LEGAL ASPECTS OF COMMERCIAL SPACE TRANSPORTATION

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"...space is the fourth domain for human activity after the land, sea, and air. Like those domains confined to Earth, space is a resource and can be utilized for scientific, strategic, and commercial applications where the benefits outweigh the cost. In this sense, for the space resource to be exploited to the fullest, the methods of accessing it should be as unconstraining as possible. Specifically, transportation to and from space should be regular, frequent, reliable, safe, and above all, as inexpensive as possible. If technology is not a boundary, getting to and from space should ultimately be as inexpensive and easy as flying a Boeing 747 or using a freight train."
Hannigan, Russell J., "Spaceflight in the Era of Aero-space Planes" (1994)

To my family whose support has been essential for the accomplishment of my studies in International Law of Air and Space and, specially to the memory of my father which has been the indispensable strength in the most difficult moments.

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ABSTRACT

The commercial space transportation industry is growing with the technology that creates more capable spacecrafts to access space. However, there are still some academic discussions related to the delimitation of the outer space and the definition of space objects that could interfere with the regulation of this growing space activity. Because these discussions are not predicted to be solved soon, the developing space policies must attempt to clarify these issues between the parts avoiding the retard in the development of the industry. Moreover, these policies have to promote public-private partnerships and the emersion of private entrepreneurs for a faster development of a safe, reliable, and affordable commercial space transportation.

RÉSUMÉ

L'industrie du transport spatial commercial croît de plus en plus avec les progrès technologiques qui créent des vaisseaux spatiaux capables d'accéder à l'espace. Cependant, il demeure encore des débats académiques liés à la délimitation de l'espace extra-atmosphérique et de la définition des objets spatiaux qui pourraient interférer avec la réglementation de cette activité spatiale en pleine expansion. Puisque ces débats ne pourront pas être résolus prochainement, les politiques de développement spatial doivent tenter de clarifier ces questions entre les parties, tout en évitant de retarder le développement de l'industrie. En outre, ces politiques doivent promouvoir les partenariats public-privé et l'émergence d'entrepreneurs privés pour contribuer au développement plus rapide d'un transport spatial commercial sûr, fiable et abordable.

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INTRODUCTION

During the entire human history the attraction to conquer unknown territories and domains has remained evident. This overpowering desire of human beings has facilitated the development of technologies allowing them to cross terrestrial territories, to defy the law of gravitation by flying above those territories and, furthermore, to travel to the greatness infinity of the outer space.

At the very first moment that a human visited outer space, numerous projects and ambitions emerged for the possible military, political, social, and economic uses of the, now reachable, domain. Moreover, through the years the main players have extended with the participation of the private sector in various projects promoting and increasing the commercial development of space activities. The spacefaring nations, understanding the important role of private entrepreneurs in developing new technologies, are currently supporting and sponsoring incentives and competitions to award the creation of new technologies.

Under this context, the transportation of goods and people to/from outer space or to/from two different points of the Earth through outer space is no longer a utopia but a tangible space activity that will facilitate and guarantee a massive access to outer space.

However, several space issues that remain unsolved and have been discussed since the beginning of the space age could prevent the extended and necessary creation of legal bodies and agreements relating the commercial uses of outer space. These academic discussions will affect important topics such as the regulations of newly created space objects which, due to the technological functions that make them capable to undertake new tasks, mix characteristics of airplanes and spacecrafts subject to different laws.

The purpose of the present research is to analyze the legal aspects surrounding commercial space transportation focusing, mostly, in the commercial human space transportation due to its upcoming development. First, we will present two fundamental debates in space law: (*i*) the definition/delimitation of outer space, and (*ii*) the definition of space objects. The discussions about the establishment of a boundary between air space and outer space as well as the attempts to define space objects are essential to understand the difficulties that space law has to regulate new space activities such as commercial space transportation where hybrid vehicles appear functioning as aircrafts and spacecrafts at the same time. Secondly, in order to understand the implication that the definition of space objects have to the present study, we will revise the space transportation systems. The differences and similarities of space objects with aircrafts and aerospace objects will be presented as well as the classification of current space transportation vehicles in order to understand the applicable law for the systems used in commercial space transportation. Thirdly, to deeply analyze the commercial human space transportation and obtain legal conclusions governing this activity, we will address the phenomenon of privatization and commercialization of space activities focusing on the commercial space transportation, its evolution, current and possible future markets, and the requirements for its success. In addition, a specific study of the commercial human space transportation will be obtained from its foreseeable markets, current projects and regulations. Finally, some conclusions and recommendations related to the legal development of commercial space transportation will be addressed.

PART I – TWO FUNDAMENTAL DEBATED ISSUES OF SPACE LAW

Chapter I – Definition/Delimitation of Outer Space

Many have been the efforts to establish specific limits of outer space and, accordingly, they have concluded that the outer frontier of the cosmic space is not possible to be established. In fact, it has been considered that the outer space may be infinite and, therefore the "law of outer space extends to infinity."[1] However, completely different is the situation of the inner frontier of outer space. For this reason, numerous have been the attempts to establish a fixed boundary, however, practical, scientific and legal debates and proposals have emerged for that purpose with no uniformly accepted achievements.

From the beginning of the space age the question of delimitation was already present, nevertheless the attention was not centered principally into the solution of this issue but in other aspects of the space activities like the exploitation of the natural resources of the Moon.[2] In 1966, the delimitation issue reappeared while elaborating the Outer Space Treaty[3] when different statements of representatives of some States suggested the inclusion of a provision related to the boundary question. In addition, the delimitation issue also emerged as part of the agenda of the Legal Sub-Committee of the UNCOPUOS requiring in many times recommendations and studies from the Scientific

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[1] Manfred Lachs, *The Law of Outer Space* (The Netherlands: A.W. Sijthoff International Publishing Company, N.V., 1972) at 55.

[2] UN COPUOS, *Report of the Ad Hoc Committee on the Peaceful Uses of Outer Space*, UN GAOR, 1959, UN Doc. A/4141. The Report expressed that it "was generally believed that the determination of precise limits for air space and outer space did not present a legal problem calling for priority consideration at this moment."

[3] *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*, 27 January 1967, 610 U.N.T.S. 205, 18 U.S.T. 2410, T.I.A.S. No. 6347 (entered into force 10 October 1967) [hereinafter Outer Space Treaty].

and Technical Sub-Committee to help addressing the question. Nonetheless, it was in 1976 when the definition and delimitation of the outer space gained practical and factual importance that required a deeper analysis and new proposals and debates, with the Bogotá Declaration.[4]

A. Debates about the necessity of delimitation

The first polemical issue about the problem of delimitation and definition of outer space is found in the divergent positions about the importance of its establishment. Some jurists and representatives of States, as well as some International Organizations, consider that it is necessary to revive the debate mainly because of the existence of hybrid systems which categorization as a space object or as an aircraft has depended, in some cases, on their location in the air space or in outer space. In fact, the International Law Association (ILA) in 1964[5] passed five resolutions related to space law and, Resolution B on "The Upper Limit of National Space," recognized "the importance of the problems of the upper limit of national space and the right of innocent passage of foreign spacecraft through

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[4] On December 3rd, 1976 some Equatorial States (Brazil, Colombia, Congo, Ecuador, Indonesia, Kenya, Uganda, and Zaire) signed a Declaration in Bogotá, Colombia claiming sovereignty rights over the Geostationary Orbit (GEO) located approximately at 35,800 km over the Earth's equator, asserting that its existence depended solely on the gravitational phenomena generated by the Earth. Nevertheless, the claims expressed in the Bogotá Declaration were rejected by most of the signatories of the Outer Space Treaty because it was mainly based on political considerations. *See e.g.* Carl Q. Christol, *The Modern International Law of Outer Space* (N.Y., U.S.: Pergamon Press Inc., 1982) at 435-546 [Christol, "Modern International Law"]; Ram Jakhu, "The Legal Status of the Geostationary Orbit", *VII Ann. Air & Sp. L.* (1982) 333-351, Marietta Benko, Willem de Graaff & Gijsbertha C.M. Reijnen, *Space Law in the United Nations* (Dordrecht, The Netherlands: Martinus Nijhoff Publishers, 1985) at 122; R.F.A. Goedhart, *The Never Ending Dispute: Delimitation of Air Space and Outer Space*, (France: Editions Frontières, 1996) at 9.

[5] The ILA started considering space law questions since its 49th Conference held in Hamburg in 1960. Then, in 1962, was established a "Space Law Committee" through the "Resolution on Air and Space Law" with the responsibility of preparing reports and questionnaires. However, it was in the 51st Conference in Tokyo in September, 1964 when the ILA passed five resolutions related to space law and, one of them recognized the importance of the issue.

such space, and the many difficulties, at once theoretical and practical, which have to be resolved before satisfactory answers can be found to them." This Resolution expressed the ILA's desire "to contribute to the study concerning the possible demarcation of the upper limit of State sovereignty and the limitation of such sovereignty to any extent necessary for ensuring that the benefits of the freedom of outer space shall be enjoyed by all Sates."[6]

In addition to those statements, there have emerged diverse arguments supporting the urgent need of recognition and establishment of a boundary between air space and outer space as well as arguments against the necessity of that delimitation.

1. Arguments in favor of the establishment of a boundary

a. Scholarly arguments

Firstly, some jurists find it necessary to delimitate outer space due to the existent opposite principles of "state's sovereignty" over the air space and the "freedom of exploration and use" of outer space by all states. If a boundary is undoubtedly fixed, those states that claim sovereignty over the entire space above their territories will have no base for their claims because the Outer Space Treaty establishes that outer space "shall be free for exploration and use by all States without discrimination of any kind, on a basis of equality and in accordance of international law, and there shall be free access to all areas

[6] As cited in Imre Anthony Csabafi, *The Concept of State Jurisdiction in International Space Law – A Study in the Progressive Development of Space Law in the United Nations*, (Hague, The Netherlands: Martinus Nijhoff, 1971) at 9.

of the celestial bodies"[7]. It also provides that outer space "is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means"[8].

Secondly, other jurists find in the possibility of damage caused by a spacecraft passing through foreign air space the importance to establish a boundary.[9] This concern is growing with the advent of technology elaborating hybrid space vehicles which pass through air space to take-off and landing and, because while flying at the height of 60 km or below, these vehicles "endanger national and/or international air traffic."[10] The space shuttle experience has not manifested any problem of this kind, by now, because its path has been always over air space of the United States and of the high seas, but this situation could change with the development of the spaceplane and other space transportation systems.

Thirdly, there is a group of academics that affirm an urgent need to define and delimitate, at least, the airspace in its upper limit for the purpose of clarifying the applicability of the sovereignty principle.[11] Moreover, other jurists in the attempt to

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[7] Outer Space Treaty, *supra* note 3, article I.
[8] *Ibid.*, article II.
[9] Benko, Graaf & Reijnen, *supra* note 4, at 130.
[10] V. Kopal, "The Question of Defining Outer Space" (1980) 8:2 J. Space L. 159, cited in Goedhart, *supra* note 4.
[11] *See* American Bar Foundation, *The Law Relating to Activities of Man in Space* (Chicago: The Univ. of Chicago Press, 1970) at 48; *see also* A.D. Terekhov, "Passage of Space Objects Through Foreign Airspace," *Proceedings of the Thirty-second Colloquium of the Law of Outer Space* (Washington, D.C.: AIAA, 1990) 50, 53; M. Benko and J. Gebhard, "The Definition/Delimitation of Outer Space and Outer Space Activities Including Problems Relating to the Free ('Innocent') Pasage of Spacecraft Through Foreign Airspace for the Purpose of Reaching Orbit and Returning to Earth" in M. Benko and K.-U. Schrogl, eds., *International Space Law in the Making*, (France: Editions Frontieres, 1993) 11, 134; M. N. Andem, *International Legal Problems in the Peaceful Exploration and Use of Outer Space* (Finland: Univ. of Lapland, 1992) 153.

elucidate the extent of the state's exclusive jurisdiction and control over their airspace have stated several proposals to identify a clear and specific boundary. [12]

Fourthly, other jurists while finding it difficult to agree in a clear boundary opine that the solution for some jurisdiction problems[13], arms race prevention and space weapons prohibition or authorization,[14] as well as other specific issues; might be the application of a limited-purpose boundary.

Fifthly, another argument supports the importance of a clear establishment of a boundary to prevent actions by states to claim sovereignty rights over outer space as it happened with the Bogotá Declaration of 1976.[15]

Finally, some jurists believe that the delimitation of outer space by establishing an upper limit of the air space will be important for the creation and development of space technologies as well as considerably significant to avoid tension and possible international disputes among States in the future[16].

b. States' positions and UNCOPUOS debates

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[12] *See, e.g.*, J.C. Cooper, "Fundamental Questions of Outer Space Law" in I.A. Vlasic, ed., *Explorations in Aerospace Law* (Montreal: McGill Univ. Press, 1968) 289 546 [Cooper, "Fundamental Questions"].

[13] *The Question of the Definition and/or Delimitation of Outer Space: Background Paper Prepared by the Secretariat*, U.N. Doc. A/AC.105/C.2/7 (1970) at 56, cited in Elizabeth Kelly, *The Spaceplane: The Catalyst for Resolution of the Boundary and 'Space Object' Issues in the Law of Outer Space?* (LL.M. Thesis, McGill University Institute of Air and Space Law, 1998) [unpublished], at 51. In this document it was proposed to create a specific boundary with the only purpose of establish where ICAO's authority or where a state's jurisdiction end.

[14] C. Voute, "Boundaries in Space" in B. Jasani, ed., *Peaceful and Non-Peaceful Uses of Space*, (New York: Taylor and Francis, 1991) 19, 22, 23, 34. Professor Voute proposed a specific boundary at 100 km. to be established in a treaty preventing arms race in outer space.

[15] D. Goedhuis, "The Problems of the Frontiers of Outer Space and Air Space," 174 *Recueil des Cours: Collected Courses of the Hague Academy of International Law* (The Hague: Martinus Nijhoff, 1982) 390, 404 [Goedhuis, "Problems of the Frontiers"]; *see also* D. Goedhuis, "Reflections on Some of the Main Problems Arising in the Future Development of Space Law," XXXVI *Netherl. Int'l L. Rev.* 255 (1989).

[16] Goedhart, *supra* note 4 at 8; S.N. Hosenball and J. S. Hofgard, "Delimitation of Air Space and Outer Space: Is a Boundary Needed Now," 57 *U. Colo. L. Rev.* (1986) 885, 892; Kelly *supra* note 13. Although these authors agree that no past problem has need solely, the establishment of a boundary and that it is premature to establish it; they agree that, with the advent of technology as the spaceplanes, this situation will change dramatically.

The question of definition/delimitation of outer space has not only been discussed among academics. Some international organizations have debated the issue supporting the position of a necessary establishment of a boundary. An illustrative case is the United Nations *ad hoc* Committee on the Peaceful Uses of the Outer Space (UNCOPUOS) that, since 1959, has been discussing the issue until nowadays. For the UNCOPUOS, this question is important to be discussed because it has been considered a priority item studied by a special working group established for that purpose[17] from which different solutions have been proposed without reaching consensus. During those debates, some states have affirmed the need of a fixed boundary.

The General Assembly of the UN, in its Resolution 61/111, endorsed a recommendation of the COUPUOS stating that the Legal Sub-committee should consider matters relating the definition and delimitation of the outer space during its 46th session.[18] During this session, held in Vienna from 26 March to 5 April 2007, the Chairman of the Working Group on the "Definition and Delimitation of the Outer Space" presented a Report on the "Definition and Delimitation of Outer Space." The report emphasized that the Working Group was reconvened in the 748th meeting of the Legal Sub-committee.[19] In this report is mentioned the view of some states considering that "the delimitation of outer space would help states to avoid possible problems connected with the rapid development of space technologies and the increasing activities of States and private

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[17] *International Co-operation in the Peaceful Uses of Outer Space*, GA Res. 38/80, UN GAOR, 38th Sess., UN Doc. A/38/80 (1983).
[18] *Report of the Legal Subcommittee on the Work of its Forty-sixth Session*, UN COPUOSOR, 50th Sess., UN Doc. A/AC.105/891 (2007).
[19] *Ibid.*, Annex II, para. 1.

entities in the exploration and use of outer space."[20] However, it was expressed that other delegations considered that "States should continue to operate under the current framework, which had functioned well, until such time as there was a demonstrated need and a practical basis for developing a definition or delimitation of outer space."[21] Other views included the economic importance to states of the definition and delimitation of outer space,[22] the complication that would follow the definition and delimitation to existing activities as well as the obstruction of space technologies that such a definition/delimitation would cause,[23] the importance of regulating space traffic rather than the definition or delimitation of outer space,[24] the opinion that sub-orbital flights could be regulated by air traffic law,[25] the need to find a balance between the freedom of exploration and use of outer space and the safety of States in the use of space objects,[26] and that the absence of consensus in this issue was due to the lack of sufficient practice of States in the exploration and use of outer space.[27] Moreover, it was expressed that "the continuing practice of States in the exploration and use of outer space could lead to the creation in the future of a customary rule that could assist States in delimiting outer space."[28]

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[20] *Ibid.* para. 4.
[21] *Ibid.* para. 5.
[22] *Ibid.* para. 6.
[23] *Ibid.* para. 7.
[24] *Ibid.* para. 8.
[25] *Ibid.* para. 9.
[26] *Ibid.* para. 10.
[27] *Ibid.* para. 11.
[28] *Ibid.* para. 12.

The most important conclusion is that some delegations considered that the definition and delimitation of outer space continue to be "a topical and important issue that should continue to be considered by the Working Group."[29]

2. Arguments against the establishment of a boundary

On the other hand, there are also arguments against the idea of delimitation of outer space. The fundamental basis of most of these arguments is that the establishment of a boundary is not needed or necessary. Moreover, the supporters of this position argue that the urgency of its existence and establishment has not been demonstrated by any argument in favor of the delimitation and definition of outer space,[30] rather, the practical experience shows that such a boundary is not required to be fixed.[31]

a. Scholarly arguments

Firstly, some authors argue that the absence of a specific boundary has not created international disputes and the most probable situation is that it will be the same in the

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[29] *Ibid.* para. 17. Furthermore, the Sub-committee continued inviting States to submit information about national regulation and practices related to the issue, "taking into account the current and foreseeable level of space and aviation technologies," as well as inviting States to answer the following questions:

> *(i) Does your Government consider necessary to define outer space and/or to delimit air space and outer space, given the current level of space and aviation activities and technological development in space and aviation technologies? Please, provide a justification for the answer; or*
>
> *(ii) Does your Government consider another approach to solving the issue? Please, provide a justification for the answer.*

[30] C.W. Jenks, *Space Law* (London: Stevens & Sons, 1965) 390; S. Rosenfield, "Where Air Space Ends and Outer Space Begins," (1979) 7 *J. Sp. L.* 137 at 147.

[31] Jenks, *ibid.* at 111. *Contra* Goedhuis, *supra* note 15, at 404.

future[32]. Moreover, if an arbitrary boundary is fixed, it will probably become a factor of disputes in the future based on boundary violations[33].

Secondly, there are those who argue that to the present days any possible problem that could have arisen has been solved without the need of any established boundary. Furthermore, they state that no incident occurred has needed a specific establishment of a boundary to solve it.[34] This group maintains that the practical experience shows that the current legal instruments have been enough to solve those problems and the boundary question has been irrelevant.[35]

Thirdly, others believe that delimitation will probably conclude in "excessive territorial demands" of some States and, in the present legal instruments, in case of accidents the location is not important rather, the object causing the damage is the relevant connector.[36]

Fourthly, there is other group that bases its position on the conclusions of the UNCOPUOS Scientific and Technical Sub-committee in 1967 which stated that a precise definition of outer space was not possible at that time due to specific technical and scientific criteria."[37]

Fifthly, some authors foresee if the boundary is established too high it could obstruct some space activities but if established too low, security concerns will arise

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[32] G. P. Zhukov, "Weltraumrecht", (Berlin Verlag, Berlin/F.R.G., 1968) 316-317 [Zhukov, "Weltraumrecht"], cited in Goedhart, *supra* note 4 at 6.
[33] *Ibid*, at 7.
[34] I.H.Ph. Diederiks-Verschoor, *An Introduction to Space Law* (The Netherlands: Kluwer, 1993) 15; Goedhuis, *supra* note 15.
[35] Benko, Graaf & Reijnen, *supra* note 4, at 134. For these authors, the relevant issue to apply the Liability Convention, the Registration Convention and the Rescue Agreement is if the object under study is a space object, rather than where the object under consideration is located or caused the damage.
[36] Zhukov, "Weltraumrecht," *supra* note 32.
[37] UN Doc. A/AC.105/39 of September 6, 1967, p.7.

among States.[38] For this reason, it is also argued that a strict establishment of a boundary will not accept further lowering due to states' concerns of violation of their air space sovereignty.

Finally, some consider that the fact of establishing a specific boundary will become obsolete in the future due to new developments and technologies like hybrid systems[39].

b. States' positions and UNCOPUOS debates

During debates in the Legal Sub-Committee of the UNCOPUOS the statements of representatives of several states are evidence of those states' position against the necessity of demarcation of a boundary. Some spacefaring nations like the United States of America[40] considered that such delimitation was unnecessary because there is no "legal or technical need or justification for a definition" and a fixed and arbitrary boundary will in fact bring difficulties.[41] Among other nations rejecting the need of a fixed boundary, appear the United Kingdom[42], Germany[43] and Romania.[44] In addition to the position of

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[38] Zhukov, "Weltraumrecht," *supra* note 32; L. Lipson and N.D. Katzenbach, *Report to the National Aeronautics and Space Administration on the Law of Outer Space* (Chicago: American Bar Foundation, 1961) 17.

[39] Benko, Graaf & Reijnen, *supra* note 4 at 135.

[40] U.N. COPUOS, Summary Record of the 396th Meeting of the Legal Subcomm. (7 Apr. 1983) U.N. Doc. A/AC.105/C.2/SR.396, 11 Apr. 1983, at 2. The delegation stated that there was no need in delimitation to the progress of space activities; *see also* U.N. COPUOS, Verbatim Record of the 362nd Meeting of COPUOS, Rep. of the Legal Subcomm. On the Work of its 30th Session (4 June 1991) U.N. Doc. A/AC.105/C.2/PV.362, 12 July 1991, at 43-44. At this moment, the U.S. Representative stated that "premature attempts to establish such a definition or delimitation may in fact complicate, if not impede, further progress in the peaceful exploration and utilization of outer space," cited in Kelly, *supra* note 13.

[41] U.N. Doc. A/AC.105/PV.193, p.47, of June 20th, 1979, as cited in Goedhart, *supra* note 3 at 5.

[42] U.N. COPUOS, Summary Record of the 560th Meeting of the Legal Subcomm. (8 Apr. 1992) U.N. Doc. A/AC.105/C.2/SR.560, 13 Apr. 1992, at 2. The statement illustrated the state's position of finding no need for delimitation or establishment of a boundary.

[43] U.N. COPUOS, Summary Record of the 560th Meeting of the Legal Subcomm. (8 Apr. 1992) U.N. Doc. A/AC.105/C.2/SR.560, 13 Apr. 1992, at 4.

[44] U.N. COPUOS, Summary Record of the 396th Meeting of the Legal Subcomm. (7 Apr. 1983) U.N. Doc. A/AC.105/C.2/SR.396, 11 Apr. 1983, at 23.

these states arguing the no need of a boundary, the U.S. also argued that is necessary to examine legal, political, military, economic, technological, and scientific factors to obtain an adequate establishment of a boundary, but such analysis has not been done.[45]

The UNCOPUOS has recognized the main arguments of the states that are against the establishment of a boundary and, in summary, they are that: (*i*) there is no practical or legal need to the delimitation/definition issue; consequently there is no need to pursue the debate of this topic[46], and (*ii*) the premature establishment of a boundary might obstruct the "progress in the peaceful exploration and use of outer space."[47]

B. Approaches to definition/delimitation

The definitions of "airspace" and "outer space" do not appear in any international instrument of air and space laws and, for that reason, numerous and diverse have been the suggestions of where the air space ends and the outer space begins without reaching consensus. There are different approaches among the authors and academics to attempt to obtain a solution to the problem of definition and delimitation of the outer space.

From the legal debates of the UNCOPUOS as well as from different positions of academics, two major approaches can be found to solve the question of delimitation of outer space. These are the *spatialist* and the *functionalist* approaches. Other approaches to

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[45] U.N. COPUOS, Summary Record of the 316th Meeting of the Legal Subcomm. U.N. Doc. A/AC.105/C.2/SR.316, 4 Apr. 1979, at 2.

[46] *Report of the Legal Subcommittee on the Work of its Thirty-fifth Session*, UN COPUOSOR, 39th Sess., UN Doc. A/AC.105/639 (1996), para. 13.

[47] *Report of the Committee on the Peaceful Uses of Outer Space*, UN GAOR, 48th Sess., Supp. No. 20, UN Doc. A/48/20 (1993), para 100;.*Report of the Committee on the Peaceful Uses of Outer Space*, UN GAOR, 49th Sess., Supp. No. 20, UN Doc. A/49/20 (1994), para. 114; *Report of the Committee on the Peaceful Uses of Outer Space*, UN GAOR, 50th Sess., Supp. No. 20, UN Doc. A/50/20 (1995), para. 115; *Report of the Committee on the Peaceful Uses of Outer Space*, UN GAOR, 51th Sess., Supp. No. 20, UN Doc. A/51/20 (1996), para. 125.

a boundary prepared by national delegations, international organizations and remarkable academics and authors have also emerged.

1. Spatialist Approach

On the one hand, there is the *spatial approach* that looks forward the establishment of a lower boundary of outer space. Among the *spatialists*, diverse have been the theoretical alternatives to obtain a solution developed by the Legal Sub-Committee of the UNCOUPOS as well as by some jurists and academics.

a. Identified alternatives by the Legal Sub-Committee of the UNCOPUOS

The Secretariat of the Legal Sub-Committee of the UNCOPUOS prepared two background papers in 1970 and 1977 identifying eight alternatives.[48] These criteria consisted in: (a) Demarcation based upon the equation of the upper limit of national sovereignty with the concept of 'atmosphere'; (b) Demarcation based on the division of the atmosphere into layers; (c) Demarcation based on the maximum altitude of aircraft flight; (d) Demarcation based on aerodynamic characteristics of flight instrumentalities; (e) Demarcation according to the lowest perigee of an orbiting satellite; (f) Demarcation based upon the Earth's gravitational effects; (g) Demarcation based on effective control; and (h) Demarcation based upon the division of space into zones.

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[48] *The Question of the Definition and/or the Delimitation of Outer Space: Background Paper Prepared by the Secretariat*, U.N. Doc. A/AC.105/C.2/7 (1970) and Addendum U.N. Doc. A/AC.105/C.2/7/Add.1 (1977) cited in Benko, Graaf & Reijnen, *supra* note 4, at 127.

From the combination and interpretation of these criteria, other alternatives have emerged among academics and will be analyzed below. For example, from the criterion based on atmospheric layers and to zones, some have proposed to call the region between 50 km above sea level and 130 km, plus o minus 10 km, the "mesospace" based on the physical properties of the atmosphere, where space objects will enjoy clear transit rights.[49]

b. Environmental/Physical/Geophysical alternatives

One of these proposals is based upon scientific and technical characteristics and physical principles like the "support from the atmospheric air in case of aircraft; absence of any such support in the case of spacecraft", the need of different environmental conditions as "a sufficiently high air density in the case of aircraft motion; sufficiently low air density in the case of spacecraft motion."[50] Nevertheless, this proposal has its weaknesses found in the fact that the air density varies with altitude and time and also because of the development of hybrid space vehicles that operate as a spacecraft in one part of the mission and as an aircraft in another part.[51]

- **Atmosphere as a boundary**

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[49] C. de Jager & G. C. M. Reijnen, *Mesospace: The Region between Airspace and Outer Space, Proceedings of the 18th Colloquium on the Law of Outer Space, IISL, IAF, Lisbon, Portugal, 1975* (California: UC Davis School of Law, 1976) 107``````, cited in Christol, "Modern International Law", *supra* note 4 at 503. *See also* C. Q. Christol, "'Innocent Passage' in the International Law of Outer Space," 7 *A. F. Jag. L. Rev.* 22 (Sept.-Oct. 1965). *See infra*, at 11.

[50] Christol, "Modern International Law", *supra* note 4 at 503.

[51] *Ibid.* at 130.

This proposal is based in the idea that the boundary between air space and outer space is located where the atmosphere looses the natural and physical properties of the air space or Earth's atmosphere and becomes outer space. However, it is not scientifically proved the exact extent and quantity of the atmosphere to establish a certain boundary based on this criterion.[52] Other interpretation of this theory considers the upper limit of the atmosphere, which is up to about 800 km, as the boundary between air space and outer space. Obviously, this position has to be rejected due to the high location of the boundary, leaving a huge mass of space where numerous satellites are orbiting out of what might be considered, following this argument, "outer space".

- **Division of the atmosphere into layers**

This theory intends to divide the atmosphere into three horizontal layers with different applicable laws. The most notable supporter of this position has been J. C. Cooper who proposed to divide the atmosphere as follows[53]: (*i*) the "territorial space", subject to State's sovereignty, would be the space over a State extended until the height where an aircraft, as defined in article 1 of the 1944 Chicago Convention, is capable to flight; (*ii*) the "contiguous space", subject to states' sovereignty with a right of passage for non-military flight instrumentalities, would extend up to 300 miles above the Earth's

[52] Goedhart, *supra* note 4 at 31-34.
[53] J.C. Cooper, "The Boundary Between Territorial Airspace and International Outer Space," *Explorations in Aerospace Law*, I.A. Vlasic, ed. (Montreal: McGill Univ. Press, 1968) 304 546.

surface; and (*iii*) the "cosmic space", subject to freedom of passage of any instrumentality, extended from the end of the "contiguous space" and beyond.[54]

The "contiguous space" located between air space and outer space finds its justification in the basis of future developments of air and space technologies. However, some jurists argue that because this concept is not mentioned in the 1944 Chicago Convention, it must be rejected[55], while others find no violations of the Convention because the "contiguous zone begins only at a height where air space is non-navigable."[56] There is also argued that this zone is not accord with the Outer Space Treaty of 1967 from which one could conclude that "outer space and the Earth's atmosphere would link up with each other perfectly" without the existence of any intermediate zone.[57] Moreover, this theory has also been criticized because of its confusing numerical values, its inconsistency and uncertainty of the location of the "contiguous space".

Nevertheless, there is an alternative proposal of this theory which, instead of a "contiguous space", refers about "mesospace" extended from 50 km to 100 km above sea level. [58] The establishment of a "mesospace" is based on scientific and technological facts procuring a more certain and authoritative veil to the theory. It is proposed that no sovereign rights apply in this zone but the rules of international law including the right of passage. However, it is highly possible that the rules applying would be mainly from the

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[54] R. T. Murphy, "Air Sovereignty Considerations in Terms of Outer Space," *Legal Problems of Space Exploration, A Symposium* (Washington, D.C.: U.S> Government Printing Office, 1961) 211-212; cited in Goedhart, *supra* note 4 at 66.

[55] Goedhart, *supra* note 4 at 69. Articles 1 and 2 of the 1944 Chicago Convention deal with the exclusive sovereignty of every State over the airspace above their territories and define the term territory as "the land areas and territorial waters adjacent thereto under the sovereignty, suzerainty, protection or mandate of such a State."

[56] *Ibid.*

[57] *Ibid.*, at 70. Article VII of the Outer Space Treaty describes the international liability of States when a space object or its component parts cause damage "on the Earth, in the air space or in outer space".

[58] *Ibid.*, at 72-74.

corpus iuris spatialis so; few differences will be between the regime applied to the mesospace and the one of the outer space making it legally useless to have two different layers. Moreover, the space law regime and its freedom of use and exploration will apply from very low altitudes which will be a threat for all States. This theory is also criticized because of the variable conditions of the Earth's atmospheric gases[59].

- **Aerodynamic theory**

This theory is based on the force of the air to establish a boundary between air space and outer space at a height between 80 km and 90 km. Because the density of the air decreases with altitude, that air force which is essential for aviation disappears and aircrafts are no more capable of flying above that altitude.[60] Nevertheless, this theory depends once again in the progress of technology capable to construct aircrafts able to flight above that height or, moreover, to go to and from outer space and return to earth.

- **Range of terrestrial gravitation or gravisphere theory/Earth's gravitational effects**

This theory is based on gravitational law according to which "two bodies attract lithe distance between their centres of mass."[61] The environment where a body attracts

[59] U.N. Doc. A/AC.105/c.1/L.76, 23 Mar. 1976, cited in Christol, "Modern International Law", *supra* note 4 at 503.
[60] Goedhart, *supra* note 4 at 55-64.
[61] *Ibid.*, at 39. Newton's law of gravitacion $F = G \cdot (m1 \cdot m2)/r^2$ (*i.e.* F = the gravitation(al force), m = the mass of each body or the matter that each body contains, radius or r for short = the distance between the centres of two bodies, and G = the constant of gravitation).

other bodies is called a gravitational field and, the "gravisphere of the Earth" is that gravitational field or region where the terrestrial gravitation (force of attraction of the Earth over other bodies) is stronger that the one of the Sun. This theory, while using the upper edge of the Earth' gravisphere as the lower limit of the outer space, was developed in order to obtain national territorial defense.[62] However, this position has been rejected and unsustainable due to its useless legal and practical characteristics.

- **Rotation theory**

According to this theory, air space would end and outer space would start at the height where the perception of the Earth's spinning around its axis' effect is no possible. In other words, that boundary should be found, based on this criterion, where the centrifugal and the gravitational forces balance each other. Nevertheless, this theory has not been widely accepted because the balance point of those forces is not a clear criterion. Moreover, it goes against scientific reality when considering that the atmosphere of the Earth rotates simultaneously up to a determined height, after which they are completely independent.[63]

- **Lowest perigee of orbiting satellites**

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[62] *Ibid.*, at 39-42. The delimitation of the Earth's gravisphere is usually found at 1.5 million km because beyond that boundary, the Sun's attracting force is predominant. For this reason, it is consider nonsense to establish the boundary between air space and outer space in such a high altitude.
[63] *Ibid.*, at 43-44.

The most debated theory under the discussions of the UNCOPUOS has been the delimitation of outer space "according to the lowest perigee of an orbiting satellite at an altitude of approximately 100-110 km above sea level."[64] The lowest perigee of an orbiting satellite is its lowest point above the surface of the Earth passed by any satellite "on its elliptic orbit around the Earth."[65] The theory of using this criterion to establish the boundary between air space and outer space has been supported by many academics and some States.[66] Since 1968, outer space was interpreted to include "all space at and above the lowest perigee achieved by the 27th January 1967, when the [Outer Space] Treaty was opened for signature, by any satellite put into orbit, without prejudice to the question whether it may or may not later be determined to include any part of space below such perigee."[67] Later on, in 1976 some conclusions about the altitude of the lowest perigee of orbiting satellites were obtained from a research prepared by the Committee on Space Research of the International Council of Scientific Unions. The different theoretical and statistical considerations concluded that between the altitude of 100 km and 90 km above sea level, only few satellites could enter but they would be strongly damaged or destroyed.[68] This criterion has the advantage of being based on physical invariable aspects which can barely depend on some technological advances concerning satellites

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[64] Benko, Graaf & Reijnen, *supra* note 4, at 128.
[65] Goedhart, *supra* note 4 at 47.
[66] *See* V.S. Vereshchetin and G.M. Danilenko, "Custom as a Source of International Law of Outer Space" (1985) 13 *J. Sp. L.* 22 at 27; B. Cheng, "The Legal Regime of Airspace and Outer Space: The Boundary Problem; Functionalism versus Spatialism: The Major Premises," *Studies in International Space Law* (New York: Oxford Univ. Press, 1997) 450; H.A. Wassenbergh, *Principles of Outer Space Law in Hindsight* (The Netherlands: Kluwer, 1991) 15.
[67] International Law Association, *Space Law Resolution: Report of the 53rd Conference of the International Law Association, Buenos Aires, 1968* (London: ILA, 1969). *See also*, International Law Association, Space Law Resolution, *Report of the 58th Conference of the International Law Association*, Manila, Sept. 1978, *excerpted in Space Law and Institutions: Documents and Materials*, I.A. Vlasic, ed. (Montreal: McGill Univ. 1997) 153. The ILA changed its former position to support the idea of considering outer space to be at an altitude of 100 km above sea level.
[68] Goedhart, *supra* note 4 at 47. CO.SPA.R.'s piece of research on the subject is entitled 'Study on altitudes of artificial Earth satellites' (U.N. Doc. A/AC.105/164, of January 6th, 1976).

which would be able to orbit at lower altitudes.[69] Nevertheless, the biggest weakness of this criterion is the difficulty of establishing a method for determining the numerical value of the boundary.[70]

This theory also shows its strength with the fact that "no state has protested against satellites passing over its territory at altitudes above 100-110 km". Also, it has been recognized that below that altitude a satellite cannot "describe a full orbit around the Earth" without burning up or e-enter the Earth's atmosphere and there have been considered the requirements of international civil aviation because over approximately 60 km above sea level an aircraft is not capable to flight.[71]

The widest accepted suggestion appears in a resolution of the International Law Association in Buenos Aires in 1968 which establishes that outer space "should be interpreted to include all space at and above the lowest perigee achieved by an orbiting satellite."[72]

- **Maximum altitude of aircraft flight**

Based on the definition of an "aircraft" of the Annex 7 to the Chicago Convention which provides that it is "any machine that can derive support in the atmosphere from the

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[69] *Ibid.*, at 48.
[70] *Ibid.*, at 51. The author also mentions that, in practice, spacefaring nations "have for many years been launching most artificial Earth satellites into orbits near the demarcation line of 100 km or above, so this practice is often seen as an international custom. In addition, certain features of the Earth's atmosphere indicate that the lower limit of outer space should be fixed in the neighbourhood of 100 km above sea level or higher."
[71] Benko, Graaf & Reijnen, *supra* note 4, at 129.
[72] Rod D. Margo & Robert Lenhard, "Space Shuttle Identity Crisis" (1984) 7:6 L.A. Law.

reactions of the air other than the reactions of the air against the Earth's surface,"[73] this theory establishes the boundary between air space and outer space at the maximum altitude where such a machine can fly. However, with the advent of air and space technologies the capabilities to flight in upper/lower altitudes of aircrafts and space objects will vary reflecting the uncertainty and weaknesses of this theory. Other proposal suggests the "limits of the earth's atmosphere" while others prefer "the maximum altitude which can be achieved by an aircraft in flight, the point at which aerodynamic lift yields to centrifugal force (approximately 55 miles above the earth's surface), the point at which the gravitational pull of the earth ceases, and the limit at which an underlying state would be able to effectively apply its authority"[74].

- **Biological theory**

This proposal supports that the atmosphere or air space's limit is located where the human beings cannot sustain their lives without requiring technical devices. However, this theory has not gained wide acceptance, mainly, due to the extreme low limit that will be obtained from the application of this criterion.[75]

c. Effective Control Approach

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[73] *Convention on International Civil Aviation*, 7 December 1944, 15 U.N.T.S. 295, Annex 7, "Aircraft Nationality and Registration Marks" (July 1981) at 7.
[74] Margo & Lenhard, *supra* note 72.
[75] Goedhart, *supra* note 4 at 35-38. *See also*, S. Mishra and T. Pavlasek, "On the Lack of Physical Bases for Defining a Boundary Between Air Space and Outer Space'" (1982) VII Ann. Air & Sp. L. 399, 406.

According to this theory, the upper limits of a State's jurisdiction "will be determined by the extent upward to which the subjacent state can exert effective control."[76] This effective control can be exerted by states by electronic or optical observation or by physical inspections.[77] It is generally argued that the use of this theory to solve the boundary problem will promote inequality among the developed States which have better technologies to expand their effective control at high altitudes and the not developed States with weaker resources to exert effective control. Moreover, this unequal situation will produce different boundary lines which go against the purpose of establishing a clear, uniform and certain boundary between air space and outer space.[78]

d. State Security and State Interests theory

This theory is based in the idea that "the farther State sovereignty extends, the better national security is safeguarded."[79] For that reason, the boundary would be established at a height where that national security is considered protected by the proper State. Nevertheless, the variety and subjectivity of the interests of States as well as the dependent relation of this theory with political relations and technology developments support this proposal in weak bases because it will not allow the establishment of a uniform and clear boundary.

e. Specific boundary's location/Arbitrary altitude

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[76] H.B. Jacobini, "Effective control as related to the extension of sovereignty in space," *7 J. Pub. L. 97* (1958) 115, cited in Goedhart, *supra* note 4 at 99.
[77] Goedhart, *supra* note 4, at 99.
[78] *Ibid.*, at 100.
[79] *Ibid.*, at 103.

Some jurists have proposed boundaries located in different altitudes based on arbitrary arguments. Most of them consider the height of 100 km above sea level[80] as the most adequate altitude for the boundary, while others prefer the altitude of 80 km above sea level.[81] It was the case of the former Soviet Union (USSR) which proposed through a working paper submitted to the Legal Sub-Committee of the UNCOPUOS on April 4, 1983 to establish the boundary "at the height of approximately 100-110 km above the sea level" which should be agreed among States and the "right of free passage" of spacecrafts "below this limit through foreign air space for the purpose of take-off and landing.".[82]

f. General critic of the spatialist approach

In addition to the specific critics revealed for the alternatives of the spatilism, there is a general weakness of this approach. By establishing a determined boundary separating the free outer space with the sovereign air space of each State, it facilitates passage problems over foreign States' territories once the object is passing through air space. For this reason "right of passage" rules have to be created an agreed to improve and aid the situation of small geographic spacefaring nations that need the passage of their objects over foreign air space or for reasons of emergency landings of space objects.[83]

2. Functionalist Approach

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[80] Diederiks-Verschoor, *supra* note 34 at 18.
[81] *See,* M.N. Andem, *International Legal Problems in the Peaceful Exploration and Use of Outer Space* (Finland: Univ. of Lapland, 1992) 152; cited in Kelly, *supra* note 13, at 57.
[82] UN Doc. A/AC.105/C.2/L.139 of April 4, 1983, cited in Benko, Graaf & Reijnen, *supra* note 3, at 128 and Goedhart, *supra* note 4 at 4. *See also,* Christol, "Modern International Law", *supra* note 4 at 486-489.
[83] Goedhart, *supra* note 4 at 87.

On the other hand, there is also a *functional approach* which focuses on the purpose, objectives and characteristics of the activities rather than the specific location of a limit or boundary between air space and outer space.

This approach distinguishes between "aeronautical" and "astronautical" activities based upon the nature and type of the activity and the flying properties of the object, rather than a specific altitude where it is realized.[84] After analyzing the nature, properties, missions, and characteristics of the object will be determined which, air law or space law, apply.

Among the *functionalists,* one proposal has been to establish "a single legal regime for air space and outer space" that should be involved under the term "aerospace", so the nature of the activities would be examined rather than the measure of the space.[85] This approach would bring the benefit of avoiding the disputes about the importance of establishing a boundary between airspace and outer space and its location. Another suggestion between the supporters of this approach has been the establishment of different boundaries to different types of activities.[86] In addition, other group considers that this approach gives states more "freedom of operation" under space law and that it also implies a "right to innocent passage"[87] which would solve the problem that the spatialism causes by demarking a specific boundary line.[88]

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[84] Benko, Graaf & Reijnen, *supra* note 4, at 129.
[85] N. M. Matte, *Aerospace Law* (London: Sweet & Maxwell, 1969) at 58-62 and N. M. Matte, "Introductory Comments on the Aerospace Medium," in *Proceedings of the 20th Colloquium on the Law of Outer Space* 47 (1978) cited in Christol, "Modern International Law", *supra* note 4 at 503.
[86] Cf. F. Zwicky, "The Morphology of Justice in the Space Age", *Proceedings of the Fourth Colloquium on the Law of Outer Space*, Washington 1961, and "The Morphology of Justice in the Space Age and the Boundaries of Outer Space", *Acta Astronautica*, 14, 1969, pp. 615 ff. as cited in Lachs, *supra* note 1 at 56.
[87] Wassenbergh, *supra* note 66, at 18.
[88] *See, supra* note 83 and accompanying text.

The greatest advantage obtained from the functionalism is that there is no need into reviving the debate of delimitation/definition of outer space because of the meaningless of a specific establishment of a boundary. Nevertheless, some problems would arise from the functionalist approach. Firstly, by leaving aside the location of the vehicle carrying out the activity, the supporters of this theory are forgetting that there is a distinction between air space and outer space due to the existence of different principles applying to them (*i.e.* freedom of exploration of outer space and sovereignty over air space) which have huge influence over those activities.[89] Secondly, although this approach seems to get an apparent simple solution by leaving behind boundary debates, the discussions related to definition of terms as "space object", "space activities", "space flight", and the distinction between "aircraft" and "spacecraft" will be revived.[90] Thirdly, this approach will make applicable the space law regime to a spacecraft since the launching phase until its landing even while passing through the air space of a foreign state.[91] This situation demonstrates a weakness of the theory due to the fact that some activities are allowed in air space and forbidden in outer space showing that the location of the vehicle pursuing a specific activity matters more than its nature.[92] Fourthly, the general international community does not widely accept the idea of a "right of innocent passage" over their territories as implied from this theory because it would affect their national security.[93] Finally, problems arising from the development of specific hybrid systems such as the

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[89] Goedhart, *supra* note 4 at 86.
[90] Benko, Graaf & Reijnen, *supra* note 4, at 129; Goedhart, *supra* note 4 at 86.
[91] Benko, Graaf & Reijnen, *ibid.*
[92] Goedhart, *supra* note 4 at 86. The author explains, for example, that the article IV of the 1967 Outer Space Treaty prohibits "to put into orbit around the Earth any space objects carrying nuclear weapons or any other kinds of weapons of mass destruction on board, or to station such weapons in outer space in any other manner." However, national law allows these activities in the air space where a Sate has sovereignty in the air space over the high seas.
[93] Wassenbergh, *supra* note 66, at 18.

aerospace plane would make it difficult to apply the functional approach because the nature of their activities are not clear but hybrid.

3. Other Approaches

a. Allocative Approach

This approach was proposed by Professor Christol who, after finding critics to the main approaches (*i.e.* the functionalism and the spatialism), suggested that the purpose of the vehicle and the effects of its activities would determine its applicable law. For that reason, if it is decided that the vehicle has only an aviation purpose, air law would apply while, if considered as having an outer space purpose, space law would be applicable. He explained the special situation of the space plane and other hybrid systems:

> "If its purpose is to enter and to return from space while having the capacity to orbit the Earth at least one time, it will be subject to the regime of space law. If, on the other hand, its purpose were to travel through an area in which it would not become orbital, it would fall within the regime of air law. If the purpose of the craft were to engage in transportation from one place on Earth even though for a brief time it might be at orbital heights, it would still be treated as an air plane and would be subject to the regime of air law."[94]

The author understands that the classification and determination of the purposes of a vehicle can be subjective and, for that reason, he also recognizes some objective criteria

[94] C. Q. Christol, "Air and Space Transit, International Law and Space Law: Clarification of Law and Policy," *Proceedings of the Thirty-fourth Colloquium on the Law of Outer Space* (Washington, D.C.: AIAA, 1992) 28 [Christol, "Air and Space Transit"]; *see also* C.Q. Christol, "The aerospace plane: its legal and political future," 9 *Sp. Policy* 35, 42-43 (Feb. 1993).

that other states and use in order to value the purposes such as the place of departure, the conduct, transit pattern and if the craft was registered in the U.N.[95]

b. Definition of outer space by defining "objects in space"

This theory, proposed by Mr. Chandrashekar, suggests defining outer space by defining a particular weapon as a "space weapon" based on specific characteristics, which should be accomplished by a treaty providing means of determination of those prohibited space weapons. However, the same representative of this theory understands the major weakness of the proposal which is the continuous changes that technology will cause over the determining characteristics of the space weapons.[96]

c. Theory of a uniform legal regime

This theory proposes to subject both, air flight and space flight, to a uniform legal regime with the same rules leaving aside the need of a boundary. This suggestion is based upon the idea that, in a future, the technology will make space flight more popular, used and frequent than air flight and, for that reason the latter will "disappear" or will be dwarfed together with its sovereignty rights.[97] Nevertheless, because of the

[95] Christol, "Air and Space Transit", *ibid.* at 30.
[96] S. Chandrashekar, "Problems of Definition: A View of an Emerging Space Power," *Peaceful and Non-Peaceful Uses of Space*, B. Jasani, ed. (New York: Taylor and Francis, 1991) 77, 87-88; cited in Kelly *supra* note 13, at 65.
[97] Goedhart, *supra* note 4 at 91-95.

inconsistencies and unreasonable arguments and fundaments, this theory has been strongly criticized and rejected.[98]

4. Conclusion of the chapter

In any case, a specific limit has not been established and, although it has not brought major difficulties for the practice of air or space activities, it certainly will gain importance and urgency with the development of more powerful and enhanced aircrafts able to flight in higher altitudes as well as the use of space objects capable to flight in lower altitudes.

[98] For a deeper understanding of the arguments exposed by the two main representatives of this theory *see,* Chaumont, Ch.: (1960) Le droit de l'espace, Presses Universitaires de France/P.U.F., Paris/France, pp. 37-61; Quadri, R.: (1959) Droit international cosmique, in: R.d.C. (Vol. 98), A.W. Sijthoff, Leiden/The Netherlands, pp. 509-524.

Chapter II – Definition of Space Objects

A. Problems to obtain a uniform definition

The term "space object" along with other terms like "space vehicle" and "spacecraft" appears in many instruments of the *corpus iuris spatialis* although never defined in any of them. The use of these similar terms with no specific definition seems to mean that, during the drafting process of the space related conventions and agreements, there was no problem in the understanding of the scope and meaning of the term and there seemed to be no need to obtain a uniform definition. However, the advances of science and technology in space activities have revived several times the definition debates along history which, until today, have not been resolved.

1. Lack of a boundary between air space and outer space

One of the main obstacles in obtaining a uniform definition of a space object is surely found in the fact that, mostly, all the proposals are based on a concept of outer space which has not been clearly defined either[99]. This topic was deeply studied and addressed in Chapter I.

2. Different approaches to a definition of a space object

[99] Prof. N. Matte, cited in G.P. Zhukov, "Definition and Classification of the Space Object: An Important Issue in International Space Law," *Liber Amicorum Honouring Nicolas Mateesco Matte: Beyond Boundaries* (Canada: De Daro Publishing, 1989) [Zhukov, "Space Object"].

Another obstacle to obtain a uniform definition of a space object has been found in the different interpretations of the mentioned *functional* and *spatialist* approaches by the different jurists. In some cases these problems arise from the confusion among the interpreters between "the problem of definition of a space object and the problem of including a space object within the scope of international space law"[100].

3. Other problems derived from the unresolved definition of a space object

In addition to the mentioned problems, to define a space object it is necessary to determinate if it encompasses "objects designed solely for movement on the surface, or within the atmosphere, of the moon or other celestial bodies"[101]. This would revive again, the discussion of the definition of the term "outer space" which, as mentioned before, is not clear or uniform. Nevertheless, it is accepted that the term "space object" does not include the moon and other celestial bodies[102].

A further problem to clearly define a space object is the debate about if a space object ceases to be considered so in a specific point in time or when it becomes space debris or non functional.[103]

Finally, a problematic consequence of the absent definition of a space object is the difficulty in determining if it involves any flight instrumentality designed "to take off and descend trough the atmosphere using aerodynamic lift but which have the capacity to

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[100] *Ibid.*
[101] W.F. Foster, "The Convention on International Liability for Damage Caused by Space Objects", (1972) *The Canadian Yearbook of International Law*, 137.
[102] *Ibid.*
[103] *Ibid.*

operate in areas beyond the atmosphere."[104] This issue is important to the present study because depending on the definition of a "space object" these "flight instrumentalities" could be considered space objects or aircrafts. Moreover, if they provoke damage, their definition into one or another is of high importance. It has been suggested that those instrumentalities might be classified according to the "*place* where the damage occurs, their *mode of operation* at the *time* the damage occurs, or the *primary purpose* which the instrumentalities are designed to fulfill."[105] However, W.F. Foster proposes that the latter method of classification would conclude that those flight instrumentalities are space objects or aircrafts "for all purposes" so, therefore, he considers that it is preferable "the two former methods of classification under which their status would vary accordingly to the circumstances"[106].

In addition to this problem, the above-mentioned author also noticed that another obstacle to obtain a uniform definition of a space object is found in the divergent interests of the launching state and the claimant states in case of damage. The launching state in such a situation would be interested into classify the flight instrumentality which caused the damage as an aircraft. On the other hand, the claimant state would be interested to classify the flight instrumentality as a space object, especially when the damage caused to it is "sustained on the surface of the earth or by its aircraft in flight."[107]

B. Attempts to obtain an acceptable definition

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[104] *Ibid.*
[105] *Ibid.*, (emphasis added).
[106] *Ibid.*
[107] *Ibid.*

1. Treaties' contents

The definition of a space object is of main importance for the international space law because it constitutes the center of the space activities and, therefore, the substance of all international space law agreements and instruments. Nevertheless, since the origin of space activities and their related rule-making, the definition and meaning of a space object have not been "universally accepted" although appearing in the different space agreements[108] because it has never been possible to reach consensus. The Liability Convention[109] and the Registration Convention[110] define some of the terms that appear along the instruments. However, they do not offer a clear mandatory and complete definition for a "space object" except of the indication that in the term are included "component parts of a space object as well as its launch vehicle and parts thereof"[111]. The insufficient indication of the term that appears in both documents demonstrate that the Legal Subcommittee of the UNCOPOUS understood a "clear meaning" for a space object but a required specification of inclusion of its component parts and equipment "which could cause damage" in their scope of application[112]. Nonetheless, from the draft definitions submitted to the Legal Subcommittee it is possible to interpret the intention of the drafters who were working on the creation of the legal instruments. Although not definitive or perfect, those draft definitions guide us to understand that the term "space object" must be an object with the minimum requirement of "being designed for

[108] Zhukov, "Space Object", *supra* note 99.
[109] *Convention on International Liability for Damage Caused by Space Objects*, 29 March 1972, 961 UNTS 187, 24 UST 2389, TIAS 7762, (entered into force 1 September 1972) [Liability Convention].
[110] *Convention on Registration of Objects Launched into Outer Space*, 14 January 1975, 1023 UNTS 15, 28 UST 695, TIAS 8480 (entered into force 15 September 1976) [Registration Convention].
[111] Registration Convention, *ibid.*, article 1 and Liability Convention, *supra* note 109, article 1.
[112] Foster, *supra* note 101.

movement in outer space"[113]. A more detailed analysis of the Liability Convention drive us to the conclusion that the partial definition obtained from its Article I refers to *all* space objects independent of the "categorization of the space object causing damage", which means that either private or state space objects are included[114]. However, the term is not extended to "persons and property on board a space object" unless the property on board constitutes itself a space object[115].

2. State's positions and UNCOPUOS' debates

Some important proposals of different States during the elaboration of the Liability Convention illustrate the divergent approaches as well as similar characteristics of their suggested definitions of a space object. The Belgian proposal indicated that a "space device" was "any device which is intended to move in space, remaining there by means other than the reaction of the air"[116]. Later, the definition was revised as meaning "any device intended to move in space and sustained there by means other than reaction of air, as well as any constituent element of such device or of the equipment used for its launching or propulsion"[117]. The Hungarians proposed that the term "space object" meant "space ships, satellites, orbital laboratories, containers and any other devices designed for movement into outer space and sustained there otherwise than by reaction of the air, as well as the means of delivery of such objects and any parts thereof"[118]. In the other hand, India proposed that "space objects" were "spaceships, satellites, orbital laboratories,

[113] *Ibid.*
[114] *Ibid.*
[115] *Ibid.*
[116] U.N. Doc. A/AC.105/C.2/L.3, 30 April 1963.
[117] U.N. Doc. A/AC.105/C.2/L.7/Rev.2, October 1964.
[118] U.N. Doc. A/AC.105/19, Annex 2, 26 March 1964.

containers and other devices designated for movement in outer space and sustained there by means other than reaction of air, as well as the means of delivery of such bodies and any part thereof"[119]. Australia and Canada jointly, as well as Poland, considered that a "space object" was "an object or any of its component parts which a launching state has launched or attempted to launch into outer space"[120]. Finally, Argentina stated that a "space vehicle" was "any device launched by man exclusively for peaceful purposes, for the exploration or use of outer space, including the Moon and other celestial bodies, as well as the equipment and any parts detached therefrom."[121]

3. "Progress Report on the Question of the Legal Status of Spacecraft" of the International Law Association (ILA)

A draft definition of "space objects" was expected to be obtained in a preliminary meeting of the Space Law Committee in Paris on 1967 after analyzing the replies and comments of the questionnaire on "The Legal Status of Spacecraft" summarized in the "Progress Report on the Question of the Legal Status of Spacecraft" (hereinafter "Progress Report") prepared by the Rapporteur of the Space Law Committee[122]. It was not possible to obtain a draft definition of "space object" but the Committee adopted a resolution recommending that "All space objects to be launched should be registered by a

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[119] U.N. Doc. A/AC.105/C.2/L.32/Rev.1 and Corr.1.
[120] U.N. Doc. A/AC.105/C.2/SR 106, p.67.
[121] U.N. Doc. A/AC.105/C.2/L.27.
[122] *See e.g.* Csabafi, *supra* note 6, at 10. The author emphasizes that this information was obtained from Professor Rene H. Mankiewicz, Faculty of Law, McGill University and Rapporteur of the Space Law Committee of the ILA. This Progress Report contains all the replies and comments on the Questionnaire prepared by the Space Law Committee to be considered on the 52nd Conference of the ILA held in Helsinki in 1966. However, the Questionnaire could not have been considered during that Conference but the Committee was requested to "present to the 53rd Conference recommendations for draft rules and the Legal Status of Spacecraft or a progress report on its study".

State or inter-governmental organization in accordance with its own regulations. All launches by a State or inter-governmental organization should be notified to the United Nations in a way which allows the identification of the launched space objects."[123]

In the first part of the Progress Report is explained that there is no uniformity of terminology used in the different treaties and agreements of international space law due to the use of the terms "space object", "space vehicle", "spacecraft", "stations", "installations" and "equipment" with no distinction or specific definition. The Rapporteur emphasizes that a uniform term must be "all-embracing" considering as essential to have the word "object" jointly to "space" and "component parts". The Space Law Committee considered that the "all-embracing" definition must be complemented with a technical and legal classification. Other proposals were to "include the launcher vehicle, debris and spent spacecraft from the beginning of the launching until landing on earth or disintegration of the spacecraft."[124] Other suggestions stressed that the purpose of the space object must be the main criterion to define.[125]

In addition, other suggested considerations appeared in the Progress Report as whether a spacecraft before its launch should be consider an "object" and if municipal air law should be applied in analogy to this situation. Moreover, the polemic debate of the boundary between air space and outer space emerged while trying to define a space object which, due to its launching to outer space as well as its moving through outer space, requires entering outer space. For this reason, the boundary issue came out in the Progress Report ending with the final analysis that "the criterion ought to be the 'capability' of

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[123] *Ibid.*
[124] *Ibid.*, at 12. This was the proposal of the German Branch of the ILA.
[125] *Ibid.* This was the proposal of the Soviet Branch of the ILA.

spacecraft to move under said physical laws, or any more appropriate definition of the forces of mechanics of its evolution."[126]

4. Scholarly approaches

As showed above, diverse and numerous have been the proposals to obtain an acceptable notion of a space object. Nowadays, the strongest support is given to one of the two approaches that have emerged to try to find a solution in the problem of absence of a uniform definition.

a. Functionalist Approach

The first one, the *functionalist* approach categorizes the objects depending on the type of propulsion systems of devices in space, generally opposing them to the propulsion systems of aircrafts which rely on the properties of air to sustain during the flight[127].

b. Spatialist Approach

The second approach, the *spatialist*, is based on the consideration of the location where the supposed space object operate, suggesting that the main characteristic of these objects should be "the fact that they were intended to flight and operate in outer space"[128].

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[126] *Ibid.*
[127] Zhukov, "Space Object", *supra* note 99.
[128] *Ibid.*

c. Critics to the Functionalist and Spacialist approaches

These two academic approaches have critics. For example, Zhoukov considers that the proponents of the functionalist approach "do not sufficiently take into consideration the potential developments of space travel – particularly the advent of reusable space ships fitted with air reactors that use the aerodynamic properties of air for their return to Earth."[129]

d. Other Approaches

A proposed definition is highlighted among the academics and comes from Stephen Gorove. This author considers that an object or a part of it that is "launched or attempted to be launched in orbit around the earth or beyond" is a space object "from the time of its launch or attempted launch, through its ascent from earth to outer space or while in outer space, as well as during its orbit, deorbit, reentry and landing on earth"[130].

Divergently, other authors, based in the widely accepted understanding that a space object should at least "be designed for movement in outer space", explain that "there is a little doubt that during the course of its orbital operations, the orbiter qualifies as a space object or spacecraft"[131].

There has also been argued that no functional or spatial approach is the adequate solution to establishing a boundary. Rather than a specific altitude, the supporters of this

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[129] *Ibid.*
[130] Stephen Gorove, "Aerospace Object – Legal and Policy Issues for Air and Space Law" (1997) 25(2) J. Space L. 101.
[131] Margo & Lenhard, *supra* note 72.

position consider that "if a boundary is to be drawn, it should be based on human experience and desire, with an acceptance that such boundary would be arbitrary."[132]

[132] Mishra & Pavlasek, *supra* note 75, at 412.

PART II – SPACE TRANSPORTATION VEHICLES

Chapter I – Space Objects

A. Space Objects v. Aircraft

There are many distinctions between aircrafts and spacecrafts. Nevertheless, it is undoubted that the main difference between them is that:

> "aircrafts derive their motion capability in some way or other from the properties of the surrounding air, whereas a spacecraft must be capable of moving in space without any support whatsoever from the air, the only exception being its planned, intact, and safe return to the ground. Of course these distinctions do not preclude the existence of hybrid vehicles which can move both on land and on water, or both in the air and on land, or both in the air and on water, or both in space and in the air."[133]

Another technical difference emerges from the fact that aircrafts possess higher freedom of motion than spacecrafts which have to move continuously in a specific and determined orbit around the Earth once they are "injected" into orbit unless they are "equipped with powerful rocket motors and sufficient amounts of fuel" to alter the orbit.[134]

As mentioned before, a "space object" has not yet been defined. Only the references in the Liability Convention and the Registration Convention that it includes the

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[133] Benko, Graaf & Reijnen, *supra* note 4, at 122-123.
[134] *Ibid.*, at123. The "injection" phase starts "after the motor of the last stage of the launching rocket has shut down."

"component parts of a space object as well as its launch vehicle and parts thereof"[135] appear as guidance of a definition. However, it is possible to find a clear definition of an "aircraft" in the international air legal regime. Although the Chicago Convention of 1944 did not mention any definition, its Annex 7 fulfilled the absence by defining an "aircraft" as "any machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth's surface"[136].

An "aircraft" has been defined by the U.S. Congress as "any contrivance now known or hereafter invented, used, or designed for navigation of or flight in the air." The term includes the airplanes as well as other objects such as balloons.

Usually, the aircrafts can be of different types depending on categorizations as "heavier-than-air/lighter-than-air", "high-wing/low-wing", "power-driven/non-power-driven" or "single-engine/multiengine" among others[137]. It has also been accepted that aircrafts are machines that can "derive support in the atmosphere from the reactions of air other than the reactions of air against the earth's surface"[138].

On the other hand, there has been accepted to classify space objects as "manned/unmanned" and "orbiting around the earth/for interplanetary travel."[139] However, problems emerge when it is not easy to define an object as a spacecraft or as an aircraft because following a functionalist or a spatialist approach, it can be situated in either category.[140]

With the advent of hybrid vehicles that can flight through airspace as well as through outer space, the first question that appears is whether those vehicles are

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[135] Registration Convention, *supra* note 110.
[136] Annex 7, *supra* note 73.
[137] Margo & Lenhard, *supra* note 72.
[138] Foster, *supra* note 101.
[139] *See infra,* Part II, Chapter I, C. Classification of Space Objects.
[140] Kelly, *supra* note 13

spacecrafts or aircrafts. The importance to define a transport vehicle as a space object or as an aircraft could be o high importance because of the legal and regulatory consequences that it may bring. Some of the issues that arise are the existence or not of the right of innocent passage over foreign countries by these hybrid vehicles, the liability issues in case of accidents, the environmental impacts of these vehicles and many others regulatory concerns about certification standards, regulatory bodies and registration procedures, among many other questions.[141]

The legal regimes applicable to aircrafts and spacecrafts in the above-mentioned cases are deeply different, so are the basic principles that govern their activities and the effects of their applicability.

If concluded or considered that the space transportation vehicle in substance qualifies as an aircraft or as a space object, different principles would govern and some problems could arise. For example, if decided that a space transportation vehicle is an aircraft, the principle of "state's sovereignty" will apply to that mode of transportation and questions of "right of innocent passage", "previous permission of a foreign state", the need of register and inspect in some cases the aircraft, mission and payload[142], as well as other issues would affect that kind of transport. In all of these situations the legal instruments that would apply are those regulating air law, which in principle are the Convention of Paris (1919), the Warsaw Convention (1929) , the Montreal Convention and the Chicago Convention (1944)[143]. However, if defined that vehicle as a "space object", the principle of "freedom of outer space" will apply because the physical

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[141] Russell J. Hannigan, *Spaceflight in the Era of Aero-space Planes* (Florida, U.S.: Krieger Publishing Company, 1994) at 205.
[142] *Ibid.*, at 205-206.
[143] *Ibid.*, at 206.

characteristics of space objects depend on the physical laws of universe and it is not possible to change the path of some space objects like satellites with the purpose of avoiding their passage over other countries.[144] For that reason, it was recognized by the main international space law instrument, the Outer Space Treaty (1967) the right of "innocent passage" of the space objects over foreign territories with no need of prior consent of the foreign state "for the benefit of all mankind."

In addition to that, if air law applies to these vehicles, "it would be possible for private entities to pursuit claims directly against airlines."[145] If space law is the applicable law, this situation is not possible because under this regime, states are responsible for the space activities of both, states and non-governmental activities. Moreover, private entities that suffer any damage from a space object are expressly forbidden to present claims directly against the operator or launching state in the Liability Convention[146]. This space instrument establishes that states have to present the claims on behalf of the private party against the damaging launching state.[147] Furthermore, foreign nationals cannot pursuit claims against the launching state occasioning the damage when those nationals participated in the launching or returning processes of the space object. In any other case of damage occasioned by a space object on earth or to an aircraft in flight, states are absolutely liable, but fault has to be proven when the damage "caused to foreign space objects located elsewhere than on the surface of the earth".

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[144] *Ibid.*

[145] Convention for the Unification of Certain Rules Relating to International Carriage By Air, 137 L.N.T.S. 11, 49 Stat. 3000, T.S. No. 876 (12 Oct. 1929) [hereinafter Warsaw Convention], cited in Kelly, *supra* note 128, at 43. "The Warsaw Convention applies to carriage by states unless the state has opted out of such coverage." Convention on Damage Caused by Foreign Aircraft to Third Parties on the Surface, 310 U.N.T.S. 181 (7 Oct. 1952) [hereinafter Rome Convention], cited in Kelly, *supra* note 128, at 43. This instrument "authorizes private parties to make claims against aircraft operators for damage caused by foreign aircraft in flight to persons or property on the surface of the earth".

[146] Liability Convention, *supra* note 109.

[147] Kelly, *supra* note 13, at 44.

Another liability difference between the air law and space law regimes is the limit in the amount of damages a state has to pay on a claim in the first one and the no limits system that governs in space law[148].

All the above demonstrate that if applicable the air law or the space law regimes, the liability situations and regulations would be completely different.

There is a similar requisite of registration in both legal regimes. The Chicago Convention establishes that states have to provide reports to ICAO on the ownership and control of aircraft registered in that state. On the other hand, the Registration Convention requires states to maintain a registry of any space object launched into earth orbit and outer space every time it is launched.

There are also differences relating the registration and airworthiness certificates of aircrafts that have no equivalence for spacecrafts. For that reason, it is obvious to conclude that "there are not minimum international standards that spaceplanes and other space objects have to meet."[149]

B. Space Objects v. Aerospace Object

The Working Group of the COPUOS Legal Sub-committee on the agenda item on "Matters relating to the definition and delimitation of outer space and to the character and utilization of the geostationary orbit"[150] elaborated a "Questionnaire on Possible Legal

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[148] *Ibid.* "There is no limit on the amount of damages the state may have to pay on a claim (however, there is also nothing that prohibits sates from recouping from private entities payments made for damage caused by private-owned space objects). In contrast, the Warsaw Convention provides for fault-based, limited liability, and the Rome Convention provides for limited, but strict, liability."

[149] *Ibid.*, at 45.

[150] The Working Group finished the "Questionnaire on possible legal issues with regard to aerospace objects" at the thirty-fourth session of the Legal Sub-committee. The report of the Working Group on

Issues with Regard to Aerospace Objects.[151] As agreed by UNCOPUOS and the Legal Sub-committee, the purpose of the questionnaire was "to seek the preliminary views of States members of the Committee on various issues relating to aerospace objects."[152] They also agreed that the future position of states exposed in their answers to the questionnaire "could provide a basis for the Legal Subcommittee to decide how it might continue its consideration of this agenda item."[153]

An "aerospace object" was defined for working purposes during the elaboration of the questionnaire as "an object which is capable both of traveling trough outer space and of using its aerodynamic properties to remain in airspace for a certain period of time". The weaknesses of this definition were expressed by different delegations arguments that the definition should only apply to "functional man-made objects as opposed to space debris or natural objects."[154] It also seems not to include all the hybrid systems used for flights in the air space as well as in outer space, which could be solved by using the terms "aerospace systems" or "space transportation systems" that have a wider meaning including[155].

Although there is not a uniform definition of an aerospace object, it is undoubted that an aerospace must have: a) the capability to travel to outer space, and b) the

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"Matters relating to the definition and delimitation of outer space" was endorsed by the Legal Sub-committee in its agenda at its forty-first session. The questionnaire was amended and circulated to all members of the UN. *See,Report of the Legal Subcommittee on the Work of its Forty-first Session*, UN COPUOSOR, 45th Sess., UN Doc. A/AC.105/787 (2002), Annex II, paras. 8, 10 and 11.

[151] *Report of the Legal Subcommittee on the Work of its Thirty-fourth Session*, UN COPUOSOR, 38th Sess., UN Doc. A/AC.105/607 (1995) and Corr. 1, para 38. The UNCOPUOS agreed with the Legal Subcommittee that "the purpose of the questionnaire was to seek the preliminary views of States members of the Committee on various issues relating to aerospace objects."

[152] *Ibid.*

[153] *Ibid.* The responses of the member states are compiled in UN documents A/AC.105/635 and Addenda.

[154] Gorove, *supra* note 130.

[155] *Ibid.*

capability to remain in the airspace for a certain period of time[156]. However, problems arise from the current and future developments of more sophisticated and modern objects with diverse functions in the air space as well as the outer space bringing confusions and begging for a reevaluation of the exposed definition.

C. Classification of Space Vehicles

A useful technical and legal classification of space vehicles can be obtained from the Progress Report of the ILA[157] which proposed the criteria for the purpose of classification. To the question "Should the definition of spacecraft be all-embracing (drafted in general terms) or proceed by distinguishing and enumerating classes or types of spacecraft?" the following was the suggestion:

> "(a) If a unique definition is adopted, should it be followed up by a classification of spacecraft (regarding the possible need for providing exemptions or special rules for specific types of spacecraft), for instance:
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> manned and unmanned spacecraft
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> active and passive spacecraft
>
> "stationary" spacecraft
>
> "space platforms"
>
> classification by use such as:
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> (i) meteorological spacecraft
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> communications spacecraft
>
> science research spacecraft
>
> (ii) military and non-military spacecraft

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[156] *Ibid.*

[157] Csabafi, *supra* note 6, at 14-15. *See also, supra* note 110 and accompanying text.

(iii) spacecraft destined to return to earth, and spacecraft destined to disintegrate

(iv) experimental and "permanent" spacecraft"[158]

From that classification, the most useful for the present study is the one that differences between *spacecraft destined to return to* earth and *spacecraft destined to disintegrate* or, what is the same, between *expendable launch systems* and *reusable launch systems.* From that point of view, the expendable launch systems are those where "each launch vehicle is launched once and then discarded,"[159] while the reusable launch systems or reusable launch vehicles (RLV) are those "capable of launching into space more than once."[160]

1. Reusable Launch Vehicle (RLV)

As explained before, a reusable launch vehicle has the main characteristic of being capable to be launched to outer space more than once.[161] It is believed that a fully reusable launch vehicle provides low cost access to Space and more frequent flights for the purpose of exploration and use of outer space. The technology has proved that the elaboration of these vehicles is feasible; however, most of the projects have failed due to

[158] Progress Report, *supra* note 122 [emphasis added].
[159] Wikipedia, *Reusable Launch System Definition*, online: Wikipedia - The Free Enciclopedia <http://en.wikipedia.org/wiki/Reusable_launch_system>.
[160] *Ibid.* A deeper analysis of the RLVs is made in the next chapter.
[161] *See, supra* note 160 and accompanying text.

"[b]ad design and poor management"[162] or, simply because of the unsuccessful achievement of a low cost production of these RLVs.[163]

2. Hybrid Systems or vehicles

The hybrid systems are those developed space vehicles with the capability to travel through the airspace as well as through the outer space. They are not regulated in any of the five treaties of the *iuris corpus spatialis* because they were far to make them a reality, at that moment, although they were already imagined at their drafting processes.[164]

The real problems and discussions related to the hybrid space vehicles appeared with the creation and development of the U.S. Space Shuttle.[165]

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[162] *See, supra* note 159.
[163] *Ibid.* The Space Shuttle proved to be more expensive than the expendable launch systems, what was a failure of the "low cost" goal of the RLVs. Nevertheless, the space shuttle "succeeded technically as a partially reusable launcher."
[164] Kelly, *supra* note 13, at 44.
[165] *Ibid.* The first flight of the U.S. Space Shuttle was in 1981 and, with the advent of this technology the discussions were centered, mainly, in the determination of the legal status of this new vehicle.

Chapter II– Space Transportation Systems

The Space Transportation Systems (STS) appeared with the purpose of making access to outer space a more routinely activity and the use of the space environment for that kind of transportation. Professor Christol identified the major problems involving this access to outer space from the beginning of the development of the STS. He observed that some of these problems might be "the means of arriving at an orbital position, in the subsequent return to Earth, possible other dispositions of space objects, and the uses to be made of cargoes – both human and material – transported by the space object."[166]

The real concerns about the legal consequences of the space transportation appeared with the advent of the U.S.' Space Shuttle, the Soviet Union's Soyuz cargo-passenger cargo and the "Progress automatic cargo vehicle," the French Ariane, the E.S.A.'s Ariane launcher and the Spacelab.[167]

A. Proposed uses of the STS

A UN study listed some uses that, at the beginning of the development of STS, were identified. These are:

> 1. Transportation of automated payloads of ever-increasing size for earth-oriented applications (telecommunications, observation, navigation) and space science research (planetary missions and orbital astronomy). Prospective nuclear waste transportation is a specific case of this category of space transportation.

[166] Christol, "Modern International Law", *supra* note 4 at 811.
[167] *Ibid.*, at 812.

2. High-reliability space flight for manned orbital operations: materials processing, Spacelab operations, spacecraft repair and refurbishment and space construction.

3. Construction and transportation of large space structures: space stations, telecommunications platforms, power plants, and antenna dishes.[168]

However, these are not the only uses that are attributed to the space transportation vehicles. More different and sophisticated functions and uses will be determined by the future developments and technologies.

B. Some types of STS

1. Space Shuttle

The Space Shuttle was distinguished from any other previous space vehicle due to its operational capacity to flight to outer space and return to the Earth with the ability of being reused.[169] The concerns about its legal status were based in the fact that for a moment this vehicle functions like an aircraft and, for another, like a spacecraft and, as analyzed above, there are major differences in the applicable legal regime if considered one or another.[170]

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[168] U.N. Doc. A/CONF.101/BP/2, p. 79, 16 Mar. 1981, cited in Christol, *ibid.*

[169] *See* F. Moss, "The Space Shuttle and the Law of Outer Space", *Proceedings of the Nineteenth Colloquium on the Law of Outer Space* (California: U.C.-Davis School of Law, 1977) 175. Senator Moss stated that the shuttle would have to be registered as a space object because it would be launched into orbit.

[170] *See,* Kelly, *supra* note 13, at 44.

The Space Shuttle is the first transportation system able to fly to and from space, returning to the Earth like an airplane. Nevertheless, it is widely considered to be a spacecraft during the entire flight and space law is applicable to it.[171]

There are many the arguments to consider the shuttle a spacecraft. Firstly, some authors understood that the shuttle was more similar of a space object than an aircraft because its engines "did not require the atmosphere to attain space, and it had no power capability in the atmosphere when it returned from space."[172] Secondly, the shuttle is considered a space object because "it is launched over water, and its reentry usually begins over the Pacific Ocean."[173] Thirdly, the constrained operations of the shuttle which involve fixed launched and landing sites, aerodynamic flight in the atmosphere mostly over water or a limited number of countries and predetermined abort landing sites with prior intergovernmental agreements among others, are also an argument to consider the shuttle a space object and not an aircraft.[174] Fourthly, even though the positions of states in certain aspects are not internationally binding, the inclusion of the Space Shuttle as a spacecraft within the meaning of the U.S. National Aeronautics and Space Act of 1958 as amended in 1978, definitively encourage the international acceptance of the shuttle as a spacecraft.[175]

2. Aerospace plane

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[171] Hannigan, *supra* note 141, at 207.
[172] David Webb, "Economic and Socio-Political Impacts of NASP-Derived Vehicles: A Technical Report," pp. 33-34, cited in Hannigan, *ibid.*
[173] *Ibid.*
[174] *Ibid.*
[175] *Ibid.*

Some authors understand that "aero-space planes" are "fully reusable vehicles that can climb out of the Earth's deep gravitational well and fly into Earth orbit, deliver or recover a payload, then return to the ground where they are turned around like aircraft, loaded with new cargo, and readied for another mission weeks or days later," in other words, as a "fully reusable vehicle that carries people or cargo to and from orbit". [176] For these jurists, the aerospace plane is planned to be a space transportation system which, operating in a similar way that aircrafts, their missions will be destined to low Earth orbit but in no case it should be confused with "high speed passenger transportation systems that take people from one continent to another, crossing the fringes of space on the way."[177] However, other group of jurists understands that the aerospace plane also comprehends that kind of transportation system that will take people and cargo from one point of the earth to another through outer space.

Professor Hannigan while illustrating about the definition of the aerospace planes, explains each term involved. For that reason, he emphasizes that the term "aero" means that these vehicles are aerodynamic and use the atmosphere in some way during flight, the term "space" explains that they go to space, and the term "planes" refers that they are operated like airplanes.[178]

It has also been understood that the principal objective of the aerospace planes is "to reduce the cost of launching payloads and to make it easier to access space."[179]

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[176] Hannigan, *supra* note 141, at 55.
[177] *Ibid.*
[178] *Ibid.*
[179] *Ibid.*, at 54-55.

Hannigan observes three main problems with aerospace planes: "(1) they take a long time to produce, (2) their initial development costs are high, and (3) they present very high levels of risk."[180]

The author also mentions that because of the high costs involved in the production of aerospace planes and due to the late occurrence of the payoff, it is improbable that the private sector would be able to develop such complex vehicles without the necessary government funding.[181] However, commercially operated aerospace planes involving government developed aerospace planes handed over commercial entities, or consortiums – either privatively or publicly financed – could sell these vehicles, or any other activity of this kind is possible "assuming an elastic market response to significantly reduced launch costs."[182]

Hannigan highlights the main effects or implications of aerospace planes[183]. Firstly, they would allow a redistribution of the launch cost savings of importance to both governmental funded missions as well as for commercial mission. Secondly, differently to the shuttle, there would be "high availability, on-orbit servicing, and recovery" translated in "frequently and routinely returns to orbital platforms." Thirdly, the will allow "mass constraint relaxation and payload redesign." Finally, "new mission opportunities" will derive from the aerospace plane possibilities to allow new uses "which demand low cost, continues and unrestricted access to space."

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[180] *Ibid., at* 185.
[181] *Ibid.*, at 192.
[182] *Ibid.*
[183] *Ibid.*, at 241-242.

C. Applicable Law

1. Space Shuttle

There have emerged also a "functionalist" and a "spatialist" approaches to define the space shuttle as an aircraft or as a spacecraft and, consequently, applicable to air law or space law.

i. Functional Approach

The jurists supporting this approach consider that the applicable law to the space shuttle can only be the space law regime.[184] This group supports its position in the fact that every space object continues having that nature when they return to Earth because the Rescue Agreement illustrate about it while providing that a *space object* or its component parts when *returned* to Earth in territory of a foreign state or on the high seas or in any other place not under the jurisdiction of any State has to be notified to the launching authority and the Secretary-General of the UN.[185]

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[184] *See, e.g.* G. Gal, "The Space Shuttle Between Air Law and Space Law," *Proceedings of the Twenty-fourth Colloquium on the Law of Outer Space* (New York: AIAA, 1982) 103, 104; *see also,* C.Q. Christol, *Space Law: Past, Present and Future* (Boston: Kluwer, 1991) 209, cited in Kelly, *supra* note 13, at 82.

[185] Art. 5, *Agreement on the Rescue of Astronauts, the Return of Astrnauts and the Return of Objects Launched into Outer Space*, 22 April 1968, 672 UNTS 119, 19 UST 7570, TIAS No. 6599, 7 ILM 149 [Rescue Agreement].

In addition, other supporters of this approach consider that due to the main purpose of the shuttle, which is conducting activities in outer space and not in airspace, the applicable law cannot be other than space law.[186]

Nevertheless, this approach is criticized mainly because the new developments of hybrid space vehicles or transportation systems able to operate in outer space and airspace seem to be avoided when explaining the applicable law[187]. Moreover, it is possible that "confusion could result when trying to apply different legal regimes to objects—that is, a space object and an aircraft—flying at the same altitude."[188]

ii. Spatialist/Territorial Approach

The supporters of this view believe that this space transportation system "should be considered a space object, and therefore subject to space law, from the moment of launch until it began its descent from orbit," but they also believe that "when the shuttle re-entered airspace, it became an aircraft, and therefore subject to air law."[189] For that reason the supporters of this approach conclude that both regimes, air law and space law, will be applicable to the space shuttle depending the phase of its flight.

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[186] *See, e.g.*, V. Kopal, "Some Considerations on the Legal Status of Aerospace Systems," 22 *J. Sp. L.* 69 (1994); Zhukov, "Space Object", *supra* note 99, at 361; Goedhuis, "Poblems of the Frontiers," *supra* note 15, at 399-400.
[187] Zhukoz, *ibid.*
[188] H.L. van Traa-Engelman, "International Legal Requirements as a Basis for Juridically Feasible Space Transportation," *Proceedings of the Twenty-fourth Colloquium on the Law of Outer Space* (New York: AIAA, 1982) 141. cited in Kelly, *supra* note 13, at 81.
[189] Kelly, *ibid.*

This approach is criticized because confusion is predicable due to the applicability of two different regimes to a same vehicle[190] and this situation will also imply the necessary reborn of the boundary between airspace and outer space debate.

iii. *Other approaches*

There is another approach that considers that the solution to this problem is to create a new legal regime applicable solely to hybrid systems, including the space shuttle.[191] One of the most notable propositions of this approach is the one that suggested that the hybrid systems are not spacecrafts or aircrafts but a different category that could be called "aerospace vehicles" which "would be treated as an aircraft or as a spacecraft depending on the circumstances." [192]

However, the weakness of this position is that, although many jurists have suggested this solution, there has not been a formal and detailed proposal prepared by any of them.

iv. *Conclusion*

The activities of this transportation system need to be regulated by a regime; however, it is considered that because the shuttle does not fly frequently, it is not useful

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[190] Traa-Engelman, *supra* note 188, at 135, 141.
[191] *See, e.g.*, C.Q. Christol, "The Aerospace Plane: its Legal and Political Future," 9 *Sp. Policy* 35, 41 (Feb. 1993); B. Stockfish, "Space Transportation and the Need for a New International Legal and Institutional Regime," XVII-II *Ann. Air & Sp. L.* 323 (1992); P.P.C. Haanappel, "The Aerospace Plane: Analogies with Other Modes of Transportation," *Proceedings of the Thirty-second Colloquium on the Law of Outer Space* (Washington, D.C.: AIAA, 1990) 341.
[192] G.P. Sloup, "The 'Aerospace Vehicle' As a Legal Concept—On Final Approach?" VIII *Ann. Air & Sp. L.* 433 (1983).

or worthy to create an especial law for this vehicle, namely, a "Shuttle Law." For that reason, the applicable law would have to be one of the existent and, the most reasonable to apply is space law due to the characteristics of the space shuttle, its nature as a space object and the purpose of its activities, namely, transportation to and from outer space.[193]

2. Aerospace Plane

For the aerospace plane the same debates and approaches explained for the legal status and applicable law of the space shuttle are valid. However, Hannigan believes that to the activity of a government owned and operated aerospace plane could be applied the international agreements that exist for the regulation of the space shuttle. He explains that due to the similar characteristics in the trajectory of the space shuttle and the aerospace plane while going to and from the space, the required intergovernmental arrangements for the passage of those vehicles over foreign territories would have no differences.[194] Nevertheless, he emphasizes that for commercially operated aerospace planes the situation may be different.[195]

[193] Hannigan, *supra* note 141, at 207.
[194] Hannigan, *supra* note 141, at 208.
[195] *See, infra* Part III, Commercial Space Transportation.

PART III – COMMERCIAL HUMAN SPACE TRANSPORTATION

Chapter I – Privatization/Commercialization of Space Activities

A. Privatization of space activities

Since the beginning of the space age, the government's participation and development of space activities and technologies was a thing of prestige of those spacefaring nations and the idea that some satellites could be launched by private companies was not even imagined. Nevertheless, although some states, mainly the "new comers", still find it important to participate in space activities due to prestige and respect, it is obvious that the most important incentive for governments, mostly the "old comers", is to participate in the development of that space related activities is the utility that they represent into solving terrestrial problems and producing terrestrial advantages.[196]

On the other hand, due to economic changes the governments had to allow the participation of private entities in the development of space activities and technologies because their funding went tighter.[197] For that reason, they were obliged to promote private incentives through their domestic regulations due to their financial constraints while emerging private entities prepared to invest in space activities and wealthy people able to pay huge amounts of money to enjoy the access to outer space. These changes have relation with the "value for money" that is considered as one of the most important values of our modern society, which surely has replaced the prior interest of

[196] Kazuto Suzuki, "Space and Modernity: 50 Years On" (2007) 23 Space Policy 144-146.
[197] *Ibid.*

environmental and humanitarian values.[198] As the author adds, it "is not the state which looks after people's dreams but the market and private capital," the role o governments and national space agencies is "adapting to this new social value of the efficiency of investment."[199]

The spaceflight idea appeared spread in the mind of the people fifty years ago as a technology that would "open a new horizon for human nature, and that the progress of technology would make our dreams come true" creating new opportunities for our society to grow to higher levels.[200] However, this enthusiasm decreased due to the public financing and support problems that caused the termination of the Apollo program and also the financial difficulties and delays in the International Space Station project as well as the complexity of developing a "safe reusable flight technology" from the Shuttle program.[201] Moreover, although many were the legal intents by the governments to promote private industry in the space activities during the 1980's, they failed "in fostering commercial launch providers to offer their services to the users."[202] The causes of that failure were:

> (i) the fact that these legal measures did not include a risk management system which could allow launch companies to transfer risks and to limit the liability, which under national and especially under International Space Law constitutes a rather onerous burden, and (ii) the conditions under which NASA offered the Space Shuttle

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[198] *Ibid.*
[199] *Ibid.*
[200] *Ibid.*
[201] *Ibid.*
[202] Julián Hermida, "Risk Management in Commercial Launches," (1997) 13(2) Space Policy 147.

services, which impeded the private space launch operators to compete with the Administration.[203]

In fact, the NASA offered a highly advantageous Space Shuttle service for national and international commercial entities as well as for foreign States, which "preferred to continue to fly their payloads on board the Space Shuttle" due to the prices below costs of the services caused by the subsidies of the US government.[204]

On the other hand, as we observe in future launch systems, the participation of the private industry in their development and operation will be essential. For that reason, while the reliability of government space programs on commercial launchers will be increasing, the role of the government will change from being a principal actor in the development and operation of those launches to a regulator of the commercial launch industry and, eventually, the licensing procedures of those launch activities "may become more like the licensing of air-transportation systems."[205]

In consequence, the current space industry is in a phase of transition where private companies actually build rockets and launch them to outer space with diverse purposes. Resulting from this situation, the options offered to the consumers to get to outer space have changed because "[w]hat once required the resources of entire nations has now become an entrepreneurial business model."[206] However, this situation does not mean that "space will change hands" rather, "[t]here will simply be more hands" that will rise the

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[203] *Ibid.*
[204] *Ibid.*
[205] R.F. Johnson & P.L. Smith, "Future Spacelift Projections," (1998) 14 Space Policy 150. This article summarizes a study created by the Aerospace Corporation "to develop long-range space transportation models for future commercial and government applications, and to analyze the design considerations and desired characteristics for future space transportation systems."
[206] Patricia Grace Smith, "The Excellent Question of *Passarola Rising*" (Remarks presented for the Tenth Annual FAA Commercial Space Transportation Conference in Arlington, Virginia, 6 February 2007) [unpublished] [Smith, "Passarola Rising"].

number of actors and entrepreneurs involved in space activities, expanding the range of applications.[207]

B. Space Commercialization

There has been considered by NASA that the term "commercial *exploitation*" of space resources, many times used by lawyers and business specialists, is "politically incorrect and unacceptable."[208] Nevertheless, it is possible to identify possible space resources that, in a near or far future, can be exploited and, surely, these potential exploitable space resources "have to do with developing the activities, services and products aimed at sustaining human*kind* life in space."[209]

The term "space commercialization" has originated many debates among professionals in the different fields related to those activities as well as different postures between the governments and the private sector.[210] It has been frequent to wrongly interpret that every activity involving space commercialization involves solely the "economics and business practices of *private* sector" when, however, the governments appear not only as regulators on the private sector enterprises but, rather, as equal participants and competitors.[211] In consequence, the offered product, service or activity can be offered by the private sector, the governments or even a mixture of both.[212]

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[207] Smith, Patricia Grace. "Commercial Human Spaceflight," (Remarks addressed at the Presentation of FAA Commercial Astronaut Wings to SpaceShipOne Pilot Mike Melvill, 21 June 2004), (2005) 71 Spaceflight 756. [Smith, "Commercial Human Spaceflight"].
[208] George S. Robinson, "Future Private Commercialization of Space Resources: Foibles of Applicable Law," (2002) 27 Ann. Air & Sp. L. 496.
[209] *Ibid.* at 497.
[210] *Ibid.* at 499.
[211] *Ibid.*
[212] *Ibid.*

Furthermore, a hugely debated issue involves the commercialization of the International Space Station (ISS). It is understood that the 'ISS commercialization' refers to:

> "the promotion of (a) utilization by the private sector, for research and development purposes, of all categories of ISS elements, not only designated in the IGA as 'user elements' – the laboratories – as basically envisaged in the ISS agreements, and (b) all other activities carried out on earth, such as sponsoring, merchandising and publicity, with the objective of maximizing revenues from the utilization of a part or the totally of the ISS."[213]

The idea of commercialization of the ISS is not a new idea since the Art. 1(1) of the Intergovernmental Agreement of 1998 (IGA) expresses that "This civil International Space Station will enhance the scientific, technological, *and commercial use* of outer space."[214] However, all the commercial activities and attempts to develop space tourism have not been completely successful due to "the high cost of getting to the ISS, construction delays, cost overruns, scalebacks in design, planned crew reductions, cumbersome regulatory requirements."[215] Furthermore, it will be necessary to obtain price stability, property protection and a consistent and predictable processing procedure for entrepreneurial offers, as well as to succeed with other challenges like "cost, financial risk, lack of resources, and safety issues."[216]

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[213] André Farand, "Commercialization of International Space Station Utilization: The European Partner's Viewpoint," (2003) XXVIII (2) Air & Sp. L. 83-84.
[214] *Agreement Among the Government of Canada, Governments of the Member States of the European Space Agency, the Government of Japan, the Government of the Russian Federation, and the Government of the United States of America Concerning Cooperation on the Civil International Space Station*, 29 January 1998 [emphasis added].
[215] Rosanna Sattler, "US Commercial Activities Aboard the International Space Station," (2003) XXVIII (2) Air & Sp. L. 66.
[216] *Ibid.* at 80-81.

Other events have proved that commercialization of outer space can work, such as the "taxi flights" on board the ISS Russian "Soyuz" vehicle.[217] The Russian ISS Cooperating Agency, Rosaviakosmos, is openly trying to carry out commercial activities while selling to the ESA and other private space flight participants a seat on the Soyuz vehicle which flies every six months to the ISS. However, every offer to flight aboard the Soyuz has to be accepted by all the other partners of the ISS "when the individual concerned (i.e. the space flight participant) is a national of a State which is not party to the ISS Intergovernmental Agreement."[218]

Russia has always had a great interest in the organization of commercial flights of foreign citizens to the ISS however, at all times they guarantee that those flight are performed by professional astronauts or well-trained persons.[219] In fact, a Japanese citizen had a one-week flight to Mir in 1990 and a year later an English citizen did the same trip, practice that continued with other European and US astronauts.[220] They even organized advertising campaign flights. In 1996, "Russian cosmonauts unfolded the transparent with the Pepsi logo in outer space overboard the Mir station" and in 1999, "the Italo-Food company launched the 'Proton' launch vehicle to the ISS branded with Pizza Hut mark," pizza eaten by the astronauts.[221]

Moreover, other events demonstrate that commercialization is a reality. For example, there is the operation of the Russian Mir Space Station as a fully private entity. In addition, the private arm of the Russian Space Agency, Energia, and a group of international investors, MirCorp, "entered into a commercial lease of the MIR Space

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[217] Farand, *supra* note 213, at 86.
[218] *Ibid.* at 84.
[219] Sergei A. Negoda, "Legal Aspects of the Commercial Development of the Russian Segment of the ISS," (2003) XXVIII (2) Air & Sp. L. 90.
[220] *Ibid.*
[221] *Ibid.*

Station.[222] In addition, NASA itself has also entered into many commercial contracts with private US businesses since May 2000.[223]

On the other hand, a study prepared by The Aerospace Corporation concluded, after precisely analyzing new space applications and their requirements, that there is no "new space application that would justify the billions of dollars of investment required to develop an advanced, high-flight-rate launch system, and it is unlikely that the ambitious technology programs needed to develop such a system will be pursued by the private sector alone."[224] Rather, "long term government funding and leadership will be needed to develop advanced low-cost launch systems" required for the future innovative space applications.[225] However, current space applications such as satellite communications, remote sensing, and space transportation, "are fully operational, highly profitable, and their number have increased substantially in comparison to the last decade" since private enterprises are commercially participating.[226] In fact, a brief observation of the number of military, civil and commercial launches occurred from 1984 to 2004 shows that as much as a 20% were commercial launches, mostly, carrying communication payloads and it is expected that the demand of these commercial launches would be steady in about 23 annual launches up to 2014.[227] This situation would imply a consequent demand for expendable launch vehicles which have been the basis of commercial space activities.[228]

C. Problems related to the space commercialization

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[222] Sattler, *supra* note 215, at 81.
[223] *Ibid.* For example, there was a contract between NASA and Stelsys, LLC signed in 2002 with the objective of develop a treatment for people with liver transplants.
[224] Johnson & Smith, *supra* note 205, at 150-151.
[225] *Ibid.*
[226] Hermida, *supra* note 202, at 145.
[227] Smith, "Commercial Human Spaceflight," *supra* note 207 at 759.
[228] *Ibid.*

In addition to the obstacles that private entrepreneurs can experiment from the national laws when the government is involved exclusively or partially into the commercial space activity or service, other problems can be identified. In that way, intellectual property rights emerge as one of the most important problems and debates derived from the commercial space activities. Furthermore, the financing of the activities as well as the anti-trust issues, the faith and the credit for the private entrepreneurs are also issues that worry the private sector.

In addition, important risks affect people, property, payloads and space vehicles involved in commercial launches due to the special environment in which space activities operate as well as the particular technologies required.[229]

In general, *space risks* can be defined as "the uncertainty regarding losses derived from a space activity" that "represent the exposure to losses faced by an organization engaged in the exploration or exploitation of Outer Space."[230] However, the specific space risks derived from commercial space activities can be classified as:[231] (i) *political space risks*, involving possible government changes, government policy, or space related legislation; (ii) *financial risks*, due to unpredictable changes in the market or in the studies of financial feasibility; (iii) *technical risks*, in the case of uncertainty in the results of innovative technology used for the space vehicle and for the payloads; (iv) *legal risks*, related to potential liable situations including the obligation to compensate damages.

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[229] Hermida, *supra* note 202, at 145.
[230] *Ibid.*
[231] Pamela Meredith & George Robinson, *Space Law: A Case of Study for the Practitioner* (Dordrecht: Martinus Nijhoff, 1992) at 249, cited in Hermida, *ibid.* at 145-146.

The political risks are susceptible to increase when the participation of the governments in the space activity is not exclusively as a regulator but also a participant.[232] Moreover, it has also been understood that the legal risks encompass:

> *First class risks* imply the possibility of damages to the participants' space objects, i.e. the space vehicle in the case of the launch company or the payload in the case of the customer, and to the participants' personnel resulting from the launch activity.
> *Second class risks* constitute risks to certain related entities which, although they do not participate directly in the space activity, are all the same exposed to some risks. In the case of launches carried out by the private sector, these are basically risks to the government or public agencies, originated in particular because of the use of government launch facilities and related range services.
> *Third-party risks* refer to the possibility of damages caused to persons and property thoroughly unrelated to the operation.[233]

The functions of "planning, organizing, leading and controlling the factors associated to risk exposure by an entity engaged in commercial space endeavors" are defined as *space risk management*.[234] However, it has been recognized that the management of commercial space transportation's risks differ from the rest of the commercial space transportation because the risk management of space transportation, at least in nations as United States, is highly regulated by domestic regulation and agreements and contracts that "have developed a certain uniformity, which has led to the

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[232] Hermida, *ibid.* at 145.
[233] *Ibid.* at 146 [emphasis added]. *See also*, R. Bender, *Space Transport Liability, National and International Aspects* (The Hague: Martinus Nijhoff Publishers, 1995) 208; Valérie Kayser, *Legal Aspects of Private Launch Services in the United States* (LL.M. Thesis, McGill University, 1991) at 136.
[234] Hermida, *ibid.*

conclusion that there is a typical private regulation of the space business, and has given rise to a Lex Mercatoria Spatialis.[235]

D. Applicable Law

The increase of commercial utilization of space activities will have influence in the reform of the current space regulations and the creation of some specific rules and legal bodies. At the beginning of the space age, all the nations, in particular the two space powers at the moment, started to consider of high importance the creation of space law principles. As a result, the Outer Space Treaty[236] was the compilation of those principles created by the international community. Nevertheless, at the moment of the drafting of the Outer Space Treaty, the main interests of scientific development of space activities were the central role of the development of space law leaving the commercialization and privatization of space activities in a secondary position.[237] However, in recent times the commercial uses of space activities are acquiring more attention from drafters and, in general, from the entire international community For the commercial space activities there can be applicable the international treaties of space law as well as national laws depending the different situations involving the product or service offered. The domestic laws are in quantity more than the space law treaties, but the international treaties are gaining a huge importance in the regulation of commercial space activities in matters

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[235] *Ibid.* The United States, since 1983 has implemented norms to regulate commercial space transportation. The Commercial Space Launch Act's amendments of 1988 ended the process with the introduction of a risk-distribution system for commercial space launch services. *See, Commercial Space Launch Act*, Pub. L. No. 100-657, 102 Stat. 3900 (1988).

[236] Outer Space Treaty, *supra* note 3.

[237] Sriram Swaminathan, "Making Space Law Relevant to Basic Space Science in the Commercial Space Age," (2005) 21 (4) Space Policy 259-266.

such as risk allocation, management issues, designation of legal responsible nations or individuals involved in the activities, registration requirements of launch vehicles and space objects, insurance, requirements for the rescue and return of commercial and non-commercial space objects, issues related to the sharing of profits derived from the commercial space activities, among other issues.[238] Some authors believe that those international space law treaties do not encourage the participation of the private sector in the space commercialization because the do not really give an incentive for "high-risk venture capitalists to support non-established products or services, where these are not supported principally by government contracts."[239] These authors also consider that there are other obstacles for the participation of the private sector in the commercialization of space activities like the "national implementing regulations and local rules and ordinances, with each of which any entrepreneur must comply before private venture capital can be secured for underwriting, in whole or in part, a commercial space venture."[240] This situation becomes a huge obstacle to the private entrepreneur especially when its government has an exclusive or competitive role in the space commercialization venture due to the fact that the government itself is the one providing an elaborating those domestic regulations and ordinances which the private actor has to comply prior to undertake the venture.

On the other hand, there is a wide practice among commercial space players to execute contracts and other agreements in a relative uniform way that has been identified by some academics as a *Lex Mercatoria Spatialis*, "formed mainly by such agreements

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[238] Robinson, *supra* note 208 at 500.
[239] *Ibid.* at 504.
[240] *Ibid.* at 504 – 505.

and the courts' interpretation of their main provisions.[241] In that sense, Julián Hermida explains that:

> The underlying idea of the Lex Mercatoria Spatialis is that the practice derived from space activities has developed a typical system of rules. Although some of these rules are taken from domestic law systems, they are applied in most of the contracts related to outer space businesses. These include mechanisms for the allocation of risks, the best efforts principle, and rules on redundant elements of capacity. The Lex Mercatoria Spatialis presents well-defined characteristics, although it is only a theoretical construction and it is not included as such by the parties in their agreements when they choose the applicable law.[242]

[241] Hermida, *supra* note 202, at 145.
[242] *Ibid.* at 146.

Chapter II – Commercial Space Transportation

A. Evolution of Commercial Space Transportation

It was not until the 1980's when the commercial space transportation industry was starting to be developed due to events such as the creation of a European organization in charge of commercial launch services and the ban to fly commercial payloads aboard the Shuttle. Before these events took place, there was still transportation of commercial satellites but aboard vehicles owned by the government, no by the private entrepreneurs.[243] The development of the commercial space transportation was supported and facilitated from those years by some governments such as the US government through its official agencies such as the FAA. The launch of the Space Shuttle Columbia in 1982 achieved three successful round-trip flights; however, the expectative that this new vehicle would reduce costs in space transportation failed when it was proved that the expendable launch vehicles (ELVs) resulted cheaper to operate.[244] Moreover, during the same year, a Presidential statement on space policy "confirmed, the space transportation system (STS) was to be the 'primary space launch system for both United States national security and civil government missions,'" adding that the "Government will provide a climate conductive to expanded private sector investment and involvement in space activities."[245] In addition, other attempts to commercialize the space transportation industry appeared in Europe when the Ariane ELV, after completing its developmental

[243] House Transportation Committee of the US, Press Release, "Future of Commercial Space Transportation to be Focus of Congressional Hearing" (7 February 2005), online: spaceref.com <http://www.spaceref.com/news/viewpr.html?pid=16086>.
[244] Ray A. Williamson, "The USA and International Competition in Space Transportation," (1987) VOL. Space Policy 116.
[245] *Ibid.*

flights, was intended to become "a commercial vehicle, marketed by Arianespace."[246] From these experiences, some already saw "the lines of governmental *and* commercial competition drawn between the reusable Shuttle and the expendable Ariane."[247]

Nowadays, is understood that, to successfully develop the space commercialization of products, services and activities in the outer space, it is hugely necessary to achieve the development of a reliable, safe and cost efficient commercial space transportation to guarantee the frequent access to outer space. Nevertheless, before 2004 the vehicles used for all commercial space launches were unmanned expendable vehicles. This situation did not, in any case, obstruct the studies and intents to develop more technologies to achieve manned commercial space flights.[248] For this purpose, one of the principal encouragements that governments have offered to private entrepreneurs for the purpose of achieving manned flights to the orbit, have been prizes to team that successfully take people into orbit.[249]

Furthermore, the commercial space industry will make commercial space transportation "more efficient, affordable and accessible" [250] than governments and space agencies like NASA, which will have "to be restructured to focus on its core mission of space exploration" and rely on the commercial space transportation industry, in order to achieve its exploration goals.[251]

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[246] *Ibid.*
[247] *Ibid.*
[248] House Transportation Committee of the US, Status Report, "House Transportation Committee Hearing on Commercial Space Transportation: Beyond the X Prize" (10 February 2005), online: SpaceRef.com <http://www.spaceref.com/news/viewsr.html?pid=15408> [House Transportation Committee, "Beyond the X Prize"].
[249] *Ibid.*. One example of these prizes has been the Ansari X Prize awarding $10 million for the winner that is planned to be annual. This was the first major Commercial Space Transportation Prize. Other prices of this nature have also been created.
[250] Rep. Ken Calvert, "Address" (Speech presented at the Eighth Annual FAA Commercial Space Transportation Conference in Washington, D.C., 10 February 2005) [unpublished].
[251] *Ibid.*

B. Possible Markets of Commercial Space Transportation

There have been identified as market segments of the commercial space transportation: space rescue, fast package delivery, space servicing and transfer, hazardous waste disposal, space tourism transportation, and ultra high speed civil transport.[252]

Furthermore, the development of other non-transportation markets can be associated with these transportation market segments, such as the space tourism transportation related to the entertainment and space business park concepts. For this reason, there have been included as markets for the commercial space transportation from the demand side: communications, military and government intelligence, positioning satellite service, science and space technology development, remote sensing, space burial, space manufacturing, entertainment, movies or TV shows made in space, advertising, novelties, space business parks, space debris management, space tourism, space settlements, extraterrestrial resources, earth transport, space utilities, space medical facilities and hospitals, strategic ozone initiative, among others.

In addition, transportation markets "provide leverage growth for many other market areas" increasing "jobs associated with developing, manufacturing, and operating the system."[253]

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[252] Boeing Company *et al. Commercial Space Transportation Study to NASA*, online: NASA <http://www.hq.nasa.gov/webaccess/CommSpaceTrans> at Section 3.5.1 [hereinafter "Commercial Space Transportation Study"].
[253] *Ibid.* at Section 3.5.1.2.

As explained above, the governments have been encouraging private entrepreneurs to successfully develop technologies to take people into orbit aboard manned commercial space transportation vehicles. In addition, is expected that after achieving that goal the other objectives will be about commercial space tourism and the aspirations are to achieve those manned commercial space flights in a regular scheduled way. It is understood that a first phase of the space tourism will be very exclusive and adventurous which could only be affordable by wealthy people[254] as what happened at the beginnings of commercial air transportation. Nevertheless, it is expected that the space tourism as well as the general commercial space transportation will be affordable by a larger amount of people when the goals of regularly-schedule, safe and cost-efficiently flights be achieved.

After accomplishing that manned commercial space flight, another expected purpose of the commercial space transportation will include the "point-to-point commercial flight services, rapid global transportation, commercial space ports, and space hotels."[255]

The study completed by the Commercial Space Transportation Study Alliance[256] identified among the most viable and important collection of market segments of commercial space transportation, the following:

1. Space Rescue

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[254] House Transportation Committee, "Beyond the X Prize", *supra* note 248.
[255] *Ibid.*
[256] Commercial Space Transportation Study, *supra* note 252 at Index. The Commercial Space Transportation Study Alliance that elaborated the Phase 1 of this study was conformed by members of the six major United States Aerospace Corporation, which were: (1) Boeing Defense and Space Group; (2) General Dynamics Space Systems Division; (3) Lockheed Missiles and Space Company, Inc.; (4) Martin Marietta Astronautics; (5) McDonnell Douglas Aerospace; and (6) Rockwell Space Systems Division.

This market consist in the development of an industry able to rescue, timely, "humans and/or valuable space assets," responding rapidly and flexibly to crisis situations that could occur in outer space which, due to the "unforgiving environment of space, minor system failures or natural disasters (...) [that] can result in loss of life or the degradation of expensive assets."[257] A successful rescue could include the extraction, stabilization, rapid repair or retrieve of the emergency situation in outer space.

The description of this market shows that the time expressed in a "rapid response", is the principal requirement of this activity because "[t]he failure to act in a timely manner could result in tremendous costs for some space ventures when one considers loss of revenue, customers migrating to functioning alternatives, and replacement costs."[258]

Other requirements imply specialized equipment and operations which represent high costs.[259] In addition, special characteristics of the transportation systems such as capability to physically attach to the rescue object and ability to reenter and land in the Earth but, moreover, depending if pre-positioned or ground-based, it will require space-based rescue assets or elements that allow the vehicle to go rapidly to outer space.[260]

2. Fast Package Delivery

[257] Commercial Space Transportation Study, *supra* note 252 at Section 3.5.2.1.
[258] *Ibid.* at Section 3.5.2.3.1.
[259] *Ibid.* at Section 3.5.2.3.4.
[260] *Ibid.* at Section 3.5.2.5.1.

The "rapid transport of products over long distances, currently [exists] in the form of air freight and express mail,"[261] but this application consists in rapid transport of physical goods in the form of commercial space transportation, which is important to entrepreneurs because "[g]etting the product to market first can be the difference between success and failure."[262] Nevertheless, it is arguable this application to be regulated by space law due to the fact that the "fast package delivery mission does not go to a stable orbit" but because "the system solution will embody almost all the attributes that an orbital system would have," this market was included in the Commercial Space Transportation Study.[263]

Among the requirements for this commercial space transportation application, there is a vehicle capable to rapid turnaround, with high degree of reusability, low unit costs, high reliability, and less demanding characteristics compared to other applications such as smaller vehicles, technically less complex.[264]

The study identified two classes of products that would require s fast package delivery system:

> "(1) commodities/services for which customers are willing to pay a premium for speed of delivery and (2) commodities/services in created markets that were previously impossible due to the perishable nature of the product. The first category is typified by the difference between fees charged for overnight letters vis-à-vis conventional postal rates. An analogous example in air freight for the second class of product would be the inception of transoceanic flights of fresh cut flowers."[265]

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[261] *Ibid.* at Section 3.5.3.3.1.
[262] *Ibid.* at Section 3.5.3.1.
[263] *Ibid.* at Section 3.5.3.1., 3.5.3.7.
[264] *Ibid.* at Section 3.5.3.1.
[265] *Ibid.* at Section 3.5.3.3.2.

At the beginning, it is speculated that the products and commodities to be transported by fast package delivery would be those with "very high value per unit weight," like original documentation, currency, precious metals, and jewels; that would make the initial high shipping fees look low for the value of the items.[266] Moreover, the transportation of specialty machines or electronic parts and assemblies would represent "[a]nother potentially lucrative area of time-value delivery." In addition, other areas could include the transportation of fresh food delicacies and biologic specimens for research and, highly important for the humanity, the transportation of human organs for transplantation.[267] In any case, the "value" of the products requires the inclusion of the "time" component which constitutes the main characteristic of the fast package delivery.

For the proper development of this commercial space transportation application it is recommended a comprehensive planning including all the aspects of an international trade such as customs, taxes, labor disruptions, landing fees and, most important, the creation of an international legal body regulating liability issues because "[t]he fast package delivery concept involves more launch and landing sites and more overflight of population centers than any other commercial space mission."[268] To make applicable the Liability Convention,[269] it must be amended because while assessing liability to the country where the launch physically occurs, it creates a disincentive "to some nations to engage in fast package commerce."[270]

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[266] *Ibid.* at Section 3.5.3.3.2.
[267] *Ibid.* "Currently, potential recipients typically relocate to an urban area that has a facility specializing in a certain type of operation and wait agonizing months until a donor is matched (assuming one is found at all, before death occurs.)" However, the importance of this market is that "[t]ransplant availability is limited by the lifetime of the organ outside of the body (as little as 4 hours in the case of the heart)" and the fast package delivery would surely increase the range of potential donors and saved lives.
[268] *Ibid.*
[269] Liability Convention, *supra* note 109.
[270] Commercial Space Transportation Study, *supra* note 252 at Section 3.5.3.3.2.

In addition, the study mentions other issues of importance to consider in the planning of the fast package delivery systems:

> "Other issues would include interface with regional, national and local air traffic control networks to ensure safety of atmospheric flight operations. Regulations concerning noise abatement, curfews, and environmental impact are real concerns for a system that must be too cumbersome to implement at so many launch sites, and will probably be eliminated in favor of strict certification requirements."[271]

It is important to analyze the two kinds of transportation systems that could be in charge of the fast package delivery because, as explained above, depending on the characteristics of the vehicles, different laws could apply. The first system "performs an initial accelerating burn that lofts the vehicle/payload in an elliptical, suborbital trajectory" and the rockets operate for only a small portion of the flight. The second system is intended to fly within the atmosphere with a propulsion system like an airplane.[272]

A worrying situation could emerge from the expedite requirement of this application since, as it was suggested in the study, "[t]here will be no time for payload checkout or inspection," and the users "must conform to some basic safety regulations, such as flammability."[273] In conclusion, due to the essential characteristic of "fast" delivery, in the planning of the system any activity that could add more time to the service is expected to be excluded with the risk of leaving aside important safety and security standards.

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[271] *Ibid.*
[272] *Ibid.* at Section 3.5.3.5.1.
[273] *Ibid.* at Section 3.5.3.5.3.

3. Space Servicing/Transfer

This application consists in an "on-orbit" repair service since, frequently, to repair a space object located in outer space means a cheaper solution than replace it. However, if launch costs tend to lower, in cases, spacecraft operators would prefer to replace the space object rather than repair it.[274]

The idea of repairing satellites on-orbit has been already materialized by some space shuttle missions but; (1) these missions have been government-funded, leaving the commercial development of the service still absent,[275] and (2) these missions "may not have been economically justified if performed in a truly commercial environment."[276]

4. Hazardous Waste Disposal

As a consequence of the human's technological progress, three kinds of hazardous waste have been developed: chemical, biological, and nuclear. The solution to destroy chemical and biological waste has been found through incineration, but the nuclear/radioactive is much harder to process and "humans can be harmed even without physical contact."[277]

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[274] *Ibid.* at Section 3.5.4.3.1.
[275] *Ibid.* at, Section 3.5.4.2.
[276] *Ibid.* at Section 3.5.4.1.
[277] *Ibid.* at, Section 3.5.5.1. The analysis of the hazardous waste disposal in space included in the study was focused only in the nuclear waste disposal due to three reasons: "a) Longevity of the hazard represents a lasting problem for humankind; b) Known budgets for terrestrial disposal from which to compare to; c) Concern for international proliferation of weapons-grade nuclear material." A known solution for a temporary disposal of nuclear waste is the nuclear waste underground storage located in Yucca Mountain in Nevada, U.S. Nevertheless, the creation of this and future permanent repositories implies high cost and

Many have been the studies about nuclear waste disposal in space but "[r]arely have these studies considered that such a venture could be conducted commercially" focusing mostly, just in the technical aspects.[278] Among the suggested space disposal solutions have emerged the Earth orbit, the Earth-Moon liberation points, Venus impact, Jupiter entry, the solar impact, and solar system escape; being the "lunar surface repository" the selected by the study.[279]

The study also examined the kind of spacecraft that would carry the nuclear waste canisters. The first option was "a reusable spacecraft that travels round-trip from LEO to the surface of the Moon," and the second one, "a partially reusable spacecraft that positions a dumb solid rocket lander on a precise lunar intercept trajectory and then returns to LEO."[280]

However, there are still technical, political, and financial issues pending to be resolved for the feasibility and development of this system which should be address as soon as possible in order to facilitate the commercial development of this space application that represents an important solution to humanity.

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publicly criticized solutions which threaten with future degradation of the storage and consequent contamination spread. For that reason, nuclear waste disposal in space has been studied for a long time as a viable and safe solution.

[278] *Ibid.* at Section 3.5.5.2.

[279] *Ibid.* The study preferred the lunar surface repository because; "a) The waste is stored in the gravity well of the Moon, so it cannot be deflected by passing asteroids or comets (...); b) The lunar transfer process is over in 3 days while the heliocentric transfer takes 165 days. If the control systems fail during transfer the waste directed to the Moon impacts the lunar surface with no possibility of Earth contamination. If a similar failure occurs during the longer heliocentric transfer, the waste is left in an orbit that could impact Earth at a future date; c) The waste is stored in a controlled manner on the lunar surface and can be located and retrieved relatively quickly if an use is found for it in the future (...); d) Nuclear waste packages are gamma ray emitters (...) Storage on the far side of the Moon would not affect astronomers; e) The lunar surface is free of an atmosphere and running water, and the deposit site is localized and would present no threat to future lunar colonists; f) A vehicle designed for disposal of nuclear waste on the Moon can have further applications such as lunar exploration, lunar mining, and lunar colonization; g) It is conceivable that, at some future time, a low efficiency power/thermal source could be made for local use on the Moon from the waste."

[280] *Ibid.* at Section 3.5.5.5.1.

5. Other markets

There are other possible markets of the commercial space transportation such as space tourism and ultra high civil transport. However, due to the essential characteristic of including humans aboard, these markets will be analyzed under the Chapter III related to Commercial Human Space Transportation.

C. Requirements for successful commercial space transportation

The commercial space transportation is a space activity that still has a lot of growing a development to do focusing, mainly, in the transportation of people and goods. To be commercially feasible, these transportation systems have to be available at low cost and reliable to the customers. On the other hand, it must produce significant profits to the entrepreneurs, however; it will not be possible until "the transportation costs are reduced to a few hundred dollars per pound,"[281] and it is expected that this activity will produce huge revenues when the volume of traffic "increase more than proportionally to the price as compared to the higher cost markets."[282] In addition, because it is expected that the traffic will be large, it will be required a substantially bigger fleet size for this activity than for other space markets.[283]

Moreover, the transportation market will require "flight schedules (availability) [that] must be maintained to a high degree of confidence" dictated due to high flight rates

[281] *Ibid.* at Section 3.5.1.1.
[282] *Ibid.*
[283] *Ibid.*

and "[t]his can be achieved through very high reliability systems, fault tolerance, and spares/extra flight vehicles."[284]

In conclusion, it is noticeable that the requirements to the development of these transportation activities are very demanding and, in some way, very difficult and expensive to satisfy. A study completed by the Commercial Space Transportation Study Alliance[285] concluded some recommendations to address the solution of these inconveniences:

> "One strategy is to exclude these markets from inclusion in a total aggregate until a second-generation commercial space transportation system is likely. Another view is that by addressing the stringent requirements for the transportation segments, other commercial markets will be able to use the same vehicles or technology without bearing the developments and risks."[286]

Because "[e]xploration needs commercial space transportation," it is necessary "to improve our access to space" through an affordable, reliable, responsive and efficient ways "to get people and hardware into orbit."[287]

To develop commercial space transportation, it is necessary the creation of commercial spaceports as the indispensable infrastructure requirement. Currently, initiatives between state and community leaders with private entrepreneurs to the creation of spaceports are already a reality.[288] Some governments such as the US have licensed

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[284] *Ibid.*
[285] *See, supra* note 256.
[286] Commercial Space Transportation Study, *supra* note 252 at Section 3.5.1.1.
[287] Calvert, *supra* note 250.
[288] Smith, "Passarola Rising", *supra* note 206 at 3-4.

commercial spaceports and commercial launch facilities, mainly to support unmanned launches and test manned commercial flights. In addition, other infrastructure projects supported by the governments include the creation of resorts and training facilities on those spaceports or, at least, near them.[289]

For the successful development of commercial space transportation is also indispensable the achievement of other goals. The most important objectives are to guarantee the safety conditions of the commercial space transportation, principally of the manned flights and the security of the launch facilities and vehicles.[290] Nevertheless, there is no perfect transportation system because, since the operators are humans, there is always the risk of accidents. This situation means that there is not and will never be perfect reliability in the commercial space transportation as there is not such in maritime, terrestrial, or aerial transportation systems and the public has to be educated to understand these risks.[291] The reliability of the service is the most important requirement for some commercial space applications such as the fast package delivery where, due to the existent risks, the operator of the service defines as a reliable fast package delivery one with the "ability to deliver a given package at its intended destination and time with a very high degree of confidence."[292]

In addition, the safe and reliable delivery of the cargo emerges as an essential requirement for future commercial transportation activities involving the transport of hazardous nuclear waste. It is suggested that "the payload can be encapsulated in a way

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[289] House Transportation Committee, "Beyond the X Prize", *supra* note 248.
[290] *Ibid.*
[291] Joel S. Greenberg, "Leadership in Space Transportation," (1987) 3 Space Policy 179.
[292] Commercial Space Transportation Study, *supra* note 252 at Section 3.5.3.5.1.

that ensures that zero waste is released, even if worst case launch vehicle failure."[293] In this sensible area where would be economically practical "to eliminate most of the nonhazardous material from the waste and only pay to launch the truly hazardous material," would also be vital to guarantee extreme safety conditions to the personnel handling the material in the ground.[294]

Other issues that will necessarily emerge with the development of commercial space transportation industry will include international competition, the analysis of the environmental impact and its mitigation, the labor laws involved in this kind of transportation and the impact of the air traffic control to the commercial space transportation as well as issues related with the use of the navigable airspace.[295]

In addition to that, the space transportation systems envisioned for a near and long term access to outer space for the purpose of different commercial and governmental applications, share a number of required characteristics to succeed. The study prepared by The Aerospace Corporation and sponsored by the NASA[296] recognized that those necessary characteristics involve a remarkable reduction in the costs of the launch, reliability, operability, facilities, payload capabilities and environments.[297] This study did not evaluate the technical or economic feasibility of the "innovative space applications"[298] which ranged from "human planetary exploration and space weapons to

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[293] *Ibid.* at Section 3.5.5.5.2.
[294] *Ibid.* at Section 3.5.5.5.3.
[295] House Transportation Committee, "Beyond the X Prize", *supra* note 248.
[296] Johnson & Smith, *supra* note 205 at 145.
[297] *Ibid.*
[298] *Ibid.* at 148. The list of the innovative future space applications considered in the study was classified in four groups: near-term innovative, passenger service, rapid access, and initial deployment. The future space applications considered in the paper included: agriculture, advertising, athletic events, beaming electromagnetic radiation, bistatic radar, broadcast services, burial, business park, civil transport, communications, debris removal, fast package delivery, fixed communication services, force delivery, reconnaissance and targeting, hazardous waste disposal, high-energy laser, human planetary exploration, hyperspectral imaging, interceptors, kinetic energy weapons, lunar settlement, manufacturing, medical,

space utilities and space tourism."[299] Instead, the characteristics of annual flight rate, the launch price to enable the application, the weight to the Low Earth Orbit (LEO) and the manned requirement were the basis of the study to establish the requirements for these innovative applications for space transportation systems.[300]

In conclusion, as the study observes, by achieving the mentioned requirements through very low cost service, reusable launch vehicles will have the same operational characteristics of airplanes.[301] Nevertheless, that required cost reduction is not possible to obtain with the current technology programs rather, "present near-term technology development programs are aimed at achieving modest cost reductions."[302]

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military spaceplane, mining, missile warning, mobile communication services, molniya deployment missions, movie studio, nanosat applications, novelties, on-demand surveillance, O'Neill habitats, planetary defense, product demonstrations, remote sensing, solar-powered high-energy laser, space control, space science outwards, Space Station missions, space tourism, space traffic control, super GPS, theme park, transportation servicing and transfer, and others.

[299] *Ibid.* at 147.

[300] *Ibid.* 147-149. It will be required a cost reduction of the mission "at least by a factor of 100x to about $100 per kilogram to LEO, or about 10x greater than long-distance air-transport costs" to become economically viable. Nevertheless, to achieve 10x and 100x cost reductions, "flight rates per vehicle must be much higher than today's Space Shuttle." On the other hand, higher flight rates require, at the same time, "extremely high vehicle reliability (...), quick turnaround and airport-like ground operations infrastructure." In addition, the study observes that "[h]igh reliability must be achieve through robust design margins, aircraft-like certification processes, in-flight health management systems and designs that eliminate single-string failures as well as provide a safe abort option. For rapid turnaround (...) there must be easy-handling fuels and convenient access for maintenance and servicing."

[301] *Ibid.* at 149.

[302] *Ibid.* 149-150. Some examples of present near-term technology-development programs include: "active thermal protection systems that can handle several hundred cycles without lengthy maintenance; improved propulsion systems that also accommodate the requirements of rugged, long-life engines and airframes; and more efficient cargo handling, crew/passenger systems and ground support equipment."

Chapter III – Commercial Human Space Transportation

A. Competition and Free Trade in Commercial Human Space Transportation

The forty years of history dealing with manned space activities have proved the appeal of the astronaut profession as well as their "attractiveness to gain resources from the private sector."[303] For that reason, the basis of the commercial human spaceflight is "leverage on the appeal and interest of businesses to participate in space commercial activities to finance more frequent human missions"[304] to outer space. Consequently, the ultimate goal of commercial space activities is "to bring privately paid astronauts into orbit," ranging from "private 'explorers' to industry employees working in space.[305]

Moreover, as one of the commercial applications of space activities there are private suborbital flights of passengers through commercial enterprises. Nevertheless, NASA achieved a human space flight a long time before SpaceShipOne, a private company, did. Although the commercial human space flight was not a novelty compared to the prior achievement of the US government agency, the success of the SpaceShipOne team was the cost of the operation which was around $20 million, cost that would be impossible to achieve by NASA "because they don't have the drive, the talent, or the will to put people in space on the cheap" and, moreover, "government agencies operate under different conditions and in a different environment than the private sector."[306]

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[303] M. Belingheri & C. Mirra, "The Challenges and Opportunities of a Commercial Human Spaceflight Mission to the ISS," (2003) 53 Acta Astronautica 652.
[304] *Ibid.*
[305] *Ibid.*
[306] Calvert, *supra* note 250.

On the other hand, there are still many risks and hazards of manned space flights that require technology improvements, legal regulations and policy developments to allow scheduled space flights of people and cargo in a regular basis.

The most important goal to achieve the commercial development of human spaceflights is to attain the highest possible *safety* standards of the mission.[307] Nevertheless, "[b]y the time a private launch vehicle leaves the ground with passengers, a dangerous rocket will be *as safe as humans can make it.*"[308] This suggestion means that because the space industry is managed by humans, the perfect and complete safety of a spaceflight cannot be obtained due to the imperfect nature of humans that always leave a possibility of accidents however the prior analysis, testing, adjustments or redesigns. In fact, every transportation systems developed in our society, have the weakness of failure in some point, causing accidents – ships sinking, trains derailing, cars colliding, airplanes crashing. However, by the time these transportation systems appeared as novelties, and presented to the society as no fail-safe propositions, the attractive offer of getting "someone or something somewhere, faster" did not extinguished the appetite of using those transportation systems.[309]

This past experience might extend to the situation of private human spaceflights although, in words of Patricia Grace Smith:

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[307] *Commercial Space Launch Amendments Act of 2004*, Pub. L. No. 108-492, 118 Stat. 3974. "[T]he future of the commercial human space flight industry will depend on its ability to continually improve its safety performance."

[308] Patricia Grace Smith, "Rockets are Dangerous," (Remarks addressed at the International Association for the Advancement of Space Safety Conference in Chicago, Illinois, 14 May 2007), (2007) 73 Spaceflight 280 [Smith, "Rockets"] [emphasis added].

[309] *Ibid.* at 280-281.

> "Today, in its infancy, private human spaceflight is not seen as a form of transportation. It is widely seen as pure experience infused with risk. While the longer view of space tourism is something evolving into an actual space transportation system, the only view that matters for now is the one we have of an enterprise in its infancy."[310]

In addition, Smith points out that it is going to be more difficult for the space transportation industry because our society is "electronically equipped to shine the spotlight of instant public judgment on anything that goes wrong."[311] However, there is an advantage for the space transportation industry that the other transportation systems like the aviation industry did not have at their early times. That is the existence of legislative and regulatory standards that help the space industry development. For example, for private human spaceflight there is the essential rule of *informed consent* according to which "any prospective passenger must be fully advised of the risk in advance and the operator must assess that the prospective space traveler/passenger is cognizant of the risk."[312]

B. Possible Markets for the Commercial Human Space Transportation

Nowadays, although commercial human space flights are not a reality, it is possible to identify the existence of a market for that activity. The commercial human space transportation is understood to be "an addition, not a replacement"[313] to the existent catalog of commercial space activities and industry. This affirmation can be easily

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[310] *Ibid.* at 281.
[311] *Ibid.* at 282.
[312] *Ibid.* at 283.
[313] Smith, "Commercial Human Spaceflight", *supra* note 207 at 760.

supported by all the initiatives and incentives of many companies that "are committing resources to private human space flight because they see a profit to be made" showing that "business is interested in this."[314] For example, there is an US firm that has collected a huge amount of money in deposits for suborbital flights which has also brokered a human trip to ISS aboard a Russian Soyuz, although this was not a private commercial space flight but illustrates the interest of private companies in this industry.[315] Furthermore, there is the company formed by Virgin Galactic and Scaled Composites, *i.e.* The Spaceship Company, "to build a fleet of nine-person, suborbital spacecraft."[316] Moreover, some initiatives as the X Prize Fuondation events and diverse prizes, such as the Bigelow Aerospace's sponsored prize to the creation of a spacecraft able to "reach an altitude of 250 miles; carry no less than a crew of five; complete two full orbits of the earth and return safely; then do it again in 60days" with a deadline in January 10, 2010.[317]

Nevertheless, it is necessary to highlight that commercial human space transportation's market is not *only* about space tourism, although this application will is surely the first stage of the industry, rather, its uses will be broader.[318]

Space Tourism

The space tourism is "an extension of the current tourism market activity"[319] and when manned commercial space transportation become an available reality, humans will spend millions to enjoy the space tourism ventures due to the growing enthusiasm of

[314] *Ibid.*
[315] *Ibid.* at 759.
[316] *Ibid.*
[317] *Ibid.*
[318] Calvert, *supra* note 250.
[319] Commercial Space Transportation Study, *supra* note 252 at Section 3.5.6.

tourists to discover exotic destinations.[320] The first manifestation of space tourism will probably be the transport to LEO as a means of recreation.[321] Moreover, it is expected that to achieve regular service "provided with one space plane flight to LEO and return every day."[322] The Commercial Space Transportation Study describes the requirements of this first step of the space tourism:

> "This requires a fleet of at least four vehicles. Service could be provided from existing airports or from newly constructed launch/recovery pads. The only new ground servicing facilities required would be a fuel storage facility and a fueling facility. A turnaround time of 24 hours with no more than 200 maintenance labor hours would be expected. The reliability would have to be at least comparable to existing air transportation systems."[323]

Under the space tourism application, there can be different paths which will be developed sooner or later depending on how attractive they could be to the private entrepreneurs due to cost and fleet size that each path implies.[324] Some of these space tourism ventures could be:[325]

> **a.** "Joyride" – Passengers would aboard a high-speed vehicle and experience an exhilarating, relatively short (in hours) ride suborbitally or up to a few orbits in duration. This scenario implies most of the cost of operation is related to the transportation elements and would probably feature rapid turnaround of reusable hardware.

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[320] *Ibid.* at Section 3.5.6.3.2.
[321] *Ibid.* at Section 3.5.6.
[322] *Ibid.*
[323] *Ibid.*
[324] *Ibid.* at Section 3.5.6.3.1.
[325] *Ibid.*

b. Orbital Visit – Tourists visit a fairly simple orbital facility (such as Space Station Freedom or MIR) for durations of 3 to 10 days. Amenities are few and the transportation elements would probably be small (few passengers) to be consistent with the orbital facility (...)

c. Space Hotel – Large numbers of tourists would stay at a multifeatured orbital facility. Both 0g and positive g zones would be available for living, playing, and looking out numerous windows (...)

d. Lunar Flyby – An Apollo 8-type mission where passengers experience 0g, the starry blackness of space, and views of the Moon and distant Earth (...)

e. Lunar "Hilton" and Beyond – Space resorts and more ambitious ventures are in a financial realm that is unlikely to occur if at least one of the previously listed space tourism ventures has not proved successful.

Among the requirements that the space tourism industry will need to become a feasible commercial venture there are: affordability of the price to the interested people;[326] an interface with some terrestrial tourism infrastructure for reservations, advertising, and financing functions;[327] an orientation facility able to prepare the passenger physically going beyond "the typical safety lecture presented on an airline flight;"[328] specially designed spaceports proximate to existing transportation nodes with air corridors for departures and arrivals and with the "[a]vailability of large hangers and maintenance equipment for performing the regularly schedule preventive maintenance procedures"[329] and protected with a "buffer zone surrounding the spaceport" to protect

[326] *Ibid.* at Section 3.5.6.3.3.
[327] *Ibid.* at Section 3.5.6.3.4.
[328] *Ibid.* at Sections 3.5.6.3.4., 3.5.6.5.4.
[329] *Ibid.* at Sections 3.5.6.3.4., 3.5.6.5.2.

from the emitted noise of the takeoff and landing operations, among other requirements.[330]

Furthermore, the transportation system used for space tourism will have to meet some *technical requirements* such as "maximization of personnel safety," maximum reliability of the vehicle, and personnel comfort.[331] In addition, some *risk control requirements* must be followed in order to "ensure financiers of a favorable return of investment" through the creation of companies supplying sources for cost competitiveness and failure recovery.[332] Finally, there are *legal requirements* which must be satisfied by the transportation system including the necessary regulation of issues involving safety issues, financial and product liability, insurance standards, possible binding waivers, operation costs and taxes, civil torts, criminal law, and the creation of international regulatory authorities.[333]

Ultra High Speed Civil Transport

This application is planned to consist in terrestrial civil transport at speeds going up to two or three times the speed of sound which will imply an important solution for time-constrained travelers, principally business people.[334] Because it is intended to constitute one more option of conventional transportation, the ultra high speed civil transport will carry passengers without any special requirements of training, clothing, or physical aptitudes. For that reason, the discomfort effect for the acceleration/deceleration must be

[330] *Ibid.* at Section 3.5.6.3.4.
[331] *Ibid.* at Sections 3.5.6.5.1., 3.5.6.5.2.
[332] *Ibid.* at Section 3.5.6.5.1.
[333] *Ibid.*
[334] *Ibid.* at Section 3.5.7.1.

analyzed and solved. One of the solutions could be limiting the acceleration which will impede the vehicle to achieve orbital-like velocities[335] and this means that this kind of transportation "would operate within general infrastructure of the world commercial airline system."[336]

C. Governmental Initiatives and Incentives to Promote Commercial Human Spaceflight

In US, for the first time ever, the FAA hosted a summit "to introduce the Air Force to entrepreneurial Reusable Launch Vehicle developers around the country".[337] This event showed the US Air Force that the private enterprise able, active and, interested in develop better ways to guarantee the access to space.

Moreover, NASA chose as commercial space transport partners two entrepreneurial companies – Kistler Aerospace, now Rocketplane Kistler (RpK), and Space Exploration Technologies (SpaceX) – which have invested in private funds comparable amounts with the government investment in the commercial space transportation industry.[338] The main goal of NASA is the development of a *commercial space-cargo industry* demonstrated by the agreements signed with the two companies to support "pressurized and unpressurized cargo delivery to the ISS." Nevertheless, "both companies already have started working on the life-support and other systems that would be needed to carry crews to and from the station (...) [a]nd the money they have spent to date gives them both a good start on the

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[335] *Ibid.* at Section 3.5.7.3.2.
[336] *Ibid.* at Section 3.5.7.3.4.
[337] Smith, "Passarola Rising," *supra* note 206, at 2.
[338] "Skin in the Game," (2006) 9 Oct. Iss. Aviation Week 66.

vehicles they hope will soon be delivering hardware and humans not just to the ISS, but to other civilian and military destinations in orbit."[339] Because the technology designed for the vehicles which is planned to be based on reusability and "rapid turnaround launch on demand," the companies have stated that they will be in a great position to compete with other commercial launch vehicles, such as the Soyuz, due to the price they will be offering and the great commercial market that exists.[340]

On the other hand, the US government has also promoted the commercial space transportation by awarding prizes to impressive space vehicles developed by private companies.

D. The US' Office of Commercial Space Transportation and the Commercial Space Launch Act:

The Office of Commercial Space Transportation (OCST) is located within the Federal Aviation Administration (FAA) and is in charge, mainly, of the regulation of commercial space transportation, while protecting the interests of public safety and the safety of property.[341] The Office also gives licenses to launch, reentry and spaceports operations and, because while licensing the Office tries to assure to the possible extent the safety of the missions, every launch licensed has been successful.[342]

When commercial spaceflights extended to transport humans, the safety on board got a higher level of importance and need of guarantee than before when commercial

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[339] *Ibid.*
[340] *Ibid.*
[341] Smith, "Commercial Human Spaceflight," *supra* note 207 at 757.
[342] *Ibid.*

launch vehicles only carried cargo.[343] For that reason, in the US the Commercial Space Launch Amendments Act of 2004 (CSLAA) became law, making responsible the Secretary of Transportation for commercial human flights and giving authority for the implementation to the FAA and the OCST.[344] Moreover, the CSLAA created an "experimental permit for research and development of new reusable launch vehicles," easier to obtain that a license, and similar to the aviation's Experimental Airworthiness Certificate for research and development.[345]

An important provision of the Commercial Space Act of 1998 addresses the market barriers that could obstruct the required partnerships between the government and the private sector "by calling for NASA and other US federal agencies and scientific researchers to acquire space science and Earth science data from commercial providers."[346]

E. Conclusions of Commercial Human Spaceflight

Since space transportation is on board rockets, they have the characteristic of traveling "very far, very fast ... or everywhere at once in a moment of a catastrophe."[347] Although these advantages, a lot of people are still considering that private human spaceflight is only a high cost and high risk way to "fulfill an ambition."[348]

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[343] *Ibid.*
[344] *Ibid.*
[345] *Ibid.* at 758.
[346] Eligar Sadeh, David Livingston, Thomas Matula and Haym Benaroya, "Public-private Models of Lunar Development and Commerce," (2005) 21 (4) Space Policy 267-275.
[347] Smith, "Rockets," *supra* note 308 at 281.
[348] *Ibid.*

Moreover, accidents will certainly occur. For that reason, some recommendations have been suggested to confront the public judgment by the official authorities. Firstly, it is important that the concerned authorities tell the truth, as soon as possible, to the media and the public about the occurred accident. Secondly, they must find the causes involved in the disaster and explain them, in a clear language. Finally, they should fix the problem, what did not work properly, test the repairs and fly again.[349]

In addition, some specialists in the subject foresee that the commercial space transportation industry, in general, will be an important "revenue producer and a job creator" for our society which is understanding more and more that the simple access to outer space is not the final frontier but "the front door to a future beyond our dreams, a future with private human spaceflight as an economic driver, a future with some of the most astute business persons coming from the industry sector."[350]

The type of vehicle used for commercial space transportation purposes is important in order to lower the costs. The debates are between the use of reusable launch vehicles (RLVs) which, potentially, will reduce costs, and the expendable launch vehicles (ELVs) or not fully reusable vehicles which, due to their simpler nature, are less expensive and are a way to reduce costs.[351] Both suggestions are very attractive.

On the other hand, commercial human spaceflight will have considerable consequences. The Associate Administrator for the US Commercial Space Transportation Office in 2004, identified that, firstly, "private human space flight will permanently expand the reach of commercial space transportation."[352] Secondly, she recognized a

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[349] *Ibid.* at 282.
[350] Smith, "Passarola Rising," *supra* note 206, at 3.
[351] "Skin in the Game," *supra* note 338.
[352] Smith, "Commercial Human Spaceflight", *supra* note 207 at 761.

symbiotic relationship between the progress in commercial rocketry making private human space flight possible and, then, this flight will conclude in "further technical progress in commercial space carriers." [353] Thirdly, commercial human space flights will renew "enthusiasm for space generally" and "will attract fresh thinking about space and entrepreneurial possibilities." [354] Furthermore, she adds that when common people actually perform commercial human space flights, "space will become more real to more people"[355] and these kinds of flights will also "reaffirm and reinforce the credibility of commercial space transportation."[356]

It is important to observe that while the orbital assets when "financed, launched, and operated by a single government, property rights and jurisdiction issue fell under the law of the controlling government."[357] Currently, the legal situation of these activities stands as follows:

> "[There are] several international space policy agreements in force that serve to guide the general framework of a private tourism venture. Additional regulation is certain to occur as commercial operations become routine so as to resolve questions of product liability, civil torts, and criminal law. A possible model for space tourism legal affairs may come from international cruise ship lines or from Antarctica tourist travel."[358]

"New technologies and design philosophies can be judiciously applied to a vehicle specifically intended for routine, safe, manned transportation that will result in low

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[353] *Ibid.*
[354] *Ibid.*
[355] *Ibid.* at 762.
[356] *Ibid.*
[357] Commercial Space Transportation Study, *supra* note 252 at Section 3.5.6.5.1.
[358] *Ibid.*

operations costs."[359] However, the high costs that will imply the creation of a transportation system for manned space flights, diverse could be the solutions ranging from buying an existing space vehicle modifying it with the required characteristics, to the support from the governments through subsidies for the private entrepreneurs.[360]

[359] *Ibid.* at Section 3.5.6.7.
[360] *Ibid.*

Chapter IV – Other Legal considerations of Commercial Space Transportation

Since the launch of the Sputnik I in 1957 to nowadays, the nature of space activities has been through many changes. As mentioned before, states found it urgent to create principles that governed space activities but mainly focused in areas other than commercial space industry. Moreover, during the drafting of the outer space treaties, there was a belief that "there was a room for all possible space applications to coexist."[361] In addition, at the time when the Outer Space Treaty and the other space law instruments were drafted, the only players in outer space were states and this situation explains why those instruments have no provisions for "private commercial operators."[362] The only provision that related to private commercial operators in the Outer Space Treaty appears in articles 6 and 7 "to the extent that states are held liable (...) for national activities in outer space, whether such activities are carried out by governmental or non-governmental agencies."[363] The focus of these instruments in governmental space activities, rise legal questions about conducting commercial operations in outer space such as, "the rights to sell for profit samples" recovered in outer space, the intellectual property rights, and real property rights and appropriation of resources.[364] While there is legal uncertainty about these issues under the current *corpus iuris spatialis*, some of the commercial space ventures would be affected by "costly legal delays."[365]

Nevertheless, the space law regime is permissive of commercial space activities, although it does not specifically regulate them, because it "establishes principles

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[361] Swaminathan, *supra* note 237 at 266.
[362] *Ibid.* at 261.
[363] *Ibid.*
[364] *Ibid.* at 262.
[365] Sadeh *et al*, *supra* note 346 at 271.

important to commercial development and allows for the private appropriation of resources."[366] Furthermore,

> "The regime allows all peaceful activities in space, which includes all commercial activities, and it deals with important issues of registration, liability and non-interference that would all doubtless reduce the legal risks of any [public-private partnership] development (...) The [Outer Space Treaty] regime also defaults to national entities or governments to regulate commercial activities in space."[367]

Some scientists argue that there are incompatibilities between the interests of science and commerce and, for that reason, the "have to look to rules, agreed by the international community, that recogni[z]e the role of basic space science and guarantee its continued existence."[368] They are concerned that commercial space activities such as space advertising[369] may endanger "the future of ground-based astronomy" and, consequently, they propose to reform the lack of regulation in that area.[370] Another concern of scientists with the growing commercial uses of outer space is the proliferation of space debris that commercialization can cause. The space debris problem is addressed

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[366] *Ibid.* at 272.
[367] *Ibid.*
[368] Swaminathan, *supra* note 237 at 261.
[369] M. Belingheri & C. Mirra, *supra* note 303 at 655. It is considered that "the private funds to support the commercial human spaceflight ticket" will principally originate from: sponsorship, products placement (e.g., using commercial products and instruments in space), merchandising (e.g., products developed in relation to the mission), and advertisement (e.g., companies using exposure to space to advertise their products/services).
[370] Swaminathan, *supra* note 237 at 262. The International Astronomical Union (IAU) has proposed a ban on 'obtrusive space advertising', excluding from this ban, real scientific missions even obtrusive to astronomy. The author expressed interest in the fact that the USA "has already prohibited the issuing of launch licenses for 'obtrusive space advertising', which it defines as 'advertising in puter space that is capable of being recognized by a human being on the surface of the Earth without the aid of telescope or other technological device'."

in a Draft Instrument for the Protection of Damage Caused by Space Debris adopted by the International Law Association (ILA) in 1994 which, although constituting an important instrument that makes states "internationally *and strictly* liable for damage caused by 'space debris' originating from objects launched by them into space," this instrument have not been able to be implemented into a binding international agreement.[371]

Finally, the development of contractual agreements between the private and public sectors for the purpose of creating partnerships to finance these commercial ventures are also going to have an important role in the space enterprise.[372]

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[371] Swaminathan, *supra* note 237 at 265. The space debris is a complex problem vastly address by the international community because it requires a fast solution and the creation of an international agreement, although being the ideal way to deal with the problem, is not the fastest way due to the consensus long process of space law making through UNCPOPUOS.

[372] M. Belingheri & C. Mirra, *supra* note 303 at 656.

PART IV – CONCLUSIONS AND FINAL RECOMMENDATIONS

There are problems surrounding the development of space transportation as a massive activity. The various intents of constructing a space vehicle for this purpose have not been capable to offer a reliable, safe, and affordable mean of transportation for potential customers.

Governments should reduce political, legal, technological, financial, and market risks for the private sector in order to increase the public-private partnerships that will guarantee the initial development of the most ambitious commercial space ventures.[373] The high costs implied in those space activities will require an initial "political support and government funding" due to the inability of private entrepreneurs to raise the required venture capital.[374] For that reason, acting in public interest, governments must elaborate a domestic legal regime facilitating partnerships with the private sector while assuming some of the venture risks.[375] A way to reduce the risks can be accomplished "through policy actions that make sure that governmental actions de not adversely affect the development of the private space industry, through a role for government in capital formation for developing space technology, or by offloading governmental activities in space to the private sector."[376] Again, it is important that governments establish national policies and laws providing a licensing and regulatory regime promoting the participation of the private sector in space activities.

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[373] Sadeh *et al*, *supra* note 346 at 267. *See* also, James Bennett and Phillip Salin, "The Private Solution to the Space Transportation Crisis," (1987) 3 Space Policy 181.
[374] Sadeh *et al*, *ibid.* at 268-269.
[375] *Ibid.* at 269.
[376] *Ibid.*

Some of the government roles to cooperate with private entities in the development of commercial space ventures would include: "(1) [Research and Development] contacting of technology; (2) technology transfer; (3) diffusion of technical knowledge; (4) intellectual property rights and patent protection; (5) contractual rewards; (6) prizes for technology innovation; (7) subsidies; (8) corporate ownership; (9) loans; (10) government procurement or purchasing of commercial services; and (11) tax benefits and credits."[377] In other words, to favor a growing space transportation industry, the space policies have to embrace scientific and commercial needs as well as the ones directly connected to nation's interests.

Nowadays, also the efforts to develop commercially based human spaceflights are based in the financial support of public entities and governments and the private sector through partnerships. However, it is expected that in the future only the private sector would be able to finance those ventures.[378]

The current challenges that emerge from the commercial space ventures are, in the first place, the financial factor due to the high required capital; secondly, the development of proper business conditions for the negotiations between the private and the public sectors and; finally, the contractual conditions and the guarantees "offered to all those spending money in this initiative."[379]

On the other hand, the academic discussions about delimitation of outer space and definition of a space object do not seem to find a final solution in the forthcoming years. For that reason, space policies and regulations cannot wait for the end of these

[377] J.A. Alic. "Policies for Innovation: Learning From the Past" in V. Norberg-Bohm, ed., *The Role of Government in Technology Innovation: Insights for Government Policy in the Energy Sector, Working Paper* (Harvard University: Belfer Center for Science and International Affairs, 2002) at 21-36, cited in Sadeh *et al*, *ibid.* at 273.
[378] M. Belingheri & C. Mirra, *supra* note 303 at 651.
[379] *Ibid.* at 656.

discussions due to the imminent growth of the space transportation industry. The agreements and other legal bodies dealing with this space activity should contain their own definitions and delimitations in order to establish the applicable law.

It is indispensable that governments develop space policies and regulations promoting and facilitating the incursion and participation on the commercial space transportation industry in order to guarantee a reliable, safe, and affordable service which will benefit the governments as well as the private entrepreneurs and which will offer to the society new broad options to enjoy the dreamed life in outer space.

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