Suborbital Flights: Selected Legal Issues

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ABSTRACT

We will soon be confronted with regular operation of suborbital vehicles. These vehicles constitute a technological novelty for which there is not yet a specific legal framework. Taking into consideration the ambiguity which exits in international law, suborbital flights have fostered lengthy debates over defining the appropriate legal regime to govern the various legal aspects of these flights. Traffic management and environmental protection issues of suborbital flight are among the areas which need to be regulated. The present research tries to give an overview of the legal issues associated with the regulation of suborbital flights and to advance the discussion in the light of possible regulatory scenarios on the environmental and traffic management aspects of these flights. The present study suggests that further clarification and development of the existing legal frameworks for aviation and space activities, careful study of the different aspects of suborbital flights and the foreseeable impacts they might have on different areas including environment and traffic management concerns, as well as possible inclusion of such flights under ICAO's regulatory system are among the considerations which need to be taken into account in relation to regulating suborbital flights.

RÉSUMÉ

Nous serons bientôt confrontés à trafic régulier de véhicules suborbitaux. Ces véhicules constituent une nouveauté technologique pour laquelle il n'existe pas encore de cadre juridique particulier. Tenant compte de ce vide juridique en droit international, les vols suborbitaux ont suscité de longs débats portant sur la nature du régime juridique requis pour régir les différents aspects juridiques de ces vols. La gestion du trafic des vols suborbitaux ainsi quel a protection de l'environnement comptent parmi les secteurs ayant besoin de réglementation.

La présente recherche a pour objectif de fournir un survol des questions juridiques liées à la réglementation des vols suborbitaux et de faire avancer les discussions sur les scénari de réglementation par rapport aux aspects environnementaux et de circulation de ces vols. La présente étude propose la clarification et le développent des cadres juridiques existantes en matière d'aviation et activités spatiales. De plus, elle aborde soigneusement les différents aspects des vols suborbitaux et leurs impacts éventuels sur divers secours, dont l'environnement, et la gestion du trafic. Par ailleurs, l'adoption éventuelle des vols suborbitaux sous le système de réglementation l'OACI représente quelques'un des éléments qui nécessitent une réflexion relative a la réglementation de ces vols suborbitaux.

ACRONYMS AND ABBREVIATIONS

ANC: Air Navigation Commission

ATC: Air Traffic Control

ATM: Air traffic management

BC: Black Carbon Particulates

CAEE: Committee on Aircraft Engine Emissions

CAEP: Committee on Aviation Environmental Protection

CANSO: Civil Air Navigation Services Organization

CO: Carbon Monoxide

CO2: Carbon Dioxide

COPUOS: United Nations Committee on the Peaceful Uses of Outer Space

DOT: Department of Transportation of the U.S.

EA: Environmental Assessments

EASA: European Aviation Safety Agency

EIS: Environmental Impact Statements

ELVs: Expendable Launch Vehicles

ESA: European Space Agency

EU ETS: European Union Emission Trading Scheme

FAA: Federal Aviation Administration

FAA-AST: Office of Commercial Space Transportation of the U.S. FAA

FCCC: Framework Convention on Climate Change

FONSI: Finding of No Significant Impact

GEO: Geostationary Earth Orbit

GHG: Greenhouse Gases

GIACC: Group on International Aviation and Climate Change

GNSS: Global Navigation Satellite Systems

HC: Hydrocarbons

IAA: International Academy of Astronautics

IADC: Inter-Agency Space Debris Coordination Committee

ICAN: International Commission on Air Navigation

ICAO: International Civil Aviation Organization

IPCC: Intergovernmental Panel on Climate Change

ISS: International Space Station

ITU: International Telecommunication Union

LEO: Low Earth Orbit

LREs: Liquid Rocket Engines

N2O: Nitrous Oxide

NASA: National Aeronautics and Space Administration of the U.S.

NEPA: National Environmental Policy Act of the U.S.

NOx: Nitrogen Oxides

PANS: Procedures for Air Navigation Services of ICAO

RLVs: Reusable Launch Vehicles

SARPs: Standards and Recommended Practices and Procedures

SATMS: Air Traffic Management System of the U.S.

SRMs: Solid Rocket Motors

SSN: Space Surveillance Network of the U.S.

STM: Space Traffic Management

VTVL: Vertical Takeoff and Vertical Landing

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CHAPTER THREE: SUBORBITAL VEHICLES AND THE RULES OF TRAFFIC MANAGEMENT

INTRODUCTION

Scaled Composites' SpaceShipOne success in completing two sub-orbital flights to an altitude of 100km within a two-week period and subsequently winning the Ansari X-Prize was a milestone in the history of human flight. Since then, important steps have been taken in realizing humans' ambitious plans for safe and affordable access to the Earth's sub-orbit, and it is almost time for these efforts to come to fruition. Such plans are not just limited to tourism purposes, and there are also long term projects for developing suborbital Earth-to-Earth transportation systems via high-technology reusable hybrid vehicles. Designs and technological initiatives and ventures with respect to commercialization of Earth's sub-orbital stratum give rise to a variety of issues and considerations.

Realization of suborbital flight fosters a debate over which legal regime is or should be applicable. Currently, international law does not provide any clear answer to the legal challenges that might arise with operation of suborbital vehicles. These vehicles reach the border of airspace and outer space, for which there is not yet any legal definition or demarcation. In this situation of lack of a regulatory system specifically designed for suborbital flights, either air law or space law might be an option as the applicable law. Considering the fundamental differences between the two regimes, the decision about choosing the appropriate legal regime for regulating suborbital flights is a crucial one, with differing consequences. International air law is comprehensive and well developed, and the International Civil Aviation Organization (ICAO) as the forum for regulating various aspects of aviation has proven successful during the previous decades.[1] To the contrary, the current international treaty law for space, although establishing a good foundation for international space law, is neither sufficiently detailed nor up-to-date enough to address all the various contemporary aspects of space activities.[2]

The legal ambiguity and uncertainties in the current legal frameworks, such as lack of a definition for 'space object', demarcation of airspace and outer space, and the restrictive nature of the classic definition of 'aircraft' in including suborbital flights, makes it complicated to decide whether air law can apply, *mutatis mutandis*, to suborbital flights or space law is the competent regime to regulate such flights. The conceptually challenging legal questions with respect to the suborbital flight industry, if we may call it this, concern issues as wide as nationality and registration, licensing and certification, safety, security, liability, traffic management systems and, last but not least, environmental protection. The two latter areas, traffic management and environmental protection issues of suborbital flight, although directly affecting the safety and sustainability of the nascent industry of suborbital flights, are less addressed in the scholarly work already done on the legal issues of suborbital flights. The purpose of the present research is to give an overview of the legal issues associated with the regulation of suborbital flights and to advance the discussions in the light of the possible regulatory scenarios on the environmental and traffic management aspects of these flights.

[1] Paul S. Dempsey, *Public International Air Law* (Montreal, Canada: McGill University, Institute and Center for Research in Air and Space Law, 2008) at 760-64.

[2] Ruwantissa Abeyratne, "ICAO's Involvement in Outer Space Affairs – A Need for Closer Scrutiny?" (2004) 30 J. Space L. 185 at 187 [Abeyratne, "ICAO's Involvement in Outer Space Affairs"].

Chapter One reviews the chain of events that led to shaping the commercial human space flight industry in its current form. It further discusses the definitions and characteristics of suborbital vehicles. Then it examines the future perspectives of the market for suborbital flights, and at the end the legal challenges and ongoing controversies in regard to regulating such flights.

Chapter Two seeks to identify the probable environmental threats that suborbital flights might cause to the environment and discusses the possible legal answers to these environmental concerns. This Chapter begins by examining the environmental impacts of aviation and space activities and the existing laws and standards in international law to mitigate such impacts. It then examines the foreseeable negative impacts of suborbital flights in both realms of airspace and outer space and tries to elaborate the possible regulatory responses.

The last Chapter of the thesis, Chapter Three, addresses the traffic management issues associated with suborbital flights. In the absence of a space traffic management system, this chapter considers the possibility of incorporating suborbital flights in the set of regulations and standards of air law and, more specifically, under the auspices of ICAO for the purpose of traffic management services. At the end, some conclusions relating to the proper regulatory responses to the environmental and traffic management aspects of suborbital flights are presented.

CHAPTER ONE

SUBORBITAL FLIGHTS: AN OVERVIEW OF THE TECHNICAL CHARACTERISTICS, MARKET REALITIES AND REGULATORY CHALLENGES

> "You literally step across a threshold into another realm, where beauty and blessed peace and quiet reign, graced by the instant karma of weightlessness. And, my God, that view! The black, foreboding void that is space is magically revealed as if someone has pulled back a stage curtain for your eyes only. This vast presence, looming and yawning through the windows, offers both menace and mystery. Below is a reassuring comfort—a 1000 mile horizon that reveals a magnificent splendour of mountain ranges, coast lines and weather patterns normally only seen on the evening news. And separating space from Earth is an improbably thin, bright, electric-blue ribbon that is the atmosphere."
>
> *Brian Binnie*[3]

1. Introduction to the Chapter

This chapter provides an introductory insight into the burgeoning industry of commercial space flights. The background and chain of the events which led to the current state of commercial space flights, as well as the future prospects of the commercial space flight market, will be examined. In this chapter, the scope of the work will be defined through briefly explaining the existing terminology and the concepts for the purpose of this study.

[3] Brian Binnie, (Address at the Royal Aeronautical Society (RAeS) Conference 'Space Tourism: From Lofty Dreams to Commercial Reality' of London, 2006) cited in John Loizou, "Turning space tourism into commercial reality" (2005) 22:4 Space Policy 289 at 290. Binnie is a test pilot of SpaceShipOne and one of only three people ever to have earned gold "astronaut wings", to be given by FAA, for a flight aboard a privately-operated spacecraft, rather than being strapped onto a rocket flying under automated control (*ibid*).

2. Retrospective and History

Human space activities have a rather short history. It was not before October 4, 1957 that the whole story began. On that date, the Soviet Union successfully launched Sputnik I, an artificial satellite about the size of a beach ball.[4] Since then, numerous complicated and advance technologies and innovations have been introduced which have helped the industry evolve its technological advances, the most recent of which is NASA's robot rover Curiosity and its landing on Mars.[5]

Chronologically speaking, the first efforts of humans to commercialize space flights go back to the positive feedback on the Apollo missions in the 1960s.[6] After the success of the Apollo 11 mission, when humans set foot upon the Moon for the first time, Pan Am Airways[7] began taking reservations for seats on shuttles to the Moon.[8] Of course, there were no real flights for those reserved seats, but Pan Am's initiative can be taken as one of the first steps to motivate and stimulate people for space tourism in return for money.[9]

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[4] *Sputnik and the Dawn of the Space Age* (Updated 10 October 2007), online: NASA <http://history.nasa.gov/sputnik/>.

[5] Jonathan Amos, "NASA's Curiosity Rover Successfully Lands on Mars", *BBC News* (6 August 2012), online: BBC News <http://www.bbc.co.uk/news/science-environment-19144464>

[6] Michael Makara, "Manned Apollo Missions" *NASA* (Updated 27 July 2004), online: NASA <http://history.nasa.gov/ap11-35ann/missions.html>.

[7] The largest international air carrier in the U.S., it collapsed on December 4, 1991. See *Pan American World Airways, Wikipedia,* online: Wikipedia < http://en.wikipedia.org/wiki/Pan_American_World_Airways >.

[8] Anders Lindsköld, "Space Tourism and its Effects on Space Commercialisation" *International Space University, Master of Space Studies Program* (1998-99) online: Space Future <http://www.spacefuture.com/archive/space_tourism_and_its_effects_on_space_commercialization.shtml>.

[9] Robert A. Goehlich, "Space Tourism" in Roland Conrady and Martin Buck, eds, *Trends and Issues in Global Tourism* (Berlin: Springer 2007) 213 at 215.

At the beginning of the space era, the common perception was that space launch activities were in the exclusive domain of States.[10] The reason for designating the government as the sole entity that should control space activities was to a great extent the space race between the U.S. and the Soviet Union[11] and also the fact that use of space was limited to military and scientific activities.[12] Space exploration was a competition between governments, mainly the U.S. and the Soviet Union, with private companies having almost no role in space-related activities.[13] Gradually, governments realized the potential of the space industry in the development of the economy and the importance of the presence of the private sector in the industry. The first move for commercialization of space was from Russia, which offered the opportunity to private individuals for a flight to space in return for money.[14] In the early 1990s, two private citizens, Toyohiro Akiyama, a Japanese journalist, and Helen Sharman, a British chemist, traveled to Mir, the Russian space station.[15] However, they probably should not be considered space tourists since they personally did not pay for their ride to space; the money came from their employers

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[10] Michael C. Mineiro, "Assessing the Risks: Tort Liability and Risk Management in the Event of a Commercial Human Space Flight Vehicle Accident" (2009) 74 J. Air L. & Com. 371 at 373; Charity Trelease Ryabinkin, "Let There Be Flight: It's Time to Reform the Regulation of Commercial Space Travel" (2004) 69 J. Air L. & Com. 101 at 114.

[11] Thomas Brannen, "Private Commercial Space Transportation's Dependence on Space Tourism and NASA's Responsibility to Both" (2010) 75 J. Air L. & Com. 639 at 642.

[12] Steven Freeland, "Fly Me to the Moon: How Will International Law Cope with Commercial Space Tourism?" (2010) 11 Melb.J. Int'l L. 90 at 96 [Freeland, "Fly me to the Moon"].

[13] Catherine E. Parsons, "Space Tourism: Regulating Passage to the Happiest Place off Earth" (2005-2006) 9 Chapman L. Rev. 493 at 498.

[14] *Ibid.*

[15] Denise Chow, "Russia's Space Station Mir: The First Space Tourist Hotspot?" *Space.com* (25 April 2011) online: Space.com <http://www.space.com/11480-space-tourists-russia-space-station-mir.html>.

and sponsorships. Both of them had cosmonaut training in the Soviet Union and were able to go to outer space owing to their non-astronautic-professional assignments.[16]

In the third millennium, the space activities industry was technically mature enough to offer private orbital and suborbital flights. The American national Dennis Tito was the person who gained the title of first space tourist and paved the way for the commercial human spaceflight industry by paying U.S. $20,000,000 for a ride on the Russian Soyuz to spend six days in the Russian section of the International Space Station (ISS) in 2001. In spite of NASA's early objection of an amateur's presence in the ISS, as they were concerned about the safety of the permanent crew, after Tito's successful journey, the U.S. became more open to the idea of space tourists within the context of the ISS project and more aware of the potential of a private spaceflight market.[17] After Tito came the African Mark Shuttleworth, who paid the same price for an eight-day trip to the ISS.[18] While in the ISS, the second space tourist conducted some research on HIV/AIDS, a widespread disease in Africa, and his research gave further credibility to the worth of orbital space tourism.[19]

Until the present time, space tourism has been limited to these one-passenger-at-a-time flights. So far seven people have made them, the last of whom was Guy Laliberté,

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[16] Frans G. von der Dunk, "Passing the Buck to Rogers: International Liability Issues in Private Spaceflight" (2007) 86:2 Neb. L. Rev. 400 at 404 [von der Dunk, "Passing the Buck to Rogers"].
[17] Freeland, "Fly me to the Moon", *supra* note 12 at 96-97.
[18] Brannen, *supra* note 11 at 643; Ministry of Arts, Culture, Science and Technology (South Africa), Ministry of Arts, culture, Science and Technology, Media Statement, "Minister Ngubane Supports Mark Shuttleworth's 10-Day Journey to the International Space Station" (22 April 2002) online: South African Government Information <http://www.info.gov.za/speeches/2002/02042212461001.htm>.
[19] Freeland, "Fly me to the Moon", *supra* note 12 at 97.

Canadian billionaire and founder of the Cirque du Soleil. He became the seventh paying space tourist, spending 12 days in the ISS in 2009.[20]

The next significant step for the commercial human spaceflight market was taken by the X Prize Foundation, which created an incentive prize modeled on the famous Orteig Aviation Prize, to spur innovations in the technology of Reusable Launch Vehicles (RLVs). The Ansari X Prize, U.S. $10 million, was to be awarded to the first non-governmental organization that built and launched a reusable spacecraft capable of carrying three people to 100 kilometers above the earth's surface twice within two weeks.[21] On October 4, 2004, Burt Rutan's designed vehicle, SpaceShipOne, was successfully launched from its mother plane, White Knight, and reached the altitude of 112 kilometers.[22] "Re-entry, including a few minutes of weightlessness, was not in a normal, fully-controlled mode, but rather was something like a sycamore leaf floating down. Once it was back at 55,000 feet, the SpaceShipOne finally transformed into a glider, descending pilot-controlled from there."[23] Following the success of this vehicle, Richard Branson teamed up with the aerospace designer Rutan and established Virgin Galactic as the world's first operator to offer suborbital flights to private passengers in the near future.[24] Virgin Galactic with its new vehicle, SpaceShipTwo, which essentially uses

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[20] "Circus tycoon Guy Laliberté becomes first clown in space", *Associated Press* (30 September 2009), online: The Guardian <http://m.guardian.co.uk/science/2009/sep/30/guy-laliberte-clown-space-circus?cat=science&type=article>.

[21] "Ansari X Prize"(2011), online: X Prize Foundation <http://space.xprize.org/ansari-x-prize>.

[22] The vehicle was launched twice: first time on September 29, 2004 piloted by Mike Melvill to 102.9 km and second time on October 4, 2004 piloted by Brian Binnie to 112 km. See "Overview of Virgin Galactic and its Project", online: Virgin Galactic <http://www.virgingalactic.com/overview/>.

[23] von der Dunk, "Passing the Buck to Rogers", *supra* note 16 at 405; Brannen, *supra* note 11 at 644.

[24] Mineiro, *supra* note 10 at 374; von der Dunk, "Passing the Buck to Rogers", *supra* note 16 at 405; See "Overview of Virgin Galactic and its Project", online: Virgin Galactic <http://www.virgingalactic.com/overview/>.

the same technology as SpaceShipOne, will take passengers daily from the New Mexico Spaceport and the Swedish Spaceport at Kiruna.[25]

Since then, the private sector has shown interest in the Reusable Launch Vehicles (RLVs) technology and suborbital flight market. Many companies are developing the capability to provide civilian space tourist flights, particularly suborbital flights.[26] For example, in 2007, the European aerospace company EADS Astrium announced that they were working on a business jet-sized spaceplane which would take off and land conventionally from a standard runway and reach an altitude of over 100km, the entire trip lasting approximately two hours.[27] In this vehicle, the proposed technology would involve just the one space vehicle, as opposed to the method of launching from a plane utilized by the Virgin Galactic program.[28] The EADS suborbital project has been suspended for financial issues.[29] Blue Origin is another company trying to develop technologies to be used in the private human space industry though designing rocket-powered Vertical Takeoff and Vertical Landing (VTVL) vehicles for its vehicle called The New Shepard.[30] Also, in 2008, the California aerospace company XCOR unveiled its project for designing and building a two-seat suborbital spaceship, the Lynx, which will provide front-seat rides to the edge of space. The Lynx will be the size of a small private

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[25] von der Dunk, "Passing the Buck to Rogers", *supra* note 16 at 406; A former example of suborbital vehicle is X-15, an experimental rocket-powered aircraft, which became the first manned aerodynamic-type aerospace vehicle to enter the sub-orbit. However, X-15 was operated by US Air Force and NASA and could not be considered a commercial flight. See George Paul Sloup, "The Nasa Space Shuttle And Other Aerospace Vehicles: A Primer For Lawyers On Legal Characterization" (1978) 8 California Western Int'l L. J. 403 at 422.

[26] Freeland, "Fly me to the Moon", *supra* note 12 at 92; Ryabinkin, *supra* note 10 at 115-16.

[27] "Spaceplane-- Rocketing into the Future" (25 May 2010), online: Astrium an EADS Company <http://www.astrium.eads.net/en/programme/space-plane.html>.

[28] Freeland, "Fly me to the Moon", *supra* note 12 at 92.

[29] "Spaceplane-- Rocketing into the Future" (25 May 2010), online: Astrium an EADS Company <http://www.astrium.eads.net/en/programme/space-plane.html>.

[30] "Research in Suborbital Space and Microgravity Environment" online: Blue Origin <http://www.blueorigin.com/research/research.html>.

airplane and is designed to operate much like a 'commercial aircraft' and allegedly is going to minimize the impact of these flights on the environment by its special design.[31]

It is important to remember that the "space prize competitions", such as the Ansari X Prize, Americas Space Prize by Bigelow Aerospace, and the Google Lunar X Prize, have been a key factor in encouraging the private sector to take an active role in the space industry by getting involved in investments and innovations and, consequently, the space tourism industry's take off.[32]

3. Space Tourism and Commercial Orbital and Suborbital Flights

In international law, there is no definition for commercial human space flights. The commentators have suggested different definitions for commercial space flights or space tourism. One of the most widely accepted definitions of the term 'space tourism' is the definition given by Stephan Hobe and Jurgen Cloppenburg, who define the term as "any commercial activity that offers customers direct or indirect experience with space travel".[33] European Space Agency (ESA), in its position on private suborbital spaceflights, defines space tourism as an activity that will "encompass the execution of

[31] XCOR Aerospace, Press Release, "XCOR Aerospace Suborbital Vehicle to Fly within Two Years: New vehicle called the Lynx" (26 March 2008) online: XCOR Aerospace<http://www.xcor.com/press-releases/2008/08-03-26_Lynx_suborbital_vehicle.html>.

[32] Brannen, *supra* note 11 at 645.

[33] Stephan Hobe, "Legal Aspects of Space Tourism" (2007-2008) 86 Neb. L. Rev. 439 at 439, citing Stephan Hobe & Jurgen Cloppenburg, "Towards a New aerospace Convention?: Selected Legal Issues of 'Space Tourism' " Proceedings of the Forty-Seventh Colloquium on the Law of Outer Space (2004), 377; see also Freeland, "Fly me to the Moon", *supra* note 12 at 98; von der Dunk, "Passing the Buck to Rogers", *supra* note 16 at 402; Brannen, *supra* note 11 at 642.

sub-orbital flights by privately-funded and/or privately-operated vehicles and the associated technology development driven by the space tourism market".[34]

It has been suggested that the term 'space tourism' can include a variety of different activities with different purposes, design and technical characteristics, and duration and location. They may range from parabolic flights in an aircraft exposing passengers to short periods of weightlessness within the Earth's atmosphere to short-term orbital or suborbital flights or long-term stays in orbital facilities.[35] One commentator has considered the scope of the space tourism industry as including "not only earth-based attractions that simulate the space experience such as space theme parks, space training camps, virtual reality facilities, multimedia interactive games and telerobotic moon rovers controlled from Earth, but also parabolic flights, vertical suborbital flights, orbital flights lasting up to 3 days, or week-long stays at a floating space hotel, including participatory educational, research and entertainment experiences as well as space sports competitions (i.e. space Olympics)."[36] With this kind of interpretation, the term space tourism might refer to certain activities the purpose of which is not taking passengers to the space edge or beyond. Parabolic flights, which are designed to provide an experience of microgravity, as well as reduced gravity levels, corresponding to Lunar and Martian gravity levels, are one example.[37]

Another problem with the term 'space tourism' is that not all types of possible space flights are for the purpose of tourism and not all the people traveling on one of the

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[34] Andrés Gálvez and Géraldine Naja-Corbin, "Space tourism: ESA's view on private suborbital spaceflights" (August 2008) ESA Bulletin 135, ESA Institutional Matters and Strategic Studies Office, online: esa.int <http://www.esa.int/esapub/bulletin/bulletin135/bul135c_galvez.pdf>.

[35] Hobe, *supra* note 33 at 439; Loizou, *supra* note 3 at 289.

[36] Goehlich, *supra* note 9 at 214.

[37] "Parabolic Flights" *ESA Human Spaceflight Research Erasmus Center,* online: esa.int <http://www.esa.int/SPECIALS/HSF_Research/SEMU945XT9G_0.html>.

high technology vehicles could be considered 'tourists'. It is foreseeable that in the future there may be suborbital liners that provide point-to-point service by suborbital aerospace vehicles.[38] The purpose of these suborbital flights is simply fast transportation of cargo and passengers, and therefore it is difficult to consider people on these aerospace vehicles as 'tourists'. The United Nations Statistical Committee in 1994 approved a definition of tourism put forward by the World Tourism Organization: ''The activities of persons traveling to and staying in places outside their usual environment for not more than one consecutive year for leisure, business, and other purposes.''[39] A space tourist has been defined as "someone who tours or travels into, to, or through space or to a celestial body for pleasure and/or recreation."[40] As is clear from these definitions, it is difficult to include paying passengers who are using the flight only for transportation purposes and not as a leisure activity in the category of tourists. Perhaps this is why U.S. Federal Aviation Administration (FAA) and ESA officials prefer to use the term 'space flight (travel) participant' rather than 'space tourist', considering the human risk factors and insurance issues involved.[41] The United States Code on Commercial Space Launch Activities defines a Space Flight Participant as "An individual, who is not crew, carried within a launch vehicle or reentry vehicle".[42] Given the reasons explained above and in spite of the widespread usage of the term 'space tourism' by legal scholars as well as in

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[38] von der Dunk, "Passing the Buck to Rogers", *supra* note 16 at 407.

[39] World Tourism Organization (WTO), *Collection of Tourism Expenditure Statistics*, Technical Manual No. 2, (1995) para 19, online: WTO <http://pub.unwto.org/WebRoot/Store/Shops/Infoshop/Products/1034/1034-1.pdf>.

[40] Tanja Masson-Zwaan and Steven Freeland, "Between Heaven and Earth: The Legal Challenges of Human Space Travel" (2010) 66 ActaAstronautica1597 at 1599, citing Zeldine Niamh O'Brien, 'Liability for Injury, Loss or Damage to the Space Tourist' (2004) *47 Proceedings of the Colloquium on the Law of Outer Space 386.*

[41] Maharaj Vijay Reddy, Mirela Nica and Keith Wilkes, "Space Tourism: Research Recommendations for the Future of the Industry and Perspectives of Potential Participants" (2012) 33 Tourism Management 1093 at 1095.

[42] *Commercial Space Launch Activities*, 49 U.S.C. s 70102(17).

the industry, some commentators have suggested 'private spaceflight'[43] or 'private space travel'[44] as more precise and helpful terms for the purpose of legal analysis.[45] For the purpose of this study, the term 'commercial space flight', meaning the transport of humans beyond the Earth's atmosphere (to, from, or through outer space) for compensation, will be used.[46]

Commercial space flights may be conducted through an aircraft and/or spacecraft with different designs.[47] In fact, there is a considerable technical variety in the design of the vehicles that are supposed to carry passengers on commercial orbital and suborbital flights, among them this thesis focuses mainly on the vehicles designed for suborbital flights.

4. Definition of Suborbital Flights

Understanding the characteristics of suborbital flights and their distinctive features is important in determining their legal status and further regulatory questions that may need to be addressed.

Suborbital flight has not been addressed in many international documents. ICAO, in its working paper on the "Concept of Suborbital Flights" in 2005, defined a suborbital flight as "a flight up to a very high altitude which does not involve sending the vehicle

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[43] von der Dunk, "Passing the Buck to Rogers", *supra* note 16 at 402-3.
[44] Masson-Zwaan and Freeland, *supra* note 40 at 1599.
[45] Henry Wassenbergh describes "international private commercial launching law" as a *lex specialis* of the *lex ferenda* of 'manned' space flight for international commercial transportation purposes. However, his definition is only with regards to ELVs: See *Henri A. Wassenbergh*, "The Law Governing International Private Commercial Activities of Space Transportation" (1993) 21:2 J. Space L. 97 at 97.
[46] Mineiro, *supra* note 10 at 372; Goehlich, *supra* note 9 at 214.
[47] Hobe, *supra* note 33 at 440.

into orbit."[48] In its report, ICAO referred to the definition of a 'sub-orbital trajectory' by the legislation of the United States which provides: "The intentional flight path of a launch vehicle, reentry vehicle, or any portion thereof, whose vacuum instantaneous impact point does not leave the surface of the Earth."[49] As one can see from this definition, it is not clear what altitude is considered as the altitude at which a flight is suborbital, not orbital or a regular flight by conventional airplanes.[50]

Various authors have tried to come up with a precise definition for suborbital flights. An important step in clarification of the concept of suborbital flight is defining 'orbital flight' first. Orbital flight has been defined as a flight in which 'orbital velocity' is achieved for the vehicle to keep flying along the curvature of the Earth, and orbital velocity itself depends on the altitude of the orbit.[51] The orbital speed, which exceeds 11.2 km/s, is also an important factor.[52] Therefore, suborbital flight can be defined as a flight in which orbital velocities and the speed required to stay in orbit are not achieved. In fact, in suborbital flight the vehicle sent to the edge of space does not complete one or more orbits around the Earth, in contrast to what happens in orbital flights.[53] The altitude

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[48] '*Concept of Sub-Orbital Flights'* Working Paper, ICAO Council 175th Session, C-WP/ 12436, (30 May 2005) at 1.2 ['*Concept of Sub-Orbital Flights*' ICAO Working Paper].

[49] *Commercial Space Launch Activities*, 49 U.S.C. s 70102(20).

[50] von der Dunk, "Passing the Buck to Rogers", *supra* note 16 at 405.

[51] Freeland, "Fly me to the Moon", *supra* note 12 at 98; Space Adventures is the first company in the world to offer "orbital space flights" to private citizens. Before Space Adventure, it was private company called MirCorp that was established specifically for bringing self-financed private persons into space-was supposed to be sent on a Russian launch vehicle to the Russian space station Mir. See Mineiro, *supra* note 10 at 374; von der Dunk, "Passing the Buck to Rogers", *supra* note 16 at 404.

[52] Ram S. Jakhu, Tommaso Sgobba and Paul Stephen Dempsey eds, *The need for an integrated regulatory regime for aviation and space: ICAO for Space?* (Vienna; New York: SpringerWienNewYork, 2011) at 79.

[53] Michael Gerhard, "Sub-orbital space tourism regulation: EASA's perspective" (Presentation delivered at the Symposium on the regulation of suborbital flights in the European context, University of Leiden, 16 September 2010); Peter van Fenema, "Suborbital Flights and ICAO" (2005) 30:6 Air and Space Law 396 at 396; von der Dunk, "Passing the Buck to Rogers", *supra* note 16 at 405; Tanja Masson-Zwaan and Rafael Moro-Aguilar, "Practical Solutions for the Regulation of Private Human Sub-Orbital Flight: A Critical Analysis" (Presentation delivered at the 2nd IAA Symposium on Private Human Access To Space, Arcachon, France, May 30-June 1, 2011) at 4 [Masson-Zwaan, Moro-Aguilar, "Practical Solutions"].

attained in suborbital flights is around 100 km (62.5 miles),[54] "a fact that is also dictated by the relevant scientific principles".[55] For other characteristics of suborbital flights, one should make reference to a few minutes of microgravity and the weightlessness which is experienced by flight participants when the engines shut down after reaching an altitude above 100 km over the Earth.[56]

The anticipated purposes of suborbital flights can be as diverse as tourism and microgravity experiments, astronomical observations and scientific purposes, astronaut training, reconnaissance and other military applications, and lastly ultra-fast point-to-point transportation of passengers and cargo.[57] Although at the moment suborbital flights are considered vertical flights, departing from and landing at the same place,[58] there are plans for suborbital point-to-point service. The idea of using exo-atmospheric technology, enabling transferring of human passengers in a very short time, has been around for a long time.[59] It has been stated that the ultimate purpose of private spaceflight activity is not to undertake tourism, but to demonstrate the safety of the technology so that it can enable companies to begin offering fast transportation service.[60] To achieve such high technology, there are technical challenges mainly in terms of "the required velocity, the amount of propellant required, and the need for a robust thermal protection system for

[54] Jakhu, Sgobba and Dempsey, *supra* note 52 at79; Freeland, "Fly me to the Moon", *supra* note 12 at 98; Masson-Zwaan and Moro-Aguilar, "Practical Solutions", *supra* note 53 at 3.
[55] Masson-Zwaan and Freeland, *supra* note 40 at 1599.
[56] Freeland, "Fly me to the Moon", *supra* note 12 at 98; Masson-Zwaan and Freeland, *supra* note 40 at 1599.
[57] Masson-Zwaan and Moro-Aguilar, "Practical Solutions", *supra* note 53 at 1 n 1.
[58] *Concept of Sub-Orbital Flights*' ICAO Working Paper, *supra* note 48 at 6.3; SpaceShipOne for example was not designed for long distance travel: it descends almost vertically, traveling no more than 3 miles (4.8 kilometers) horizontally: See Dean N. Reinhardt, "The Vertical Limit Of State Sovereignty" (2007) 72 J. Air L. & Com. 65 at 89.
[59] Freeland, "Fly me to the Moon", *supra* note 12 at 98.
[60] Will Whitehorn, the CEO of Virgin Galactic, quoted in von der Dunk, "Passing the Buck to Rogers", *supra* note 16 at 403, 407.

safe re-entry to the Earth's atmosphere."[61] Of course, there is skepticism with respect to the developments in the technology required for suborbital point-to-point transportation in the near future, as Virgin Galactic and others seem to envisage it.[62]

5. Suborbital Aerospace Vehicles: Features and Characteristics

A 'space object' has not been defined in the existing international conventions on space activities.[63] Although the term 'space object' is one of the concepts most frequently encountered in international documents and the domestic laws of space-faring countries,[64] the only reference to this term is found in the Liability and Registration conventions, which state that the meaning of space object includes 'component parts' of a space object as well as its 'launch vehicle' and 'parts' thereof.[65] Aircraft, however, is defined in Annex 7 to the Chicago Convention as "Any machine that can derive support

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[61] Freeland, "Fly me to the Moon", *supra* note 12 at 98.

[62] Masson-Zwaan and Freeland, *supra* note 40 at 1600. One should mention the planned V-Prize, in which spaceflight companies are to compete to become the first to create a vehicle capable of launching from Virginia and land in Europe in approximately an hour: Paul de Brem, "The V-Prize: one hour to Europe", *The Space Review*, 27 August 2007, online: The Space Review <http://www.thespacereview.com/article/940/1>.

[63] UN has used the term 'aerospace object'. The coupling of the terms 'aerospace' and 'object' in the joint expressions of 'aerospace object' surfaced first in the Legal Subcommittee of the U.N. Committee on the Peaceful Uses of Outer Space (COPUOS) when trying to provide a definition and delimitation of outer space. See Stephen Gorove, Aerospace Object - Legal and Policy Issues for Air and Space Law (1997) 25 J. Space L. 101 at 101 [Gorove, "Aerospace Object"].

[64] *Ibid* at 107.

[65] Convention on International Liability for Damage Caused by Space Objects, adopted by the UN General Assembly in its resolution 2777 (XXVI), 961 U.N.T.S. 187 (Opened for signature on 29 March 1972). Article I (*d*) [Liability Convention]; Convention on Registration of Objects Launched into Outer Space, adopted by the UN General Assembly in its resolution 3235 (XXIX), 1023 U.N.T.S. 15 (Opened for signature on 14 January 1975) Article I (*b*) [Registration Convention]; A definition proposed for the space objects, defines the term as "an object launched or attempted to be launched in orbit around the earth or beyond. Such object (or a part of it) is a space object (or a part of it) 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." See Stephen Gorove, "Toward a Clarification of the Term 'Space Object' – An International Legal and Policy Imperative?"(1993) 21 J. SPACE L. 11 at 25-26 [Gorove, "Clarification of the Term Space Object"].

in the atmosphere from the reactions of the air other than the reactions of the air against the earth's surface."[66] In the same document, 'aeroplane' is defined as a "power-driven heavier-than air aircraft, deriving its lift in flight chiefly from aerodynamic reactions on surfaces which remain fixed under given conditions of flight."[67] These definitions do not encompass rocket-powered vehicles.[68] Vehicles designed for suborbital flights, however, even considering different designs and technologies, do not operate exactly like aircraft, especially when considering the whole flight, including the ballistic part.[69]

In 1992, the Russian Federation submitted a working paper to UN COPUOS entitled "Questionnaire on Possible Legal Issues with Regard to Aerospace Objects", the aim of which was to clarify issues concerning the definition and delimitation of outer space.[70] The opinions expressed by different states in reply to this Questionnaire are important because they can provide a legal basis for further development of the law in this field. In this Questionnaire, it was asked if the 'aerospace object' could be defined as "an object which is capable both of traveling through outer space and of using its aerodynamic properties to remain in airspace for a certain period of time."[71] Some consider this definition to be intended to cover future aerospace-plane-type vehicles aimed to provide point-to-point transportation, regardless of the brief period of time such

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[66] Annex 7 to the Convention of International Civil Aviation, *Aircraft Nationality and Registration Marks*, adopted by International Civil Aviation Organization (ICAO) at 1.

[67] *Ibid.*

[68] Masson-Zwaan and Moro-Aguilar, "Practical Solutions", *supra* note 53 at 1.

[69] SpaceShipOne, for example, does not operate as an aeroplane or aircraft during the ballistic portion of the flight, while it is not supported by the reactions of the air. Nevertheless, some degree of aerodynamic control exists throughout the trajectory from launch altitude until the craft enters the upper reaches of the atmosphere where the air density is no longer sufficient for aerodynamic flight: see *Concept of Sub-Orbital Flights*' ICAO Working Paper, *supra* note 48 at 2.2.

[70] The Committee of Peaceful Uses of Outer Space Legal Sub-committee, *Questionnaire on possible Legal Issues with regard to Aerospace Objects*, UN COPUOS, 34th Session, A/AC.105/635, 1996 [COPUOS Questionnaire]. Available online at: <http://www.oosa.unvienna.org/oosa/SpaceLaw/aero/index.html>.

[71] COPUOS Questionnaire, replies from member States have been published in A/AC.105/635 and the Adds. 1 to 17, online: <http://www.oosa.unvienna.org/oosa/SpaceLaw/aero/index.html>.

vehicle would be traveling through the fringes of outer space.[72] This definition has been subject to different opinions from states up to now, most of which have agreed on the dual capability of the aerospace object through both outer space and airspace.[73] However, there have been suggestions for a more precise definition of the object. Some states have proposed including the purpose and function of the flight in the definition.[74] While, a number of states have suggested that the distinction between space object and aerospace object should be clarified,[75] other states have considered an aerospace object as a type of 'space object' intended exclusively to operate in outer space.[76]

Russia, the country first to propose a definition, stated that aerospace objects, aside from the type that transport crew and/or payload into outer space and back to the Earth, can refer to vehicles which undertake a flight from one point on the Earth to another (for this purpose the object may undertake part of its flight in outer space, but not attaining cosmic speed).[77] The Government of the Netherlands goes further and defines an "aerospace object" as "a human-made object that can proceed to any altitude and that is subject to human control at any altitude as regards its altitude, direction and speed", a

[72] Gorove, "Aerospace Object", *supra* note 63 at 104.
[73] For the different opinions from states reflected in their replies to the Questionnaire, generally see the website of United Nations Office for Outer Space Affaires, Replies from member States to the Questionnaire on possible Legal Issues with regard to Aerospace Objects, online: <http://www.unoosa.org/oosa/en/SpaceLaw/aero/index.html>
[74] For a few examples of such opinion see: The reply received from South Africa in 2003, A/AC.105/635/Add.7; Replies received from Rwanda, Turkey and Ukraine in 2005, A/AC.105/635/Add.11; Reply received from Venezuela in 2007, A/AC.105/635/Add.14; Reply received from Egypt in 2007, A/AC.105/635/Add.15.
[75] The reply received from Venezuela in 2007, A/AC.105/635/Add.14; the reply received from Portugal in 2005, A/AC.105/635/Add.11.
[76] Reply received from Germany in 1996, A/AC.105/635; Reply received from Egypt in 2007, A/AC.105/635/Add.15; Reply received from Algeria in 2003, A/AC.105/635/Add.7; Reply received from Chile in 2004, A/AC.105/635/Add.10. Brazil, in the contrary, states that "an aerospace object is an object capable of flying either in outer space or in airspace and it is also capable of carrying out activities in both environments", See document A/AC.105/635/Add.10, Reply received from Brazil in 2004.
[77] Reply received from Russian Federation in 1996, A/AC.105/635/Add.1.

definition that, allegedly, excludes aircraft, rockets, meteorites and space debris and even the Space Shuttle.[78] Generally speaking, it seems that most of the states that have expressed their viewpoints with respect to this definition are of the view that the term 'aerospace object' can be applied exclusively for space activities and not for Earth-to-Earth transportation. However, many States have expressed the opinion that for a precise and correct definition, the latest technological achievements and developments should be taken into account.

A suborbital Reusable Launch Vehicle is considered a 'suborbital rocket' in the U.S. Code, which defines it as a "vehicle, rocket-propelled in whole or in part, intended for flight on a suborbital trajectory, and the thrust of which is greater than its lift for the majority of the rocket-powered portion of its ascent."[79] What is clear from all the definitions proposed and technical aspects of the suborbital (or aerospace) vehicles is that they have a dual or hybrid nature.[80] Speaking from a technological point of view, there are or might be numerous designs for suborbital aerospace vehicles. Apparently there are different methods possible for the 'ascent' and 'descent' phases. Ascent in suborbital aerospace vehicles involves two major types of horizontal or ballistic aerospace vehicles.[81] This means that the vehicle might ascend in a horizontal take-off or launch (sometimes from an aircraft, like WhiteKnightTwo), while others could take off vertically. "From ground to space, concepts can be Single Stage, Dual Stage, Multiple

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[78] Reply received from the Netherland in 2003, A/AC.105/635/Add.8.

[79] *Commercial Space Launch Activities,* 49 U.S.C. §70102(19). Suborbital rocket is considered as a launch vehicle in this code, see 49 U.S.C. §70102(8).

[80] Sloup, *supra* note 25 at 407, 415; "Concept of Suborbital Flights: Information from the International Civil Aviation Organization (ICAO)", Committee on the Peaceful Uses of Outer Space Legal Sub-committee, 49th session, 2010, UN Doc. A/AC.105/C.2/2010/CRP.9 (19 March 2010).

[81] Sloup, *supra* note 25 at 415.

Stage, with a carrier, from an aircraft, from a balloon, or using rocket propulsion."[82] After reaching the projected altitude above the atmosphere, there are two possibilities for return, one of which is the return of the vehicle to its place of origin, while the other is a return to a different location on Earth, what could be called point-to-point suborbital transportation.[83] The means of re-entry or descent can vary from aircraft (glider) to parachute, and "here, one of the technology challenges is thermal protection during re-entry into the atmosphere."[84] With respect to the design of SpaceShipOne, after apogee and during re-entry into the atmosphere, the vehicle transitions to unpowered aerodynamic (gliding) flight for the return to earth, a part of the flight in which the operation of the vehicle can be compared to that of an aircraft.[85]

5.1 RLVs

When speaking about suborbital vehicles, it is important to mention Reusable Launch Vehicles (RLVs), which can be considered as a revolution for commercial space flights

[82] Masson-Zwaan and Freeland, *supra* note 40 at 1599, citing Cf. Erik Laan, "Technological aspects of Space Tourism", presentation delivered at the Leiden LLM programme in air and space law, May 2009.

[83] Hobe, *supra* note 33 at 440. As Dr. von der Dunk describes: "With a view to possible application of the applicable regime to private human space flight, this makes it more likely to apply the label of 'space object' to some of the technical/operational concepts for private human space- flight (e.g. Blue Origin, Armadillo Aerospace) than to others (e.g. the XCOR vehicle, as this essentially constitutes an aircraft-like vehicle able to take off, traverse the air space and enter outer space in one seamless operation), with two-stage vehicles (such as WhiteKnightTwo -plus- SpaceShipTwo) somewhere in between. However, where the boundary lies between what should be considered a space object and what not is far from clear— and there would be excellent arguments for including even XCOR-types of vehicles within the concept of 'launch', for the simple reason of its intention to reach outer space." See Frans G. von der Dunk, "The integrated approach—Regulating private human space flight as space activity, aircraft operation, and high-risk adventure tourism" (2012) Acta Astronautica at 4 [von der Dunk, "The integrated approach"].

[84] Masson-Zwaan and Freeland, *supra* note 40 at 1599, citing Cf. Erik Laan, "Technological aspects of Space Tourism", presentation delivered at the Leiden LLM programme in air and space law, May 2009. The U.S. Space Shuttle, though it acts like an aircraft (a glider) on its descent.

[85] SpaceShipOne was granted a launch license by the Office of Commercial Space Transportation (AST) of the U.S. FAA as a "Reusable Launch Vehicle". SpaceShipOne is classified as a rocket in its license, but it has not been registered as a space object. See "Concept of Suborbital Flights", COPUOS Legal Subcommittee, *supra* note 80.

and the industry as a whole.[86] What has made commercial space tourism (both orbital and suborbital) a promising industry in which many have faith is the emergence of the new technology of RLVs.[87] Before the advent of RLVs, access to space was dominated by Expendable Launch Vehicles (ELVs), the problem with which was their extremely high cost.[88] By contrast, RLVs are designed as an efficient response to the high costs of ELVs and therefore represent a considerable reduction in the expense of transferring payloads to the orbit or sub-orbit. "According to some estimates, RLVs could reduce space launch costs from $10,000 per pound to $1,000 per pound."[89]

With respect to orbital space flight, the U.S. Space Shuttle and Space X's Dragon can both be examples of 'partially' reusable vehicles.[90] The idea for suborbital flights, on the other hand, requires reusable technology in the design of suborbital vehicles so that the industry can offer more accessible flight opportunities to those interested. SpaceShipOne, SpaceShipTwo, XCOR Lynx and EADS Astrium are examples of reusable suborbital technology.[91]

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[86] John C. Mankins, "Highly Reusable Space Transportation: Advanced Concepts and the Opening of the Space Frontier" (2002) 51 Acta Astronautica 727 at 732.

[87] Steven Freeland, "Up, Up and... Back: The Emergence of Space Tourismand Its Impact on the International Law of Outer Space" (2005-2006) 6 Chicago J. Int'l L. 1 at 2 [Freeland, "The Emergence of Space Tourism"].

[88] Ryabinkin, *supra* note 10 at 110.

[89] *Ibid* at 103.

[90] "Dragon Overview", Spacex.com online: Spacex <http://www.spacex.com/dragon.php>; "Space Shuttle Program: Spanning 30 Years of Discovery", NASA Space Shuttle, online: NASA <http://www.nasa.gov/mission_pages/shuttle/main/index.html>; "Space Vehicles: Vehicle Designs", Spacefuture.com, online: Space Future <http://www.spacefuture.com/vehicles/designs.shtml>.

[91] "Overview of Virgin Galactic and its Project", online: Virgin Galactic <http://www.virgingalactic.com/overview/>.; XCOR Aerospace, Press Release, "XCOR Aerospace Suborbital Vehicle to Fly within Two Years: New vehicle called the Lynx" (26 March 2008) online: XCOR Aerospace<http://www.xcor.com/press-releases/2008/08-03-26_Lynx_suborbital_vehicle.html>; "Spaceplane-- Rocketing into the Future" (25 May 2010), online: Astrium an EADS Company <http://www.astrium.eads.net/en/programme/space-plane.html>.

6. Reality of Market and Future Perspectives

The commercial space flight industry is still a budding industry, but one with great potential. In general, commercial space-related activities, of which the commercial space flight industry is a part, have proven profitable, generating remarkable revenues.[92] In the first decade of the third millennium, the gross domestic product increased 16% per year for the world's commercial space related activities, with the market reaching more than $250 billion yearly.[93] Some claim that the industry, having the potential to bring in investors and enthusiasts and create immediate profits, is even larger than most people realize, especially when the wide range of possible services with different price levels as well as additional turnovers from novel secondary markets such as space fashion, space food, space entertainment, space sports, etc. is added in.[94] However, the commercial orbital space flight industry has not been expanding robustly, and this is for a clear reason. Within one decade, only seven people have had the chance of being non-astronaut guests of the International Space Station; all of them were affluent and able to pay the high cost of a ticket to space. Guy Laliberté, the seventh person travelling to space, paid $35 million to spend 12 days in the ISS.[95] Tourism in general is very much dependent to the discretionary income of the customer as well as on an adequate infrastructure provided for the desired activity. Neither of these prerequisites is available in high levels for the orbital commercial space flight industry. Not many people can afford such an

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[92] Goehlich, *supra* note 9 at 214.

[93] Svetlana Shkolyar, "Reaching for the stars", online: (March 2009) 4:5 Engineering and Technology Magazine <http://eandt.theiet.org/magazine/2009/05/reaching-for-stars.cfm>.

[94] Goehlich, *supra* note 9 at 214; Parson, *supra* note 11 at 493; Ryabinkin, *supra* note 10 at 108.

[95] "Circus tycoon Guy Laliberté becomes first clown in space", *Associated Press* (30 September 2009), online: The Guardian <http://m.guardian.co.uk/science/2009/sep/30/guy-laliberte-clown-space-circus?cat=science&type=article>.

expensive experience.[96] The infrastructure, on the other hand, is about accommodations and transportation systems, which are not well developed in this industry. There have been different plans for building space hotels, one of the most recent of which is the proposed plan by Galactic Suites Spaceresorts, a Barcelona-based company, which is developing “a mini space station orbiting in low earth orbit (LEO) dedicated to accommodate private passengers, the space tourists, and conceived as a non-permanently occupied shelter for tourists and crew.”[97] Also in 2010, Orbital Technologies, a private Russian company, announced its intention to build, launch and operate the world's first Commercial Space Station (CSS) as a destination for commercial, state and private spaceflight exploration missions.[98] Neither of these proposed plans, however, is anywhere near operational. Right now, the only possible destination for an orbital space traveler is the ISS, which at most is able to offer one-at-a-time accommodations. With respect to the transportation means, the same inefficiency exists, especially after the retirement of U.S Space Shuttle, which reduced the chances for a space tourist to obtain the third seat aboard the Russian Soyuz spacecraft, the vehicle that has been used to take space tourists to the ISS.[99] Given the current price of an orbital flight for a short-term stay at the ISS as well as the existing inadequate infrastructure, one cannot expect a rapid development of the industry. More attention and investment are needed to support the relevant industries’ sustainable growth. “This will be a challenging task involving significant investment, especially in infrastructure, and either a significant reduction in

[96] Roger D. Launius and Dennis R. Jenkins, “Is It Finally Time for Space Tourism?” (2006) 4:3 Astropolitics: The International Journal of Space Politics & Policy 253 at 254.
[97] “Galactic Suites Spaceresorts”, 2012, online: Galactic Suites Group <http://www.galacticsuitegroup.com/galactic-suite-spaceresort-eng/>.
[98] “Commercial Space Station”, *Orbital Technologies*, 2011, online: Orbital Technologies <http://orbitaltechnologies.ru/en/purpose-of-the-commercial-space-station.html>.
[99] Reddy, Nica and Wilkes, *supra* note 41 at 1094; Ryabinkin, *supra* note 10 at 118.

the costs of space tourism to broaden the market or a greater attraction for those with enormous fortunes to spend on their leisure activities."[100]

But what is the future outlook for the suborbital flights market? Compared to orbital space flights, the predicted price for suborbital flights is considerably less, the main reason being the short time of the flight and different technical characteristics suborbital vehicles and their trajectories have compared to those of orbital flight.[101] For example, Space Adventure, a private space tourism agency, offers on its website to reserve tickets for a suborbital flight starting at $110,000 for a flight 100 kilometers above the Earth.[102] Virgin Galactic, on the other hand, offers tickets at the starting price of $200,000, with refundable deposits starting from $20,000.[103] Similarly, the EADS Astrium project on its website predicts that operators using the Astrium spaceplane could offer a space flight at a price per passenger of around €200,000.[104]

Since the price a customer would have to pay for a flight on an suborbital vehicle compared to the price the customer would pay for an orbital flight is much lower, it could be concluded that when the time for regular service of suborbital projects arrives, many people will be willing to pay for a flight, including those space enthusiasts who cannot afford an orbital flight but can pay for a suborbital flight ticket.[105] The two most

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[100] Launius and Jenkins, *supra* note 96 at 254.

[101] Freeland, "Fly me to the Moon", *supra* note 12 at 98.

[102] "Suborbital Spaceflight", online: Space Adventure <http://www.spaceadventures.com/index.cfm?fuseaction=Suborbital.welcome>.

[103] "Overview of Virgin Galactic and its Project", online: Virgin Galactic <http://www.virgingalactic.com/overview/space-tickets/>.

[104] "Spaceplane-- Rocketing into the Future" (25 May 2010), online: Astrium an EADS Company <http://www.astrium.eads.net/en/programme/space-plane.html>.

[105] "Space Tourism Market Study: Orbital Space Travel & Destinations with Suborbital Space Travel" Futron Corporation (October 2002), online: Futron.com <http://www.futron.com/upload/wysiwyg/Resources/Reports/Space_Tourism_Market_Study_2002.pdf> at 7 [hereinafter Futron Study]; G. Crouch, T. Devinneyb, J. Louvierec and T. Islamd, "Modeling Consumer Choice Behaviour in Space Tourism" (2009) 30 *Tourism Management* 441 at 441-454.

important factors for the growth of the suborbital flight market are economic and technological concerns.[106] Generally speaking, it seems that the orbital and suborbital flight markets are both price elastic markets, meaning that the lower the price, the more the people who will make the purchase.[107] But when evaluating the market potential of suborbital flights as a transportation mode and not a means of entertainment, it is not clear whether people will be willing to pay such high prices only to save time.[108] Therefore, it is foreseeable that both the markets for orbital and, especially, suborbital flights will grow as the costs are gradually reduced by maturing technology, economies of scale, and competition.[109]

In addition, it is important to remember that the demand in the orbital and suborbital flight markets will always be influenced by safety concerns since "zero risk in space activity is unattainable.…"[110] In other words, the inherent risk in space activities, as compared to other kinds of transportation or entertainment, will lead to a disinclination on the part of many people and affects their decision about undertaking the space flight experience, at least for the first decades of the regular operation of these vehicles until public trust is secured to some extent. For this reason, many see this industry as being far

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[106] Martin Ross et al, "Limits on the Space Launch Market Related to Stratospheric Ozone Depletion" (2009) 70: 1 Astropolitics: The International Journal of Space Politics & Policy 50 at 73.

[107] The price of suborbital flights seems to be an important deterrent factor, especially when it comes to point-to-point passenger transportation or rapid package delivery services; people may not be ready to accept a huge difference in the prices of conventional and suborbital high technology flights only to save time; *See* Crouch et al, *supra* note 105 at 441-454;Futron Study, *supra* note 105 at 2, 18; "Space Tourism: Opening the space economy" NSS Positional Paper on Space Tourism (2009) online: National Space Society <http://www.nss.org/ tourism/position.html>; Reddy, Nica and Wilkes, *supra* note 41 at 1095; Brannen, *supra* note 11 at 639.

[108] Masson-Zwaan and Freeland, *supra* note 40 at 1600.

[109] Goehlich, *supra* note 9 at 215; Reddy, Nica and Wilkes, *supra* note 41 at 1094; See generally Launius and Jenkins, *supra* note 96.

[110] Molly K Macauley, "Flying in the Face of Uncertainty: Human Risk in Space Activities" (2005) 6:1 Chicago J. Int'l L. 131 at 132.

from a routine operational undertaking,[111] to the extent that some even see 'public reception' as the first challenge to the commercialization of the space flight industry.[112] Should any accident happen to private participants on an orbital or suborbital flight, the industry would lose its reliability and people's trust and confidence, at least for a while.[113]

Despite the foregoing, there are still many thrill-seekers who would enjoy the experience of flying on one of these top-notch technology vehicles to the orbit or sub-orbit. For this segment of travelers, the risk involved in the flight is part of the attraction.[114] Besides, there are other risky activities in which safety is highly secured, such as parachuting with a very low rate of fatality, despite the common perception of danger.[115] Many people are fascinated by adventurous and exciting activities and are less concerned about safety issues and the risks inherent in the activities. A recent example of this is the amazing jump by Felix Baumgartner, the Austrian skydiver, which broke the

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111 "Columbia Accident Investigation Board Report" online: Columbia Accident Investigation Board (CAIB) (2003), Vol I, at 19 <http://www.nasa.gov/columbia/home/CAIB_Vol1.html>; Macauley, *supra* note 110 at140; Reddy, Nica and Wilkes, *supra* note 41 at 1099-1100.

112 Ryabinkin, *supra* note 10 at 117.

113 Challenger and more recently Colombia disasters cast a shadow on the industry by causing skepticism about human space flight and safety issues, see Ryabinkin, *supra* note 10 at 117. However, one can claim that fatal accidents have also happened with a high rate in the first days of aviation. But the aviation industry was able to survive. As one commentator explains, "The early days of commercial air travel, however, were not without setbacks. Planes were falling out of the sky on a regular basis, with aircraft fatality rates that would translate into more than 250,000 deaths per year in modern times" (*Ibid* at 104).

114 "Space Tourism: Opening the space economy" NSS Positional Paper on Space Tourism (2009) online: National Space Society <http://www.nss.org/ tourism/position.html>

115 In 2010, the United States Parachute Association (USPA) announced the fatality record of 21 out of nearly 3 million jumps, which means 0.007 per 1000 jumps. Information available in the website of United States Parachute Association <http://www.uspa.org/AboutSkydiving/SkydivingSafety/tabid/526/Default.aspx>; See Reddy, Nica and Wilkes, *supra* note 41 at 1100.

record for the highest skydive by his jumping out of a balloon 128,000ft (24 miles, 39km) above New Mexico.[116]

Some surveys conducted to predict the outlook for suborbital flights foresee an unprecedented frontier of economic growth in the industry. Futron Corporation, which conducted a suborbital market study in 2002 (with an updated version in 2006), has estimated that the suborbital space tourism business can absorb 10,000 passengers by 2021 and make more than $650 million in revenue.[117] Considering the current speed of development and the extent of investments in the suborbital flight industry, these figures may seem overly optimistic.[118] In reality, space-related projects are very expensive, and working on suborbital aerospace vehicles is no exception. Together with technical details and safety issues, financial problems seem to be a very important obstacle faced by the companies working on these kinds of projects.[119] Therefore, it is important to address the problem of obtaining the private sector's trust and absorbing investments, which are needed to "lower the cost of access to space as well as to mobilize public and private sector support to increase the capacity to accommodate commercial passengers in the space."[120] However, to capture the interest of investors and raise the funds required for continuous growth of the industry, precise and reliable studies and assessments of real

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[116] Jonathan Amos, "Skydiver Felix Baumgartner lands highest ever jump" BBC News Science and Technology (14 October 2012) online: BBC<http://www.bbc.co.uk/news/science-environment-19943590>.

[117] See "Space Tourism Market Study: Orbital Space Travel & Destinations with Suborbital Space Travel" (the updated version of 2006) Futron Corporation, online: Futron.com<http://www.futron.com/upload/wysiwyg/Resources/Whitepapers/Suborbital_Space_Tourism_Revisited_0806.pdp>.

[118] Rene Joseph Rey, "Regulatory Challenges, Antitrust Hurdles, Intellectual Property Incentives, and the Collective Development of Aerospace Vehicle-Enabling Technologies and Standards: Creating an Industry Foundation" (2009) 35 J. Space L. 75 at 81; Loizou, *supra* note 3 at 290.

[119] Rey, *supra* note 118 at 84-6

[120] *Ibid* at 84; Reddy, Nica and Wilkes, *supra* note 41 at 1094; Futron Study, *supra* note 105 at 6.

market demand and potential public interest are essential in order to secure the confidence and participation of the capital market.[121]

One can conclude that since up to the present time there has not been any private suborbital flight tourist (participant), it is difficult to foresee whether a considerable decrease in the prices of flights and safety improvements will help the industry to enter the transportation and entertainment market as a routine and well-received mode. Along with pricing and affordability as well as safety concerns, there are other factors that affect the decision of people in undertaking space travel, including the type of launch and the design of the spacecraft, liability and insurance, public awareness, and even details such as location of spaceports, training required, duration, health and age conditions, attractions and services offered during the flight and the reputation of the operating company. These all seem to have some influence on tourist decision-making.[122] Nevertheless, some analysts see the existence of several travel agents in Europe selling tickets for space travel[123] or projects for spaceports in various places, such as the UAE, Singapore, the Netherlands and the Antilles and similar plans in the European Union (EU) countries, for example, Sweden, France, Spain and the United Kingdom, as a witness to the bright prospects for this industry.[124]

Even a comparison with the very first decades of the aviation industry supports the idea of the feasible expansion of the commercial suborbital flights market and, in the long run, point-to-point suborbital transportation as an accepted and common mode of

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[121] Crouch et al, *supra* note 105 at 441-454.

[122] Reddy, Nica and Wilkes, *supra* note 41 at 1093-1098. See Futron Study, *supra* note 105 at 22-24; See generally Crouch et al, *supra* note 105.

[123] Tanja Masson-Zwaan, “Regulation of Sub-orbital Space Tourism in Europe: A Role for EU/EASA?” (June 2010) 35:3 Air and Space Law 263 at 264.

[124] *Ibid* at 263-4.

transportation and consequently a promising industry.[125] The European Space Agency (ESA) has announced its intention to develop an all-rocket-powered SpaceLiner, which will provide high-speed suborbital transportation, although not in the near future.[126] It seems there is no end to people's desire to experience challenging, matchless and thrilling moments, and suborbital flights can be an answer to this ongoing demand of the market for adventure.

7. Suborbital Flights and Legal Complexities

As an innovation in the realm of technology, suborbital aerospace vehicles have given rise to their own specific legal concerns. New technologies create questions with respect to rights and duties. "Mankind travels, so does the law, and thus a thorough view of the governing international and domestic legal regimes, is important to realizing the various opportunities and limitations of commercial space transportation and space tourism."[127] Some of the questions with respect to suborbital flights pertain to issues such as the nationality and registration of the aerospace vehicles, licensing, certification and airworthiness of the aerospace plane, personnel licensing, safety, security, international and national liability regimes, traffic management and navigation and environmental protection issues.

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[125] Paul S. Dempsey, *Public International Air Law* (Montreal, Canada: McGill University, Institute and Center for Research in Air and Space Law, 2008) at 742; For an opposing argument see Rey, *supra* note 118 at 89; see also Veronique Ziliotto, "Relevance of the Futron/Zogby survey conclusions to the current space tourism industry" (2010) 66 *Acta Astronautica* 1547.
[126] "Fast20XX: Future High-altitude, High-speed Transport 20XX", European Space Agency (October 2012), online: ESA <http://www.esa.int/Our_Activities/Space_Engineering/FAST20XX_Future_High-Altitude_High-Speed_Transport_20XX>.
[127] Brannen, *supra* note 11 at 645.

To date, there has been no legal framework specifically tailored to answer the legal concerns of suborbital aerospace flights. Until the development of such laws and regulations, determining the appropriate set of laws and regulations from the existing legal frameworks seems to be the most practical solution. Two major questions with respect to the laws applicable to suborbital flights might arise: 1) Which of the national laws of each country or international law is competent to deal with the legal questions emerging from the operation of suborbital aerospace vehicles? 2) Should the regime of air law or that of space law govern these flights?

As for the first question, it might be suggested that the authority to deal with the legal issues regarding suborbital flights should be vested in the national law of the state above which the flight occurs.[128] Although this approach might seem to be practical, mainly because the existing plans for suborbital flights do not include long distance horizontal movements for aerospace vehicles, meaning that these vehicles horizontally travel a very short distance and do not cross the borders of other countries, it is not an answer to all the relevant legal issues. The reason is, suborbital vehicles fly beyond the atmosphere and to the edge of space; and as incorporated in the Outer Space Treaty, space is the heritage of mankind and is therefore not subject to national appropriation.[129] Therefore it is difficult to postulate that the national law of a state beneath the aerospace vehicle and its trajectory would be competent to govern all the legal concerns of the 'complete' suborbital flight.[130] However, the definition and delimitation of space is

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[128] Gorove, "Aerospace Object", *supra* note 63 at 105-06; Masson-Zwaan and Moro-Aguilar, "Practical Solutions", *supra* note 53 at 4.

[129] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and other Celestial Bodies (Outer Space Treaty), 610 U.N.T.S. 205 (Opened for signature on 27 January 1967) Articles I and II.

[130] Loizou, *supra* note 3 at 290.

another challenge about which more will be said later. In addition, with respect to future flights, such as the plan announced by Virgin Galactic for providing point-to-point transportation services,[131] the vehicles would cross borders; and therefore, the flight would be international, which means that more than one state would be involved in dealing with any arising legal issues.[132] Yet it is difficult to find national laws specifically dealing with the legal issues of suborbital flights. One reason may be that the number of countries involved in the projects for operating suborbital flights is a mere handful. Secondly, none of the projects has been put into operation; and consequently, countries do not feel the necessity of developing proper regulations tailored specifically for such flights. With more developments in this burgeoning industry, however, more and more countries will be impelled to pass laws and regulations that fill this gap in their laws.

The answer to the second question, about choosing one of the air law or space law regimes as the competent legal regime to regulate suborbital flights in the absence of a comprehensive regulatory regime specifically for suborbital flights, is more complicated. The answer to this question is very important and at the same time challenging because of the fundamental differences between the two legal regimes.[133] While the airspace above each country is considered part of its territory and, consequently, under its sovereignty,[134] outer space cannot be subject to ownership rights or any claims of sovereignty.[135] "Two different registries exist for aircraft and space objects and this itself presupposes two

[131] Rob Coppinger, "SpaceShipThree Revealed?" Flight Global (29 February 2008) online: <http://www.flightglobal.com/blogs/hyperbola/2008/02/spaceshipthree-revealed.html>.
[132] '*Concept of Sub-Orbital Flights*' ICAO Working Paper, *supra* note 48 at 5.1 and 5.2.
[133] Masson-Zwaan, *supra* note 123 at 265; Freeland, "Fly me to the Moon", *supra* note 12 at 99-101.
[134] "Every State has complete and exclusive sovereignty over the air space above its territory", Convention on International Civil Aviation (Chicago Convention), 7 Dec. 1944, 15 U.N.T.S. 295, Article 1.
[135] Outer Space Treaty, *supra* note 129 Article II; See also Alexandra Harris and Ray Harris, "The need for air space and outer space demarcation" (2006) 22 Space Policy 3 at 3.

different sets of functions, activities or modes of operation for them as well."[136] The so-called principles of outer space, such as 'common interest', 'freedom and non-appropriation' and 'registration and control of space object', together with the other principles and rules enshrined in the outer space treaties represent a major departure from the legal rules relating to airspace.[137] However, to examine the applicability of a space law or air law regime to suborbital flights and the respective surrounding legal concerns, it is essential first to determine what the definition of 'outer space' is and to decide where airspace ends and outer space begins. It is crucial to answer these questions because this is exactly how national and international rights and obligations are determined.[138]

Although since the beginning of the space era there have been important international documents that attempt to provide a legal response to different concerns with respect to space activities, and in spite of all the developments in space activities, public and commercial, there is still no definition of outer space, delimitation of space or even of spacecraft or space object, as explained previously in this chapter.[139] In international air law, on the other hand, although aircraft has been defined,[140] there is no

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[136] *Ibid* at 4.
[137] Brannen, *supra* note 11 at 645-7; Freeland, "Fly me to the Moon", *supra* note 12 at 100-101.
[138] Harris and Harris, *supra* note 135 at 5.
[139] See Elizabeth Mat Kelly, *The Spaceplane: The Catalyst for Resolution of the Boundary and 'Space Object' Issues in the Law of Outer Space?* (Master of Laws, McGill University Institute of Air and Space Law, 1998) [Unpublished] at 29 and 36; Peter van Fenema, "The Unidroit Space Protocol, the Concept of 'Launching State', Space Traffic Management and the Delimitation of Outer Space", The 41st session of the UNCOPUOS Legal Subcommittee, Vienna, 2-12 April 2002 (September 2002) 27:4/5 Air and Space Law 266-279; Freeland, "The Emergence of Space Tourism", *supra* note 87 at 6; Gorove, "Aerospace Object", *supra* note 63 at 102; Masson-Zwaan, *supra* note 123 at 265. Draft Treaty on the Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force against Outer Space Objects (PPWT), presented in 2008 at the Plenary Meeting of the UN Conference on Disarmament in Geneva in its Article I(a) of the PPWT defines outer space as "space beyond the elevation of approximately 100 [kilometres] above [the] ocean level of the Earth." However, this definition is vague, especially with respect to the word approximately. See Freeland, "Fly me to the Moon", *supra* note 12 at 102.
[140] Annex 7 to the Convention of International Civil Aviation, *Aircraft Nationality and Registration Marks*, adopted by International Civil Aviation Organization (ICAO) at 1.

definition of where airspace ends.[141] Demarcation between the two realms will help to clarify the scope of governance of each of the two legal regimes, and it is necessary to avoid disputes in relation to state sovereignty.[142] The issue of delimitation of outer space has been considered by UN COPUOS since 1962, but no conclusion has yet been reached.[143]

Two major methodologies have been proposed for the demarcation of air and space: functional and spatialist approaches, both of which have opponents and proponents.[144] In the functional approach, the emphasis is on the type of activity the object or vehicle is engaged in and its nature, objective and function, which means that where aircraft fly is airspace and where space objects operate is outer space.[145] In the spatialist or vertical approach, however, the idea is to establish a definitive demarcation and a fixed boundary at a certain altitude above sea level.[146] In the absence of rules and principles to define the limit between airspace and outer space in existing treaty law, some have suggested agreeing on a physical point, such as the Karman Line, which is the uppermost altitude at which an aircraft is capable of flying, as the boundary of air and space.[147] Some others have proposed 100-110 km above sea level as the beginning of

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[141] Masson-Zwaan, *supra* note 123 at 265.
[142] Harris and Harris, *supra* note 135 at 3; Kelly, *supra* note 139 at 50-55; for arguments against Delimitation of air and space see *Ibid* at 66-71.
[143] '*Concept of Sub-Orbital Flights*' ICAO Working Paper, *supra* note 48 at 4.2.
[144] See generally Dempsey, *supra* note 125 at 746-56; Gbenga Oduntan, "The Never Ending Dispute: Legal Theories on the Spatial Demarcation Boundary Plane between Airspace and Outer Space" (2003) 1:2 Hertfordshire Law Journal 64; Reinhardt, *supra* note 58 at 65.
[145] According to Dr. Bin Cheng, the functional approach was supported by major space powers, in whose interest it was not to have boundaries which might restrict their freedom to get into space without permission or hindrance. See Bin Cheng, "The Legal Regime of Airspace and Outer Space: the Boundary Problem", V Annals of Air and Space Law, 323 (1980) at 324.
[146] Jakhu, Sgobba and Dempsey, *supra* note 52 at 54-61; Reinhardt, *supra* note 58 at 119-122; Harris and Harris, *supra* note 135 at 6.
[147] This altitude has been estimated by Dr. Theodore von Karman to be 275,000 feet (52 miles, or 83 kilometers): see Reinhardt, *supra* note 58 at 114.

outer space.[148] A reason for the latter position might be the fact that space activities are definitely not possible at an altitude below 100 km.[149] In fact, the atmosphere does not end suddenly at a point, but it fades and thins gradually as the altitude increases; and at the altitude of 100 kilometers above Earth's surface, there are almost no atmospheric particles.[150] However, there is no evidence of a general practice among countries to constitute an international customary law.[151] Australia, in its Space Activities Act of 1998, defined a space object as consisting of a launch vehicle and a payload that the launchvehicle is to carry into or back from an area beyond the distance of 100 km above mean sea level.[152] Some have concluded that Australia had thus defined its airspace limit as 100 km above sea level. Yet it is difficult to conclude that Australia was renouncing any claims to sovereignty over the area above this limit of 100 kilometers.[153] There reason that (UN member) states did not achieve a consensus on the limit of airspace probably is that the delimitation directly influences the valuable sovereignty rights of states; and when sovereignty is the concern, countries act cautiously.[154]

The debates on the issue of air and space delimitation were ignited with the advent of vehicles with a hybrid technology, more specifically since the birth of the space

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[148] *Ibid* at 115-116.

[149] Natalie Pusey, "The Case for Preserving Nothing: The Need for a Global Response to the Space Debris Problem" (2010) 21 Colo. J. Int'l Envtl. L. & Pol'y 425 at 426.

[150] Michael W. Taylor, "Trashing the Solar System One Planet at a Time: Earth's Orbital Debris Problem" (2007-2008) 20 Georgetown Int'l Envtl. Law Review 1 at 2.

[151] Article 38 of the Statue of the International Court of Justice describes international custom, as evidence of a general practice accepted as law, as a source of international law.

[152] Australia *Space Activities Act1998* (Cth) Part 2, Section 8, available at: <http://www.austlii.edu.au/au/legis/cth/consol_act/saa1998167/s8.html>.

[153] Reinhardt, *supra* note 58 at 82.

[154] United States, United Kingdom, Germany and some other States, at early stages of the work at UNCOPUOS, argued against any immediate need for a boundary between airspace and outer space. See Cheng, *supra* note 145 at 327; See generally Freeland, "Fly me to the Moon", *supra* note 12 at 101; Harris and Harris, *supra* note 135 at 6; von der Dunk, "The integrated approach" *supra* note 83 at 4.

shuttle as a vehicle ascending into outer space with the assistance of rockets just as a conventional spacecraft does and descending from outer space bygliding through the atmosphere and touching down on a runway in a manner reminiscent of the landing of an aircraft.[155] In relation to suborbital flights, some scholars have suggested the functional approach, which means air law should be the applicable legal regime if a suborbital flight is regarded as aviation, and that space law should be applied when it is treated as a space activity.[156] It has been argued that the spatialist approach, according to which air law would be applied to the portion of the flight taking place in the airspace and space law to the part of the flight taking place in outer space, is not practical because there is still no internationally agreed delimitation between air space and outer space.[157] In order to apply the functional approach, it has to be decided whether the activity of carrying several passengers in a vehicle to an altitude of approximately 100-110 kilometers above the Earth and returning them is aviation or a space activity. Although in the commercial space industry, this activity is sold as 'space tourism', unless there is a legal definition for aviation and space activities in order to clarify the nature of suborbital flights, the choice of competent law will depend on the marketing choices of a handful of companies and on the legal response of the State under whose jurisdiction the activity will take place.[158] On the basis of the functional approach, it has been suggested that space law should be applied to flights in which the vehicle carries tourists and the intention of which is to reach outer space.[159] Nevertheless, applying the functional approach to flights that would

[155] Gorove, "Aerospace Object", *supra* note 63 at 106; Jakhu, Sgobba and Dempsey, *supra* note 52 at 59.
[156] Gorove, "Aerospace Object", *supra* note 63 at 110.
[157] Masson-Zwaan, *supra* note 123 at 264.
[158] von der Dunk, "Passing the Buck to Rogers", *supra* note 16 at 418; Masson-Zwaan and Moro-Aguilar, "Practical Solutions", *supra* note 53 at 3-4.
[159] Freeland, "The Emergence of Space Tourism", *supra* note 87 at 9.

be merely in transit through suborbital space in the course of earth-to-earth transport, and any crossing of outer space being brief and only incidental to the flight, would remain subject to air law.[160]

For the present, it seems that the legal situation of suborbital flights and the applicability of the air law or space law regimes depend to a great extent on the design of the vehicles. For instance, ICAO in its working paper for the Council's 17th session deems vehicles that would operate earth-to-earth services through suborbital space to have the elements of aircraft and to fly as such, at least during descending phase while gliding. By this description, it would be possible to incorporate them into the existing air law regime, though rocket-propelled vehicles would be excluded, seeing that they do not fall under the classification of aircraft.[161] As for the opposite argument, other scholars consider both orbital and suborbital flights (without any distinction between different types) in space to fall under space law.[162] Professor Tanja Masson-Zwaan, in her article

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160 '*Concept of Sub-Orbital Flights*' ICAO Working Paper, *supra* note 48 at 4.3 and 6.2; With respect to hybrid situations, Steven Freeland argues: "This methodology of regulating space tourism is, however, complicated by "hybrid" circumstances like the *SpaceShipOne* example, where there is a launch of a space vehicle from another vehicle in air space. The most appropriate way of regulating such flights under existing legal principles would be to apply air law to the "combined" vehicle (that is before the launch) and then apply space law to *SpaceShipOne* from the moment it is launched until its return to earth. *White Knight,* of course, would always remain subject to the law of air space. Even this solution, though pragmatic, is somewhat unsatisfactory in that, in the event of an accident during the flight, it will depend on when the accident occurs as to the relevant legal regime that is to apply. The legal position of the victim will depend on "fortuitous" circumstances. This, further points to the need for a comprehensive set of rules-based on existing space law principles-to cover all space tourism activities." Freeland, "The Emergence of Space Tourism", *supra* note 87 at 9.

161 *Concept of Sub-Orbital Flights*' ICAO Working Paper, *supra* note 48 at 6.1 and 6.2. Even if it is decided that the aerospace plane with the primary purpose of operating as an aircraft and engaged in earthbound transportation should be governed by air law, it is important to remember that such objects may be expected to comply with space debris mitigation, rules of the road, and other requirements while operating briefly around the fringes of outer space: See Gorove, "Aerospace Object", *supra* note 63 at 106.

162 *Concept of Sub-Orbital Flights*' ICAO Working Paper, *supra* note 48 at 9; von der Dunk, "The integrated approach" *supra* note 83 at 10; Freeland, "Fly me to the Moon", *supra* note 12 at 102; Jakhu, Sgobba and Dempsey, *supra* note 52 at 57.

on the regulation of suborbital space tourism in Europe, argues that suborbital space tourism will probably be regarded as aviation within the EU context, with the possible involvement of the European Aviation Safety Agency (EASA).[163] The current law of the U.S. seems to prefer to classify such vehicles as rockets.[164]

Achievements in technology and new designs of airplanes, spaceplanes and other types of vehicles, including those with mixed elements of both airplanes and spaceplanes, will probably in future herald the move towards a widely recognized demarcation point and bring the debates around this subject to an end. But what is clear, since aircraft and suborbital vehicles share the same airspace, a unified set of legal regulations in areas such as safety, navigation and traffic management should be applied to them.[165] Within the existing legal framework for air and space, and in spite of different proposals from legal scholars, it is not clear whether COPUOS, ICAO, or some other organization is competent to regulate suborbital flight.[166]

[163] Masson-Zwaan, *supra* note 123 at 263; Masson-Zwaan and Freeland, *supra* note 40 at 1599.
[164] *Commercial Space Launch Activities*, 49 U.S.C. ss 70102(8), 70102(19).
[165] Jakhu, Sgobba and Dempsey, *supra* note 52 at 57.
[166] Masson-Zwaan and Moro-Aguilar, "Practical Solutions", *supra* note 53 at 1.

CHAPTER TWO

ENVIRONMENTAL IMPACTS DUE TO SUBORBITAL FLIGHT OPERATIONS

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[167]

1. Introduction to the Chapter

For several decades the international community has been trying to be vigilant about the threats that human activities pose for the environment. This vigilance includes efforts made to find the most practical and efficient measures for removal of anthropogenic negative effects on the Earth's environment and the stability of its climate and, more recently, on outer space. We cannot single out suborbital flights from environmental measures; and thus, one might aptly ask whether suborbital vehicles have climate-friendly technologies. The next stage will be deciding on the proper legal framework that can regulate the environmental impacts of suborbital flights.

As explained in the first chapter, vehicles designed for suborbital flights are of different designs and technologies. They do not operate exactly like an aircraft or space object. In other words, they are not pure aircraft or spacecraft; they mix some characteristics of both.[168] As is clear from the existing and proposed designs, suborbital vehicles are supposed to operate in both airspace and outer space. In SpaceShipOne, and

[167] *Our Common Future*, Report of the World Commission on Environment and Development (WCED),A/42/427 Annex - Development and International Co-operation: Environment, 1987 para. 27, Full Report available online: <http://www.un-documents.net/our-common-future.pdf>.

[168] Sloup, *supra* note 25 at 407, 415; "Concept of Suborbital Flights: Information from the International Civil Aviation Organization (ICAO)", Committee on the Peaceful Uses of Outer Space Legal Sub-committee, 49th session, 2010, UN Doc. A/AC.105/C.2/2010/CRP.9 (19 March 2010).

its successor vehicle SpaceShipTwo, there is a ballistic portion of the flight in which the vehicle is not supported by the reactions of the air and it reaches the upper atmosphere where the air density is no longer sufficient for aerodynamic flight.[169] The proposed suborbital aerospace vehicle designs include varied possibilities for the 'ascent' and 'descent' phases. Ascent in suborbital vehicles involves two major types of horizontal or ballistic aerospace vehicles.[170] This means that the vehicle might ascend in a horizontal take-off or be launched from an aircraft, like SpaceShipOne from WhiteKnightTwo, or it could use rocket propulsion for a vertical take-off.[171] As with the ascent phase, there are two possibilities for the descent part of the flight, one of which is return of the vehicle to where it started from and the other return to a different location on Earth, so-called point-to-point suborbital transportation.[172] With respect to the design of SpaceShipOne, during re-entry into the atmosphere, the vehicle transitions to unpowered aerodynamic (gliding) flight for the return to Earth, and in this phase it can be compared to an aircraft.[173] Being a new technology, with an unprecedented combination of two areas of operation in air and space, suborbital flights give rise to questions about the environmental effects of such flights. Studying such concerns is important because dealing with the consequences after the problem emerges is always more difficult than taking precautionary measures, and environmental protection is an important and inseparable part of sustainable

[169] '*Concept of Sub-Orbital Flights*' ICAO Working Paper, *supra* note 48 at 2.2.
[170] Sloup, *supra* note 25 at 415.
[171] Masson-Zwaan and Freeland, *supra* note 40 at 1599, citing Cf. Erik Laan, "Technological aspects of Space Tourism", presentation delivered at the Leiden LLM programme in air and space law, May 2009.
[172] *Ibid*; Hobe, *supra* note 33 at 440. The U.S. Space Shuttle, however, acted like an aircraft (a glider) on its descent.
[173] "Concept of Suborbital Flights: Information from the International Civil Aviation Organization (ICAO)", Committee on the Peaceful Uses of Outer Space Legal Sub-committee, 49th session, 2010, UN Doc. A/AC.105/C.2/2010/CRP.9 (19 March 2010).

development.[174] In many instances, the activist efforts of environmental movements in bringing their concerns to general attention have been insufficient and too late.[175]

The dual environment of operation for suborbital vehicles raises the important question about which laws and regulations ought to regulate the operation of these vehicles of a hybrid nature when it comes to environmental concerns. This chapter identifies the probable environmental threats that suborbital flights may cause and examines the existing laws and regulations and the possibility of the inclusion of suborbital flights within or in relation to the exiting environmental regulatory standards of aviation and space activities.

2. Aviation and the Environment

The two major environmental concerns associated with the aviation industry are emissions and noise.[176] Below, we will examine the existing concerns and the regulatory responses to those issues.

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[174] Mark William, *Space: The Fragile Frontier* (Reston, United States: American Institute of Aeronautics and Astronautics, 2006) at 242; Malgosia Fitzmaurice, *Contemporary Issues in International Environmental Law* (UK: Edward Elgar Publishing, Inc., 2009) at 67-87. Principle 4 of the Rio Declaration provides: "In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it." United Nations Conference on Environment and Development, *Report of the United Nations Conference on Environment and Development,* 1992, U.N. Doc. AICONF. 151/26/Rev.1 (Vol. I) [Rio Declaration] Principle 2.

[175] William, *supra* note 174 at 242.

[176] Peter Morrell, *Aviation and Environment*, Presentation for the Air Transport Management Course: Universidade Lusofona (Crandfield University, January 2008) at 1; Heather L. Miller, "Civil Aircraft Emissions and International Treaty Law" (1997-1998) 63 J. Air L. & Com. 697 at 704. Even in human rights law there is reference to the right to a healthy environment. Article 1 of the Additional Protocol of San Salvador to the American Convention, Right to a Healthy Environment, provides:

1. Everyone shall have the right to live in a healthy environment and to have access to basic public services.

2.1 Emissions

The potential impact of aircraft emissions on the Earth's climate is one of the most important environmental issues the aviation industry has faced.[177] Emissions from aircraft, both at ground level and at altitude, can give rise to numerous negative effects on air quality, climate and the ozone layer. Statistics show that the aviation sector is a small contributor to the degradation of the quality of the human environment and is responsible for only a small portion of total anthropogenic emissions (2 to 4 percent).[178] Nonetheless, some scientists believe that because aircraft emissions take place at a high altitude they may have a disproportionate effect on the atmosphere.[179] The ongoing growth of the industry makes the problem even more serious.[180]

The principal emissions of aircraft released during the fuel combustion process in aircraft engines include chemicals and gases such as carbon dioxide (CO2), water vapour

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2. The States Party shall promote the protection, preservation, and improvement of the environment.

See Additional Protocol to the American Convention on Human Rights in the Area of Economic, Social and Cultural Rights "Protocol of San Salvador" Adopted in San Salvador on November 17, 1988 (Protocol of San Salvador).

[177] L.Q. Maurice. and D.S. Lee (eds.), *Assessing Current Scientific Knowledge, Uncertainties and Gaps in Quantifying Climate Change, Noise and Air Quality Aviation Impacts*, Final Report of the International Civil Aviation Organization (ICAO) Committee on Aviation and Environmental Protection (CAEP) Workshop (Washington DC and Manchester: US Federal Aviation Administration and Manchester Metropolitan University, 2009) at 25 [hereinafter Assessing Climate Change, Noise and Air Quality Aviation Impacts].

[178] *ICAO Environmental Report 2010: Aviation and Climate Change*, The Environment Branch of ICAO in collaboration with FCM Communications Inc. (2010), at 18 (Available online at: <http://www.icao.int/environmental-protection/Documents/Publications/ENV_Report_2010.pdf>.)

[179] Miller, *supra* note 176 at 701; for example, because of a longer lifetime and lower ambient pollution, a NOx molecule emitted at cruise altitude (8 - 14 km) produces a larger amount of O3 than when emitted at the Earth's surface. As the atmospheric temperature at cruise altitude is lower than at the Earth's surface, the radiative forcing per ozone unit is larger than the RF from the same amount of ozone near the surface. See *ICAO Environmental Report 2007*, The Environment Unit of ICAO in collaboration with FCM Communications Inc. (2007), Part 4, Climate Change, at 123 (Available online at: <http://www.airportattorneys.com/files/ICAO_Env_Report_07_part4only.pdf>); *IPCC Special Report: Aviation and the Global Atmosphere*, Intergovernmental Panel on Climate Change, Summary for Policymakers, (1999) at 3 (Available online at: <http://www.ipcc.ch/pdf/special-reports/spm/av-en.pdf>).

[180] Miller, *supra* note 176 at 701; IPCC Special Report, *supra* note 179 at 3; ICAO Environmental Report 2010, *supra* note 178 at 18.

(H_2O), nitrogen oxides (NOx) and sulphur oxides (SOx), along with small amounts of carbon soot (Csoot), hydrocarbons (HC) and carbon monoxide (CO).[181] These gases and particles can cause harmful effects in different stages of the flight, from the ground to higher altitudes. At ground level, one of the adverse effects of aircraft emissions is degradation of the air quality, which may directly impact human health.[182] Particulate matter, NOx, HC, SOx, and CO from aircraft engine emissions can affect air quality, health and welfare.[183] To reduce such negative effects, it is important first to quantify air quality and health impacts of air pollutants caused by the aviation transport sector and then control them.[184]

In addition to aviation ground pollution, aircraft can harm the environment at altitudes by adversely affecting the climate and the ozone layer. In relation to the climate, emissions of gases and particles by aircraft engines during fuel combustion perturb the radiative balance of the Earth, alter the concentration of atmospheric greenhouse gases and, consequently, lead to climate change.[185] Climate change has been referred to as "any change in climate over time, whether due to natural variability or as a result of human activity".[186] Global climate change is caused by the accumulation of greenhouse gases (GHG) in the lower atmosphere.[187] Greenhouse gases trap heat in the Earth's atmosphere

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[181] IPCC Special Report, *supra* note 179 at 3; Miller, *supra* note 176 at 704.

[182] Rae Andre, *Take Back the Sky: Protecting Communities in the Path of Aviation Expansion* (London: Sierra Club Books, University of California Press, 2004) at 26; Assessing Climate Change, Noise and Air Quality Aviation Impacts, *supra* note 177 at iv.

[183] ICAO Environmental Report 2010, *supra* note 178 at 18; Assessing Climate Change, Noise and Air Quality Aviation Impacts, *supra* note 177 at 7.

[184] *Ibid* at 10; Andre, *supra* note 182 at 26.

[185] These emissions mainly include carbon dioxide (CO_2), ozone (O_3), and methane (CH_4). They may trigger formation of condensation trails (contrails) and increase cirrus cloudiness, and they can all contribute to climate change. See IPCC Special Report, *supra* note 179 at 3.

[186] ICAO Environmental Report 2010, *supra* note 178 at 105.

[187] *Ibid*. The key anthropogenic greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N20), chlorofluorocarbons (CFCs), and tropospheric ozone (03). Carbon monoxide (CO) and nitrogen

and cause an overall rise of global temperatures, which could dramatically disrupt natural climate patterns.[188] There is no doubt that dramatic changes to our climate may occur if greenhouse gas emissions are not controlled.[189] The aviation industry needs to do its part. When at cruising altitudes, aircraft release harmful chemical gases and particles directly into atmosphere, and many of them remain in the atmosphere for a long time (for carbon dioxide and nitrous oxide, it takes many decades or even centuries for them to dissipate).[190] Once released, they interact with the background atmosphere and undergo complex processes, resulting in potential climate impacts, with damage to and effects on global welfare.[191]

Another concern arising from aircraft emissions is the role they play in ozone depletion. Ozone is a greenhouse gas that shields the Earth's surface from harmful ultraviolet (UV) radiation as well as being a common air pollutant.[192] Aircraft emissions cause changes in the chemistry of ozone that could eventually lead to depletion of the ozone layer.[193]

But what has been done to control and mitigate the adverse effects of aviation emissions on the environment? What is the legal framework to monitor and restrain the influence of these effects on the quality of the human environment? The principle treaty

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oxide (NOx) are not greenhouse gases, but these two gases indirectly affect the climate because they chemically interact with other gases. See Jonathan H. Adler, "Eyes On A Climate Prize: Rewarding Energy Innovation To Achieve Climate Stabilization" (2011) 35 Harv. Envtl.L. Rev. 1 at 5; Miller, *supra* note 176 at 701. The latest IPCC guidelines, the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, provide comprehensive and precise information on this matter. See generally H.S. Eggleston et al (eds.), *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Hayama, Japan: Institute for Global Environmental Strategies [IGES], on behalf of the IPCC, 2006).

[188] Assessing Climate Change, Noise and Air Quality Aviation Impacts, *supra* note 177 at 8; ICAO Environmental Report 2007, *supra* note 179 at 105; Adler, *supra* note 187 at 5.

[189] Miller, *supra* note 176 at 699.

[190] IPCC Special Report, *supra* note 179 at 4.

[191] Assessing Climate Change, Noise and Air Quality Aviation Impacts, *supra* note 177 at 25.

[192] IPCC Special Report, *supra* note 179 at 3.

[193] *Ibid.*

governing international civil aviation is the Convention on International Civil Aviation (Chicago Convention) of 1944, the adoption of which was an attempt to respond to international concerns about the nascent aviation industry. The Chicago Convention, together with its annexes, has provided guidelines and international standards and procedures with respect to registration, licensing and navigation in the aviation industry, and it established the International Civil Aviation Organization (ICAO), which possesses the authority to adopt and amend international Standards and Recommended Practices dealing with a wide range of matters affecting the international aviation industry, such as safety, security, regularity and efficiency. One of the goals of the Chicago Convention is to achieve uniformity in regulations, standards, procedures and all other matters affecting international aviation.[194]

When the Convention was first drafted in 1944, environmental issues were not contemplated by its authors.[195] But now, along with other assignments, ICAO has an environmental mission. Being aware of the role of environmental concerns with respect to aviation emissions,[196] ICAO issued in 1977 the Control of Aircraft Engine Emissions Circular, in which a number of aspects of aircraft emissions were addressed.[197] This document, together with other early studies and research conducted by ICAO on the negative effects of aviation activities on the environment, led to the adoption of Annex 16 to the Chicago Convention, entitled Environmental Protection,which introduced international Standards and Recommended Practices for the environmental aspects of

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[194] Chicago Convention, *supra* note 134 Article 37.
[195] Jakhu, Sgobba and Dempsey, *supra* note 52 at 42.
[196] In 1972 ICAO announced its position at the United Nations Conference on the Human Environment. ICAO Assembly Resolutions A31-11 and A18-11 are two of the very first documents developed by ICAO to address the aviation matters related to the environment at the time of their adoption. See ICAO, Assembly Resolution, 18th Session, A18-11 (1972).
[197] Miller, *supra* note 176 at 713.

aviation.[198] Annex 16 Consists of two volumes: Volume I, which establishes standards and recommended practices in regard to aircraft noise, and Volume II, which deals with the issue of control mechanisms for aircraft emissions, specifically through an engine certification scheme. States ensure that their manufacturers of aircraft or engines follow the standards and practices adopted by Annex 16 in their products.[199] Those States that are unable to abide by Annex 16, as required by article 38 of the Chicago Convention, should notify ICAO of any differences between their national regulations and practices and the international Standards and Recommended Practices introduced by the Annex.[200] Although article 38 gives States the right to reject the application of the international Standards and Recommended Practices to their aviation industry, there is great pressure from the international aviation community to comply; and as a result, the standards and practices adopted though the ICAO system normally enjoy widespread compliance.[201] ICAO environmental activities with respect to aircraft emissions were first undertaken through the Committee on Aircraft Engine Emissions (CAEE), which later was replaced by the Committee on Aviation Environmental Protection (CAEP), by a decision of the Council in 1983.[202] Currently, CAEP is charged with making recommendations regarding international noise and emission standards to the decision-making bodies of ICAO.[203] As the principal international forum for regulating all the issues relevant to aviation, ICAO is

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198 Annex 16 to the Convention On International Civil Aviation, *Environmental Protection*, International Standards And Recommended Practices adopted by International Civil Aviation Organization (ICAO) Vol. II (3d ed. July 2008, Amendment 7) at v.

199 Miller, *supra* note 176 at 714.

200 Chicago Convention, *supra* note 134 Article 38.

201 Miller, *supra* note 176 at 729.

202 Committee on Aviation Environmental Protection (CAEP), ICAO Website at: <http://www.icao.int/environmentalprotection/pages/CAEP.aspx>.

203 *Ibid.*

involved with different aspects of the environmental impacts of aviation.[204] With respect to reducing emissions of GHGs and climate change, ICAO has been trying to respond actively through establishing policies and adoption of standards and guidelines that provide an internationally harmonized regulatory process for the implementation of those measures adopted.[205] For the recent activities of ICAO, one can refer to the decision of the 36th Session of the ICAO Assembly in September 2007 to establish the Group on International Aviation and Climate Change (GIACC) with a mandate to develop an ICAO Programme of Action on International Aviation and Climate Change, which was realized in October 2009 and is an unprecedented action in addressing the climate impacts and CO2 emissions from a specific sector.[206]

Together with the Chicago Convention, other international agreements were developed in an attempt to address the current environmental problems, some of which are related to the aviation industry. The United Nations Framework Convention on Climate Change was finalized in the United Nations Conference on Environment and Development in Rio de Janeiro, Brazil, in June 1992 and adopted in New York on 9 May 1992. This Convention established a process for responding to climate change over the decades to come, especially by creating a system of information on national greenhouse gas emissions and climate change strategies.[207] UNFCCC in an attempt to monitor and mitigate the adverse effects of human activities on environment has established the goal

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[204] ICAO has three environmental goals for international aviation: 1) reduce the number of people exposed to significant aircraft noise; 2) reduce the impact of aviation emissions on local air quality; and 3) reduce the impact of aviation emissions on the global climate. See ICAO Environmental Report 2010, *supra* note 178 at 13.
[205] ICAO Environmental Report 2007, *supra* note 179 at 104.
[206] *Consolidated statement of continuing ICAO policies and practices related to environmental protection – Climate change*, ICAO Assembly Resolution, 37th Session, A37-19 (October 2010).
[207] *United Nations Framework Convention on Climate Change*, UNFCCC, May 1992, 1771 UNTS 107; S. Treaty Doc. No. 102-38 (entered into force in March 1994).

of stabilizing atmospheric concentrations of GHGs at a level that avoids dangerous anthropogenic interference with the climate system. The ultimate objective of the UNFCCC is to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous human interference with the global climate system.[208] Today there are now 195 parties to the Convention.[209]

Intergovernmental Panel on Climate Change (IPCC), which was jointly established by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) in 1988, is one of the international entities that deal with global environmental concerns. Its mission is to assess the environmental impacts caused in different sectors and to propose strategies for mitigating and adapting to climate change as well as providing scientific, technical and socio-economic advice to the Conference of the Parties to the United Nations Framework Convention on Climate Change. IPCC has produced a series of Reports and Papers that have become standard works of reference, widely used by policymakers, scientists and other experts.[210] The draft of the FCCC was prepared on the basis of the report of the IPCC to the UN General Assembly.

The Kyoto Protocol of 1997 adopted at the third conference of the United Nations' Framework Convention on Climate Change (FCCC), is another important

[208] ICAO Environmental Report 2007, *supra* note 179 at 105.

[209] The United Nations Conference on Environment and Development (UNCED), Rio de Janeiro, 13-14 June 1992 (also known as the Earth Summit) has had very important outcomes, and it has resulted in several important documents on the environment, one of which is UN FCCC.

[210] It also produced a Special Report following a request from ICAO and the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer. This special report assessed the consequences of greenhouse gases from aircraft engines and the potential effects from aviation on both stratospheric ozone depletion and global climate change. See IPCC Special Report, *supra* note 179 at Foreword.

international agreement.[211] It encourages industrialized countries to agree on binding national targets for greenhouse gas emissions of CO2, methane, NOx and three halocarbons used as substitutes for ozone-damaging chlorofluorocarbons.[212] It might seem that the focus of Kyoto Protocol is only on national targets, and that the issue of emissions from the international aviation sector has been excluded from its coverage. In fact, however, the Kyoto Protocol expressly recognized ICAO as the principal forum for regulating international aircraft emissions.[213] The question of whether ICAO is the forum for addressing purely domestic aircraft emissions remains open.[214]

In general, regulating and reducing the environmental impacts of the aviation industry is done through various mechanisms. Within this wide range of measures and mechanisms, technological improvements play an important role.[215] Fuel-related measures, operational practices[216] and regulatory and economic mechanisms, one of the most important of which is market-based measures, are some of the mechanisms

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[211] Kyoto Protocol to the U.N. Framework Convention on Climate Change, December 1997, U.N. Doc. FCCC/CP/1997/7/Add.1 (entered into force Feb. 16, 2005).

[212] *Ibid.*

[213] Prior to the Kyoto Protocol, two United Nations organizations, the FCCC and ICAO, were both regulating aircraft emissions, but the Kyoto Protocol recognized ICAO as the principal forum for regulation of all international aviation matters. See Kyoto Protocol *supra* note 211 at Article 2(2); see also Morrell, *supra* note 176 at 3.

[214] Miller, *supra* note 176 at 721.

[215] ICAO Environmental Report 2007, *supra* note 179 at 132. With respect to CO2 emission procedures, Martin Hoffert et al. argue that "the most effective way to reduce CO2 emissions with economic growth and equity is to develop revolutionary changes in the technology of energy production, distribution, storage, and conversion." See Martin I. Hoffert et al., "Advanced Technology Paths to Global Climate Stability: Energy for a Greenhouse Planet" (2002) 298 Science 981 at 981.

[216] Measures are conducted with respect to land-use management, airport infrastructure and equipment, ground systems and ATM. For example, important fuel saving opportunities come from ATM systems that permit more direct routings and the use of more efficient conditions, such as optimum altitude and speed. Shortening routes can indeed significantly reduce CO2 emissions. See ICAO Environmental Report 2007, *supra* note 179 at 108.

applied.[217] Emissions trading schemes are among the market-based measures alleged to be practical and effective approaches to reducing CO2 emissions by setting an overall limit on emissions.[218] The European Commission in recent years has been implementing its Emission Trading Scheme (EU ETS), a cap and trade system that includes aviation at both the domestic and international levels.[219] The EU ETS will be further discussed below.

2.1.1 ICAO's Effectiveness in Addressing Environmental Issues and the EU ETS

The European Union, pursuant to approval of the Kyoto Protocol and committed to the obligations there-under, established a scheme for greenhouse gas emission allowance trading through the European Parliament and Council Directive 2003/87/EC of 13 October 2003. The decision of the European Parliament and the Council of the EU in development of such a trading scheme was an important initiative in reducing the negative impacts of anthropogenic greenhouse gas emissions. The aim was to establish a cap and trade system that would permit the price of allowances to be set by market dynamics and not by the government.[220] However, in 2008, the EU, in an attempt to amend the previous directive, issued Directive 2008/101/EC, in which aviation activities

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[217] IPCC Special Report, *supra* note 179 at 10. For reviewing the operational and market-based procedures through which ICAO monitors and controls the emissions of the aviation industry, see generally ICAO Environmental Report 2007, *supra* note 179, Part 4 (Climate Change).

[218] Morrell, *supra* note 176 at 3; ICAO Environmental Report 2007, *supra* note 179 at 108.

[219] Directive 2003/87/EC of the European Parliament and of the Council establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC (13 October 2003); see also Directive 2008/101/EC of the European Parliament and of the Council of European Union amending Directive 2003/87/EC so as to include aviation activities in the scheme for greenhouse gas emission allowance trading within the Community (19 November 2008).

[220] Gareth Price, *The EU ETS and Unilateralism within International Air Transport* (Master of Laws, McGill University Institute of Air and Space Law, 2009) [Unpublished].

were included in the scheme for greenhouse gas emission allowance trading within the Community. There was much debate on the legal issues surrounding this decision, and it is still going on.[221]

The new amendments provided that "[f]rom 1 January 2012 all flights which arrive at or depart from an aerodrome situated in the territory of a Member State to which the Treaty applies shall be included."[222] Therefore, the scheme was intended to cover all flights entering or departing from EU airspace as of 2012, regardless of the nationality of the air carrier, and even if only a portion of the flight were within the EU. The legitimacy of the EU's decision has been questioned ever since. Questions relating to extraterritoriality in the EU's decisions and infringement on other states' sovereign rights are two of the more important arguments.[223] In addition, there have been discussions on unilateralism and the legality of the EU's unilateral initiative in imposing taxes on fuel consumption and, in other words, expansion of the EU ETS to non-EU air carriers. Those who question these moves point to the Kyoto Protocol's explicit provision which states working towards diminishing greenhouse gas emissions by aviation should be done through ICAO.[224] Objections have been expressed on this issue by various air carriers and countries, and the EU ETS has been challenged before the European Court of Justice. The Court decided that the application of the emissions trading scheme to aviation infringes neither the principles of international law nor the E.U.-U.S. Open Skies Agreement of

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[221] The Commission Decision of 2009/450/EC of 8 June 2009 provided a detailed interpretation of the aviation activities listed in Annex I to Directive 2003/87/EC of the European Parliament and of the Council. Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 also amended Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community.

[222] Directive 2008/101/EC of the European Parliament and of the Council, Annex, at 1 (b).

[223] Price, *supra* note 220 at 26-30.

[224] Kyoto Protocol *supra* note 211 at Article 2(2). On the matters of the "extraterritoriality and unilateralism" of EU ETS, see Price, *supra* note 220 at 31-38; Dempsey, *supra* note 125 at 476-77.

2007/2010.[225] However, in November 2012, in an attempt to find a global solution through the ICAO General Assembly, the European Parliament and the Council in a decision temporarily derogated from implementation of the ETS.[226]

Regrettably and in spite of its mandate under the Kyoto Protocol, limited progress has been made through ICAO in regard to developing measures for reducing greenhouse gas emissions in the aviation sector.[227] As a matter of fact, lack of progress in ICAO can be claimed as the main reason behind independent efforts similar to the EU's initiative.[228] An important reason is that, as in many other collective decisions, there is not enough incentive in many States to bind themselves by measures that limit their power in unilaterally regulating issues, and it is difficult to reach the consent required in international law for conclusion of an international agreement in these circumstances.[229] "In the case of climate change mitigation, there is a strong incentive to free-ride on the efforts of other states because successful climate change mitigation is a 'global public good', meaning that its benefits are non-excludable and non-rivalrous."[230] Therefore, perhaps it is appropriate to pay more attention to the fact that under current conditions, when international measures have not yet been developed, initiatives such as the move of

[225] Court of Justice of the European Union, *Air Transport Association of America and Others v Secretary of State for Energy and Climate Change,* Press Release No 139/11, Luxembourg, 21 December 2011Judgment in Case C-366/10.

[226] Proposal for a Decision of the European Parliament and of the Council derogating temporarily from Directive 2003/87/EC of the European Parliament and of the Council establishing a scheme for greenhouse gas emission allowance trading within the Community, 697 2012/328 (COD).

[227] See Remi Moncel and Harro van Asselt, "All Hands on Deck! Mobilizing Climate Change Action beyond the UNFCCC" (November 2012) 21:3 Review of European Community & International Environmental Law 163 at 170, 285; Joanne Scott and Lavanya Rajamani, "EU Climate Change Unilateralism: International Aviation in the European Emissions Trading Scheme" (2012) 23:2 *European Journal of International Law 469 at 475.*

[228] Moncel and van Asselt, *supra* note 227 at 170.

[229] An Hertogen, "Sovereignty as Decisional Independence over Domestic Affairs: The Dispute over Aviation in the EU Emissions Trading System" (2012) 1:2 Transnational Environmental Law 281 at 299-301

[230] *Ibid.*

the EU are better than a state of 'inaction' against a global concern.[231] However, an international response to global threats such as climate change would be the most preferable course, and the EU ETS could be considered a form of leverage stimulating ICAO to accelerate its endeavors to diminish the negative effects of the aviation industry on the climate change.

2.2 Noise

Excessive noise is one downside of human technological advances. It can cause profound negative effects on humans' health[232] and their physical, psychological and social well-being and quality of life.[233] For a community's perspective, one of the most obvious environmental problems is noise pollution.[234] Noise can be defined as any unwanted sound, and thus the definition contains a subjective element.[235] Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 defines 'environmental noise' as "unwanted or harmful outdoor sound created by human activities, including noise emitted by means of transport, road traffic, rail traffic, air traffic, and from sites of industrial activity.…"[236]

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[231] *Ibid* at 299; Moncel and van Asselt, *supra* note 227 at 170.

[232] The definition of health by the World Health Organization (WHO) indicates that health is "a state of complete physical, mental, and social wellbeing and not merely the absence of disease, or infirmity." Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference, New York, 19-22 June, 1946, signed on 22 July 1946 by the representatives of 61 States (Official Records of the World Health Organization, no. 2, at 100) and entered into force on 7 April 1948.

[233] Zeldine Niamh O'brien, "Civil Subsonic Jet Aeroplane Noise: Its Impact, Regulation and Remedies" (2006) 14 Irish Students Law Review 156 at 156; Assessing Climate Change, Noise and Air Quality Aviation Impacts, *supra* note 177 at 7.

[234] Andre, *supra* note 182 at 36.

[235] O'brien, *supra* note 233 at 156.

[236] Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002, Relating to the Assessment and Management of Environmental Noise – Declaration by the Commission in the Conciliation Committee on the Directive relating to the assessment and management of environmental noise.

Since the emergence of the aviation industry, aircraft noise has been one of the most important sources of excessive noise generated by human activities. Two sources of aircraft noise are the engines, which include two major types of jet and piston engines, and the aircraft frame.[237] The problem is more with jet engines, which produce noise while "fuel ignites and exhausts gasses and turbine blades strike the surrounding air."[238] Aircraft produces more noise during take-off and landing, and airports are considered to be contributors to the problem of excessive noise.

ICAO has been a forum in which the problem of noise produced by the aviation industry has been addressed, and numerous instruments governing the international regulation of permissible aircraft noise levels have been developed. To control the negative effects of aircraft and airport noise, ICAO adopted noise certification limits, standards and noise reduction technologies in Chapters 2, 3 and 4[239] of Volume I, Annex 16 of the Chicago Convention.[240] EU Directive 2002/49/EC was also intended to be a means to monitor and address environmental problems and to develop long-term EU strategies to reduce the number of people affected.[241] It should be noted that the EU in this Directive did not set binding limit values for noise, nor did it prescribe the measures to be included in the action plans. ICAO, on the contrary, has introduced permissible levels of airplane noise in Annex 16 of the Chicago Convention. The ICAO noise certification standards apply only when an aircraft design or type is first approved for

[237] O'brien, *supra* note 233 at 158.
[238] Dempsey, *supra* note 125 at 406.
[239] ICAO adopted Chapter 4 in 2001 to update its standards based on the new technologies and establish more stringent standards for modern airplanes. The new standards introduced in this chapter are applicable to jet airplanes, for which a type certificate was requested as of 1 January 2006.
[240] Annex 16 to the Convention on International Civil Aviation, *Environmental Protection*, International Standards and Recommended Practices adopted by International Civil Aviation Organization (ICAO), Vol. I (6th ed. July 2011).
[241] Directive 2002/49/EC, *supra* note 221.

operational use; it does not prevent the use of existing designs for current aircraft in production.[242] With respect to the noise problem in airports, the 33d ICAO assembly adopted Resolution A33/7 endorsing the concept of a 'balanced approach' to aircraft-noise management. The Assembly in 2007, through Resolution A36-22, Appendix C, reaffirmed the 'balanced approach' principle, with an emphasis on the role of airports in dealing with the problems of aircraft noise.[243] The EU Directive incorporates the balanced approach to noise reduction in the Community's law.[244] ICAO provides guidance and different manuals for implementation of its technical requirements for reduction of noise levels and how to deal with people exposed to excessive noise, namely the *Environmental Technical Manual on the Use of Procedures in the Noise Certification of Aircraft* (Doc 9501) or the ICAO *Manual of Airport and Air Navigation Facility Tariffs* (Doc 7100). Together with technological improvement in aircraft manufacture and fuel efficiency programs, some proposed strategies to control and mitigate noise include land zoning and noise-abatement procedures and local airport night curfews, as well as operational restrictions, aircraft landing fee surcharges, developing noise schemes and compensation for affected installations.[245] Apart from all the attempts to reduce the effects of noise from aviation at the international level, national laws and regulations, through certification and licensing requirements, play an important role in adopting and

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[242] "Noise Certification Standards", IATA Environmental Review 2004 (Aviation Industry, Environmental Issues), International Air Transport Association, at 9.

[243] *Consolidated Statement of Continuing ICAO Policies and Practices Related to Environmental Protection,* ICAO Assembly Resolution A36-22, 36th session, Doc 9902, Appendix C (Policies and Programmes Based on a "Balanced Approach" to Aircraft Noise Management), in force as of 28 September 2007; ICAO's aim in these Resolutions is to identify the noise problem at an airport and then analyze the various measures available to reduce noise through the exploration of the following four principal elements: 1) reduction at source (quieter aircraft), 2) land-use planning and management, 3) noise abatement operational procedures and 4) operating restrictions. See *Aircraft Noise,* ICAO Air Transport Bureau, Environment Branch, online: <http://legacy.icao.int/env/noise.htm>.

[244] O'brien, *supra* note 233 at 167.

[245] Dempsey, *supra* note 125 at 406.

implementing procedures and standards which can lead to reduction and management of aviation-caused noise.

3. Space and the Environment

Human activities inevitably have the potential to affect the environment, and commercial ventures in outer space are not an exception. Considering the fact that space activities begin on the Earth's surface and continue to be carried on in outer space, they no doubt have environmental impacts on different stages of the activity: that is, ground and atmospheric level impacts and outer space impacts.[246] Below, we will review the existing concerns about these two stages and the regulatory responses to these issues.

3.1 Ground/Atmospheric Impact

Although the impacts are far fewer than those caused by the aviation industry, each object sent to space has an impact on Earth's air quality and atmosphere. Launch activities and the propellants released can lead to environmental degradation.[247] However, launching activities and rocket emissions generally are not included in environmental assessments; and new rocket propulsion systems, such as hybrid propellants and hypersonic propulsion, are being developed and promoted without due regard to their possible environmental impacts.[248] The reason is that the contribution of space activities

[246] Extraterrestrial microorganisms are also considered as potentially capable of contaminating the earth. See HE QizHi, "Environmental Impact of Space Activities and Measures for International Protection" (1988) 16 J. Space L. 117 at 119.
[247] Ross et al, *supra* note 106 at 51; Lars Carlsen, O. A. Kenesova, and S. E. Batyrbekova, "A preliminary assessment of the potential environmental and human health impact of unsymmetrical dimethylhydrazine as a result of space activities" (2007) 67 Chemosphere 1108 at 1112.
[248] Ross et al, *supra* note 106 at 76.

in atmospheric pollutions at the current rate does not alarm environmentalists so that they would take serious action.

Depending on their types and designs, rocket engines emit different gases and particles of soot, aluminum oxide and water vapor, which are potentially harmful to human health and the quality of life, as well as to the environment, by contributing to climate change and ozone depletion.[249] There are two major types of rocket engines, Solid rocket motors (SRMs) and liquid rocket engines (LREs); both produce negative environmental effects. Among these two major types, SRMs emit greater amounts of gases and particles.[250] There is another type of engine, called the hybrid rocket engine, which is not completely environmentally friendly and can cause greater or less ozone loss.[251] Combustion emissions from rocket launches can cause long-term changes to the composition of the atmosphere.[252] Although greenhouse gas emissions from rockets have a very small effect on climate change, the chemical releases from spacecraft, such as nitrogen oxide, carbon dioxide, chlorine and hydrogen chloride, have some negative effects, one of which is to deplete the ozone layer.[253] SRMs and LREs deplete the global

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[249] During launch, a spacecraft produces a so-called "ground cloud" consisting of exhaust gases, cooling water, sand and dust, etc. See QizHi, *supra* note 246 at 118.

[250] Ross et al, *supra* note 106 at 61.

[251] Because even particles and water vapor play an important role in ozone destruction. Ross et al, *supra* note 106 at 52; see also *Scientific Assessment of Ozone Depletion: 2010*, Report by WMO-UNEP (Global Ozone Research and Monitoring Project—Report No. 52), Chapter 5: *A Focus on Information and Options for Policymakers*, at 25, online: <http://www.esrl.noaa.gov/csd/assessments/ozone/2010/report.html> [Scientific Assessment of Ozone Depletion].

[252] Ross et al, *supra* note 106 at 51.

[253] QizHi, *supra* note 246 at 118; Ross et al, *supra* note 106 at 51-2. Some statistics show that ozone is reduced by 40% in the exhaust trail of a Titan 3 solid rocket at an altitude of 18 km 13 minutes after launch. However the accuracy of this measurement is not clear; and even if it were, emissions resulting from launches are much less than those from aircraft in the stratosphere. See Charles H. Jackman, “Space Shuttle’s Impact on the Stratosphere: an Update” (1996) 101 D7 Journal of Geophysical Research 12,523 at 12,524-7.

ozone layer in various capacities.[254] NASA's Space Shuttle and similar rockets inject hydrogen chloride, carbon monoxide, water vapor and other chemicals directly into the stratosphere, where they cause immediate effects.[255] Statistics indicate that the contribution of launch activities in global ozone depletion is an insignificant fraction of the depletion; however, with the expansion of commercial activities in space, ozone depletion resulting from rockets could become significant.[256]

Burned-out rocket-carrier stages as well as spilling of unburned substances from the falling stages are another type of pollutants.[257] Launching from continental spaceports and launch sites can expose the population of nearby areas to environmental and health problems resulting from the spread of harmful substances.[258] "Negative influence of the space activities influences thousands of square kilometers including both the launching facilities as well as fall regions of burned-out rocket-carriers stages."[259] Furthermore, at an altitude of 80 km above the Earth, where the ionosphere is located, chemical and operational water releases can distort radio communications by affecting the radiowave-reflecting properties of the ionosphere.[260] The negative effects of rocket emissions in the upper atmosphere, where only very rarefied natural gases exist, should not be ignored. At

[254] Ross et al, *supra* note 106 at 50. The ozone-depletion effect of rocket emissions is mainly related to the stratospheric ozone (O3), which is the layer of atmosphere between 20–30km above the Earth and which absorbs harmful solar ultraviolet radiation before it reaches the Earth's surface.
[255] Jackman, *supra* note 253 at 12,523.
[256] Ross et al, *supra* note 106 at 50; Jackman, *supra* note 253 at 12,528.
[257] QizHi, *supra* note 246 at 119; Carlsen et al, *supra* note 247 at 1108-9.
[258] *Ibid* at 1108.
[259] *Ibid* at 1109. Although choosing the trajectories and fall regions only in unproductive and inhabitable areas, such as poorly inhabited steppes, semi-deserts and desert areas, all the negative effects of launch activities even in those natural areas could not be completely avoided. See *ibid.*
[260] QizHi, *supra* note 246 at 118.

those altitudes, exhaust gases and substances would not easily dilute and mix; they would remain for a long time and would spread over a large area.[261]

Because space launch activities have not been conducted very frequently and hence their contribution to contamination of the atmosphere has been trivial, the atmospheric impacts of space activities have not been a concern for the drafters of international treaties on space activities, and regulatory actions to mitigate and control the emissions of space activities at the international level have not been undertaken.[262] Like the Kyoto Protocol on climate change, the Vienna Convention for Protection of the Ozone Layer of 1985,[263] and the Montreal Agreement Protecting the Ozone Layer from Chlorofluorocarbons of 1987,[264] with its subsequent amendments have been international attempts to preserve the Earth's atmosphere from adverse changes resulting from human activities. However, these documents do not encompass the emissions of launch activities; and it is not clear whether the Montreal Protocol, which has proven to be very successful in controlling the emissions leading to ozone depletion, or any other framework, is applicable to emissions caused by space activities.[265] Nonetheless, as more and more interest is shown in the commercial use of outer space, the share of space activities in Earth's pollution will increase.[266] Launch activities, if they grow rapidly, will eventually result in greater pressures on the Earth's environment, leading to the pollution

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[261] *Ibid.*

[262] Ross et al, *supra* note 106 at 58.

[263] Vienna Convention for the Protection of the Ozone Layer, Vienna, 22 March 1985, United Nations, *Treaty Series*, T.I.AS. *No*. *11,097*, *1513 U.N.T.S.* 293, *26 I.L.M. 1529 (*entered into force in 1988).

[264] Montreal Agreement Protecting the Ozone Layer from Chlorofluorocarbons of 1987, entered into force in 1989, United Nations, *Treaty Series*, 1522*U.N.T.S.* 3 *(*entered into force in January 1989).

[265] Ross et al, *supra* note 106 at 57, 77. This is especially the case because some gases with significant environmental impacts, such as CO_2, nitrous oxide (N_2O) and Methane (CH_4), are not controlled by the Montreal Protocol. See Scientific Assessment of Ozone Depletion, *supra* note 236 at 1.

[266] *Ibid* at 25.

of previously pristine areas.[267] Rocket engines in their trajectories to outer space discharge their emissions directly into different layers of the atmosphere, where they can start causing damage immediately, which is another reason for taking the role of space activities in endangering the Earth's environment more serious and therefore trying to regulate these activities from the environmental point of view.[268] Yet, adopting international regulatory regimes to control the emissions in the launch market might have an impact on the economic viability of possible large-scale, low-cost launch systems.[269] Therefore, regulating such emissions should be carried out with careful consideration of viability of the industry.

3.2 Outer Space Impact

It has been five decades since humans first started exploration and exploitation of space by sending out rockets, satellites and other space objects. The objects sent to space for different purposes produce derelict objects, generally known as space debris when they become non-functional or when collisions or explosions occur.[270] Space debris has been the subject of attention at both national and international levels because it can pose a serious threat to other objects in space. The threat can be in the form of physical damage in case of collision, disrupting precisely positioned satellites and unbalancing them, or

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[267] Reddy, Nica and Wilkes, *supra* note 41 at 1096; Freeland, "Fly me to the Moon", *supra* note 12 at 116.
[268] "Rocket combustion products are the only human-produced source of ozone-destroying compounds injected directly into the middle and upper stratosphere. The stratosphere is relatively isolated from the troposphere so that emissions from individual launches accumulate in the stratosphere." See Ross et al, *supra* note 106 at 52, 61.
[269] *Ibid* at 74-6, 80.
[270] Primary sources of space debris can be: (*a*) accidental and intentional break-ups which produce long-lived debris, (*b*) debris released intentionally during the operation of launch vehicle orbital stages and spacecraft and (*c*) fragments generated by collision. See Space Debris Mitigation Guidelines of the United Nations Committee on the Peaceful Uses of Outer Space 2007 (A/62/20), adopted by UN General Assembly Resolution 62/217, at 1; see also Taylor, *supra* note 150 at 9.

creating electric charges causing impediments in the functioning of other objects, as well as interference with the observation function.[271] Another type of problem arising from the creation of space debris is the potential for surface harm when it re-enters the atmosphere.[272] Some scholars have used the terms 'forward' pollution and 'back' pollution for the environmental harms resulting from commercial activities in space. In this categorization, 'forward' pollution refers to the pollution that occurs in outer space as a result of human activity, while 'back' pollution refers to the pollution occurring on Earth as a result of extraterrestrial matter entering the Earth's environment.[273] The point is that both of these types of environmental damages are caused by the creation of space debris in outer space; therefore, we can consider both types under the category of 'outer space impact'.

Space debris has been defined as all man-made objects, including fragments and elements thereof, in Earth's orbit or re-entering the atmosphere, that are non-functional.[274] Defunct satellites, spent and jettisoned rocket bodies, lens caps, bolts, and even paint flecks and other small pieces of metal are examples of space debris.[275] What happens to the debris left behind from human activities in outer space? It is the Earth's

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[271] Theresa Hitchens, "Debris, Traffic Management, and Weaponization: Opportunities for and Challenges to Cooperation in Space" (2008) 14 Brown J. World Aff. 173 at 174; Pusey, *supra* note 149 at 430; QizHi, *supra* note 246 at 120.

[272] Pusey, *supra* note 149 at 432.

[273] Harold Craig Manson, "The Impact of International Outer Space Commerce on the Environment" (1991) 26 Texas Int'l L. J. 541 at 546; Stephen Gorove, "Pollution and Outer Space: A Legal Analysis & Appraisal" (1972)*5 N.Y.U. J. Int'l* L. & Pol. 53 [Gorove, "Pollution and Outer Space"]; QizHi, *supra* note 246 at 119.

[274] The Space Debris Mitigation Guidelines, *supra* note 270 at 1; this is the same definition of space debris as in the IADC Guidelines, see *IADC Space Debris Mitigation Guidelines*, Inter-Agency Space Debris Coordination Committee, IADC-02-01 Revision 1 September 2007, at 3-1.

[275] Hitchens, *supra* note 271 at 174.

gravity and altitude that determine the destiny of a piece of space debris.[276] Without employing enough speed and velocity in the proper direction, gravity eventually pulls the objects toward the Earth, in a time frame which is totally dependent on the altitude and the object's size and volume. With the proper velocity, a space object can orbit Earth in a desirable location, remaining there until external forces act upon it.[277] It has been foreseen that space could become unusable if the population of debris continues to increase as expected and collisions become the most dominant way in which more and more debris is generated.[278] Space debris imposes a threat for satellites being operated in Geostationary Earth Orbit (GEO). Of course the objects in GEO move slower compared to those in LEO, which means the expected maximum collision velocity in LEO is much higher. However, considering the congestion of functioning and non-functioning objects in GEO, space debris has been viewed as posing greater danger for GEO and its operational satellites.[279] The last scenario or, as some call it, back pollution may involve the risk of causing damage on the ground to people, land or property.[280] It is estimated that about 200 space objects return to Earth each year, some of which are quite large pieces of debris surviving reentry.[281] However, it is alleged that the threat from these kinds of debris is not substantial.[282]

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[276] William, *supra* note 174 at 49-51.
[277] Taylor, *supra* note 150 at 3.
[278] The Space Debris Mitigation Guidelines, *supra* note 270 at 1; Hitchens, *supra* note 271 at 174; Pusey, *supra* note 149 at 426; Manson, *supra* note 273 at 547.
[279] William, *supra* note 174 at 50-51; Pusey, *supra* note 149 at 430.
[280] The Space Debris Mitigation Guidelines, *supra* note 270 at 1.
[281] Taylor, *supra* note 150 at 22-23; Pusey, *supra* note 149 at 432. There are various examples of space debris re-entering Earth. In 1978 the Soviet satellite Cosmos 954 reentered Earth's atmosphere and crashed into Canada, spreading radioactive debris over an extensive area. In September 2011, The US Federal Aviation Administration (FAA) warned all pilots to exercise caution during flight as NASA's decommissioned Upper Atmosphere Research Satellite (UARS) was entering the atmosphere over the North Pacific Ocean, off the west coast of the United States. See Ram S. Jakhu, "Environmental Issues Related to Outer Space: Space Debris or Junk in Space", Faculty of Law, McGill University, 2012. Also in

Except for a trace of environmental concerns in the Outer Space Treaty and Moon Agreement, in current international space treaty law there is no direct reference to matters associated with protection of the environment in space-related activities. Some provisions of the various space treaties that may be applied to space debris and the related legal issues will be discussed below.

3.2.1 Outer Space Treaty: The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies of 1967, referred to as the 'Outer Space Treaty',[283] is known as the foundation for legal regulation of space activities. The Outer Space Treaty, having been signed at a time when the international community could not foresee such widespread and ever-expanding use of outer space, does not embrace environmental concerns about human activities in outer space, except in Article IX.[284] Article IX deals with the issue of preservation of outer space by stating that the States Parties should avoid harmful contamination of space.[285] However, the emphasis of this Article is on pursuing 'studies' and 'exploration' of outer space; and apparently its aim is not to protect outer space environment from exploitation and commercial human activities in space; therefore, it is neither comprehensive and detailed nor efficient in terms of protection of the space environment.[286] In addition to this explicit reference to environment preservation in

1997, a falling piece of debris, which later was confirmed to be part of the fuel tank of a Delta II rocket, was reported by a woman in Oklahoma (*ibid*).

[282] Of course this general conclusion cannot be applied to radioactive debris, which definitely poses a serious risk to the Earth's population. See Taylor, *supra* note 150 at 22-23.

[283] Outer Space Treaty, *supra* note 129.

[284] Pusey, *supra* note 149 at 435.

[285] Outer Space Treaty, *supra* note 129 Article IX.

[286] Lawrence D. Roberts, "Addressing the Problem of Orbital Space Debris: Combining International Regulatory and Liability Regimes" (1992) 15 B. C. Int'l & Comp. L. Rev. 51 at 52-3; Pusey, *supra* note 149 at 437; Freeland, "The Emergence of Space Tourism", *supra* note 87 at 20; Article IX provides: "States Parties to the Treaty shall pursue studies of outer space, including the Moon and other celestial bodies, and

Article IX, other provisions of the Outer Space Treaty indirectly restrain irresponsible use and contamination of space by the States Parties. Some commentators believe that the creation of debris can be considered a violation of the Outer Space Treaty.[287] The Treaty in Articles I and II considers that the exploration and use of outer space, as the province of all mankind, shall be carried out for the benefit and in the interests of all countries, and that space is not subject to national appropriation by claim of sovereignty.[288] In Article VI, the Outer Space Treaty vests the international responsibility for national activities in outer space and the compliance of governmental or private entities with the Treaty upon the States Parties.[289] This means that the States are responsible for the space activities of their nationals and the activities conducted in their territory. It can be interpreted that the Outer Space Treaty 'implies' the responsibility of the member States to avoid activities that might endanger the right of other states to the use of outer space.[290]

3.2.2 Registration Convention: The Convention on Registration of Objects Launched into Outer Space of 1974, known as the Registration Convention, is another international treaty that could be applicable to the environmental impacts of human space activities.[291] This Convention foresees 'national' and 'international' registry requirements, which would include submission of certain information, for all the objects launched into

conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose". In addition, the article requires the States to undertake international consultations before proceeding with activities in space that might interfere with the activities of other states in the peaceful use of outer space.

[287] Pusey, *supra* note 149 at 436.
[288] Outer Space Treaty, *supra* note 129 Articles I and II.
[289] *Ibid* Article VI.
[290] Manson, *supra* note 273 at 549.
[291] Registration Convention, *supra* note 65.

space.[292] However, the information required by this convention is not sufficient to locate debris and eliminate its risk to functional space objects.[293] The requirements of the Registration Convention simplify the identification of space objects in cases of damages or space debris threats caused by space objects.[294]

3.2.3 Liability Convention: The Convention on International Liability for Damage Caused by Space Objects of 1972, the Liability Convention,[295] is another treaty applicable to space debris.[296] Under this convention, the launching state will be held liable for the damages its nationals or entities within its territory cause to another state or its nationals by its activities in space.[297] The Liability Convention defines the term 'damage' widely enough to encompass loss of life; personal injury or other impairments to health; loss of or damage to property of States or persons, natural or juridical, or to the property of international intergovernmental organizations.[298] This means that in cases in which the Liability Convention is applicable, damages caused by debris both in outer space and in the Earth's atmosphere will be covered. The Liability Convention foresees a dual system for liability for damages caused by space activities. In this two-fold system, strict liability is imposed for damages caused "on the surface of the Earth or to aircraft in flight",[299] which might be the case when space debris re-enters the Earth's atmosphere and causes damage to the Earth's atmosphere.[300] On the other hand, fault-based liability

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[292] *Ibid* Articles II to VI.
[293] Pusey, *supra* note 149 at 438.
[294] Manson, *supra* note 273 at 551.
[295] Liability Convention, *supra* note 65.
[296] Pusey, *supra* note 149 at 438-9.
[297] Liability Convention, *supra* note 65 Articles II to V.
[298] *Ibid* Article I (a).
[299] *Ibid* Article II.
[300] The Soviet Union-Canada dispute in 1978 is an example. A Soviet space object, Cosmos 954, on re-entry and disintegration deposited space debris on Canadian territory and caused damage to Canadian property.

is imposed in cases of damages occurring in outer space or, in the Convention's words, "elsewhere than on the surface of the Earth to a space object of one launching State or to persons or property on board such a space object by a space object of another launching State".[301] It can be concluded that space debris and the damages caused to other objects in space are covered under this provision. However, the determination of fault in cases of damages caused in space is not always easy.[302] It is important to mention that the liability of the State with respect to space objects extends as well to component parts of space objects.[303] However, it is not clear whether the provisions are applicable to 'creation' as well as 'mitigation' of space debris and the liability for damages caused by them, or whether they govern only the 'consequences' of the space debris created by the commercial activities of states.[304]

3.2.4 Moon Agreement: Together with Outer Space Treaty, the Agreement Governing the Activities of States on the Moon and Other Celestial Bodies of 1979, or the Moon Agreement, is an important international treaty that explicitly points out space environmental concerns.[305] States Parties to the Moon Agreement undertake to avoid disruption of the existing balance of the Moon's and other celestial bodies' environments as well as to avoid causing adverse changes and harmful contamination in these environments.[306] It seems that the terminology and definitions in this space law Agreement with respect to environmental protection are vague and ineffective. The

[301] Liability Convention, *supra* note 65 Article III.
[302] Jakhu, *supra* note 281.
[303] Outer Space Treaty, *supra* note 129 Article VII; and Liability Convention, *supra* note 65 Article I to III.
[304] Taylor, *supra* note 150 at 27-28.
[305] The Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, UN General Assembly Resolution 34/68 (Opened for signature on 18 December 1979 and entered into force on 11 July 1984) [Moon Agreement].
[306] *Ibid* Article 7.

responsibility of states generally to avoid disruption of the existing balance of the Moon or other celestial bodies is not clarified, and it might be concluded that any kind of activity affecting these celestial bodies could change their environment and would therefore constitute a breach of the Agreement.[307] Unfortunately, the heritage-of-mankind system envisaged in Article 11 of Moon Agreement has ignited lengthy debates, the result of which has been that the Moon Agreement has not been well received by the majority of the members of international community.[308]

3.2.5 Mitigation Guidelines: In addition to the current international space law framework and the provisions which indirectly and by implication may be relevant to space, a number of documents have been developed specifically to deal with the associated issues of space debris; they call for States and the international community to take action to prevent the creation of new debris and suggest practical measures.[309] Not until 1994 did the Technical and Scientific Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) place the issue of space debris on its agenda for the first time on a priority basis; the result was the decision of the Committee to conduct research on matters associated with space debris.[310] Later, in 1995, the U.S. National Research Council took one of the earliest steps in responding to the growing concern about space debris by publishing a study, entitled *Interagency Report on*

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[307] Freeland, "The Emergence of Space Tourism", *supra* note 87 at 21.

[308] Moon Agreement, *supra* note 305 Article 11.

[309] Besides the abovementioned space treaties, the Partial Test Ban Treaty of 1963, the UN Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques Convention, the Prohibition Convention of 1977, the Principles Relevant to the Use of Nuclear Power Sources in Outer Space, and other international documents with respect to demilitarization and weapon testing in space may also be applicable to space debris issues. See Pusey, *supra* note 149 at 441-2; QizHi, *supra* note 246 at 122.

[310] *Report of the Scientific and Technical Subcommittee on the Work of its Thirty-first Session*, Committee U.N. Committee on the Peaceful Uses of Outer Space, A/AC.105/571 (10 March 1994) paras. 63-74

Orbital Debris.[311] This report, which is a technical assessment, included the results of the tests and studies conducted to evaluate the magnitude of the problem, modeling as well some recommendations for mitigation procedures. In 1999, the Scientific and Technical Subcommittee of COPUOS adopted the *Technical Report on Space Debris* at its thirty-sixth session.[312] The Inter-Agency Space Debris Coordination Committee (IADC), an international forum of governmental bodies for the coordination of activities related to the issues of man-made and natural debris in space, founded in 1993, developed a set of guidelines for space debris mitigation called the IADC Space Debris Mitigation Guidelines 2004, which was revised and updated in 2007.[313] The IADC Guidelines provided a basis for another document adopted by UN COPUOS: Space Debris Mitigation Guidelines of COPUOS 2007.[314] None of these guidelines are legally binding, and they are not considered as an accepted source of international law. However, they are widely respected by the major space-faring states that try to contribute to these guidelines.[315]

Obviously, with the current speed of commercial space activities, the growth of space debris in outer space is inevitable and that each collision contributes to making space more and more cluttered with debris, a fact that imposes a sense of urgency for the international community to take appropriate and effective measures, including both preventive and remedial mechanisms, before space is rendered unusable by the ever-

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[311] *Interagency Report on Orbital Debris*, Office of Science and Technology Policy, Executive Office of The President (Washington DC, The National Science and Technology Council, November 1995).

[312] The Space Debris Mitigation Guidelines, *supra* note 270 at 1; Report of the Scientific and Technical Subcommittee, *supra* note 295.

[313] IADC Space Debris Mitigation Guidelines, *supra* note 274.

[314] The Space Debris Mitigation Guidelines, *supra* note 270.

[315] Pusey, *supra* note 149 at 444; Hitchens, *supra* note 271 at 175. There are also European space debris mitigation guidelines that are more technically oriented; e.g. see *European Code of Conduct for Space Debris Mitigation*, Issue 1.0, 28 June 2004; and *Requirements on Space Debris Mitigation for Agency Projects,* ESA/ADMIN/IPOL(2008)2 Annex 1.

growing danger of space debris. This urgent need for action includes adoption and implementation of a strong legal framework to address the concerns about space debris.

3.3 State Responsibility and the Inadequate Space Liability Regime

As explained in the previous sections, the bedrock of the liability system in space law is Articles VI, VII and VIII of the Outer Space Treaty, which were later developed in the Liability Convention. Each state should ensure that its space activities, governmental or non-governmental, are in conformity with the provisions of the space law treaty[316] and, in case of damages to other States Parties, are internationally liable.[317] The Liability Convention foresees an absolute liability system for damages on the Earth's surface or in airspace and a fault-based liability system for damages caused in outer space.[318] The lack of definitions for key terms, such as ‘space object’, ‘objects launched into outer space’ and, most importantly, the term ‘fault’, can lead to many legal complications, particularly in relation to damages caused by space debris.[319] There is only a clear definition of the term ‘damage’, and it relates only to persons or property but not to the environment of outer space itself.[320] In addition, no standards of care have been established, and it is not clear how the element of ‘fault’ occurring in outer space should be proven, for collecting evidence and proof there is relatively difficult.[321] Therefore, the important step to be taken is to modify the current liability system in order to clarify what constitutes ‘fault’,

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[316] Outer Space Treaty, *supra* note 129 Article VI.
[317] *Ibid* Article VII.
[318] Liability Convention, *supra* note 65 Articles II and III.
[319] Lawrence Roberts, *supra* note 286 at 64; Michael W. Taylor, *Orbital Debris: Technical and Legal Issues and Solutions*, (Master of Laws, McGill University Institute of Air and Space Law, August 2006) [Unpublished].
[320] Lawrence Roberts, *supra* note 286 at 64.
[321] Pusey, *supra* note 149 at 439-40.

how 'causation' should be established, and even to establish an absolute liability system for damages occurring in outer space.[322] Evidently, elimination of the existing ambiguity and expansion of the current system require political incentives for states.

4. Suborbital Flights: An Environmental Concern?

Suborbital flights will soon be a routine part of tourism and the transportation industry. Currently there is not any information about the possible contribution of suborbital flights to contamination of the Earth's atmosphere and outer space; and there will not be, until the regular operation of such flights begins and assessment of the resulting pollution becomes possible. Obviously, as is the case for environmental protection movements in every other sector, it is better to be 'proactive' rather than taking 'retroactive' measures after the problem emerges. If left unregulated, suborbital vehicles might be a source of environment pollution in future and aggravate the already alarming statistics concerning anthropogenic pollution in the atmosphere and outer space. The question is whether the existing environmental regulatory regimes are, or should be, applicable to the operation of suborbital flights, or whether a new system should be designed to control the environmental effects of suborbital flights. The first step in the identification of the proper regulatory system for the environmental impacts of these vehicles is to examine the type of pollution that they might create; the next step will be quantification and assessment.[323] Below, possible environmental effects from the operation of suborbital

[322] For suggestions with respect to establishment of a 'liability pool' for damages caused in outer space and the notion of 'market share', see Lawrence Roberts, *supra* note 286 at 69-70.
[323] Assessing Climate Change, Noise and Air Quality Aviation Impacts, *supra* note 177 at v.

vehicles will be discussed. Afterwards, the regulations that could be applicable to controlling the environmental effects of suborbital flights will be reviewed.

4.1 Ground/Atmospheric Impact

In practice, considering the scientific uncertainty, informational problems, and the fact that suborbital vehicles are not in regular operation yet, it is difficult to assess the nature of possible environmental threats and the magnitude and the extent of the risks caused by suborbital vehicle emissions. However, there are some scientific facts that can help to obtain an initial perception of the potential problems. The trajectory for a suborbital airspace vehicle vertically will extend more than 100 km, and the flight can have environmental effects while passing through different altitudes, from ground through levels of the atmosphere to the edge of space and the Low Earth Orbit (LEO).

Earth's atmosphere consists of different levels which range from the troposphere to the exosphere, where the Earth's atmosphere ends.[324] Since the most aviation activities include subsonic flights, aircraft emissions are currently released between the lower stratosphere and the troposphere.[325] This is not the case, however, for rockets and launching activities. As explained in previous sections, space activities begin on the Earth's surface and continue from there up to outer space, while crossing the various levels of the atmosphere in their trajectory. The effects include degradation of air quality in the troposphere (from 0 to 16 km above Earth), to ozone depletion and climate change

[324] "Atmospheric Layers", Weather & Climate, online: <http://www.weather-climate.org.uk/02.php>.

[325] Aircraft typically operate at cruising altitudes of 8 to 13 km. See ICAO Environmental Report 2007, *supra* note 179 at 105-06; Scientific Assessment of Ozone Depletion, *supra* note 236 at 24.

impacts in the stratosphere (16 to 50 km), to other negative changes in the ionosphere and the thermosphere (extending from 80 km to about 600 km above the Earth's surface).[326]

Suborbital vehicle emissions and noise problems will basically depend on the engines and the kinds of designs deployed. Even if alleged to be environmental friendly, the engines designed for these vehicles cannot be totally emission free. All propellant types and different kinds of fuels contribute to environmental pollution. Even water vapor emissions have ozone depletion and climate change effects. In other words, no engine type is absolutely environmentally friendly.[327] As with aviation and launch activities and the types of pollution of suborbital flights, the extent to which negative environmental effects may occur and the altitudes at which pollution occurs will be dependent on the technical characteristics and propulsion systems designed for the engines, the kind of ascent phase (horizontal or vertical), the re-entry stage, the fuel consumed and the operational practices.[328] The vehicles operating with engines similar to those of aircraft burn different fuels and create different pollutants than do those operating with rocket engines. Regardless, to evaluate the environmental effects of suborbital flights, modeling and assessment techniques need to be developed. In measuring engine fuel efficiency, many factors, including the amount of fuel consumed per unit of traffic carried, should be assessed.[329]

Some projects have been planned based on the use of jet and rocket engines for different phases of the flights, which include 'horizontal take-off and landing', as well as

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[326] Atmospheric Layers, *supra* note 324.
[327] Ross et al, *supra* note 106 at 52.
[328] The abovementioned factors have been taken into account in different studies as the key factors influencing aviation and space activities' ground and atmospheric environment. See generally IPCC Special Report, *supra* note 179 at 10.
[329] Morrell, *supra* note 176 at 16.

the phase in which they reach space. Examples are the Virgin Galactic and EADS Astrium projects.[330] Virgin Galactic will be using air launch for its suborbital vehicle, SpaceShipTwo, through WhiteKnightTwo, a conventional aircraft with jet engines.[331] SpaceShipTwo itself will rely on a type of hybrid rocket engine, which uses a rubber compound as fuel and Nitrous Oxide as the oxidizer.[332] The EADS Astrium project, however, will be using usual jet engines for take-off and landing and a 'methane oxygen rocket engine' for reaching sub-orbit of the Earth, all engines contained in one vehicle.[333] At the other end of the spectrum are projects involving designs with 'vertical take-off and landing' and employing rocket fuels. Blue Origin's New Shepard will be powered by '90-percent hydrogen peroxide and rocket grade kerosene'.[334] Armadillo, together with Space Adventures, working on another suborbital vehicle project, is developing 'ethanol and liquid oxygen fueled engines' for its suborbital tourism flights project.[335]

The companies currently working on suborbital vehicles have introduced their projects as environmental friendly. These companies refer to the reusability of the vehicles as a feature that considerably reduces their environmental harm.[336] Virgin

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[330] The EADS Astrium project for developing a suborbital vehicle has been suspended at the moment. See Jeff Foust, "Space Tourism: A European Perspective" (July 2006) The Space Review: Essays and Commentary about the Final Frontier, online: <http://www.thespacereview.com/article/1411/1>.

[331] "Safety, The North Star", Overview of Virgin Galactic and its Project, online: Virgin Galactic <http://www.virgingalactic.com/overview/safety/>.

[332] *Ibid.*

[333] "Spaceplane—Rocketing into the Future" (25 May 2010), online: Astrium an EADS Company <http://www.astrium.eads.net/en/programme/space-plane.html>.

[334] "About Blue Origin", online: Blue Origin <http://www.blueorigin.com/about/about.html>.

[335] "Suborbital Spaceflight", Space Adventures, Vehicle Design, online: Space Adventure <http://www.spaceadventures.com/index.cfm?fuseaction=Suborbital.welcome>.

[336] "Spaceplane—Rocketing into the Future" (25 May 2010), online: Astrium an EADS Company <http://www.astrium.eads.net/en/programme/space-plane.html>; "Environment: Making Space for Earth and the Environment", Overview of Virgin Galactic and its Project, 2009-2013, online: Virgin Galactic <http://www.virgingalactic.com/overview/environment/>. In an opposite argument, reusable launch vehicles have been alleged to be more harmful to the environment: "The Space Shuttle emits several times more stratospheric emission per payload mass than the general trend for other launchers. Greater stratospheric emission for reusable launch vehicles (RLVs) compared to expendable vehicles would be

Galactic argues that the vehicle it has designed is environmentally benign for different reasons. SpaceShipTwo and its carrier, WhiteKnightTwo, are being built from carbon composites, which are light and therefore need less energy for propulsion compared to other materials.[337] Air launch itself has been introduced as a method whereby the air quality issues of ground-based launch are avoided and the time of the rockets burn the fuel is shortened.[338] In addition, SpaceShipTwo will have a hybrid motor, which burns solid fuel with liquid oxidizer, and which is alleged to be safer and less harmful to the environment than solid motors while possessing the efficiency of liquid engines.[339] Nevertheless, there are environmental activists who do not share these views. In a report on the potential environmental impacts of suborbital flights presented to the American Geophysical Union in 2012, it was estimated that emissions from a fleet of 1000 launches per year of suborbital rockets would create a persistent layer of black carbon particulates (BC)[340] in the northern stratosphere that could give rise to significant climate change as

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characteristic of RLV systems in general and so in this sense RLVs are more harmful to ozone than expendables." Ross et al, *supra* note 106 at 66.

[337] "Safety, The North Star", Overview of Virgin Galactic and its Project, online: Virgin Galactic <http://www.virgingalactic.com/overview/safety/>. ICAO in its 2007 Environmental Report also refers to the use of composites coupled with other advanced materials, systems optimizations, and new manufacturing techniques as having significant weight savings results. ICAO Environmental Report 2007, *supra* note 179 at 132.

[338] "Environment: Making Space for Earth and the Environment", Overview of Virgin Galactic and its Project, 2009-2013, online: Virgin Galactic <http://www.virgingalactic.com/overview/environment/>.

[339] There are three types of rocket propulsion: solid, liquid, and hybrid. In solid engines, fuel and the oxidizer needed for fuel combustion are in the form of solids and are mixed in a tube. Once ignited, they cannot be stopped and they have more negative impacts on the environment. Liquid engines have both the fuel and oxidizer in the form of liquid, kept in separate storage. They are safer and less environmentally harmful, but more expensive. The third type is the hybrid engine, with solid fuel and liquid oxidizer. The advantage of these types of engines is that they are controllable and can be shut down whenever needed. See generally George Paul Sutton and Oscar Biblarz, *Rocket propulsion Elements*, Eight Edition (New Jersey, United States: John Willy & Sons, 2010); "Safety, The North Star", Overview of Virgin Galactic and its Project, online: Virgin Galactic <http://www.virgingalactic.com/overview/safety/>.

[340] Black Carbon, in the Glossary of IPCC Fourth Assessment Report: Climate Change 2007, has been defined as: "Particle matter in the atmosphere that consists of soot, charcoal and/or possible light-absorbing refractory organic material. Black carbon is operationally defined matter based on measurement of light absorption and chemical reactivity and/or thermal stability." Climate Change 2007:

well as stratospheric ozone depletion.[341] This report argues that the probable effect of this amount of BC is comparable to that emitted by the world's fleet of subsonic aircraft and that the result of such an amount of BC emission could be global warming exceeding even that of the CO2 emitted by rockets.[342] While stratospheric emissions from a single suborbital rocket are minimal, with frequent operation of the vehicles, the emissions and potential atmospheric impacts could become a concern.[343] The chosen propellant for suborbital vehicles produces emissions of BC directly into the upper stratosphere; and these emissions are capable of modifying the radiative properties of the atmosphere, with larger amounts and longer lifetimes compared to those emitted from aircraft.[344] Regardless, perhaps it is not the time to talk decisively about the magnitude of the effects of BC on the environment, as long as the information about the actual amount of emissions is uncertain and based on assumptions.[345] Some other studies, on the other hand, refer to a possible increase in the emission of carbon dioxide if there is a growth of the suborbital flight industry in the future.[346] Therefore, it has been suggested that

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Mitigation of Climate Change, IPCC Fourth Assessment Report, Contribution of Working Group III Report (Cambridge: Cambridge University Press, 2007) Glossary at 810.

[341] Martin Ross, Michael Mills and Darin Toohey, "Potential Climate Impact of Black Carbon Emitted by Rockets" (December 2010) 37:24 Geophysical Research Letters 1 at 2; see also M.Z. Jacobson, "Strong radiative heating due to the mixing state of black carbon in atmospheric aerosols" (2001) 409 *Nature*, 695 at 695.

[342] Ross, Mills and Toohey, *supra* note 341 at 9-11. The unique altitude, persistence, and asymmetric nature of the rocket-produced BC soot layer have been cited as possible reasons for such results and atmospheric response. See *ibid* at 11-12; also Jacobson, *supra* note 319 at 695; Scientific Assessment of Ozone Depletion: 2010, *supra* note 236 at 25.

[343] Ross, Mills and Toohey, *supra* note 341 at 2.

[344] There are two main types of BC-emitting rocket engines, one burning kerosene and liquid oxygen and the other ("hybrid") burning solid HC (e.g. synthetic rubber or plastic) and N2O. See Ross, Mills and Toohey, *supra* note 341 at 2-3.

[345] Climate Change 2007: Mitigation of Climate Change, *supra* note 340 at 193 (Chapter 3); Makiko Sato et al, "Global atmospheric black carbon inferred from AERONET" (May 2003) 100:11 Proceedings of National Academy of Science 6319 at 6319; Jacobson, *supra* note 319 at 697.

[346] Steven Fawkes, "Space tourism and carbon dioxide emissions" Space review: Essays and Commentary about the Final Frontier, *(19 February 2007) online: Space Review <http://thespacereview.com/article/813/1>.*

suborbital flight operators should consider making the whole experience ‘carbon neutral’ to avoid criticism or opposition.[347] Nitrous oxide (N2O) and methane (CH4), other proposed propellants for suborbital projects, are also key anthropogenic greenhouse gases with negative atmospheric effects.[348]

Considering that the vertical trajectory of a suborbital vehicle extends to at least 100 km above the Earth, the potential impacts of suborbital flight on upper levels of the atmosphere, other than the troposphere and stratosphere, should also be studied and assessed. Two other atmospheric levels that can potentially be influenced by the operation of suborbital vehicles are the thermosphere and the ionosphere. These levels start around 80 km and extend to about 500-600 km above the Earth.[349] It has been argued that as a result of anthropogenic pollutions, the thermosphere is becoming less dense, and that carbon dioxide has a cooling effect on this level of the atmosphere.[350] Satellites and other space objects in the LEO will thus be dragged closer to the Earth by this level of the atmosphere. The amount of drag depends on the density of the thermosphere. If density of thermosphere changes constantly under the influence of human-caused emissions, satellite operators will need constantly to be observing and predicting the thermosphere’s changes.[351] The ionosphere could also be affected by engine emissions. Chemicals such as nitrogen oxide, carbon dioxide, and hydrogen chloride reduce the density of the electrons in the ionosphere, and this reduction could

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[347] *Ibid.*

[348] IPCC Guidelines for National Greenhouse Gas Inventories, *supra* note 184; Adler, *supra* note 187 at 5; Miller, *supra* note 176 at 701; ICAO Environmental Report 2007, *supra* note 179 at 116.

[349] William, *supra* note 174 at 27-9; Atmospheric Layers, *supra* note 302.

[350] “Climate Change Affecting Earth's Outermost Atmosphere”, The National Center for Atmospheric Research (NCAR) (December 2006) online: University Corporation for Atmospheric Research <http://www.ucar.edu/news/releases/2006/thermosphere.shtml>.

[351] *Ibid.*

change the radiowave-reflecting properties of the ionosphere and consequently distort radio communications.[352]

It seems that the negative effects of human activities on the upper levels of atmosphere, which until now have not been significantly affected by anthropogenic pollutants and particularly aviation activities, might be increased significantly by the suborbital flight industry in the future. Studying the residence time of the emitted gases and particles in the atmosphere, temperature responses, interaction of the particles and potential changes remains a challenge for future scientists. To this end, assessment and modeling techniques and concepts similar to techniques and concepts for quantification of the environmental impacts of emissions from other sources are required.[353]

4.2 Suborbital Impact

As explained in the previous sections, the proposed designs for suborbital vehicles include a trajectory that vertically extends beyond the Earth's atmosphere. When these vehicles enter space can they as possible pieces of debris cause any threat to other functional space objects? Space debris or other environmental threats to space have not been defined or sufficiently addressed in the international treaties of outer space. UN COPUOS in its space debris mitigation guidelines of 2007 has defined space debris as "man-made objects, including fragments and elements thereof, in Earth orbit or re-entering the atmosphere, that are non-functional."[354] Suborbital vehicles, like space objects, might create debris by collision or breakups. The important question will be

[352] QizHi, *supra* note 246 at 118.
[353] Assessing Climate Change, Noise and Air Quality Aviation Impacts, *supra* note 177 at v.
[354] The Space Debris Mitigation Guidelines, *supra* note 270 at 1. This is the same definition of space debris as in the IADC Guidelines; see IADC Space Debris Mitigation Guidelines, *supra* note 274 at 3-1.

whether or not the debris produced by these vehicles has the potential to cause harm to functional space objects. Suborbital activities take place in a region that is the lower part of LEO.[355] LEO is also the perfect orbit for operating satellites with high-resolution imaging functions because satellites in LEO can fly over the entire planet.[356] In fact many human space activities are conducted in LEO.[357] Debris at lower altitudes, in LEO, will eventually re-enter the Earth's atmosphere.[358] Once an object enters the measurable atmosphere, atmospheric drag will slow the orbiting object down rapidly.[359] On return, these objects either are incinerated by the atmospheric effect or they survive atmospheric re-entry and crash to Earth, which usually is the case with larger pieces of debris.[360] Considering the altitude, it does not seem probable that the debris caused by suborbital vehicles in cases of collision or breakup pose a risk to orbiting space objects. However, there are chances of collisions between these vehicles and spacecraft and objects launched into space or de-orbiting objects,[361] especially in the absence of an efficient traffic management system for space activities; and this might lead to creation of more

[355] The IADC Space Debris Mitigation Guidelines define LEO as extending from the Earth's surface up to an altitude of 2,000 km, whereas the Interagency Report on Orbital Debris, 1995, expands LEO's limits up to an altitude of 5500 kilometers above Earth. See Interagency Report on Orbital Debris, *supra* note 296 at 4.
[356] Pusey, *supra* note 149 at 426-7.
[357] Lucinda R. Roberts, "Orbital Debris: Another Pollution Problem for the International Legal Community" (1996-1997) 11 Fla. J. Int'l L. 613 at 616; Pusey, *supra* note 149 at 426-7.
[358] Unless they are reboosted, satellites in circular orbits at altitudes of 200 to 400 kilometers re-enter the atmosphere within a few months. The more mass per unit area of the object, the less the object will react to atmospheric drag. See Interagency Report on Orbital Debris, *supra* note 296 at 6.
[359] *Ibid*.
[360] Lynda Williams, "Space Ecology: The Final Frontier of Environmentalism", Natural Living Magazine 8, online: Science Entertainment <http://www.scientainment.com/spaceecology.pdf>; Interagency Report on Orbital Debris, *supra* note 296 at 6.
[361] De-orbit has been defined as "intentional changing of orbit for re-entry of a spacecraft or orbital stage into the Earth's atmosphere to eliminate the hazard it poses to other spacecraft and orbital stages, by applying a retarding force, usually via a propulsion system." IADC Space Debris Mitigation Guidelines, *supra* note 274 at 3.4.2.

debris.[362] In cases of collisions or breakups that produce debris, it should be noted that some particles could survive the atmospheric effect and crash to Earth, causing damage to people and property. In this regard, assessments and studies on risk calculation should be carried out for better imaging of the risk, its magnitude, consequences and possible mitigation mechanisms.

4.3 Regulatory Responses

4.3.1 The International Regulatory System

As a new technological innovation with unsettled associated legal issues, suborbital flights are not explicitly referred to in the current international regulatory framework.[363] To make the problem more complex, there is no clarification with respect to the boundary between airspace and outer space. Therefore, scholars try as best they can to respond to the legal concerns that may be associated with the regular operation of suborbital vehicles in future. At one end of the spectrum are scholars who try to incorporate the legal issues of these flights into the international air law regime, and at the other end are those who believe these flights should be included in the existing international regime of space law.[364] A third approach suggests applying both legal regimes in order to regulate

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[362] The other side of the problem is that, in addition to physical damages that debris may cause, there is a chance that debris could knock out suborbital vehicles. In LEO, objects travel at such rapid speeds that a piece of debris just 1 centimeter in diameter could disable a functioning satellite upon collision. Pusey, *supra* note 149 at 430.

[363] The reason for this lack of legal clarity in respect to suborbital flights might be that at the time of the drafting of the legal documents forming the framework for both aviation and space activities, large-scale commercial use of space and orbital and suborbital flights were not probable and therefore did not constitute a concern. Freeland, "Fly me to the Moon", *supra* note 12 at 90.

[364] Masson-Zwaan and Freeland in their article vote for space law as the applicable legal regime for suborbital flights: "… for the interim, we believe that the best approach would be to apply space law to the entire orbital or suborbital international flight, simply on the basis of the proposed function of the

suborbital flights, but this will obviously be accompanied by some complexities and practical hurdles.[365] The reason is that the two legal regimes are very much distinct, with fundamentally different legal principles. While the international air law regime, which is primarily defined by multilateral treaties such as the Chicago Convention, is based on the principle of the 'sovereignty' of individual states,[366] the international space law regime, with the Outer Space Treaty as the pivotal part of this regulatory regime, incorporates concepts such as 'freedom of exploration and use', 'non-appropriation', and 'Province of Mankind'.[367] In addition, there are fundamental differences in liability principles in each legal system,[368] and of course inconsistencies between the two regimes do not end there.[369] Accordingly, the present international regulatory system needs to be adapted in order to embrace the technological novelties in the fields of air and space activities.

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vehicle—namely that it involves a flight in(to) outer space." Masson-Zwaan and Freeland, *supra* note 40 at 1063; Stephen Gorove, taking a functional approach, has suggested that for objects having the aim of transportation, air law might be the competent regime: "… it may be suggested that if the aerospace object is used as an aerospace plane for the primary purpose of operating as an aircraft engaged in earthbound transportation and only incidentally reaches the fringes of outer space, air law should be applicable to it. However, it stands to reason that such objects may be expected to comply with space debris mitigation, rules of the road, and other requirements while operating briefly around the fringes of outer space." And he continues: "If the primary function of the aerospace object was to operate as a spacecraft, then air law would not be applicable to it except in situations in which the craft returns in a non-accidental situation to a non-launching state." Gorove, "Aerospace Object", *supra* note 63 at 106, 110.

[365] Jakhu, Sgobba and Dempsey, *supra* note 52 at 50; Some commentators argue that there is no need for demarcation of the air and space, and the location of the vehicle simply determines the applicable regime: "It would not be logical to apply international air law, or national, liability regimes to a spaceplane just because it happened to become involved in an accident in airspace while en route to or from outer space." Kelly, *supra* note 139 at 108.

[366] Chicago Convention, *supra* note 134 Article I.

[367] Outer Space Treaty, *supra* note 129 Articles I and II.

[368] Liability Convention has foreseen a two-fold liability system for the damages caused through space activities: absolute liability for the injuries and damages caused on the surface of Earth or to the aircrafts in flight, and fault-based liability for accidents in outer space. In contrast, the Warsaw and Montreal Conventions, founding the liability system in air law, created a fault-based limited liability system. The Rome Convention, on surface damage by foreign aircraft, provides for capped strict liability.

[369] The principles and provisions concerning registration issues, rights of flight participants, as well as airworthiness and spaceworthiness are other examples of different approaches between the two legal systems.

Still, there are provisions and principles in current treaty law that may relate to environmental protection with respect to the operation of suborbital flights. In previous sections it has been explained that the Outer Space Treaty contains a brief mention of environmental protection in Article IX, by requiring the States Parties to avoid harmful contamination of space when pursuing research and exploration of outer space.[370] Besides this insufficient reference to the preservation of outer space, the Outer Space Treaty in Article VI assumes that member States are responsible for the space activities of their nationals. This article and other provisions of the Outer Space Treaty preclude States and their nationals from following an inconsiderate and self-serving approach in their activities in outer space. In sum, States Parties are obliged to ensure that their space activities comply with the Outer Space Treaty, recognize international law as it applies to the State, and both authorize and supervise their nongovernmental activities.[371] Articles VII and VIII establish a legal basis for holding the launching states as internationally liable for damages to other states. Article VII provides that the liability is for " … the damage to another State Party to the Treaty or to its natural or juridical persons by such object or its component parts on the Earth, in air space or in outer space, including the Moon and other celestial bodies."[372] As one can see, this obligation is very general in nature, and it might therefore be possible to interpret it in a way to extend such liability to the environmental consequences of space activities.

The Liability Convention, on the other hand, defines the term 'damage' as "loss of life, personal injury or *other impairment of health*…".[373] It is not clear what kind of

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[370] Outer Space Treaty, *supra* note 129 Article IX.
[371] Ronald L. Spencer, "State Supervision of Space Activity" (2009) 63 A.F. L. Rev. 75 at 82.
[372] Outer Space Treaty, *supra* note 129 Article VII.
[373] Liability Convention, *supra* note 65 Article I.

health effects were intended by the drafters of the Convention as capable of 'impairment', but this term also seems to be general and therefore open to interpretation in a way to include the health effects directly or indirectly caused by environmental consequences of space activities. Finding the answer for this legal uncertainty will add to existing discussions over extending the Liability Convention to the damages caused by space debris. However, as has already been mentioned, it is important first to determine whether suborbital flights are considered as space activities in order for them to be covered under the current regulatory framework.

The air law regime is no clearer. Although the air law regime is quite detailed and well developed in various areas, with regulations with respect to noise and emissions,[374] it is not clear whether or not control of the emissions and possible effects of the operation of suborbital vehicles can come under this regulatory system. There is a definition of an aircraft in Annex 7 to the Chicago Convention that defines it as a machine which derives support in the atmosphere from the reactions of the air,[375] a definition that does not incorporate suborbital vehicles with the designs and characteristics proposed.[376] Therefore, it is not possible to include suborbital vehicles in the environmental regulations of air law, such as Annex 16 to the Chicago Convention, without applying necessary changes and amendments.

Further attempts to avoid leaving this nascent industry unregulated from the environmental perspective leads us to the area of international environmental law. As

[374] "The international legal regime governing air transport on issues such as liability, security, navigation, and air traffic management are well developed, and set forth in various conventions, treaties, and various 'soft law' standards." Jakhu, Sgobba and Dempsey, *supra* note 52 at 49.

[375] Annex 7 to the Convention of International Civil Aviation, *Aircraft Nationality and Registration Marks*, adopted by the International Civil Aviation Organization (ICAO) at 1.

[376] A more detailed explanation of suborbital vehicles and their features has been presented in Chapter One.

some scholars believe, legal techniques of regulating correlations between man and his environment require that environmental law be applicable not only on Earth, but also extraterrestrially and even outside the Solar System.[377] Therefore, examining the application of the international environmental law to our case, suborbital flights, might be a step in filling this legal gap.[378] There are general rules and principles that urge states to act in an environmentally conscious way when exploring the new realms of technology and science or exploiting natural resources. The Declaration of the United Nations Conference on the Human Environment, Stockholm 1972 (Stockholm Declaration) is one example.[379] This declaration asks for cessation of the discharge of toxic and other substances and of the release of heat in such quantities or concentrations as to exceed the capacity of the environment to render them harmless.[380] The Declaration goes further to assume states as responsible for ensuring that activities within their jurisdiction or control do not cause damage to the environment of other states or to areas beyond the limits of national jurisdiction.[381] The Rio Declaration on Environment and Development 1992 (Rio Declaration) repeats this emphasis on ensuring the non-harmful activities of the nationals of states to the environment of other states or beyond.[382] In addition, in order to protect the environment, Principle 15 of the Rio Declaration provides that "lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to

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[377] Mate Julesz, "Space Waste and Environmental Space Law" (2010) Jura A Pecsi Tudomanyegyetem Allam-es Karanak tudomanyos lapja (JURA) 39 at 40.

[378] There are international environmental treaties on a variety of areas that might be relevant to suborbital flights. They include conventions about protection of the atmosphere and climate change or ozone depletion effects, protection against hazardous substances or nuclear products, as well as the hostile uses of the environment.

[379] *Report of the United Nations Conference on the Human Environment,* U.N. Conference on the Human Environment, U.N. Doc.A/Conf.48/14/Rev. 1 (1972) [Stockholm Declaration].

[380] *Ibid* at Principle 6.

[381] *Ibid* at Principle 21.

[382] Rio Declaration, *supra* note 174 at Principle 2.

prevent environmental degradation"; it therefore calls for a 'precautionary approach' to be taken by states where there are threats of serious or irreversible damage.[383] This approach is an expansion of 'preventive approach' according to which it is argued that prevention is always better than employing measures to restore the environment.[384] The 'precautionary principle' is based on the idea that environmental matters should be taken into consideration even if there is a lack of certainty.[385] According to environmental legal experts, the precautionary principle is one of the founding principles of international environmental law and thus needs to be taken into account by states.[386]

In addition to the cited declarations, which constitute an important part of international environmental law, there have been other international efforts to address the environmental concerns of the international community. Agenda 21, which was adopted by the same United Nations Conference on Environment and Development of 1992 that adopted the Rio Declaration, refers to the commitment of states to environmentally sound management of chemicals and encourages conducting transparent risk assessments and management procedures.[387] Ten years later, the Johannesburg Declaration on Sustainable Development again put emphasis on mutual efforts for environmental protection and considered environmental protection as one of the three pillars of sustainable

[383] Rio Declaration, *supra* note 174 at Principle 15.
[384] Elli Louka, *International Environmental Law, Fairness, Effectiveness, and World Order* (New York: Cambridge University Press, 2006) at 50.
[385] *Ibid*; Simon Marsden, *Strategic Environmental Assessments in International and European Law: A Practitioner's Guide*, (London, UK: Earthscan, 2008) at 52.
[386] Fitzmaurice, *supra* note 174 at 1-10. There is still a controversy with respect to this principle and its status in international environmental law. See Louka, *supra* note 384 at 50-51; Marsden, *supra* note 385 at 52.
[387] *Agenda 21*, U.N. Conference on Environment and Development, Rio de Janeiro, A/CONF.151/26 (Vol. I-III) (5 June 1992).

development.[388] As explained in previous sections, the possible negative effects from suborbital vehicles, unless the operation of them is very frequent, will be minimal. On the other hand, the abovementioned international declarations are not binding and do not have the enforceability of treaty law.[389] However, it is argued that the obligation not to cause environmental harm is arguably a principle of international customary law and therefore binding.[390] The international environmental obligations of states with respect to suborbital flights have yet to be further clarified and defined.

4.3.2 National Regulatory System

Since currently there is not a uniform comprehensive international regime in place to regulate suborbital flights, each country has the sovereign right to regulate human suborbital flights operating within its airspace.[391] In order to control the emissions of engines, there are mandatory requirements and standards adopted for engine licenses and certifications necessary for the operation of aircraft and spacecraft.[392] These regulations

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388 *Johannesburg Declaration on Sustainable Development,* World Summit on Sustainable Development, U.N. Doc. A/CONF.199/20 (4 September 2004).

389 The accepted sources of international law are those envisaged in Article 38 of the Statute of the International Court of Justice; they include:

> a. international conventions, whether general or particular, establishing rules expressly recognized by the contesting states;
>
> b. international custom, as evidence of a general practice accepted as law;
>
> c. the general principles of law recognized by civilized nations;
>
> d. subject to the provisions of Article 59, judicial decisions and the teachings of the most highly qualified publicists of the various nations, as subsidiary means for the determination of rules of law.

Statute of the International Court of Justice, 3 Bevans 1179; 59 Stat. 1031; T.S. 993; 39 AJIL Supp. 215 (1945) (entered into force 24 October 1945).

390 David Hunter, James Salzman and Durwood Zaelke, *International Environmental Law and Policy*, 3rd ed. (New York: Foundation Press, 2007) at 502.

391 Masson-Zwaan and Moro-Aguilar, “Practical Solutions”, *supra* note 53 at 1.

392 IPCC Special Report, *supra* note 179 at 11.

are adopted to serve aims such as protection of public health, safety, compliance with international obligations of countries, etc. Licensing is carried out under national regulatory procedures and varies from country to country. Currently, the only country that has adopted specific regulations related to reusable launch vehicles is the United States. Other countries, if they are developing suborbital vehicles that are ready to start experimental flights or regular operation, will need to decide whether they should pass laws specifically designed to regulate such vehicles, or if they can incorporate them into their existing national regulations on aviation or space activities. For Europe, the Treaty of the European Union[393] allows for development of common policies among member states of the EU in all sectors of transport, including aviation, and some directors and organizations, such as the European Aviation Safety Agency (EASA), have been developed with this aim in view.[394] Therefore, it is argued that it is possible to incorporate suborbital flights in these regulations that are already in place, but of course with the necessary changes; and consequently, EASA will have the mandate to regulate suborbital flight activities.[395] ESA, the European authority for regulating space activities, and EASA, responsible for regulating the safety and environmental aspects of aviation, both have considered suborbital flights under the category of aviation.[396] The European Union, however, has not yet taken any position on this matter. Depending on whether suborbital flights are considered aviation or space activities, the EU will have different

[393] Treaty on the Functioning of the European Union (TFEU).O.J. C. 115/47 (2008).
[394] Jean-Bruno Marciacq et al, "Accommodating Sub-Orbital Flights into the EASA Regulatory System", Proceedings of 3d IAASS Conference—Building a Safer Space Together, Rome, Italy 21-23 October 2008 (ESA SP-662, January 2009) at 1.
[395] *Ibid.*
[396] Masson-Zwaan and Moro-Aguilar, "Practical Solutions", *supra* note 53 at 1, 11.

competencies on the respective flights.[397] As for transportation, to which aviation belongs, the EU has been vested with the regulatory competence to regulate the industry, and EU's initiative in regulating pre-empts the Member States from exercising their own competence. On the other hand, the EU's competence co-exists with Member States competence on space activity issues, which will result in different outcomes.[398] The closer the date of operation of suborbital vehicles with the involvement of the EU and its member states approaches, the more urgent the need for a regulatory response from the European countries will be. Chances are that the authority to regulate suborbital flights in Europe will be vested in EASA, which follows Commission Regulation (EC) No 748/2012 and its subsequent amendments in verifying the compliance of aircraft with safety and environmental protection requirements.[399] However, it has also been suggested that EASA's role ceases when a suborbital vehicle enters outer space, and that it thus does not extend to the entire flight.[400]

4.3.2.1 U.S. Law: The U.S., instead, being heavily involved in space-related activities, has taken an active role in promulgating national regulations with respect to space tourism and the launch industry. In the U.S., the Commercial Space Launch Act of 2004[401] granted the Department of Transportation (DOT) the authority to oversee, license and regulate commercial launch activities and the operation of launch sites carried out by U.S. citizens or within U.S. territory, and this responsibility is exerted through the

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[397] Masson-Zwaan, *supra* note 123 at 267-8.

[398] *Ibid.*

[399] Commission Regulation (EU) No 748/2012 of 3 August 2012, which replaces Commission Regulation (EC) No 1702/2003 of 24/09/2003, lays down implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production; Marciacq et al, *supra* note 394 at 1.

[400] *Ibid* at 9; Masson-Zwaan and Moro-Aguilar, "Practical Solutions", *supra* note 53 at 14.

[401] This Act is the re-codified version of 49 U.S.C. Subtitle IX, ch. 701, the Commercial Space Launch Act of 1984.

Associate Administrator for Commercial Space Transportation of the Federal Aviation Administration (FAA/AST) of DOT.[402] FAA/AST imposes its delegated responsibilities by issuing commercial space transportation licenses or experimental permits, for which necessary requirements have to be fulfilled.[403] But how are the environmental impacts of reusable launch vehicles dealt with in the U.S. regulatory system? The National Environmental Policy Act of 1969 (NEPA), is part of U.S. environmental law, which requires federal agencies to integrate environmental values into their decision-making processes by considering the environmental impacts of their proposed projects and reasonable alternatives to those actions.[404] Section 102(2)(C) requires detailed analysis for proposed 'major Federal actions'[405] that significantly affect the quality of the human environment.[406] To this end there is a detailed statement known as an Environmental Impact Statement (EIS) which is prepared by the agency involved in the proposed project.[407] The FAA and the licensing of new space technologies are not an exception. The reason is that licensed launches constitute a major Federal action; and under NEPA,

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[402] *Commercial Space Launch Activities*, 49 U.S.C. §§ 70101-70121 (2000 & Supp. V 2006).

[403] *Licenses, Permits & Approvals*, Office of Commercial Space Transportation, U.S. Federal Aviation Administration (FAA), online: FAA <http://www.faa.gov/about/office_org/headquarters_offices/ast/licenses_permits/>.

[404] The purpose of this Act is "to declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation; and to establish a Council on Environmental Quality." *National Environmental Policy Act of 1969* (NEPA), 42 U.S.C. 4321 et seq., Congressional Declaration of Purpose.

[405] In the Terminology and Index of Regulations for Implementing NEPA, "major federal action" is defined as including "actions with effects that may be major and which are potentially subject to Federal control and responsibility. Major reinforces but does not have a meaning independent of significantly (Sec. 1508.27). Actions include the circumstance where the responsible officials fail to act and that failure to act is reviewable by courts or administrative tribunals under the Administrative Procedure Act or other applicable law as agency action". See the Council on Environmental Quality (CEQ), the Procedural Provisions of NEPA (40 CFR Part 1508).

[406] NEPA, 42 U.S.C. 4321 et seq., Sec. 102(2) (C).

[407] "National Environmental Policy Act", U.S. Environmental Protection Agency, online: <http://www.epa.gov/compliance/nepa/>.

major federal activities are required to be examined concerning their potential environmental impacts.[408] In fact, the FAA is responsible for "analyzing the environmental impacts associated with licensing proposed commercial launches or proposed commercial launch sites."[409] The environmental documents that NEPA requires as part of the review process include Environmental Assessments (EAs), Environmental Impact Statements (EISs), Finding of No Significant Impact (FONSIs) and Categorical Exclusions (CATEXs).[410] AST, in addition to NEPA, needs to comply with The Council on Environmental Quality (CEQ) Regulations for Implementing NEPA,[411] FAA Environmental Impacts: Policies and Procedures,[412] Executive Order 12114, Environmental Effects Abroad of Major Federal Actions, and other related environmental laws, regulations and orders applicable to FAA actions.[413] Executive Order 12114 requires the FAA to consider the environmental effects of major Federal actions outside

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408 NEPA, 42 U.S.C. 4321 et seq.; see also *Environmental Review for Licensed/Permitted Commercial Space Transportation Activities*, Office of Commercial Space Transportation, U.S. Federal Aviation Administration (FAA), online: FAA <http://www.faa.gov/about/office_org/headquarters_offices/ast/environmental/review/>.

409 *Guidelines for Compliance With the National Environmental Policy Act and Related Environmental Review Statutes for the Licensing of Commercial Launches and Launch Sites*, Revised by the Office of the Associate Administrator for Commercial Space Transportation, U.S. Federal Aviation Administration, Department of Transportation (22 February 2001).

410 NEPA, 42 U.S.C. 4321 et seq.; *Order 1050.1E: Environmental Impacts: Policies and Procedures*, U.S. Department of Transportation, FAA Order 1050, Change 1, Washington DC (Effective Date: March 20, 2006) at 201, 201(b). With respect to the Categorical Exemptions the Act states: "Agency procedure under Section 2-1 may provide for categorical exclusions and for such exemptions in addition to those specified in subsection (a) of this Section as may be necessary to meet emergency circumstances, situations involving exceptional foreign policy and national security sensitivities and other such special circumstances. In utilizing such additional exemptions agencies shall, as soon as feasible, consult with the Department of State and the Council on Environmental Quality." There are also other documents, such as the Proposal or Notice of Action, which are applicable to the environmental assessment required when issuing launch licenses and permits.

411 The Council on Environmental Quality (CEQ), the Procedural Provisions of NEPA (40 CFR Part 1508).

412 Order 1050.1E, *supra* note 388. As explained in the Order itself, Order 1050.1E supplements CEQ Regulations by applying them to FAA programs.

413 *Environmental Review for Licensed/Permitted Commercial Space Transportation Activities*, Office of Commercial Space Transportation, U.S. Federal Aviation Administration (FAA), online: FAA <http://www.faa.gov/about/office_org/headquarters_offices/ast/environmental/review/>.

the geographical borders of the United States and its territories that could significantly affect the environment of the 'global commons' beyond the jurisdiction of any nation, or that could affect a foreign nation in certain cases of a major federal action abroad.[414] This Executive Order provides strong support for environmental regulation of space activities, which can be considered part of the 'global commons' protected by the Executive.[415]

After the FAA environmental requirements are met and all the information and documents needed are provided, an AST official determines the environmental impacts of a proposal either by issuing a FONSI or a Record of Decision (ROD), which is a public record of a decision indicating final approval of a proposed action analyzed in an EIS.[416] This decision will form part of the license or experimental permit evaluation.[417]

The United States, as is evident from all the rules and regulations, has a comprehensive regulatory system with respect to environmental protection in different fields, including launch activities. Suborbital vehicles are classified as launch vehicles in U.S. law; and therefore they are licensed or permitted by the same governmental office that approves licenses and permits for other launch vehicles, reusable or expendable, which means FAA/AST.[418] Similar to other launch activities, environmental analysis and assessments are part of the licensing or permission process for suborbital vehicles. In

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[414] *Executive Order 12114: Environmental Effects Abroad of Major Federal Actions*, President Jimmy Carter, January 4 1979 (Ex. Or. No. 12114 of Jan. 4, 1979, 44 Fed. Reg. 1957).
[415] David Enrico Reibel, "Environmental Regulation of Space Activity: The Case of Orbital Debris" (1991) 10 Stanford Envtl. L. J. 97 at 128-9.
[416] Order 1050.1E, *supra* note 388 at 201d.
[417] *Environmental Review for Licensed/Permitted Commercial Space Transportation Activities*, Office of Commercial Space Transportation, U.S. Federal Aviation Administration (FAA), online: FAA <http://www.faa.gov/about/office_org/headquarters_offices/ast/environmental/review/>.
[418] *Launch or Re-entry Vehicles, Reusable*, Office of Commercial Space Transportation, U.S. Federal Aviation Administration (FAA), online: <http://www.faa.gov/about/office_org/headquarters_offices/ast/licenses_permits/launch_reentry/#reusable>.

May 2012, the FAA issued its final environmental assessment for the launch and reentry of the SpaceShipTwo and WhiteKnightTwo carrier aircraft at the Mojave Air and Space Port.[419] A similar assessment was issued in November 2011 for the experimental assessment of SpaceX concerning the operation of its vehicle, Grasshopper, the purpose of which was to conduct suborbital launches and landings.[420] In both cases, the FAA determined that issuing experimental permits and/or launch licenses to operate the proposed vehicles would not significantly impact the quality of the human environment; and, therefore, preparation of an Environmental Impact Statement was not required. The FAA issued FONSIs, with EAs incorporated by reference into the FONSIs.[421] The areas on which the inquiry on probable environmental consequences in these assessments were carried out have been as broad as air quality; biological resources; hazardous materials, pollution prevention, and solid waste; historical, architectural, archaeological, and cultural resources; land use; noise and compatible land use; light emissions and visual resources; natural resources and energy supply; socioeconomics, environmental justice, and children's environmental health and safety; and water resources.[422] In the case of SpaceShipTwo, the FAA by using its emission modeling systems has examined the emissions from SpaceShipTwo, WhiteKnightTwo and the support aircrafts involved in

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419 *Final Environmental Assessment for the Launch and Reentry of SpaceShipTwo Reusable Suborbital Rockets at the Mojave Air and Space Port*, U.S. Federal Aviation Administration (May 2012).
420 *Final Environmental Assessment for Issuing an Experimental Permit to SpaceX for Operation of the Grasshopper Vehicle at the McGregor Test Site, Texas*, U.S. Federal Aviation Administration (November 2011).
421 *Ibid*; *Final Environmental Assessment for the Launch and Reentry of SpaceShipTwo Reusable Suborbital Rockets at the Mojave Air and Space Port*, U.S. Federal Aviation Administration (May 2012).
422 *Ibid*; *Final Environmental Assessment for Issuing an Experimental Permit to SpaceX for Operation of the Grasshopper Vehicle at the McGregor Test Site, Texas*, U.S. Federal Aviation Administration (November 2011).

the flights, in both the lower and upper atmosphere.[423] It was concluded that the emissions from operations of WhiteKnightTwo, the support aircraft and SpaceShipTwo in the upper atmosphere could affect global climate change, but the total amount of emissions was a very small fraction of national and global emissions, and the adverse impacts would be negligible.[424] Such was also the case with the noise issue. Noises produced by SpaceShipTwo, WhiteKnightTwo and the support aircrafts were estimated to be insignificant and therefore would not be a concern at the time.[425] Similar examinations were carried out for experimental assessment of Grasshopper, and they likewise led to the conclusion that the environmental impacts of launching and landing Grasshopper would be negligible.[426]

As explained, the FAA is also responsible for licensing launch sites. In 2006, this Administration issued an environmental assessment for the experimental permits/licenses of a private launch site proposed by Blue Origin to launch reusable launch vehicles on suborbital, ballistic trajectories to altitudes in excess of 99,060 meters.[427] These are the sole national regulations the country has promulgated for regulating different aspects of suborbital flights, including environmental impacts, which, considering the U.S.'s leading role in commercial space activities, is no surprise. However, only time will determine the extent to which the procedures in place and the regulatory system of U.S. can address the environmental concerns about the frequent operation of suborbital vehicles. Many years

[423] *Final Environmental Assessment for the Launch and Reentry of SpaceShipTwo Reusable Suborbital Rockets at the Mojave Air and Space Port*, U.S. Federal Aviation Administration (May 2012) at 26-32.
[424] *Ibid* at 30.
[425] *Ibid* at 38-39.
[426] *Final Environmental Assessment for Issuing an Experimental Permit to SpaceX for Operation of the Grasshopper Vehicle at the McGregor Test Site, Texas*, U.S. Federal Aviation Administration (November 2011).
[427] *Blue Origin West Texas Proposed Launch Site Final Environmental Assessment*, Department of Transportation Federal Aviation Administration Office of Commercial Space Transportation (August 2006).

of suborbital flights will have to pass and data and statistics will have to be collected in order to develop a comprehensive and efficient regulatory system for these flights.

4.3.3 Inefficiency of the 'Air-or-space Approach' in Addressing Environmental Concerns

In the absence of a regulatory system specifically developed to regulate different aspects of suborbital flights, some scholars have tried to choose one of the air or space legal regimes as competent to regulate this emergent technology. We assume that choosing one of the two regimes to regulate suborbital flights might not be the best approach, at least when it comes to the protection of environment. Considering the trajectory in a suborbital flight that extends from surface of the Earth to outer space, a suborbital vehicle might have environmental impacts on the surface of the Earth, on different levels of the atmosphere, and finally on outer space; one example is the creation of a piece of debris that falls back to Earth, causing environmental damage. This means that traces of suborbital human flight activities could probably be found in both the air and space law regimes. Therefore, from the environmental point of view, it might not be practical and efficient to try to apply regulations of one of the systems to the entire journey. Also, it has been argued that insofar as the trajectories of these vehicles are purely vertical and they do not intend to cross any international frontiers, the activity is not international and could be regulated solely through national legal systems.[428] This might not be true, however, in relation to protection of the environment. The reason is that in terms of international law, air and outer space are shared and common sources among states, and

[428] Masson-Zwaan and Moro-Aguilar, "Practical Solutions", *supra* note 53 at 3.

suborbital vehicles are associated with transboundary environmental pollution.[429] Avoiding transboundary pollution is a rule which stipulates that one State cannot allow activities under its jurisdiction or control to harm the environment of a neighboring country or areas beyond national jurisdiction.[430] Some of the environmental effects that might arise from operation of the suborbital flights, such as climate change, are global environmental threats, and countries are responsible for avoiding them. The obligation to avoid transboundary pollution is allegedly part of customary international law.[431] Thus according to some scholarly comments:

> One of the well-recognized principles of customary international law included for example, in many international environmental law conventions, is the prohibition against trans-boundary harm, meaning a State cannot allow its territory to be used in a manner which causes injury to another State. As is the case with many general principles of customary international law, the prohibition against trans-boundary harm is significantly broader than individual conventions, environmentally-based or otherwise, that may incorporate it.[432]

The international community is based on cooperation; and when there is a threat that involves more than one state, it is important to find an international solution to the problem that will serve the interests of all. In other words, what concerns all must be approved by all: *Caveat humana dominandi, quod omnes tangit ab omnes approbatur.* Having a similar ideology, the Stockholm Declaration provides that "International matters concerning the protection and improvement of the environment should be

[429] Louka, *supra* note 384 at 90.
[430] Hunter, Salzman and Zaelke, *supra* note 390 at 539.
[431] *Ibid.*
[432] Jakhu, Sgobba and Dempsey, *supra* note 52 at 47. On the issue of transboundary air pollution there is one international convention, the Convention on Long-Range Transboundary Air Pollution, concluded in 1979, with four protocols added to it. See *Convention on Long-Range Transboundary Air Pollution* (CLRTAP), TIAS 10541; 1302 UNTS 217; 18 ILM 1442 (1979).

handled in a cooperative spirit by all countries, big and small, on an equal footing."[433] Eventually, the frequent operation of suborbital vehicles will bring about the need for states to engage in such efforts at the international level.

What is clear is the fact that the law needs to adapt itself to current and emerging technological innovations, and that environmental law, specifically, must be innovative and adaptable to science, with respect to both the terrestrial environment and other parts of the universe.[434] In regulating the negative anthropogenic effects of suborbital flights on the environment, it is important to consider two criteria. First, in regulating the effects of these flights, especially regarding operational or technology-related abatement measures, there should be a balance of considerations among many factors. For example, the regulator needs to balance between controlling noise and emissions, on the one hand, and reliability and safety standards, on the other.[435] Second, the growth of this nascent industry should not be impeded by too many regulatory actions. Both aviation and space activities contribute to anthropogenic pollution; but if they are under cumbersome and more-than-necessary regulatory controls, they may not be able to develop and flourish. The current projects for suborbital flights include entertainment and tourism. However, they are also proposed for purposes of transportation in the future. Even more importantly, considering their altitude and the microgravity experience they offer, these flights have the potential to contribute to scientific research.[436] These research possibilities include spectroscopic measurements of the stars and other benefits from a

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[433] Stockholm Declaration, *supra* note 379 at Principle 24.

[434] *Julesz*, *supra* note 355 at 40.

[435] This is the same challenge the regulators of aviation and space activities face. For example, see Miller, *supra* note 176 at 724.

[436] Katherine Sanderson, "Science lines up for a seat to space" (2010) 436 *Nature: International Weekly Journal of Science*, 463, at 716-717, online: Nature <http://www.nature.com/news/2010/100210/full/463716a.html>.

suborbital trip with a telescope on board, monitoring the human body's response to changes in gravity and other biological and human physiology types of research and physics experiments, as well as the opportunity for the space object developers to test the technical aspects of their plans or even to launch objects such as satellites from high altitudes.[437] Virgin Galactic argues that the flights offered by SpaceShipTwo will open up access to an area previously known as the 'ignosphere', and that this will enable scientists to carry out research on climate change and other negative anthropogenic effects at an altitude that was not possible previously.[438] Therefore, it is important to help an industry with good potential for serving human beings by enacting efficient and inclusive but not burdensome and unnecessary regulations.

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[437] *Ibid.*

[438] "Environment: Making Space for Earth and the Environment", Overview of Virgin Galactic and Its Project, 2009-2013, online: Virgin Galactic <http://www.virgingalactic.com/overview/environment/>.

CHAPTER THREE

Suborbital Vehicles and the Rules of Traffic Management

> "Laid out on the drawing boards of aircraft manufacturers and futurists are spacecraft that one day will carry passengers into the upper airspace and eventually into outer space. When that day comes, and it may not be that far away, real issues will need to be addressed by government regulators."[439]
>
> *Dr. Assad Kotaite*

1. **Introduction to the Chapter**:

The first human flight was performed more than one hundred years ago, when no one could foresee that one day it would become such an important mode of transportation. Considering its potential for facilitating communications and national defense as well as participating in economic development, the air transportation industry has been growing and expanding ever since.[440] The growth of aviation as a mode of transportation stimulated regulators to think of practices and techniques to ensure the safe, orderly and expeditious flow of traffic. Regulations and procedures developed with respect to air navigation and traffic management have been an important part of such efforts. Today, air navigation, traffic management and their respective services are an indispensable part of aviation. Although the suborbital flight industry, if we can call it such, is taking its very first steps, ensuring safety and efficiency through navigation and traffic management services is a concern which needs to be addressed. This chapter reviews the traffic

[439] Assad Kotaite, "Space for New Regulations", (March-April 2001) Flight Safety Australia, at 58.
[440] Dempsey, *supra* note 125 at 1-2.

management services in general and specifically in regard to suborbital flights as well as the possible integration of such flights into the existing regulatory frameworks.

2. Air Traffic Management and Its Functions

Air traffic management systems are used for the guidance, separation, coordination and control of the aircraft movements.[441] Traffic control is a critical element in the safe and efficient operation of any transportation system. The first attempt to develop air traffic control rules can be traced to 1919 when the International Commission on Air Navigation (ICAN), which was the forerunner of ICAO, was created.[442] Today, air traffic management ensures the safety, regularity and efficiency of the aviation transport system as well as protection of the environment against dangers aviation activities may create against it.[443] Air traffic management can be defined as "the aggregation of the airborne functions and ground-based functions (air traffic services, airspace management and air traffic flow management), required to ensure the safe and efficient movement of aircraft during all phases of operations."[444]

Air traffic management (ATM) consists of both ground and air parts.[445] In fact, ATM is composed of a number of complementary systems: airspace management, air traffic

[441] IPCC Special Report, *supra* note 179 at 11.
[442] Jim Cistone, "Next Century Aerospace Traffic Management: The Sky is No Longer the Limit" (January–February 2004) 41:1 Journal of Aircraft 36 at 36.
[443] Bill Siuru, "Air traffic management moves into the 21st century" (January 1997) 68:1 Electronics Now 43 at 43;
Vaidotas Kondroška and Jonas Stankūnas, "Formation of Methodology to Model Regional Airspace with Reference to Traffic Flows" (2012) 16:3 Aviation 69 at 70.
[444] *Global Air Navigation Plan for CNS/ATM Systems*, International Civil Aviation Organization Doc 9750 AN/963 (Second Edition — 2002) at 1-4-1.
[445] Dempsey, *supra* note 125 at 165.

flow and capacity management (ATFCM) and air traffic control (ATC).[446] It comprises the interactions among the different elements, including human operators, procedures and the technical systems that all together form the air traffic management system.[447] The services provided by the air traffic management system are integrated, and it is through this integrity that the system properly functions.[448] ATM generally affects three areas: (1) safety, (2) efficiency and (3) environmental mitigation. Each area will be discussed separately below.

2.1 Safety

Like other modes of traffic, air traffic requires navigational rules to ensure safety.[449] Perhaps it can be claimed that one of the most important reasons for the emergence of the air traffic management services is collision avoidance and ensuring safety during all the different stages of the flight by establishing adequate separation between vehicles.[450] Correspondingly, Annex 11 to the Chicago Convention expressly provides that the primary objective of air traffic services is to "prevent collision between aircrafts" in all steps of the flight.[451] It is all about the processes, procedures and resources which come

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446 *What Is Air Traffic Management*, Eurocontrol, Media and Info Center, online: Eurocontrol<http://www.eurocontrol.int/articles/what-air-traffic-management>.

447 H.A.P. Blom et al, "Accident Risk Assessment for Advanced Air Traffic Management" (2001) Report of the National Aerospace Laboratory NLR, The Netherlands, at 5; *What is Air Traffic Management*, Eurocontrol, Media and Info Center, online: Eurocontrol<http://www.eurocontrol.int/articles/what-air-traffic-management>.

448 *Global Air Traffic Management Operational Concepts*, International Civil Aviation Organization, Doc 9854 AN/458 (First Edition, 2005) at 2-1.

449 Jiefang Huang, *Aviation Safety through the Rule of Law, ICAO's Mechanisms and Practices* (The Netherlands: Kluwer Law International, 2009) at 47.

450 "By now, safety is recognised as a key quality on which to select/design advanced air traffic management (ATM) concepts, even when capacity and efficiency are the drivers of the development." Blom et al, *supra* note 447 at 5; Ruwantissa Abeyratne, *Air Navigation Law* (Berlin: Springer, 2012) at 9.

451 Annex 11 to the Convention of International Civil Aviation, *Air Traffic Services*, adopted by International Civil Aviation Organization (ICAO).

into play to make sure that aircrafts "are safely guided" from the time they are still on the ground to takeoff, flight and landing.[452] The ICAO Air Navigation Commission (ANC) defines safety as the "state of freedom from unacceptable risk of injury to persons or damage to aircraft and property."[453] This definition indicates the wide range of risks that need to be avoided and controlled to protect the aircraft itself as well as other vehicles in flight, people and property. Some even define safety as not only comprising the procedures for accident prevention, but also as a concept which can be broadly considered 'risk management'.[454] The responsibility of the ATM system to ensure safety is divided into three controlled airspaces—airport, terminal, and en route—and it is done through complex interactions between multiple human operators, procedures and technical systems.[455] It is difficult to imagine that the considerable growth of the aviation industry would have occurred without air traffic management services. Safety undoubtedly will remain the highest priority in aviation.[456]

2.2 Efficiency

Another objective of a proper air traffic management system is the orderly and expeditious flow of air traffic. This goal has been clarified in Annex 11 to the Chicago Convention.[457] Air traffic management systems, and particularly airspace organization, play a key role in optimizing the use of airspace and the efficiency of flight trajectories

[452] *What is Air Traffic Management*, Eurocontrol, Media and Info Center, online: Eurocontrol<http://www.eurocontrol.int/articles/what-air-traffic-management>; Siuru, *supra* note 443 at 1.
[453] ICAO Working Paper AN-WP/7699, *Determination of a Definition of Aviation Safety* (11 December 2001) at 2.2.
[454] Huang, *supra* note 449 at 6; Blom et al, *supra* note 447 at 5.
[455] *Ibid*; Siuru, *supra* note 443 at 1.
[456] Global Air Traffic Management Operational Concepts, *supra* note 448 at F-1.
[457] Annex 11 to the Convention of International Civil Aviation, *Air Traffic Services*, adopted by International Civil Aviation Organization (ICAO).

and regularity.[458] "The effectiveness of air transport operations is determined by both a reduction in the costs of every airspace user and the efficiency of the air traffic management system."[459] The result of an organized and properly operated air traffic management system is straighter routes of flights and shorter delays, which give rise to better service and less cost for the aviation industry.[460] Aviation is a dynamic and rapidly changing field. In order to provide the best possible service, improvements in the methodologies and technologies related to air traffic management and air navigation services are constantly being developed in an attempt to fulfill the needs caused by the rapid growth of the industry.[461] In addition to safety, 'efficiency and optimization of the use of airspace' is the ultimate goal of developing a well-organized traffic management system. Perhaps for this reason it is suggested that the ATM system be designed in such a way that is "inherently safe" at "the capacity-level required".[462]

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[458] Vaidotas Kondroška and Jonas Stankūnas, "Analysis of Airspace Organization Considering Air Traffic Flows" (2012) 27:3 Transport 219 at 219 [hereinafter Kondroška and Stankūnas, "Analysis of Airspace Organization"]. The main function of airspace organization is to provide the strategies, rules and procedures by which the airspace will be structured to accommodate the different types of air activity, volume of traffic, and differing levels of services and rules of conduct. See Global Air Traffic Management Operational Concepts, *supra* note 448 at 2-5.

[459] Kondroška and Stankūnas, "Analysis of Airspace Organization", *supra* note 458 at 219.

[460] *Ibid* at 220-1.

[461] *Ibid* at 220.

[462] Blom et al, *supra* note 447 at 6.

2.3 Environmental Mitigation and Sustainability

Ensuring the sustainability of the airspace that aircrafts share has been a concern for environmental activists for the last few decades. One of the strategies to reduce the adverse effects of aviation on the environment is operational measures, one of which can be accomplished through improvement of air traffic management services. "The most important fuel saving opportunities come from ATM systems that permit more direct routings and the use of more efficient conditions such as optimum altitude and speed. Shortening routes can indeed significantly reduce CO2 emissions."[463] ATM and other operational procedures, reportedly, can reduce aviation fuel burn between 8% and 18%.[464] However, fuel efficiency through ATM operational procedures requires that institutional and regulatory arrangements be applied at both the national and international levels. Operational measures are considered an effective and quantifiable means of minimizing aircraft emissions, with near-term results.[465] Therefore, the contribution of ATM systems to the protection of the environment, both in the implementation and operation of the global ATM system and the global air navigation plan, is encouraged.

In May 2007, aware of the importance of the air navigation service contribution to mitigating the impact of aviation on the environment, the Civil Air Navigation Services Organization (CANSO) adopted a voluntary code of conduct that establishes a framework within which air navigation service providers can seek to offset the environmental impacts of growth through their own initiatives and collaboration with other industry stakeholders.[466] These efforts, together with the initiatives of ICAO for

[463] ICAO Environmental Report 2007, *supra* note 179 at 108.
[464] IPCC Special Report, *supra* note 179 at 11.
[465] ICAO Environmental Report 2007, *supra* note 179 at 139.
[466] *Ibid* at 138.

improving the global ATM systems, are steps towards the environmentally sustainable use of airspace.

3. Regulating Air Traffic Management

With the ever-expanding growth of the aviation industry, regulators realized the importance of developing air traffic management standards and regulations, harmonization of the standards and, later, regular revisions and amendments of those regulations.[467] Today, air traffic management services in national airspace are usually provided and supervised nationally, with international standardization and coordination provided by ICAO.[468] Since civil aviation is international by its nature,[469] ICAO has taken the lead in standardization and regulation of air traffic management in order to ensure that flying on international air routes is carried out under uniform conditions and is safe and orderly. Article 28 of the Chicago Convention provides:

> Each contracting State undertakes, so far as it may find practicable, to:
>
> (a) Provide, in its territory, airports, radio services, meteorological services and other air navigation facilities to facilitate international air navigation, in accordance with the standards and practices recommended or established from time to time, pursuant to this Convention;
>
> (b) Adopt and put into operation the appropriate standard systems of communications procedure, codes, markings, signals, lighting and other operational practices and rules

[467] David Rubalcaba, "Unrestricted global mobility through Global Air Traffic Management" (May 1997) 6:3 Mobility Forum 18 at 18-21.
[468] Dempsey, *supra* note 125 at 165.
[469] Huang, *supra* note 449 at 8.

which may be recommended or established from time to time, pursuant to this Convention;

(c) Collaborate in international measures to secure the publication of aeronautical maps and charts in accordance with standards which may be recommended or established from time to time, pursuant to this Convention.

As is clear from Article 28, states are 'responsible' for providing air navigation facilities and standard systems.[470] There are numerous articles of the Chicago Convention that address air navigation, air traffic and related issues.[471] ICAO, which develops regulations dealing with different aspects of aviation mainly through adopting annexes to the Chicago Convention and international standards and recommended practices and procedures (SARPs) thereto, has adopted annexes specifically dealing with standardization of air traffic management and navigation, namely Annex 2 (Rules of Air) and Annex 11 (Air Traffic Services).[472] These provisions together with other ICAO documents[473] provide air transportation with a comprehensive and detailed set of regulations and standards for air navigation and traffic management.[474] ICAO's framework for standards and provisions of air traffic management services govern the conduct of both service providers (including providers of elements of the services, such

[470] Francis Schubert, "An Introduction to Air Navigation Services: From Conventional Air Traffic Control to CNS/ATM" presentation delivered at McGill University LLM program in air and space law, November 2011.
[471] They include Articles 1, 3*bis*, 5, 8, 9, 11, 12, 15, 22, 25, 26, 28, 44, 68, 70, 71, and 74.
[472] Other provisions relevant to air traffic management and air navigation can be found in Annex 3 (Meteorological Service for International Air Navigation), Annex 4 (Aeronautical Charts), Annex 5 (Units of Measurement), Annex 6 (Operation of Aircraft), Annex 10 (Aeronautical Telecommunication), and Annex 15 (Aeronautical Information Services).
[473] Such as *PANS: Air Traffic Management* (PANS-ATM), International Civil Aviation Organization, Doc 4444 ATM/501 (Fifteenth Edition, 2007), and *Regional Supplementary Procedures*, International Civil Aviation Organization, Doc 7030 (Fifth Edition, 2008).
[474] See Jakhu, Sgobba and Dempsey, *supra* note 52 at 49.

as navigation aid positioning signals) and users (including air operators).[475] The current concern is how air traffic management and navigation systems can be integrated globally in order to achieve a more unified system and, consequently, better results.[476] This goal may be attained through improvements in the systems and regulatory preparations in the long term.

4. Space Traffic Management

Unlike the situation in aviation, there is no comprehensive and unified set of regulations for Space Traffic Management (STM).[477] Even at the national level, although some rules with respect to collision avoidance and safe operation of space activities may exist, these rules were not originally developed to deal with traffic management issues.[478] But why is it important to have a space traffic management system in place? There are different phases of a space flight which all need STM in order to ensure safety and orderly flow of traffic, both for spacecraft and aircraft. These phases include the launch, in-orbit and reentry phases.

Although the environment in which space objects are designed to operate is outer space, the potential interference of such objects with air traffic is unavoidable. The reason is that spacecraft cannot reach outer space and return to earth except through the same

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[475] *Global Air Traffic Management Operational Concepts*, International Civil Aviation Organization, Doc 9750 AN/963 (Second Edition, 2002) at I-1-4.

[476] Rubalcaba, *supra* note 467 at 18-21; Schubert, *supra* note 470.

[477] Marciacq et al, *supra* note 394 at 12-13. Another definition for space traffic management is: "…the entire gamut of technical and regulatory guidelines and requirements necessary for the prevention of unintentional physical or radiofrequency interference in the conduct of space activities." Jakhu, Sgobba and Dempsey, *supra* note 52 at 105.

[478] Marciacq et al, *supra* note 394 at 12-13.

airspace that aircraft are using.[479] This physical interference of air flights and space flights needs to be handled by an effective traffic management system so that the safety of both aircraft and space objects is not jeopardized. The second reason for establishing an effective STM system is to guarantee the safety and sustainability of space while the space objects are in outer space. In the absence of such STM system, there are high risks of collision between operating and non-operating objects in orbit and creation of more space debris. This problem is so serious that space debris and collision avoidance issues have caught the attention of the international community and are considered the main reason for developing STM rules that will ensure safe and sustainable space activities.[480] Perhaps it is because of all the concern about orbital crowding and space debris issues that some authors have defined STM as "rules of the road" for safe "on-orbit operations".[481] However, the physical interaction of space objects with other objects operating in airspace calls for a STM system that is not limited to on-orbit operations. Space activities on a broader scale will definitely need a STM system that will cover all segments of the flight.

As has been indicated, "[i]n the near future, an international traffic management regime and system will be imperative not only to avoid navigational hazards like space debris, but also to regulate space bound transportation vehicles that will be routinely using free international and controlled national airspaces of various nations."[482] For many years, the

[479] von der Dunk, "Passing the Buck to Rogers", *supra* note 16 at 427; Paul Stephen Dempsey and Michael C. Mineiro, "Space Traffic Management: A Vacuum in Need of Law" (Presented at the 59th IAC, Technical Session E3.2 on Space Policies and Programs of International Organizations, held in Glasgow, Scotland 2008) at 1.

[480] Yu Takeuchi, "Space Traffic Management as a Guiding Principle of the International Regime of Sustainable Space Activities" (2011) 4 J. East Asia and Int'l L. 319 at 325-8; Jakhu, Sgobba and Dempsey, *supra* note 52 at 104.

[481] Hitchens, *supra* note 271 at 176.

[482] Jakhu, Sgobba and Dempsey, *supra* note 52 at 16.

necessity of having an STM system in place, given the frequency of space operations, was not appreciated. Today, however, the considerable growth of space launches and activities has started to give cause for alarm.[483] Therefore, some studies and scholarly works have focused on the issue in recent years.

The most complete research conducted in regard to STM is reflected in a report called the *Cosmic Study on Space Traffic Management* of 2006,[484] which was prepared by the International Academy of Astronautics (IAA) study group.[485] This report defines STM as:

> "… the set of technical and regulatory provisions for promoting safe access into outer space, operations in outer space and return from outer space to Earth free from physical or radio-frequency interference."[486]

Referring to the principles included in the existing space treaties, this report suggests a model and principles that need to be incorporated in any future comprehensive STM system. It thoroughly explains all the technical and regulatory requirements in all three

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483 See Cistone, *supra* note 442 at 41.

484 *Cosmic Study on Space Traffic Management,* Report of International Academy of Astronautics (IAA) (2006), available at: <http://iaaweb.org/iaa/Studies/spacetraffic.pdf> [Cosmic Study].

485 IAA is a non-governmental organization established in 1960. IAA describes its purposes as:

- to foster the development of astronautics for peaceful purposes,
- to recognize individuals who have distinguished themselves in a branch of science or technology related to astronautics,
- to provide a program through which the membership can contribute to international endeavors and cooperation in the advancement of aerospace science, in cooperation with national science or engineering academies. More information online: IAA <http://iaaweb.org/content/view/246/378/>.

486 *Cosmic Study*, *supra* note 480 at 10.

phases of launch, in-orbit operations and reentry.[487] The IAA Report proposes a notification and information sharing system; coordination and consultation among the space-faring countries; various measures, such as pre-launch and maneuver notifications, zoning and right of way rules for maneuvering; and some detailed safety provisions.[488]

Generally speaking, in current international space law, there are provisions and principles that might be only indirectly relevant to space traffic management.[489] The existing legal framework is by no means sufficient when it comes to space safety or establishment of a comprehensive space traffic management system.[490] Therefore, in the absence of a harmonized STM system and in order to cope with space traffic issues, different solutions have been proposed.

Some commentators support the involvement of COPUOS, as the forum with a leadership role in space-related matters, and the International Telecommunication Union (ITU) in regulating STM issues.[491] Another group of authors consider ICAO to be the competent forum for establishing an efficient STM system. Various reasons have been expressed to support ICAO's involvement in establishment of such system. First, the valuable experience ICAO possesses in terms of air traffic management and the detailed set of standards and regulations it has developed over the past decades could be used as a

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[487] *Ibid* at 59-90.

[488] *Ibid* at 14.

[489] There are arguments which state that space debris mitigation or sustainable space activities could be crystallized as a rule of customary international law. For a discussion of the possibility of considering sustainable space activities as a principle of customary international law, see Takeuchi, *supra* note 480 at 331-32.

[490] Jakhu, Sgobba and Dempsey, *supra* note 52 at 30, 109.

[491] Hitchens, *supra* note 271 at 178; Parimal Majithiya, Kriti Khatri and J. K. Hota, "Technique for Initialization and Synchronous Setting of Space Vehicle Time with Navigation System Time" (2012) 65 Journal of Navigation 159 at 159.

model for the new traffic management system.[492] Second, as mentioned above, reaching space without the physical passage of the space object through airspace is impossible, and this means that logically there should be a traffic management system that can handle the entire traffic of airspace, including both space objects and aircraft.[493] However, there are legal problems with respect to ICAO's involvement in the establishment of an STM system. They center mainly on the fact that ICAO has only been given the authority of regulating the aviation industry, and that it cannot deal with flying objects that cannot be defined as 'aircraft'.[494] Therefore, it is argued that ICAO's involvement in establishing a traffic management system for outer space would require an amendment to the Chicago Convention.[495] To this end, the example of ICAO's authority to deal with traffic management issues in the airspaces over the high seas has been put forward.[496] Others might support establishment of a separate space traffic management system under a new international space management organization.[497] Seeing that it might be difficult to establish a legally binding regime in the short term, it is suggested that as a first step, individual nations could adopt national regulatory and licensing requirements based on the rules and standards suggested by American Institute of Aeronautics and Astronautics (AIAA) in its *Cosmic Report*.[498] This could be an advantageous approach for the present, because when the time comes for space-faring states to incorporate the suggested unified

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[492] von der Dunk, "Passing the Buck to Rogers", *supra* note 16 at 427; Jakhu, Sgobba and Dempsey, *supra* note 52 at 16, 49.
[493] von der Dunk, "Passing the Buck to Rogers", *supra* note 16 at 427.
[494] *Ibid* at 42; Jakhu, Sgobba and Dempsey, *supra* note 52 at 62.
[495] von der Dunk, "Passing the Buck to Rogers", *supra* note 16 at 428.
[496] *Ibid*.
[497] Jakhu, Sgobba and Dempsey, *supra* note 52 at 63-64.
[498] Hitchens, *supra* note 271 at 178.

STM into their national legal systems, they would probably support the international legal regime or the organization established to deal with STM in the future.

5. Suborbital Vehicles and Traffic Management: ICAO Involvement

In the first chapter we explained how the uncertainty in the legal definitions of the terms 'outer space', 'space object', and 'suborbital aerospace vehicle', as well as the undefined borderline of air and space and the demarcation issues of the two realms cause difficulties in regulating these kind of flights. Rules of traffic management represent one aspect of this kind of legal challenge. Safe, efficient and sustainable operation of suborbital flights in future will be dependent, to a great extent, upon a proper regulatory system to handle the future suborbital traffic.[499]

While some might suggest creation of a separate traffic management system specifically for suborbital flights, this idea might not be practical for two important reasons. First, considering the current status of the suborbital flights industry, where no suborbital vehicle is yet operational, it is unrealistic to assume that states would feel the necessity of developing an international system for standardization and regulation of the traffic management aspects of suborbital flight in the near future. Second, in the absence of an international framework, states will implement their own national laws. Obviously states are more willing to implement national regulatory systems, where they better exert their sovereignty. But having different traffic management systems for these giant flying birds might endanger safety, the most important concern of the regulators of air and space activities. Suborbital vehicles share the airspace with aircraft and spacecraft, and it is therefore important to consider the notion of 'integrity' while regulating the traffic

[499] Dempsey and Mineiro, *supra* note 479 at 1-2.

management aspects of different types of flying vehicles so as to prevent collisions and ensure the optimum use of airspace.[500]

For purposes of traffic management, the perfect scenario could be one integrated traffic management system that would render services for all types of aircraft, spacecraft and suborbital vehicles at all altitudes.[501] However, bearing in mind all the legal hurdles in the existing international legal frameworks of air and space, as well as the technical complications, this might be too optimistic, at least in the near future. Therefore, for our case, namely, suborbital flights, the most achievable and at the same time practical legal answer would seem to be to work through ICAO.[502]

As explained in the previous section on developing an STM system, ICAO's involvement has many advantages. Through its specialized panels and study groups, it has developed a detailed and comprehensive set of standards that are set out in its Annexes, PANS and several manuals and circulars.[503] This means that ICAO during all the decades of its activities has gathered a valuable package of standards and regulations which, with the necessary modifications, could be used for suborbital flights.[504] In addition, since the suborbital vehicles traverse the same airspace that aircraft use,

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[500] Jakhu, Sgobba and Dempsey, *supra* note 52 at 121;

[501] Dempsey and Mineiro, *supra* note 479 at 1-2.

[502] Dempsey and Mineiro, in their article, mention four possible actions the international community could take to address the legal challenges of regulating traffic management issues of suborbital and orbital flight: "(1) maintenance of the status quo (the 'do nothing' alternative); (2) uniform regulation on a case-by-case basis through bilateral or regional agreements (3) establishment of a new international organization with jurisdiction over these issues; or (4) the exercise by ICAO or an alternative international organization currently in existence of authority to standardize suborbital and orbital traffic management." Dempsey and Mineiro, *supra* note 479 at 3.

[503] *Air Traffic Management*, ICAO Safety and Infrastructure Policy and Standardization, online at: < http://www.icao.int/safety/AirNavigation/Pages/atm.aspx>.

[504] See Tanja Masson-Zwaan and Rafael Moro-Aguilar, "Regulating private human suborbital flight at the international and European level: Tendencies and suggestions" (2012) Acta Astronautica at 5 [hereinafter Masson-Zwaan and Moro-Aguilar, "Regulating private human suborbital flight"]; van Fenema, *supra* note 53 at 402; von der Dunk, "Passing the Buck to Rogers", *supra* note 16 at 427; Jakhu, Sgobba and Dempsey, *supra* note 52 at 16.

application of uniform procedures and practices will lead to better control of the movements in airspace. Furthermore, it is the responsibility of ICAO to ensure safety in international airspace, and this is not possible without having due regard to other types of vehicles that operate in this airspace.[505]

However, an important question arises. Is it legally possible to regulate suborbital vehicles under ICAO's rules of air? The Chicago Convention clearly indicates that this convention applies only to 'civil aircraft'.[506] In Annex 7 of the Chicago Convention both the terms 'aircraft' and 'airplane', together with other flying objects which could have been considered part of the aviation industry, are defined.[507] In this document, aircraft and 'aeroplane' are defined, respectively, 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", and as a "power-driven heavier-than air aircraft, deriving its lift in flight chiefly from aerodynamic reactions on surfaces which remain fixed under given

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[505] Article 44 of the Chicago Convention states the objectives of the ICAO as follows: "The aims and objectives of the Organization are to develop the principles and techniques of international air navigation and to foster the planning and development of international air transport so as to:
(a) Insure the safe and orderly growth of international civil aviation throughout the world;
(b) Encourage the arts of aircraft design and operation for peaceful purposes;
(c) Encourage the development of airways, airports, and air navigation facilities for international civil aviation;
(d) Meet the needs of the peoples of the world for safe, regular, efficient and economical air transport;
(e) Prevent economic waste caused by unreasonable competition;
(f) Insure that the rights of contracting States are fully respected and that every contracting State has a fair opportunity to operate international airlines;
(g) Avoid discrimination between contracting States;
(h) Promote safety of flight in international air navigation;
(i) Promote generally the development of all aspects of international civil aeronautics." Therefore, ICAO has an obligation to its member States and has to consider any issue that might affect the safety, regularity and efficiency of the aviation industry. See Abeyratne, "ICAO's Involvement in Outer Space Affairs", *supra* note 2 at 200; Dempsey and Mineiro, *supra* note 479 at 121; van Fenema, *supra* note 53 at 401-02.

[506] Chicago Convention, *supra* note 134 Article 3.

[507] Airship, Balloon, Glider, Gyroplane and Helicopter are some of the examples of the terms defined in the Annex 7 of the Chicago Convention.

conditions of flight."[508] It is difficult to include vehicles designed for suborbital flights under these definitions. Even considering different designs and technologies, suborbital vehicles do not operate exactly like aircrafts, especially when the entire flight, including the ballistic portion, is taken into consideration.[509] This, however, should not be seen as a barrier for regulating traffic management services of suborbital flights under the auspices of ICAO for the following reasons.

First, the term 'aircraft' was not defined in the Chicago Convention itself; the definition was added later in the Annexes to the Convention, mainly on the basis of a definition originally provided by the International Commission for Air Navigation in the *Glossary of Terms Used in Aeronautical Technology*.[510] Therefore, Article 3 of the Chicago Convention can be interpreted in a way that would include suborbital vehicles.[511] As Professor Dempsey and Dr. Mineiro have suggested, "the purpose of the

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[508] Annex 7 to the Convention of International Civil Aviation, *Aircraft Nationality and Registration Marks*, adopted by International Civil Aviation Organization (ICAO) at 1.

[509] SpaceShipOne, for example, does not operate as an aeroplane or aircraft during the ballistic portion of the flight while it is not supported by the reactions of the air, even though some degree of aerodynamic control exists throughout the trajectory from launch altitude until the craft enters the upper reaches of the atmosphere where the air density is no longer sufficient for aerodynamic flight: see ICAO Working Paper, *supra* note 46 at 2.2 Dr. van der Dunk argues that the definition of 'aircraft' includes the machines which 'can' derive support…, and "the use of the word ''can'' points out that, with the exception of craft which can only operate in a completely ballistic mode, all envisaged vehicles for private human space flight would fit the bill, and hence entail application of the regimes which the existence and operation of aircraft trigger. Strictly speaking therefore, it is not necessary for a vehicle to actually ''derive'' such ''support'' for any portion of the flight to qualify as aircraft, as long as it would at least have (had) the option to do so." See von der Dunk, "The integrated approach" *supra* note 83 at 6.

[510] In that Glossary, 'aircraft' was defined as a machine which can drive support in the atmosphere from reactions of the air. See Dempsey, *supra* note 125 at 752; Also International Commission for Air Navigation had adopted Annex A named *Classification of aircraft and definitions, the markings of aircraft*. See The postal History of ICAO, *ICAN's Global prospects reduced to regionalism*, online: Legacy ICAO <http://legacy.icao.int/icao/en/hist/stamps/ican_global_prospects_reduced_to_regionalism.htm>.

[511] Article 3 of the Chicago Convention Provides:

"(a) This Convention shall be applicable only to civil aircraft, and shall not be applicable to state aircraft.

(b) Aircraft used in military, customs and police services shall be deemed to be state aircraft.

(c) No state aircraft of a contracting State shall fly over the territory of another State or land thereon without authorization by special agreement or otherwise, and in accordance with the terms thereof.

Convention is *not* to regulate a specific type of vehicle, but rather to ensure international civil aviation is safe and orderly. It would thwart the Convention's essential purpose to conclude the treaty was meant to be frozen in time, only regulating vehicles that fit within the conception of aircraft existing at the time of the drafting of the Convention, in 1944."[512] If such an extension of the meaning of the term 'civil aircraft' is accepted, then the Chicago Convention could be applicable to suborbital vehicles too.[513]

Second, there is no reason that precludes ICAO from regulating vehicles that, although they have different technical characteristics, operate in the airspace up to the limit of 100-110 km above the Earth (a limit which generally, but not officially, is considered the boundary between the Earth's atmosphere and space).[514] As an analogy, one can refer to ICAO's initiative in addressing concerns that were not initially contemplated in the Chicago Convention of 1944, such as the Annexes on environmental issues and aviation security.[515] While there is no reference in the Chicago Convention to security matters and environmental protection, today one can witness the amount of work done through ICAO for the purpose of regulating the security and environmental aspects of aviation. Fortunately, the legal basis for considering the incorporation of new matters, such as suborbital flights, into ICAO's regulations exists. The Chicago Convention in Article 37 gives ICAO the authority to adopt, as may be necessary, international standards and recommended practices and procedures dealing with different issues, "…

(d) The contracting States undertake, when issuing regulations for their state aircraft, that they will have due regard for the safety of navigation of civil aircraft."
One possibility can be amendment of the definition of 'aircraft' in the Chicago Convention and its Annexes, to include the suborbital vehicles: Jakhu, Sgobba and Dempsey, *supra* note 52 at 62.

[512] Dempsey and Mineiro, *supra* note 479 at 6; see also Masson-Zwaan and Moro-Aguilar, "Regulating private human suborbital flight" *supra* note 504 at 6-7.

[513] *Ibid* at 5.

[514] For more details about the issue of demarcation of airspace and space, please refer to the Chapter One, Suborbital Flights and Legal Complexities.

[515] Jakhu, Sgobba and Dempsey, *supra* note 52 at 42-43.

and such other matters concerned with the safety, regularity, and efficiency of air navigation as may from time to time appear appropriate."[516] It is true that at the time of the conclusion of the Chicago Convention, the idea of human flight to outer space or even the edge of it did not seem to be feasible, but it is an undeniable fact that air transport is a dynamic and rapidly changing field, with new technological advancements every day.[517] It is not logical for the States to adopt a treaty frozen in time without having the ability to move with innovations. The States, by adopting provisions such as Article 37, have proven that maintaining the status quo is not the aim for the Chicago Convention. Nevertheless, since amending the Chicago Convention to embrace suborbital vehicles may not be achievable in the short run, the best approach seems to be to proceed by invoking Article 37 or by amending the Annexes to the Chicago Convention.[518]

Even with respect to next stage of suborbital flight, when the vehicle leaves airspace and enters outer space, ICAO still can be effective. Because ICAO has already standardized the aeronautical mobile satellite services in compliance with the ITU Radio Regulations, these facilities and their respective regulations can be extended to suborbital vehicles for traffic management and collision avoidance purposes.[519]

There is an important benefit for regulating suborbital vehicles through ICAO, especially from the traffic management perspective. States have sovereignty up to the limit of airspace, and they have vested ICAO with the power to develop and adopt regulations and standards relevant to different aspects of aviation. Therefore, by amending the existing Annexes or by adding a new annex to the Chicago Convention, the

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[516] Chicago Convention, *supra* note 134 Article 37.
[517] Kondroška and Stankūnas, "Analysis of Airspace Organization", *supra* note 458 at 220.
[518] Bringing an amendment to the Chicago Convention into force would take a long time (allegedly, about 25 years) to accomplish. Jakhu, Sgobba and Dempsey, *supra* note 52 at 138-39.
[519] Marciacq et al, *supra* note 394 at 12-13.

problems and difficulties of adopting a new treaty or establishment of a new organization could be avoided, seeing that progressive development of the law, and especially space law, is sometimes very sluggish.[520] Still, given the dual nature of suborbital vehicles, their specific technical characteristics, and the purpose of their operation in reaching the fringes of space, it would be in the best interest of the suborbital flight industry that a detailed and comprehensive study program be undertaken, with appropriate synergy between the aviation and space industry regulators and the involvement of both ICAO and UNCOPUOS, to ensure that all the aspects necessary for ensuring safety and regularity of suborbital flights as well as their interactions with other participants in airspace are given due consideration.[521] Up to this point, UNCOPUOS has only fractionally addressed the legal issues related to suborbital flights, perhaps because as the first step it needs to clarify important definitions such as ‘outer space’ and ‘space object’; and, besides, suborbital flights being small-scale activities are not yet considered a priority for UNCOPUOS.[522] International Air Law and Space law today have to adapt to the rapid changes and everyday technological innovations. As Dr. Abeyratne explains, “[P]ublic international law is increasingly becoming different from what it was a few decades ago. We no longer think of this area of the law as a set of fixed rules, even if such rules have always been a snapshot of the law as it stands at a given moment.”[523]

[520] The last important multilateral space treaty was the Moon Agreement of 1979, which because of the reluctance of most space-faring countries to ratify it, is considered a failure.
[521] Abeyratne, with respect to regulating space activities and their effects on aviation, suggests as warranting some study and cautious scrutiny an ICAO-UNCOPUOS synergy that could perhaps be established through the ICAO Council and UNCOPUOS and would be based on past ICAO work in CNS/ATM systems. See Abeyratne, “ICAO's Involvement in Outer Space Affairs”, *supra* note 2 at 193.
[522] von der Dunk, “The integrated approach” *supra* note 83 at 9; Masson-Zwaan and Moro-Aguilar, “Regulating private human suborbital flight” *supra* note 504 at 6.
[523] Abeyratne, “ICAO's Involvement in Outer Space Affairs”, *supra* note 2 at 201.

6. A Role for Individual States in the Status Quo

From the traffic management perspective, the ideal situation would be an international air and outer space traffic management system that would cover all the altitudes and orbits aircraft, suborbital and orbital vehicles traverse. It would be a system that would integrate aircraft, suborbital and orbital vehicles' navigation and communications into a single unified system to ensure safety and efficiency at the highest possible level.[524] In the absence of such international system, or a system designed specifically to deal with the traffic management issues of suborbital flights, states should take the lead and ensure the safety of suborbital vehicles and aircraft operating in the same airspace.

In accordance with international law, each state can exert complete and exclusive sovereign jurisdiction and control over its territory; and this territory includes the airspace above the state up to the point at which airspace ends and outer space begins, the precise boundary of which, as discussed in previous sections, has not yet been defined.[525] Therefore, each state may promulgate its own regulations with respect to such issues as safety, security and prevention of pollution.[526] But where international obligations do exist, the national regulatory system should abide by the international framework. For example in the case of aviation, member States by ratifying the Chicago Convention have agreed to conform to the standards and practices governing civil aviation and developed through ICAO, and traffic management rules are not an exemption.[527] This is the

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[524] Dempsey and Mineiro, *supra* note 479 at 1-2.

[525] Traditionally, states have claimed sovereignty over the whole of their airspace, but today non-appropriation of outer space is an indisputable principle. Antonio Cassese, *International Law*, second ed. (Oxford: Oxford University Press, 2005) at 94.

[526] Generally, States are recognized as having three types of jurisdiction: a) Territorial jurisdiction, b) Quasi-territorial jurisdiction, and c) Personal jurisdiction. Cheng, *supra* note 145 at 339-40.

[527] Article 12 of the Chicago Convention provides: "Each contracting State undertakes to adopt measures to insure that every aircraft flying over or maneuvering within its territory and that every aircraft carrying its nationality mark, wherever such aircraft may be, shall comply with the rules and regulations relating to

situation at a time when a system for space traffic management has not been yet developed through the international framework of space law, and therefore each state establishes its own set of rules.[528] Consequently, in the absence of an international set of regulations for traffic management of suborbital flight, each state can apply its own standards and practices within the limits of its sovereignty.[529] For implementing ATM standards and rules, it has been suggested that the upper limit of its competence could be set around 100-110 km,[530] to cover the highest suborbital flights and overlap with space-controlled areas.[531]

National laws, which a State can implement on suborbital flights, may include those relating to space activities, such as various licensing and certification regulations for undertaking such activities, although national space laws were originally not meant to deal with traffic management.[532] Another possibility would be to apply the same traffic management standards and regulations that pertain to conventional aircraft, which, since nearly all States are parties to the Chicago Convention, would be to a large extent the same standards as those developed by ICAO through SARPs and PANS.[533] Apparently, the authority of a state to unilaterally regulate these vehicles in the absence of an

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the flight and maneuver of aircraft there in force. Each contracting State undertakes to keep its own regulations in these respects uniform, to the greatest possible extent, with those established from time to time under this Convention. Over the high seas, the rules in force shall be those established under this Convention. Each contracting State undertakes to insure the prosecution of all persons violating the regulations applicable."

[528] Jakhu, Sgobba and Dempsey, *supra* note 52 at 105.

[529] The U.S. can be mentioned as an example. According to Dr. van Fenema "The fact that virtually *all* space objects, launched by the USA since the early 1960's, have transited US air space and that aviation has not suffered indicates that the necessary procedures have been in place to separate the two activities effectively." See van Fenema, *supra* note 53 at 400.

[530] 330,000-360,000 ft.

[531] Marciacq et al, *supra* note 394 at 12-13.

[532] *Ibid.*

[533] Today 191 states are parties to the Chicago Convention. See <http://www.icao.int/secretariat/legal/List%20of%20Parties/Chicago_EN.pdf>.

international regime does not extend to foreign vehicles operating outside their territorial airspace. Therefore, vehicles operating either over the high seas or in outer space would only be subject to the rules and regulations of the State of registry.[534] In this situation, if the vehicle traverses the airspace of more than one state, the involved states need to make the required arrangements, or set up a system of bilateral agreements, similar to the system of bilateral agreements in the aviation industry.[535]

An example of new national regulatory approaches to traffic management is the initiative of US FAA/AST[536] in introducing the concept of the Space and Air Traffic Management System (SATMS).[537] SATMS, which is more like a roadmap, represents, according to AST, "a conceptual 'aerospace' environment in which space and aviation operations are seamless and fully integrated in a modernized, efficient National Airspace System (NAS)."[538] Of course such plans, which will facilitate rendering traffic management services to both the aviation and space activity industries, will need modernization of infrastructures and procedures.

Whichever regulations States may choose to apply to suborbital flights, they should take into account the unique technical requirements of the suborbital vehicles and the conditions of high-altitude airspace. These considerations can include characteristics of different phases of flight, maneuverability of vehicles, and density of airspace in each part of the trajectory as well as horizontal and vertical flight trajectories, because

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[534] Dempsey and Mineiro, *supra* note 479 at 3.

[535] Manfred Lachs, *The Law of Outer Space: An Experience in Contemporary Law Making* (Leiden; Sijthoff, 1972), at 59; van Fenema, *supra* note 53 at 401.

[536] Office of Commercial Space Transportation of the Federal Aviation Administration.

[537] Space and Air Traffic Management System (SATMS), Office of Commercial Space Transportation of the Federal Aviation Administration: <http://www.faa.gov/about/office_org/headquarters_offices/ast/about/satms/>.

[538] *Ibid*; see also Spencer, *supra* note 371 at 100.

suborbital vehicles' vertical trajectories will be significantly expanded. In order to ensure safety, all the important factors of traffic management—such as positioning, separation from other traffic and collision avoidance, in addition to routing, efficiency and optimization of traffic flows—need to be carefully studied. All these precautionary measurements are important because when it comes to traffic management issues, there is simply no prudent place for reactionary approaches, or in other words, *ex post facto* measures.

In this situation, cooperation of operators in having systems of notifications and information sharing can be in the interest of all.[539] For instance, there are the possibilities of satellite-based screening and tracking systems, which can be of great importance, especially for the tasks performed at higher altitudes. The use of Global Navigation Satellite Systems (GNSS) for air traffic services, or the U.S. Space Surveillance Network (SSN), now dedicated to tracking space debris, are examples of such satellite-based services. With a proper information sharing system, suborbital flights will enjoy higher levels of safety until a proper traffic management system is established. With further development and growth of the suborbital flight market, it is important to have an international response to the issues, with great attention being paid to safety aspects of the flight through traffic management, rather than leaving them to the discretion of individual states.

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[539] Takeuchi, *supra* note 480 at 328. In aviation, there is a concept of Information management which "provides accredited, quality-assured and timely information used to support ATM operations. Information management will also monitor and control the quality of the shared information and provide information-sharing mechanisms that support the ATM community." Global Air Traffic Management Operational Concepts, *supra* note 448 at 2-16.

CONCLUSION

The viability of the suborbital flight market depends to a great extent on the legal regime regulating the various aspects of the industry. At present, there is not any clear answer in international law for the numerous questions pertaining to the operation of suborbital vehicles. In these conditions, the lack of legal clarity in the existing legal frameworks for aviation and space activities represents a major challenge. The first step towards greater clarity in law is through reaching agreement on the legal definition of the key words, such as 'outer space', 'space object', 'space tourism', or making necessary modifications in the definition of 'aircraft'. Demarcation of airspace and outer space is another important step to be taken. Despite this obvious legal ineffectiveness, there is not yet enough incentive among States to take the necessary steps to fill these gaps of law, and the legal questions are still open for debate at the academic level without any definite conclusions being reached.

As for the environmental impacts, suborbital vehicles may have negative environmental effects on the surface of the Earth, at different levels of the atmosphere, and finally in outer space. Because these vehicles cause transboundary environmental pollution in the airspace and outer space, which are both considered 'common sources' among all the States, it is important to have an international regulatory response to this concern.

Traffic management issues and defining the appropriate set of regulations and standards represent another aspect of the legal difficulties related to suborbital flights, without which the safety, efficiency and sustainability of the industry will be at risk. For traffic management purposes, the ideal situation would be to develop an integrated system rendering services for all types of aircraft, spacecraft and suborbital vehicles at all altitudes. Until the time such a system is developed and in the absence of a space traffic management system, the best possible approach might be to apply the standards and regulations developed by ICAO. This solution, however, would require amending the existing Annexes of the Chicago Convention or adopting a new Annex so that suborbital vehicles could be incorporated into ICAO's regulatory system.

A very important factor that might be considered in regulating different aspects of suborbital flights is that the role of the regulatory system is crucial to the growth of the industry. While the absence of law and policy intervention may give rise to uncertainty and even losses for the industry, burdensome and unnecessary regulations may thwart the efforts for growth and the viability of the industry. Therefore, it is important to maintain a balanced position in regulating such vehicles in order to encourage and promote the growth of the industry and at the same time to avoid the possible undesirable impacts of their operation. In addition, the special technical characteristics of suborbital vehicles that distinguish them from conventional aircraft and spacecraft should be kept in mind while regulating such vehicles.

Acting proactively with respect to regulating suborbital flights is very important because generally when it comes to transportation systems, there is simply no place for *ex post facto* measures.

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