments, and this implies a learning process in public policy, industry, science and civil society at large.*"[38] Anyhow, one must consider that, through proper reference to a precautionary approach, irrespective of approval of further treaty rule on that regard, however necessary, it may be possible, in our time, to effectively protect the outer space environment from the dangers represented by space debris, and to assure the viability of space activities for generations to come.

36 H. Klinkrad, C. Martin, R. Walker and R. Jehn. "Effects of Debris Mitigation Measures on Environmental Projections", *In:* H. Klinkrad. *Space Debris: Models and Risk Analysis.* Chichester: Springer-Praxis, 2006. p. 165/168.

37 David Baiocchi and William Welser IV. *Confronting Space Debris: Strategies and Warnings from Comparable Examples, Including Deepwater Horizon.* Santa Monica: RAND, 2010. p. 27/44.

38 Poul Harremoës. "*The Precautionary Principle in the 20th Century: Late Lessons from Early Warnings*" London: Earthscan, 2002. p. 212.