A new Approach towards Outer Space „Democratisation“?
Legal, Political, and Economic Issues concerning Small Satellite
Missions

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Preface

The idea for this thesis was born in late summer 2011, a year filled with global changes. The so-called “Arab Spring”, a spontaneous democratisation process in the Middle East, was in progress. Throughout these events, broadcasting facilities as well as the Internet and social media played a decisive role in maintaining the peaceful nature of the movement. At the same time in March 2011, the world was shocked by a disastrous earthquake and the subsequent nuclear catastrophe in Japan. To help manage and monitor the aftermath of these incidents, Earth observation satellites were used and played a crucial role.

Being moved by these events, I want to highlight the special role which small satellite missions can assume. The capability of small satellites to develop on short time and low cost in comparison to conventional satellite missions should allow developing, emerging and smaller countries in general to participate in space activities. Moreover, the stagnating economies of the West, resulting from the persistent global economic crisis, plus the constant increase in the price of mineral oil put conventional satellite missions which rely on budget constraints, at risk.

2011 was also the year that witnessed the last ever space shuttle flight. An enormous national U.S. space programme was brought to an end. However, private space operators such as SpaceX¹ have started to enter outer space. This demonstrates an increasing shift from public to private engagements in space. Small satellite missions have been particularly affected by this shift due to a growing number of small satellite launches undertaken by universities and other non-governmental entities.

During the drafting process of this thesis, Austria was about to launch its first satellite into space, which was a small satellite. This remarkable Austrian event allowed me to obtain a deeper insight into the “real” issues and challenges of small satellite missions. The recently enacted Austrian Outer Space Act was a further motive for focusing on the legal impact of small satellite missions. The fact that small satellites may have a big political and socio-economic impact, and the growing numbers of complex legal issues were additional motives directing me towards this interesting topic. Eventually, a doctoral thesis, focusing more

¹ SpaceX is a private U.S. company established in 2002 by Elon Musk. The flagship projects are the “Falcon” launch vehicles and “Dragon” spacecraft. In spring 2012 the first commercial reusable capsule “Dragon” was successfully launched to the ISS. For further details see <http://www.spacex.com/dragon.php> (25.03.2013).

profoundly on small satellite launches from the International Space Station as well as on space debris mitigation and space traffic management is envisaged.

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Preface.....	3
1 Introduction.....	7
1.1 Purpose and benefits of small satellites	7
1.2 Research and analysis	8
2 General aspects	11
2.1 Definition and classification of small satellites	11
2.2 Historical survey of small satellite development.....	13
2.3 Small satellite applications	16
2.4 Technical and operational aspects of small satellites	18
2.5 TUGSAT-1 and UniBRITE - the first Austrian small satellites.....	20
3 Legal issues	23
3.1 Sources of space law	23
3.1.1 General aspects	23
3.1.2 Specific aspects relating to small satellites	24
3.2 The legal nature of small satellites	28
3.3 State responsibility for national space activities.....	31
3.3.1 General aspects	31
3.3.2 Specific aspects concerning small satellite missions	33
3.3.3 The Austrian Outer Space Act	36
3.3.4 Harmonisation of national space legislation in favour of small satellite missions?	39
3.4 International liability for space objects launched into outer space	42
3.4.1 General aspects	42
3.4.2 Specific aspects focusing on small satellite missions.....	45
3.4.3 Risk allocation - challenges for small satellites?	49
3.5 Digression: Non-territorial, non-fixed facility and non-terrestrial small satellite launches	52
3.6 Registration of space objects	57
3.6.1 General aspects	57
3.6.2 Specific aspects focusing on small satellite missions.....	59
3.7 Property in space in particular consideration of small satellites	61
3.7.1 Ownership in space	61
3.7.2 Intellectual property rights.....	64
3.7.3 Technology (export) control	66
3.7.4 Space data	69
3.7.5 Space contracts	72

3.8	Sustainable use of outer space in particular consideration of small satellites	74
3.8.1	Space debris	75
3.8.2	Frequency management.....	81
3.8.3	Space traffic management	85
4	Political aspects	88
4.1	Outer space “democratisation” – what does it mean?	88
4.2	Actors in a “democratisation” process through small satellites – a quantitative perspective.....	90
4.2.1	Governmental entities	90
4.2.2	Non-governmental entities and the significant role of universities	90
4.2.3	Individuals - you and me in outer space?	92
4.3	Capacity building – a qualitative perspective through small satellite missions.....	93
4.3.1	A new approach for developing countries.....	94
4.3.2	Chances for small countries.....	97
4.4	Small satellites and international cooperation - changes on the skyline.....	98
4.5	A “democratised” outer space through small satellites – spin-offs to society	100
4.6	The need for a sustainable approach towards outer space “democratisation”	102
4.7	Institutional aspects concerning small satellite missions	105
4.7.1	The role of the United Nations	105
4.7.2	ESA and the European Union	107
4.7.3	Other institutions.....	108
4.8	Instruments that support sustainable outer space “democratisation” through small satellites	109
5	Economic aspects	112
5.1	The economic value of small satellites and their assigned orbits	112
5.2	Financing small satellite missions	114
5.2.1	Private Finance Initiatives (PFI).....	115
5.2.2	Public Private Partnerships (PPPs)	115
5.2.3	Public sector procurement.....	117
5.3	Further economic and financial considerations concerning small satellites	117
5.3.1	Standardised items – a cost minimiser	117
5.3.2	Launching opportunities.....	118
5.3.3	Small satellites – a future prospect on outer space “democratisation”	122
6	Conclusions.....	124
	List of Abbreviations/Acronyms.....	126
	Bibliography.....	129

1 Introduction

1.1 Purpose and benefits of small satellites

The notion about small satellite technology is equivocal. Conventional space industry and large space faring countries sometimes consider small satellite activities carried out, in particular, by universities and individuals nothing more than “toys”. This general and narrow view is strictly rejected by the author for many reasons.

Small satellite technology is targeting *inter alia* the economic and political challenges of these days. Domestic budgets have been suffering from a long lasting economic crisis. Industrialised countries complain about increasing unemployment rates. As regards developing countries, most of them are not able to access space due to budget constraints and a lack of technology.² Food and nutrition insecurity, lack of drinking water, global climate change and its negative effects constitute the need for Earth observation missions with lower budgets,³ which are affordable in particular for developing countries. Hence, small satellites meet societal and human needs.

Conventional satellite missions are rather expensive (e.g. a typical Earth observation satellite mission may cost far in excess of US \$ 250 M⁴) and have long production times, and may therefore prove to be unfeasible for developing countries. According to *Sandau*, conventional satellites are also subject to a cost spiral: “*higher costs led to fewer missions which led to the demand for higher reliability which again leads to longer schedules and higher costs*”.⁵ With lower costs, shorter production times and fewer financial risks, small satellites enable developing countries to enter outer space.⁶

The increasing numbers of small satellites are a consequence of cuts in national space budgets, and of vast technological advancements.⁷ Small satellites are more flexible in their operation, which leads to an increase in the number of users. Furthermore, the low budget approach leads to greater engagement of small (local) satellite industries.⁸

² See *Dhanji*, 2002, 308.

³ See *Sandau*, International Study on Cost-Effective Earth Observation Missions, 2006.

⁴ *Sweeting*, Keynote Address Micro/Nanosatellites – The new World, 2002, 9.

⁵ *Sandau*, Small Satellite Missions, 2010, 84.

⁶ See *Dhanji*, 2002, 311.

⁷ See UNISPACE III, *Small Satellite Missions Background paper 9*, 1998, 5 para 2, <http://www.un.org/Docs/journal/asp/ws.asp?m=A/CONF.184/BP/9> (25.03.2013).

⁸ Ibid. 7 para 14.

Small satellites may positively contribute to build up technological, scientific, research and educational capacities. Accordingly, affordable technology may empower universities, research centres and other institutions as well as individuals to initiate small satellite projects, allowing students and young graduates to benefit from technology acquisition and from technical and scientific training. Small satellites can also promote cultural and artistic projects; hence, the benefits of small satellites listed in the present thesis are not complete. It would go beyond the discussion to describe all of them.

Moreover, small satellites can be launched “piggyback” alongside other payloads at a relatively low launching cost. Typically, the launching costs for 1 kg payload for a conventional satellite mission range between € 10,000 and € 30,000.⁹ However, while the price can vary strongly among the operators, it can nonetheless be drastically reduced through “piggyback” launching (for launching opportunities in general see chapter 5.3.2). Since a foreign “piggyback” launch depend on cooperation small satellite missions may enable space faring countries to cooperate¹⁰ with less space experienced or small national economies.

However, the benefits of small satellites face various factual and legal challenges. The general rules of space law do not refer to the mass and size of a space object and, therefore they do not differentiate between conventional (expensive) and small satellites, which may be developed at short time and launched at affordable costs. Hence, the author tries to provide legal solutions in the present thesis, which supports the benefits of small satellites such as, in particular, the possible low-budget approach, the shorter production time, and the reduced (accident and financial) risk.

1.2 Research and analysis

The thesis provides a broad analysis of various legal, political, and economic issues concerning small satellite missions. The range and scope of small satellites is vast and based on large technological knowledge. Nonetheless, this thesis cannot provide details on all types, classes and technological aspects of small satellites. For the purpose of this thesis, small satellites are generally considered to weigh less than 500 kg (for a general classification see chapter 2.1).

Relying on studies in this field, this thesis raises the following core questions:

⁹ See Koudelka, *Tugsat-1: The first Austrian Satellite*, 2008, 140.

¹⁰ See Dhanji, 2002, 311.

a) What are the legal aspects and challenges of small satellites, as regards “responsibility” (Art VI Outer Space Treaty) and “liability” (Art VII Outer Space Treaty and the Liability Convention) and registration (Art VIII Outer Space Treaty and the Registration Convention) are concerned? In addition, what are the current and future challenges of small satellite missions, as far as property in space and a sustainable use of outer space are concerned?

b) Can small satellites serve as new instruments towards outer space “democratisation”? What is meant by outer space “democratisation”¹¹ and does this process also demonstrate factual and legal limitations?

c) What is the economic value of small satellites and which models are best suited to finance small satellite missions?

This thesis is based on a multidisciplinary approach. It mainly focuses on the legal and regulatory issues of small satellites. Legal issues cover the question of state approval, international liability in case of damage, and the registration of small satellites according to the space treaties and national space laws. Since small satellites often use imported items and technology from foreign countries, Chapter 3.7 (“Property in space”) focuses *inter alia* on the transfer of ownership, on intellectual property rights, and on technology (export) control of small spacecraft. Furthermore, small satellites also raise the issue of space debris mitigation, frequency allocation as well as space traffic management. Thus, Chapter 3.8 deals with the sustainable use of outer space, with a particular focus on small satellites.

Political aspects deal with the notion of outer space “democratisation” through small satellites. Hence, the benefits and potentials of a “democratised” space through small satellites will be described in this paper. Chapter 4.6 answers the question as to whether outer space “democratisation” through small satellites has legal and political limitations.

In Chapter 5 (“Economic aspects”) the crucial task is to define the economic value of small satellites, to find low-cost launching opportunities and to apply appropriate financing models.

¹¹ *Elon Musk*, the founder of SpaceX was stating on the occasion of the successful test launch of Falcon 9 in 2010: “(...) this is a momentous moment and one that will ensure the democratization of space. This will increase the ease of access to space. (...)” http://www.thaindian.com/newsportal/sci-tech/paypal-millionaires-rocket-launch-could-herald-a-new-epoch-for-space-exploration_100375974.html. (25.03.2013); *Radcliffe/Summerer*, 2002, 132 made the following statement concerning PISCES (Proposal for International Spacecraft Constellation for Education and Science): “PICES will ambitiously encourage the participation of cultures long-excluded from space exploration, stimulate new approaches, and open the way to democratize humanity’s further steps into outer space.”

In Chapter 2 (“General aspects“) technical issues and basic functional processes of small satellites, such as small satellite applications, and operational aspects are explained, and the launch of the first Austrian small satellite is described.

The thesis may be in the interest of academic and political institutions, and it may also be of importance for other entities, governmental or non-governmental, that deal with small satellite missions. The present thesis may also encourage non-space faring nations, developing countries and non-governmental entities etc. by highlighting the benefits and high democratisation potential which come with the use of small satellites.

2 General aspects

2.1 Definition and classification of small satellites

The definition of small satellites is rather dynamic and depends widely on technological progress. However, no universal definition or classification has been accepted so far.¹² A summary of various co-existing definitions shows that mainly two indicators are important for qualifying a satellite as small: the actual mass of the satellite, and the overall costs. For widely adopted classifications see the following tables. Regularly the tables of classification refer to the “wet” mass of a small satellite.¹³ The tables of classification in the present thesis are not exclusive; there are many other definitions which would go beyond the scope of the discussion.

Class	Mass	Cost (US \$ M)
Large Satellite	> 1000	> 140
Small Satellite	500-1000	50-140
Mini-Satellite	100-500	10-30
Micro-Satellite	10-100	3-6
Nano-Satellite	1-10	0.3-1.5
Pico-Satellite	< 1	< 0.3

Table 1 Classification of satellites according to mass and typical cost: removed from: Sweeting, 2002, 2.

The table above, drawn by *Sweeting*,¹⁴ recognises satellites with a mass over 1,000 kg and a cost up to US \$ million >140 as “large” or “conventional”. This definition refers to satellites as “small” if they weigh no more than 500 – 1,000 kg. This table presents a narrow classification of “small” satellites.

According to a broader interpretation, such as the one used by the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III) in its Small Satellite Missions Background paper 9 (1998), satellites are classified as small if they weigh less than 1,000 kg. In addition to the classifications set up by UNISPACE III, satellites ranging from 100 – 1,000 kg can be referred as “mini,” followed by those < 100 kg (Micro-satellites), and those < 10 kg (defined as Nano-satellites).

¹² See UNISPACE III, *Small Satellite Mission Background paper 9*, 1998, 5 para 3.

¹³ One has to distinguish between “dry” and “wet” mass of a (small) satellite. “Dry” mass refers to the mass of a (small) satellite without fuel. “Wet” mass refers to the in-orbit mass including the fuel or other propulsion systems. Many definitions are not precise about the dry or wet mass of a (small) satellite, which makes a classification difficult http://centaur.sstl.co.uk/SSH/ssh_classify.html (25.03.2013).

¹⁴ Professor *Sir Martin Sweeting* is Director of the Surrey Space Centre and Executive Chairman of SSTL. He can be considered as the “father” of small satellites development in Europe. He achieved recognition and numerous prizes for his work done. In addition to that he was also awarded a Knighthood by the Queen http://www.ee.surrey.ac.uk/SSC/profiles?s_name=Martin_Sweeting (25.03.2013).

A further definition established by researchers in the Surrey Space Centre (see table below) refers to satellites as “small” when weighing below a mass of 500 kg.¹⁵ Additionally, new sophisticated research has successfully developed so called Femto- and Atto-satellites (< 1 kg) qualified as “ultra-small” satellites. The smallest currently acknowledged type is a Xeno-satellite weighing < 10 mg. Extremely tiny satellites carry no additional payloads and are merely used for auxiliary duties on bigger missions.¹⁶

Mini satellite	100-500kg	Small Satellites
Micro satellite	10-100kg	
Nano satellite	1-10kg	
Pico satellite	0.1-1kg	
Femto satellite	<100g	

Table 2 removed from http://centaur.sssl.co.uk/SSHP/sshp_classify.html (25.03.2013).

A recent definition is provided by Eurospace - a non-profit European organisation to support space agencies and industry with relevant information about the space sector. Notably, recent classifications do not refer to the typical costs.

Pico (Mass <1 kg)	Nano (1 – 10 kg)
Micro (10 – 120 kg)	Mini (120 – 500 kg)
Medium (500 – 1500 kg)	Large (1500 – 4000 kg)
Very Large (4000 – 8000 kg)	Extra Large (Mass >8000 kg)

Table 3 removed from the ASD Eurospace report on space trends, 1st edition May 2012, 10.

Other classification parameters refer to the shape of a satellite. One example would be a Cube-satellite, referring to its cubic form measuring mostly 10x10x10 cm with about 1 kg of mass. Such Cube-satellites are often carried out as “student satellite” projects. Although there is no universal definition of a “student satellite”, such satellite indicates that students are involved in each phase of the mission ranging from design, manufacture, test and operation of the satellite.¹⁷

A very common type of satellite, mainly developed by high school students, is a Can-satellite. The name of this type of small satellite refers to the cover of the space object, which can be made out of or which resembles a soda can. Inside, these satellites are equipped with

15 Notably, most of the accepted tables of classifications refer to the International System of Units standard prefixes such as “Micro”, “Nano”, “Pico” and “Femto”.

16 See *Janson*, *The History of Small Satellites*, 2008, 47; see also *Janson*, 2008, 88. Usually such a small spacecraft can only be a passive satellite which is merely used for auxiliary work such as radar calibration.

17 See <http://www.esa.int/Education/CubeSats> (25.03.2013).

microelectronics. Due to their short life span, these objects are not intended to be sent into outer space. Usually the value of student-managed Can-satellite is rather experimental in nature, aiming at a successful (self-made) rocket launch designed for a few minutes flight in air space.¹⁸

However, a small satellite is not necessarily defined by small size and light weight. The term “small” may also include short development time, small development and testing infrastructure and a small team involved in a small satellite mission.¹⁹

In summary: Although there is no universally accepted definition of small satellites, the classification is an indicator for the production costs and development time as well as for the launch costs, since launch costs usually refer to the “wet” mass of a satellite.²⁰ Moreover, the classification of small satellites helps in particular industries and manufacturers to find potential markets in order to launch their satellite products and payloads.²¹ As already mentioned, for the purpose of this thesis the term “small satellite mission” basically refers to all satellites weighing approximately less than 500 kg. As regards specific types of small satellites the author refers to the most recent classification provided by ASD-Eurospace report on space trends (2012) in Table 3.

2.2 Historical survey of small satellite development

The first artificial satellite Sputnik 1, launched by the former USSR on 4th October 1957 was already something we would nowadays define as a small satellite. The total weight of Sputnik 1 was less than 85 kg, and the size of the rounded body was no more than 59 cm in diameter (according to recent definitions probably a Micro-satellite). The satellite was sent into the Low Earth Orbit (LEO) and was equipped with rather simple facilities and technology in use then.²²

In July 1955, U.S. President Eisenhower held out the prospect of the first launch of a U.S. (small) satellite in the approximate future. In response, the USSR published a press release communicating sophisticated plans in early (small) satellite development a few days later.²³ In

18 For a Can-satellite project see <http://www.cansat.eu/index.php/european-competition.html> (25.03.2013).

19 See *Balogh*, Satellite Projects Capacity Building & Legal and Regulatory Aspects, 2012.

20 See http://centaur.sstl.co.uk/SSH/ssh_classify.html (25.03.2013).

21 Talk with *Michael Loweth*, MMS, Business Development Manager at ABSL, UK at the 4S Small Satellites Systems and Services Symposium, 6th June 2012, Portoroz, Slovenia.

22 See *Moore*, 2008, 16. For the definition of orbits see chapter 5.1.

23 Ibid. 12.

sum, between 1957 and 1958, during the International Geophysical Year (IGY),²⁴ three types of initial small satellites were launched, namely Sputnik 1 (former USSR), Explorer 1 (U.S. on 31 January 1958) with a total mass of virtually 13.9 kg, and Vanguard 1 (U.S. on 17 March 1958) with, about 16.5 cm in diameter and weighing no more than 1.5 kg.²⁵ Those satellites had already the size of what are nowadays called Micro- or Nano-satellites, but they were quite inflexible and inconvenient in their operation.

The first “piggyback” launch, which is defined as transporting a small satellite alongside the primary payload (e.g. conventional massive Earth observation satellite) on the same launch vehicle,²⁶ took place in 1961 when the U.S. launched the first (small) radio amateur satellite, OSCAR-1. This development was followed by Ariel-1, the first British (small) satellite mission in 1962, and by the (small) French A-1 (Asterix) in 1965 with the intention to break the U.S. and USSR hegemony in space.²⁷

In the 1970s, immense progress was made in technology, and as time passed, bigger, more complex and advanced satellites were developed and launched into space.²⁸ This development went hand in hand with an increase in cost and developing time. By the mid-1970s, most space-faring countries focussed on the so called “conventional” satellites (mostly between 1,000 and 5,000 kg).²⁹ The invention of direct broadcasting television required massive and reliable satellites to be placed in the Geostationary Orbit (GEO) for a rather long period of operational time (typically 15-18 years for a communication satellite³⁰).

At the beginning of the 1990s small satellite development and research for a smarter technology started to work out widely.³¹ *Daniel S. Goldin*, former NASA administrator, announced in 1992 the widely cited “*smaller, faster, cheaper*” approach, which was a leitmotiv of several small satellite missions by that time as well.³²

24 The IGY has its origin in the International Polar Years 1882-1883 where contemporary scientific issues and research were carried on about the solar system. The IGY made a large contribution to make the first (small) satellite missions feasible. For further information see <http://history.nasa.gov/sputnik/igy.html> (25.03.2013).

25 See *Moore*, 2008, 1. For details on the size and mass of Sputnik 1, Explorer 1 and Vanguard 1 satellites see *Moore*, 2008, 16ff.

26 See *Bovet et al.*, 2002, 470.

27 For the launch of OSCAR-1 and Asterix see <http://centaur.sstl.co.uk/SSH/micro/micro60s.html> (25.03.2013).

28 See *Janson*, 2008, 60.

29 Ibid. 62f; notably, all main international organisations dealing with satellite communication were established between 1971 and 1977: INTELSAT (1971), ARABSAT (1976), EUTELSAT (1977).

30 See *Koudelka*, 2011, 48.

31 See UNISPACE III, *Small Satellite Mission Background paper 9*, 1998, 6 para 9.

32 See *Janson*, 2008, 64.

Therefore, the magic word in making small satellites fashionable in the early 1990s was cost reduction. The table below reflects the increasing numbers of modern Nano- and Pico-satellites (light blue bars) in the mid-1009s until now.

Table 4 removed from the ASD-Eurospace report on space trends, 1st edition May 2012, 10.

As a consequence, universities and research institutions were able to start developing and operating small satellite programmes for educational purposes.³³

The millennium was represented by a cost-effective³⁴ approach. Off-the-shelf standardised production of component satellite parts, which can be a production in series,³⁵ was born in order to minimise and, therefore, amortise over the overall mission

costs. As a consequence, small satellite launches significantly increased. Already 38% of all spacecraft launched during the last 5 years were small satellites. Most of them were Mini- and Micro-satellites.³⁶ Although, the deployment rate of Nano- and Pico-satellites has been growing over the last 10 years, the overall launching rate of small satellites is still low in comparison to conventional satellites (see table above).

There is no universally accepted list available of how many small satellites have been launched in total since Sputnik-1. The Small Satellites Homepage, which is maintained by researchers in the Surrey Space Centre, provides a comprehensive list with names of small spacecraft launched since Sputnik-1 until 2004.³⁷

Recalling the fact that it was with small satellites that the U.S. and the USSR first stepped into space, more and more developing and emerging countries initiated small satellite missions and accessed space for the very first time.³⁸

33 In Europe, the University of Surrey and later the Surrey Satellite Technology Ltd. made a major and significant contribution to small satellite development. It started with the University of Surrey, which initiated the first European small satellite research programmes in 1978. See *Sweeting*, 2002, 3.

34 „Cost-effective“ is defined by *Sandau*, 2006, 11 as „We tend to recognize a mission that was cost effective more by what came out of it than how much money went into it (...)“.

35 See UNISPACE III, *Small Satellite Missions Background paper* 9, 1998, 14 para 66.

36 See ASD-Eurospace report, 2012, 10.

37 See the Small Satellites Homepage <http://centaur.sstl.co.uk/SSHP/index.html> (25.03.2013).

38 To provide evidence to this notion, see the list of emerging and developing countries which launched a small satellite

Nowadays, small satellites have not replaced conventional satellites; they have rather complemented big missions.³⁹ Eventually, small satellites in the past reached a considerable level of technological advancement with complexity, accuracy and more flexibility. Given this important progress, we may very well be witnessing a steadily increasing number of small satellite launches in the future.

2.3 Small satellite applications

Small satellites can be found in all areas of conventional satellite applications, though with some restrictions. This chapter provides an overview of the main fields of small satellite applications referring to the UNISPACE III Small Satellite Missions Background paper 9 (1998). It has divided the fields of purpose into several applications such as telecommunications, Earth observations (remote sensing), or technology demonstrations, and academic training.

Telecommunication satellites are mainly placed in GEO (~36,000 km), which is rather unattainable for small spacecraft for several reasons. These satellites typically carry heavy payloads such as multiple transponders and receivers and propulsion systems which small satellites, due to budget and mass constraints, are not capable of.⁴⁰ A telecommunication satellite placed in GEO covers about 40% of the surface of the Earth. In contrast, for an effort to cover the same area through (small) satellites placed in LEO, about 48 to 66 (small) spacecraft would be needed.⁴¹ However, it is technically possible to even use small satellites for telecommunication by installing small communication satellite constellations in lower Earth orbits.⁴² Examples for LEO communication constellations (Mini- and Micro-satellites) in the past were Orbcomm (26 satellites), and Globalstar (24 satellites).⁴³

Although LEO satellite communication has been replaced by low-cost ground networks such as mobile communication and fibre technology (Internet), a small satellite mission, consisting of only two Micro-satellites, named HealthSat-1 &2 manufactured by SSTL and operated by SatelLife (U.S.) in LEO were fully in operation dedicated to remote areas in order to install

provided by the Small Satellites Homepage.

39 See UNISPACE III, *Small Satellite Missions Background paper 9*, 1998, 7 para 13.

40 There are many other reasons why small satellites are not intended to serve the GEO such as the absence of reliability resulted from less mass. See UNISPACE III, *Small Satellite Mission Background paper 9*, 1998, 7 para 15.

41 See *Baumann/Dodel*, 2011, 374.

42 See UNISPACE III, *Small Satellite Mission Background paper 9*, 1998, 8 para 24.

43 See examples of small satellite telecommunication missions in the past *Bovet et al.*, 2002, 458, table 5-1.

medical and health programmes.⁴⁴ This constellation sets a striking example for small satellites to be encouraged again in the LEO telecommunication sector.

Nowadays, small satellites are also found in the area of Earth observation, e.g. in disaster warning and support (cyclones, floods, fires, Earthquakes etc.), agriculture (measurement of crop status, determination of soil character etc.), watching and controlling de-forestation and so forth.⁴⁵ Thus, the list of small satellite applications in the field of Earth observation is quite long and not exhaustive.

Small satellites in comparison to conventional satellites play a fundamental role in the educational field including technology development.⁴⁶ A striking number of small satellites, notably Nano-, Pico- or Cube-satellites are launched under the umbrella of student programmes carried out by universities and research centres. The major benefits gathered from those missions are a gain of knowledge, the acquisition of useful data, and staff training and education in the field of space technology. Nano-, Pico- and Cube-satellites are therefore commonly used for the advancement and verification of space technology and for carrying out research projects for educational purposes. Small satellite missions also enter the fields of new technologies. Once novel systems are tested by small satellites, they might even be adjusted by conventional satellite missions.⁴⁷

A less influential field of small satellite applications is satellite navigation. This field is still satisfactorily covered by conventional satellites missions with large mass and reliable operation rates. Currently, small satellites are commonly used to support big navigation systems by doing auxiliary measurements and data calibration or corrections on behalf of geodesy matters.⁴⁸

In conclusion, small satellites enter new areas of space applications such as Earth observation or education, technology demonstration and verification whereas the field of telecommunication and navigation is still dominated by conventional massive satellites.

⁴⁴ See *Sweeting*, 2002, 7.

⁴⁵ See *Sandau*, 2006, 79ff.

⁴⁶ Ibid. 111ff.

⁴⁷ See UNISPACE III, *Small Satellite Missions Background paper 9*, 1998, 10, para 38ff.

⁴⁸ Although not being classified as a navigation satellite, small satellites are able to carry GPS receivers in order to assist bigger navigation missions http://centaur.sstl.co.uk/SSHP/list/list_gps.html (25.03.2013).

2.4 Technical and operational aspects of small satellites

In principle, a small satellite can have the same construction as a conventional satellite. It is regularly composed of the very same components such as enclosure, bolts, nuts, and electronics with certain restrictions: the satellite and (with its component parts) is miniaturised and because of mass constraints is equipped with a limited number of payloads. The term “payload” is used for all instruments that a satellite is equipped with. However, the term “payload” is also generally used for a satellite itself when stored on a launch vehicle. Due to the fact that small satellites are typically identified by their light weight and low costs it is impossible for them to carry a vast number of payloads. The limitation of on-board instruments leads to rather targeted missions.⁴⁹

According to the hardware, the enclosure of small satellites often has a cubic form (Cube-Sat) or looks like a rectangular box. The box is the main body of the satellite, and depending on the mission target, is equipped with suited payloads (e.g. camera). In contrast, a conventional satellite is composed of a large and heavy platform called “satellite bus” that carries all required payloads. The interior contains the very sensitive microelectronics and on-board computers.⁵⁰ Particular attention has to be paid to standardised items or so-called commercial off-the-shelf (COTS) components which enable universities and other budget constrained missions to use prefabricated items.

In order to successfully carry out small satellite missions, the following matters are required as a minimum standard: power supply systems such as solar panels and/or batteries as well as telemetry infrastructure in order to carry out on-board calibrations (calculations) and communication facilities such as ground stations, antennas, transponders and receivers.⁵¹ It would go beyond this discussion to describe and mention further items required to properly operate a small satellite mission.

Once a small satellite is in space its on-board computers needs to be operated by solar cells or rechargeable batteries.⁵² The power supply of a small satellite is directly linked to its operational mission life-time. Typically small satellites (depending on the mass, size,

49 See UNISPACE III, *Small Satellite Missions Background paper 9*, 1998, 5 para 4.

50 Concerning microelectronics, two concepts dedicated to small satellites have been proposed – the combination of Micro-Electromechanical Systems (MEMS) and the system of Application Specific Integrated Micro-instruments (ASIM). Those are among the most miniaturized on-board computers available for small satellites. See *Sandau*, 2006, 4.

51 For the anatomy of a small satellite http://centaur.sstl.co.uk/SSHP/sshp_technology.html (25.03.2013); for the description of “Telemetry” and “Telecommand” see *Soucek*, *Space science data policies*, 2011, 666.

52 See *Koudelka*, 2008, 136. For example the Austrian Tugsat-1 uses both, solar cells and a battery. The solar cells will generate power (6 Watts on average) which will be stored in the battery.

payloads, propulsion systems, orbital parameters etc.) are expected to have an operational life time of about a few weeks up to 5 years (for Nano-, Pico- or Cube-satellites)⁵³ which is very little in comparison to conventional telecommunication satellites which usually have an operational life-time of about 15-18 years.⁵⁴ The smaller and the lighter a satellite is, the smaller the battery or other system for the power supply of the on-board computer is.

The limitation of size and mass is both at the same time, one of the most benefits (cost reduction and short development time) and one of the most fundamental disadvantages.⁵⁵ Taking into account that a small spacecraft would have to fly manoeuvres to increase altitude, to change its inclination or to deorbit from a certain position, a certain velocity increment through additional propulsion systems is needed as well.⁵⁶ However, due to budget and other factual constraints, a significant number of small satellites, in particular Nano-, Pico-, Cube-, and Ultra-small-satellites do not carry on-board propulsion systems⁵⁷ which raise the question of whether such small satellites meet the need for a sustainable use of outer space (see chapter 3.8).

Ground stations are inevitable in order to maintain communication in terms of sending uplinks (communication to the satellite) and receiving downlinks (obtaining signals from the satellite). In order to receive and transmit complex data, e.g. for Earth observation, a conventional ground station needs to be equipped with rather dense and multifaceted technology, based on high costs. According to the UNISPACE III Small Satellite Missions Background paper 9 (1998), a (reduced) ground station for small satellites has to fulfil the following functions: a) operations b) tracking, telemetry and command c) data reception and transmission.⁵⁸

One may not forget to consider the cost for setting up the ground station. To serve a professional ground station, any personnel recruited thereof would be needed. The Global Educational Network for Satellite Operations (GENSO) project aims to providing a

53 See Resolution COM6/10 (WRC-12) lit c.; http://www.itu.int/en/ITU-R/space/AmateurDoc/RES-COM6_10.pdf (25.03.2013).

54 See Koudelka, 2011, 48.

55 See Sandau, 2010, 85.

56 See Maeda, 2002, 124.

57 See Sandau, 2006, 43.

58 See UNISPACE III, *Small Satellite Missions Background paper 9*, 1998, 13 para 54ff.

worldwide cost-effective ground station segment in order to realise small satellite programmes initiated by universities.⁵⁹

Further, launching opportunities and frequencies so as to communicate are needed, which can indeed, be a real challenge to obtain (for frequency management in general see chapter 3.8.2). Small satellites, in particular Nano-, Pico-, Cube-, and Ultra-small satellites are launched “piggyback” as “secondary payload” on a large rocket together with the “primary payload” or in groups on a medium-sized rocket. “Primary” payload means the main payload (e.g. a conventional Earth observation satellite). A “secondary” payload can be a drastically lighter payload such as a small satellite launched at the same launch vehicle.

During the piggyback launching method the small satellite is usually stored inside the upper stage, mostly near the primary payload. When the upper stage passes the dedicated orbit of the small satellite, the satellite will simply be ejected. Usually the small satellite does not use kinetic energy in order to reach its dedicated inclination; physical forces direct the satellite in its position.⁶⁰ The main challenge for small satellites is not the launching phase itself; it is the lack of adequate launching opportunities which can result in mission delays (for the launching opportunities in general see chapter 5.3.2).

Small satellites can operate in constellations consisting of dozens of small satellites. A practical example is the DMC (Disaster Monitoring Constellation), consisting of several small satellites for Earth observation.⁶¹ Another example for a future planned small satellite constellation is the QB50 project, consisting of about 40 small spacecraft (for the project description see chapter 3.3.4).

2.5 TUGSAT-1 and UniBRITE - the first Austrian small satellites

The Graz University of Technology, in cooperation with the Vienna University of Technology and the University of Vienna, has designed and manufactured two similar Nano-satellites which were the first Austrian satellites launched into space on 25th February 2013, piggyback on the Indian Polar Satellite Launch Vehicle (PSLV) rocket from the Indian space port Satish Dhawan Space Centre (SHAR) in Shriharikota. The two Nano-satellites were

⁵⁹ For further details on GENSO see <http://www.genso.org/> (25.03.2012).

⁶⁰ For the description of the launch phase of Tugsat-1 and UniBRITE see *Koudelka*, The BRITE Nanosatellite Constellation: Symposium: Small is beautiful? Potentials and Risks of Small Satellite Projects, Juridicum Vienna, 27 Nov.

⁶¹ See *Sandau*, 2010, 85; See also http://www.dmcii.com/about_us_constellation.htm (25.03.2013).

placed into a sun synchronous orbit in LEO at an altitude of about 800 km above the surface of the Earth.⁶²

This project is carried out in cooperation with the University of Toronto. The entire mission is called BRITE (Bright Target Explorer) and consists of six Nano-satellites (two from Austria, two from Poland and two from Canada). This undertaking measures the brightness of very luminous stars. Data gathered by this experiment are intended to contribute to the exploration of the expansion of the universe. The satellites have a size of 20 x 20 x 20 cm and weights between six and seven kilograms and would thus fall into the category of a Nano-satellite.

TUGSAT-1 and UniBRITE are prime examples of space science and education. Although Tugsat-1 and UniBRITE cannot be considered as a typical “student satellite”, students are involved in all phases ranging from design, manufacture and testing. The management will be done by faculty and university staff.⁶³ Financial contributions for Tugsat-1 and UniBRITE come from the Austrian Federal Ministry for Transport, Innovation and Technology as well as from the Austrian Research Promotion Agency (FFG).⁶⁴

Due to this project, Austria is going to become a launching state for the very first time, which also has a significant legal impact. In December 2011, the first Austrian Outer Space Act (hereinafter cited as: AOSA) was enacted.⁶⁵ Examples of legal issues that have been raised were:

A) The fact that Austria became a launching state for the very first time raised the question whether TUGSAT-1 and UniBRITE needed state approval according to the recently enacted AOSA.

Since TUGSAT-1 and UniBRITE were commissioned in 2005, before the AOSA entered into force (December 2011), TUGSAT-1 and UniBRITE were only notified to the Ministry for Transport, Innovation and Technology instead of the initiation of a formal authorisation procedure (§ 15 AOSA).

62 Mission details are provided by *Koudelka*, 2008, 133ff; See the website of the BRITE mission <http://www.brite-constellation.at/> (25.03.2013) and for TUGSAT-1 <http://www.tugsat.tugraz.at/der-satellite> (25.03.2013).

63 See *Koudelka*, 2008, 134f.

64 Ibid. 133.

65 Austrian Federal Law on the Authorisation of Space Activities and the Establishment of a National Space Registry (Austrian Outer Space Act, adopted by the National Council on 6 December 2011, entered into force on 28 December 2011) The English Version (unofficial translation) is provided by Austria and available under <http://www.oosa.unvienna.org/pdf/spacelaw/national/austria/austrian-outer-space-actE.pdf> (25.03.2013).

B) According to the insurance obligation laid down in § 4 (4) AOSA in conjunction with § 11, it had to be clarified, whether the small satellite fell under the insurance regime of the AOSA.

Pursuant to § 15 AOSA the state's right of recourse (§ 11) against a non-governmental entity in case of damage is excluded for space activities which are commissioned before the law enters into force. Hence, TUGSAT-1 and UniBRITE are also excluded from the recourse obligation.

However, § 4 (4) is still applicable, thus the Nano-satellites needed an insurance cover, but they applied for exoneration for space activities which are "in the public interest", laid down in the same paragraph.

C) In addition to that, the mission had to apply for both, amateur frequencies and international radio frequencies, which were subject to a time consuming allocation regime and coordination process through international institutions such as the International Telecommunication Union (ITU) and the International Amateur Radio Union (IARU) as well as national authorities.⁶⁶ Eventually, they obtained all necessary frequencies they had applied for (for frequency management in general see chapter 3.8.2).

D) The Graz University of Technology used an imported item ("star tracker"), which underlay the International Traffic in Arms Regulations (ITAR). Hence, the university had to deal with foreign national export control provisions (for export provisions in general see chapter 3.7.3).

E) Finally, Launch Service Agreements (LSA) between the Graz University of Technology as well as the partner universities and the launch service provider had to be negotiated (for space contracts in general see chapter 3.7.5).

⁶⁶ See Koudelka, 2008, 145.

3 Legal issues

3.1 Sources of space law

3.1.1 General aspects

Article 38 (1) of the Statute of the International Court of Justice (ICJ)⁶⁷ constitutes the main sources of international law (hereinafter briefly described), namely, a) international conventions; b) international custom; c) general principles of law; and d) judicial decisions and teachings of the most highly qualified publicists. Those sources also apply to space activities.

The main international space conventions (treaty law) will be briefly described in the following chapters. Custom is defined in Art 38 (b) “*as evidence of a general practice accepted as law*”. Due to the significant number of states that ratified the OST, although disputed, some of the principles contained might have already become customary law (for further details see chapter 3.1.3).⁶⁸ The general principles of law such as the prohibition of genocide, or the principle of *pacta sunt servanda*, have to be applied in space as well. At the moment judicial “space” decisions only exist at domestic level.⁶⁹

However, space law not only originates from international law. There are other layers of law such as supra-national law (EU law) and increasingly national space legislation. International space law ranges from public international law (e.g. space treaties) to international private law (e.g. arbitration law) to regulations which are enacted by international organisations (e.g. ESA).⁷⁰

There is a distinction between “hard law” and “soft law” regulations. Whereas “hard law” is defined by binding and enforceable rules, “soft law” is considered as less formal and unbinding.⁷¹ A few “soft law” documents are paramount even for small satellite activities: The IADC Space Debris Mitigation Guidelines, as well as the UNCOPUOS Space Debris Mitigation Guidelines, and the European Code of Conduct (status of a draft).

⁶⁷ Statute of the International Court of Justice (1945).

⁶⁸ See Lyall/Larsen, 2009, 70f.

⁶⁹ See a list of judicial decisions by domestic courts http://www.esa.int/SPECIALS/ECSL/SEMT9MMKPZD_0.html (25.03.2013).

⁷⁰ See Lyall/Larsen, 2009, 31.

⁷¹ Ibid. 51.

The main institutions for assisting the production procedure of international binding and non-binding space law are the United Nations Committee for the Peaceful Uses of Outer Space (UNCOPUOS) Legal Subcommittee, the International Telecommunication Union (ITU), which is a UN specialised organisation and the International Institute for the Unification of Private Law (UNIDROIT).

Notably, the production of national space law is growing. By March 2013, 20 states have enacted national space legislation,⁷² still quite few in comparison to the rate of space-faring nations or of those which have already launched a (small) satellite (about 57).⁷³

3.1.2 Specific aspects relating to small satellites

Regarding the international level, the most important provisions to be applied to all space activities including small satellite missions is treaty law. The Outer Space Treaty⁷⁴ (OST) contains the main principles of outer space legislation. According to the opinion of some authors,⁷⁵ some of the principles laid down in the OST may have already achieved the status of customary law, and therefore, even non-state parties to the treaty would be bound by them.

The Agreement on the Rescue of Astronauts, and the Return of Astronauts and Return of Objects launched into Outer Space,⁷⁶ (ARRA), encompasses the rights and duties of astronauts, as well as the obligation to render any possible assistance in a case of accident. State parties to the treaty have to return stranded foreign space objects on demand (Art 4). As small satellites regularly burn-up completely while re-entering, the treaty might be neglected.

The Convention on international Liability for Damage caused by Space Objects,⁷⁷ hereinafter cited as LIAB, is a vital document concerning damage caused by space objects on the surface of the Earth, to aircraft in flight as well as in outer space. Since small satellites when launched into space are considered as “space objects” (Art I (d)) this document remains important (for aspects on liability in general see chapter 3.4).

72 See UNOOSA Space Law Database <http://www.oosa.unvienna.org/> (25.03.2013).

73 Notably, Wikipedia provides one of the most informative overviews of all first satellites of countries launched. See <http://en.wikipedia.org/wiki/Satellite> (25.03.2013) under the category “First satellites of countries”.

74 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, adopted by the GA in its resolution 2222 (XXI) of 19 Dec 1966, status of ratification by 2012: 101; preceded by the Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space, United Nations General Assembly Res 1962, entered into force in 1963.

75 See *Lyall/Larsen*, 2009, 71. The question whether some principle of the OST became customary law is still disputed.

76 Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space, adopted by the GA in its Res 2345 (XXII) of 19 December 1967, status of ratification by 2012: 91.

77 Convention on International Liability for Damage Caused by Space Objects, adopted by the General Assembly in its resolution 2777 (XXVI) of 29 Nov 1971, status of ratification by 2012: 88.

Further, the Convention on Registration of Objects Launched into Outer Space,⁷⁸ hereinafter cited as REG, is one of the most important frameworks concerning the registration of (small) spacecraft (for details on the registration of spacecraft in general see chapter 3.6).

Even the Agreement Governing the Activities on the Moon and other celestial Bodies,⁷⁹ hereinafter cited as Moon Agreement, might become important considering that non-terrestrial small satellite launches such as, for example, small satellites launched from the Moon or the planet Mars might not be beyond the bounds of possibility anymore in the near future (for non-terrestrial small satellite launches in general see chapter 3.5).

Other notable documents concerning small satellites are the basic texts of the ITU, namely the ITU Constitution, the ITU Convention and the Administrative Regulations (Art 4 ITU Constitution) which include the Radio Regulations.⁸⁰ Those provisions deal with radio frequency coordination and affect small satellite missions in various ways (for the ITU procedures in general see chapter 3.8.2).

The Convention on International Interests in Mobile Equipment, “Cape Town Convention”, 2001⁸¹ and the Protocol on Space Assets, “Berlin Protocol”, which was agreed in 2012, may become significant, for instance, as regards intellectual property rights concerning items and technology of (small) satellites.

Moreover, several principles were adopted by the UN General Assembly (UNGA). Generally, these principles are accepted as “soft law”.⁸² The most relevant UNGA Resolution which may apply to small satellites in general is the Declaration on International Cooperation in space.⁸³ Since the principles laid down in this declaration highlight the importance of cooperation in the exploration and use of space in particular for developing countries (annex para 3), these principles may encourage developing countries in general to participate in outer space activities, which can be through small satellites.

78 Convention on Registration of Objects Launched into Outer Space, adopted by the General Assembly in its resolution 3235 (XXIX) of 12 Nov 1974, status of ratification by 2012: 56.

79 Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, adopted by the GA in its resolution 34/68 of 5 Dec 1979, status of ratification by 2012: 14.

80 Constitution and Convention of the International Telecommunication Union, Geneva, 22 December 1992.

81 Convention on International Interests in Mobile Equipment (Cape Town Convention), adopted 16 November 2001, entered into force 01 March 2006.

82 See *Freeland*, 2012, 25.

83 Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries, adopted by the GA in its resolution 51/122 of 13 December 1996.

The Remote Sensing Principles⁸⁴ stipulate the handing over of data and information about a nationally remote sensed land by a foreign state on demand (for details on space data in general see chapter 3.7.4). The Principles relevant to the Use of Nuclear Power Sources, as well as the Safety Framework and the Resolution on Some Aspects Concerning the Use of the Geostationary Orbit, have less impact on small satellite missions because small satellites typically use solar cells and batteries instead of nuclear power sources and because the geostationary orbit is usually not served by small satellites.⁸⁵

The listed sources of space law applicable to small satellites in the present thesis are not closed. It would go beyond the scope of discussion to describe all of them. Since small satellite missions may involve several states with diverging laws, utmost attention has to be drawn on legal issues. Hence, cross-border small satellite missions may create situations where multiple laws are applicable. Such missions may be affected by legal situations where several participating states might not even be parties to some of the space treaties.

3.1.3 The main principles of outer space legislation in the context of small satellites

This chapter describes in brief the main principles of outer space legislation laid down in the OST, which are also relevant for small satellites and which are basics for the legal understanding of the upcoming chapters.

Article I OST enshrines the principle of free use of outer space, irrespective of the degree of economic development. This article is becoming very important for small satellites, because the low-cost approach of several types of small satellites enables developing and smaller countries to participate in outer space activities. However, small satellites often use certain orbits of the LEO which in future might become overcrowded.

Notably, the LEO in this discussion is not a particular orbit, but is rather defined as a specific area where a satellite can be placed. Nonetheless, the question emerges whether small satellite activities and, in particular, future planned small satellite constellations consisting of hundreds of (ultra)-small satellites may hinder others in using outer space harmlessly (for the limits of outer space “democratisation” in general see chapter 4.6).

84 Principles Relating to Remote Sensing of the Earth from Outer Space, 3 December, UNGA Res. 41/65, 1986.

85 Principles Relevant to the Use of Nuclear Power Sources in Outer Space, adopted by the GA in its resolution 47/68 of 14 December 1992; Safety Framework for Nuclear Power Source Application in Outer Space, endorsed by the Committee on the Peaceful Uses of Outer Space at its fifty-second session and contained in A/AC.105/934; Resolution concerning the use of the geostationary orbit, adopted by the Legal Subcommittee at its thirty-ninth session (A/AC.105/738, annex III).

Article II OST states the principle that outer space is not a subject of territorial claims. Since this article does not raise legal issues concerning small satellite missions in general, a further analysis of this article is negligible in this thesis.

Article III OST stipulates that state parties to the treaty shall act in accordance with international law and with the Charter of the United Nations.⁸⁶ This means that states shall refrain from any acts against international law and against the principles laid down in the UN Charter.

Article IV OST refers to the military use of outer space and Art V OST to human spaceflight (astronauts) and the return of space objects. Those aspects will be neglected in the present thesis.

Article VI OST formulates that state parties to the treaty shall bear international responsibility for activities carried on by governmental agencies or even by non-governmental entities. This provision plays a central role concerning small satellite activities since a steadily increasing number of small satellites is carried out by non-governmental entities such as universities, research centres and other private institutions and even by individuals. States have the obligation to authorise (e.g. licence) and continuously supervise small satellite activities carried on by non-governmental entities, irrespective of their size, weight and harm potentiality. Additionally, Art VI is vital for the enactment of national space legislations which also affect small satellite missions (for further details on responsibility in general see chapter 3.3).

Article VII OST manifests the notion that, according to public international space law, it is always a state and never a private entity which is liable for damages caused by a space object on the surface of the Earth, in airspace or in outer space. This provision plays a central role when multiple actors are involved in the event of a small satellite (piggyback) launch.

Article VIII OST stipulates that each space object (regardless of its size and weight), shall be registered. In addition to that, a state of registry shall retain jurisdiction and control of a space object.

⁸⁶ Charter of the United Nations (26.06.1945).

Article IX OST lays down the principle of international cooperation and mutual assistance, and the obligation to avoid harmful contamination of space. This provision becomes important towards the limits of outer space “democratisation” through small satellites.

Digression: If one follows the notion of a few authors that some of the principles laid down in the OST have already achieved the status of customary law, due to general practice accepted as law (101 states have ratified the OST by 2012), small satellite missions carried out by non-state parties to the treaty would also be bound by the main principles. According to a few authors, this might be true for the principle of non-appropriation, the freedom of exploration and use of outer space, and for state responsibility, liability and jurisdiction, and control over a space object.⁸⁷

3.2 The legal nature of small satellites

The OST does not refer to any specific space mission, but merely to “space activities” (Art VI), and to “space objects” (Arts V, VII, VIII). Moreover, Art VI OST provides no definition of the term “space activity”. Since neither the OST, nor the other space treaties, refer to the size and weight of a space activity, small satellites missions carried on in space are doubtlessly “space activities” and subject to space law.

Proofing the lack of definition of “space objects”, one is provided with a mere description rather than a definition:⁸⁸ *“The term space object includes component parts of a space object as well as its launch vehicle and parts thereof”* (Art I (d) LIAB and in Art I (b) REG).

Referring to Art I (d) LIAB, a possible argument would be that during the piggyback launch a small satellite might be considered as “component part” of the primary payload or as “parts of the launch vehicle”. According to the opinion of the author, this assumption has to be rejected. Each part of the primary payload, which may be a conventional Earth observation satellite, has to contribute to its function. Therefore, individual parts such as solar sails or optical instruments may be considered as “component parts of a space object”. In contrast, a small satellite which is not participating in the primary payload mission has no function in making the primary payload work. Although launched together, both the primary payload, and the secondary payload (small satellite) are to be considered as separate space objects.

⁸⁷ See Lyall/Larsen, 2009, 71. It would go beyond the discussion to list diverging opinions.

⁸⁸ See Kerrest/Smith, 2009, 140 recital 51.

Moreover, a small satellite does not even have a function in making the launch vehicle feasible. Hence, a small satellite shall not be considered as “part of the launch vehicle”.

Digression:⁸⁹ Due to the description of Art I (d) “*The term space object includes (...) its launch vehicle (...)*” a small satellite (space object) and its launch vehicle might be considered as one space object, since it “includes its launch vehicle” according to the description of Art I (d). Hence, the launching state of the launch service provider theoretically may also register the small satellite (Art VIII OST, REG) and in turn - although not recommended⁹⁰ - the launching state of the small satellite can also register the launch vehicle (for further details on the registration of space objects see chapter 3.6). Part 2 “Definitions” of the Australian Space Activities Act⁹¹ (hereinafter: ASAA) which defines the term “space object” as “(a) a launch vehicle; and b) a payload (if any) that the launch vehicle is to carry (...)”. Hence, this definition explicitly refers to the launch vehicle and its payload as being qualified as (one) space object.

Furthermore, Article II para 1 REG states: “*When a space object is launched to the Earth orbit or beyond (...)*”. This means that any object in airspace, like an airplane, is not a space object, hence it serves in airspace and is not intended to leave airspace.⁹² Since a small satellite is intended to serve in outer space, it shall be considered a “space object” starting from the ignition of the launch.⁹³

During the pre-launch phase which comprises the design and manufacture of the small satellite, it is usually not considered as a space object. However, states are basically free to define the term “space activity” which includes an autonomous definition of when an activity turns into a “space” activity in their national space legislation (e.g. § 1 AOSA).

The legal function of a small satellite does not end with its technical function. This means that even space debris (e.g. a small satellite after its operational life-time) may be legally considered as “space object”.⁹⁴ This would probably go in line with the victim-orientated

89 As far as the author researched, the issue whether a small satellite and its launch vehicle can be considered as one space object was not explicitly described in the literature used by the author.

90 See UNGA Res 62/101 of 17 December 2007 para 3(c): “In cases of joint launches of space objects, each space object should be registered separately (...)”. The document is available under www.unoosa.at (25.03.2013).

91 Australian Space Activities Act 1998 Act No. 123 of 1998 as amended by Act No.8 of 2010.

92 See Kerrest/Smith, 2009, 141 recital 54; see Schmidt-Tedd/Mick, 2009, 151 recital 20.

93 See Hobe, 2009, 35 recital 37. Usually international space law applies when an object turns into a “space object” which is accepted at the ignition of the launch.

94 For the discussion in general whether space debris shall be identified as “space object” see Schmidt-Tedd/Mick, 2009, 154 recital 33. This is a controversial opinion. However, it would go beyond this discussion to further elaborate on those opinions.

character of the OST and the LIAB, since space debris may harm third parties when it does not completely burn up while re-entering the atmosphere. Space debris may even constitute harm to space activities in orbit.⁹⁵ Thus, registering and controlling space debris or fragments may even be in line with the notion of Art VIII OST and the REG. This specific point of view may also be reflected in the concept of “sustainable use of outer space” as well as in ideas of “space traffic management” (for space traffic management in general see chapter 3.8.3).

Moreover, the OST does not provide a definition of the exact location of outer space and where it begins. According to Theodore van Kármán, who established a demarcation line, everything beyond an altitude of 100 km can be considered outer space.⁹⁶ According to Art I of the Convention on International Civil Aviation⁹⁷ (Chicago Convention) a state retains sovereignty over the airspace above its territory. Thus, the question where outer space begins may become crucial as Art VI OST refers to “activities in outer space”. The purpose of legally delimiting outer space from airspace is that activities carried out on the surface of the earth and in airspace - excluding the high sea and Antarctica⁹⁸ – shall underlie all rules referring to the territory of a state (areas of territorial sovereignty). In contrast, activities carried out in outer space shall be free from claims of territorial sovereignty (Art II OST).

Currently, only Australia, in Part 2 of the ASAA defines the term “space object” as relating to an exact altitude of 100 km where outer space shall begin. According to this definition, a “space object” is an object to be launched beyond 100 km.

In addition to that, the ASAA in Part 2 explicitly differentiate between “launch vehicle” and “launch facility”. Whereas a “launch vehicle”, which is a “space object” (e.g. rocket) is intended to lift up a payload, a “launch facility” might not necessarily go to outer space (e.g. launch pad). It is sufficient that the “facility” is primarily dedicated to conducting the launch of space objects (e.g. space ports, launching pads, even airplanes; see also the definition in Part 2 ASAA). The distinction between “launch vehicle” and “facility” might be interesting for trying to solve issues of liability concerning small satellite piggyback launches from airplanes, which is further described in chapter 3.5.

⁹⁵ See *Smith/Valic*, conference proceedings, 2012, 12.

⁹⁶ T.v.K. was a Hungarian physicist who claimed that the boundary for outer space, according to the aerodynamic lift, is located at about 100 km above sea level. For further details see *Lyall/Larsen*, 2009, 165ff.

⁹⁷ Convention on International Civil Aviation, adopted in Chicago on 7 December 1944.

⁹⁸ For claims of territorial sovereignty of the Antarctic see Art IV of the Antarctic Treaty (1959).

Summing up, the legal nature of a small satellite mission being qualified a “space activity”, as well as a small satellite intended to be launched into space as a “space object” typically starts with the ignition of the launch. A small satellite, although stored alongside the primary payload (piggyback), during the launch shall not be qualified as a component part of the primary payload. As a legal consequence, both the primary payload, and a small satellite shall be perceived as two separate “space objects”.

Further, the character of a “space object” shall not end with the function of the small satellite in orbit. A small satellite shall be considered as a “space object” even when it has lost its function and re-enters the atmosphere in an uncontrolled mode. Eventually, the legal nature of a small satellite is directly linked with the issue of state responsibility (Art VI OST), liability (Art VII OST) and registration of a small spacecraft (Art VIII OST) which will be examined in the up-coming chapters.

3.3 State responsibility for national space activities

3.3.1 General aspects

The first sentence of Article VI OST establishes the following provision:

“States Parties to the Treaty shall bear international responsibility for national activities in space (...) whether such activities are carried out by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty. (...).”

One of the major legislative principles stated in the OST is the commitment of states to bear international responsibility for national⁹⁹ activities in space. The main aim of Art VI, first sentence, is to make states responsible for any activities in space, regardless of whether this activity is carried out by the state itself or by a non-governmental entity (including individuals).

The term “responsibility” is not defined in the OST. However, a state which is “responsible” under Art VI has to ensure that the space activity is in line with the provisions laid down in the OST (Art VI, first sentence). Nevertheless, “responsibility” should not be confused with the term “liability” in case of damage as, laid down in Art VII OST.¹⁰⁰

Article VI OST, second sentence, stipulates:

⁹⁹ For comments on the term “national” see Gerhard, 2009, 109 recital 31.

¹⁰⁰ Ibid. 104 recital 2.

“The activities of non-governmental entities in outer space, including the Moon and other celestial bodies, shall require authorisation and continuing supervision by the appropriate State Party to the Treaty.”

The second sentence provides for regulatory measures such as “authorisation” and “continuously supervision” of activities carried out by non-governmental entities. Governmental agencies include space agencies such as NASA, ROSCOSMOS, CNES or governmental departments such as ministries.¹⁰¹ Thus, according to *argumentum e contrario* (converse argument) of Art VI second sentence, governmental agencies do not need any formal authorisation.

If an activity is carried out by a non-governmental entity, the responsible state has to make sure that the activity is in compliance with the treaty through authorisation (Art VI, first and second sentences). Examples for non-governmental entities are natural or legal persons, universities, research centres and other private institutions.¹⁰² However, the treaty does not stipulate those measures that have to be undertaken by the state in order to fulfil its responsibilities. An adequate measure can be national space laws which can furnish specific authorisation measures such as licencing systems (e.g. § 3 AOSA).

The order of “continuing supervision” means the obligation to supervise the space activity (if national laws exist, from the time on which is autonomously defined) starting from becoming operational even over its end of life-time and re-entry into the atmosphere. However, the term “supervision” does not only implicate obligations, but it also includes the right of the state to obtain appropriate information¹⁰³ about the space activity regardless of whether the activity is carried out by non-governmental entities.

Finally, the third sentence of Art VI OST states:

“When activities are carried on in outer space (...) by an international organization, responsibility for compliance with this Treaty shall be borne both by the international organization and by the States Parties to the Treaty participating in such organization.”

Regarding the last sentence of Art VI, even international organisations are responsible for space activities. It is crucial to highlight this obligation because only states are parties to the OST and therefore, without this obligation, international organisations would not be internationally responsible for their activities pursuant to Art VI OST since the OST would

101 Ibid. 110 recital 32.

102 Ibid. 110 recital 35.

103 Ibid. 119 recital 70.

not be applicable. Notably, a project carried out by the ESA bears international responsibility by both the ESA and its member states.¹⁰⁴

3.3.2 Specific aspects concerning small satellite missions

Regarding small satellites, there is one major question: “Do small satellites need state approval?”

Regularly, non-governmental entities (if they are not an international organisation) and individuals are not subject to international law.¹⁰⁵ Since small satellite missions are “space activities” when launched into space under Art VI OST, first sentence, they have to be authorised by the appropriate state if the activity is carried out by a non-governmental entity or an individual.

Due to their low-budget approach and other benefits, of several types of small satellites small satellite missions are increasingly carried out by non-governmental entities. Non-governmental entities are not bound by the OST¹⁰⁶ and therefore require “authorisation” according to Art VI, second sentence. As a consequence small satellites launched by universities, research centres and other private institutions or individuals require state approval.

In contrast, small satellite missions carried out by governmental space agencies such as NASA or CNES or by the intergovernmental agency ESA, do not need formal state approval according to Art VI. However, the need for formal state approval has to be strictly distinguished from the general obligations to bear international responsibility. While states do not need formal state approval, if several foreign governmental entities carry out a joint venture small satellite mission, then those states though might jointly be responsible for being in line with international law.¹⁰⁷

Furthermore, only the “appropriate” state shall authorise (licence) and supervise the mission carried out by a non-governmental entity. According to *Gerhard*, the “appropriate” state may be that state, which retains “(...) *personal jurisdiction, territorial jurisdiction or jurisdiction over objects registered in a national registry* (...)”.¹⁰⁸ Therefore, a small satellite mission

¹⁰⁴ Ibid. 123 recital 82.

¹⁰⁵ See *Neuhold et al.*, 2004, 133f.

¹⁰⁶ See *Gerhard*, 2009, 110, recital 35.

¹⁰⁷ Ibid. 109f, recital 31.

¹⁰⁸ Ibid. 117, recital 58.

carried out by a university for instance may require state approval from a respective state which becomes a launching state due to Art I and II REG (for the concept of a launching state in general see chapter 3.4.1).

Digression: According to the issue of the “appropriate” state, the French Space Operations Act¹⁰⁹ (hereinafter cited as FSOA) does not include an authorisation regime for launches which are procured by foreign natural or legal persons, which would include foreign small satellites launched piggyback from a French launcher, pursuant to Art 2 in conjunction with Art 1. The act assumes that when a French launch service provider (e.g. Ariane rocket) is already authorised (licensed), France is not the “appropriate” state that shall even authorise a foreign payload¹¹⁰ such as a small satellite on board.¹¹¹ Hence, France refers to the “launch” of a space object, rather than to “space activities” in general. Indeed, in the given example, a foreign space operator “procures” (in contrast, the wording of Art 2 para 1 is “launch”) the entire launch and France usually does not retain jurisdiction and control of any foreign payload including a small satellite (Art 2 para 1 and 2 FSOA). Thus according to Art 1 and 2 the FSOA is not applicable to licence space activities procured by foreign natural or legal persons such as foreign small satellites launched through French launch service providers.¹¹² On the contrary, the AOSA refers to “space activities” and also requires formal state approval for each “space activity” on Austrian territory or on board of Austrian vessels or airplanes, regardless of whether the space activity is carried out by foreign operators (§ 1 in conjunction with § 2 AOSA).

However, the question of the “appropriate” state, which authorises an activity, may become an interesting question concerning cross-border small satellite missions, in which several non-governmental entities from different countries participate. As mentioned above, it might be the respective state which in fact retains jurisdiction and control of the space activity that will actually authorise and supervise the jointly organised space activity.¹¹³

Generally, the main obstacle for small satellite missions is that national space legislation does not distinguish between small and conventional satellite activities. The main differences are (notably, those differences are not absolute – of course - they may be not true for each small and conventional satellite mission) typically: low-cost versus high-cost; short development

109 The French Act relating to space operations, Loi n° 2008-518 du 3 juin 2008 relative aux opérations spatiales.

110 For the issue of the “appropriate” state, which authorises a space activity in general see *Gerhard*, 2009, 116 recital 51.

111 For the issue to procure foreign launches under the FSOA in general see *Clerc*, 2011, 122.

112 Ibid. 122.

113 See *Gerhard* above.

time versus long lasting design and development time; low harm potential for third parties while re-entering the atmosphere versus moderate harm potential while re-entering since a conventional satellite may not be completely burned up.

An authorisation (licencing) process for space activities can be time-consuming, in particular when a provision concerning the decision frame does not exist. However, the AOSA in § 4 (3) contains a maximum decision frame of six months. Indeed, this provision is quite unique in comparison to other national laws (e.g. the Dutch Space Activities Act¹¹⁴ also contains a six-month authorisation limit in section 5a), which is in favour of small satellite missions with a short development time of e.g. under one year. The lack of an autonomous decision frame in many national space laws may be not in favour of small satellite missions with a short development time since it does not assure them authorisation on time. Piggyback launching opportunities are rare and therefore have to be booked early.

Moreover, formal conditions set up in national space acts typically consider the highest harm potential a space activity may have and, therefore, mostly reflect the harm potential of conventional space activities. Authorisation conditions can be linked to mandatory expensive insurance obligations (e.g. § 4 (4) AOSA). Although national space laws may contain exoneration or relaxation, small satellites with a lesser harm potential still might face tight and expensive authorisation requirements (for the issue of exoneration and relaxation of insurance obligation contained in the AOSA see chapter 3.3.3).

To sum up: Small satellite missions as being space activities need state approval under Art VI OST if they are carried out by non-governmental entities. The “appropriate” state shall authorise and continuously supervise the activity. However, national space laws do not distinguish between conventional and small satellite activities. A licencing process for small satellite missions can be time consuming. This situation becomes an obstacle for small satellites with a rather short development time and may lead to unexpected time delays and a loss of adequate piggyback launching opportunities. Additionally, strict formal authorisation conditions may challenge small satellite missions with budget constraints. Hence, national space legislation should take into account the very short development time, less harm potential and budget constraint that various types of small spacecraft might show and should therefore, facilitate the authorisation process for small satellites with less development time and little harm potential.

114 Rules Concerning Space Activities and the Establishment of a Registry of Space Objects (Dutch Space Activities Act).

3.3.3 The Austrian Outer Space Act

This chapter provides an example for national space legislation. The Austrian Outer Space Act¹¹⁵ (hereinafter AOSA) was recently enacted as a consequence of the first Austrian small satellite launch.¹¹⁶ Since small satellite missions carried out by non-governmental entities have to be authorised (Art VI OST) Austria, having ratified the OST, had to enact a set of rules in order to fulfil this internationally binding provision.

§ 1 (1) AOSA defines the scope of the law:

“This Federal Law is applicable to space activities carried out

- 1. on Austrian territory,*
- 2. on board of vessels or airplanes, registered in Austria or*
- 3. by a natural person with Austrian citizenship or legal persons seated in Austria.”*

The AOSA contains an autonomous interpretation of the term space activity as the following:

§ 2 (1) “‘Space activity’: the launch, operation or control of a space object, as well as the operation of a launch facility.”

Paragraph 1 in conjunction with § 2 states the scope of the AOSA. Hence, the AOSA is applicable when a small satellite mission is carried out by an individual person (Austrian citizenship) or by a legal person (e.g. university) seated in Austria. The AOSA is also applicable when a small satellite is launched from an Austrian airplane or Austrian ground facility.¹¹⁷ In addition to that, § 2 indicates that Austria is not willing to take over responsibility for a space activity before the ignition of the launch.

Regarding the obligation to “authorise” space activities (Art VI OST, second sentence):

§ 3 AOSA “Space activities require authorisation by the Minister for Transport, Innovation and Technology. Authorisation requirements under other provisions than under this Federal Law remain unaffected.”

Paragraph 4 (1) in conjunction with § 5 stipulate the following:

“The authorisation according to § 3 shall be issued if (...)

- 4. Appropriate provision has been made for the mitigation of space debris according to § 5 (...).”*

115 Bundesgesetz über die Genehmigung von Weltraumaktivitäten und die Einrichtung eines Weltraumregisters (Weltraumgesetz) BGBl. I Nr. 132/2011 original (German) version available under www.ris.bka.gv.at (25.03.2013); Notably, Austria has ratified all five space treaties; All law materials and proposals for the AOSA are available under http://www.parlament.gv.at/PAKT/VHG/XXIV/I/I_01466/index.shtml (25.03.2013).

116 See *Marboe*, The New Austrian Outer Space Act, 2012, 28f.

117 Ibid. Annex II, Special Part, as to § 1, 44.

§ 5 “The operator has to make provision for the mitigation of space debris in accordance with the state of the art and in due consideration of the internationally recognised guidelines for the mitigation of space debris. Especially measures limiting debris released during normal operations have to be taken.”

As far as small satellite missions are concerned, these paragraphs may turn out to be a cumbersome provision since § 5 AOSA (space debris mitigation) as a binding provision explicitly refers to “internationally recognised guidelines”, which are non-binding provisions. As a consequence intentionally drafted non-binding provisions turn into a nationally binding provision.¹¹⁸ Two space debris mitigation guidelines have been internationally recognised so far, namely the IADC Space Debris Mitigation Guidelines (2002) and the UNCOPUOS Space Debris Mitigation Guidelines (2007).

Accordingly, the IADC Space Debris Mitigation Guidelines¹¹⁹ stipulate in item 5.2.1 (4) a general restriction for space objects in orbit as “25 years to be a reasonable and appropriate lifetime limit”. This means that after the end of life of a space object (end of operational lifetime) the spacecraft shall not stay in LEO longer than 25 years.

This might be a reasonable challenge in particular for small satellites (e.g. Nano-, Pico-, and Cube-satellites), which have technically and financially limited capacities, for instance, in order to carry propulsion systems for post-mission disposal manoeuvres or to afford other de-orbiting systems.¹²⁰ One will observe how restrictive the Austrian authority in charge interprets the formulation “in due consideration of the internationally recognised guidelines for the mitigation of space debris” in future authorisation procedures.

As regards the issue of liability, § 11 (1) and (2) in conjunction with § 4 (4) AOSA are important concerning small satellites:

§ 11 (1) “In the case that the Republic of Austria has compensated damage caused by a space activity in accordance with international law, the Federal Government has the right of recourse against the operator.”

(2) “For damage caused on the surface of the Earth or to aircraft in flight, the right of recourse comprises an amount up to the sum of the insured risk, but no less than the minimum amount of insurance set out under § 4. This limitation does not apply if the damage is due to fault by the operator or his agents or if the operator has infringed the provisions of § 3 or § 4.”

¹¹⁸ See Smith/Valic, conference proceedings, 2012, 5.

¹¹⁹ Inter-Agency Space debris Coordination Committee (IADC), Space Debris Mitigation Guidelines, 2002 (revised 2007), IADC-02-01.

¹²⁰ See Sandau, 2006, 43.

§ 4 (4) “In order to cover liability for damages caused to persons and property, the operator is under the obligation to take out an insurance covering a minimum amount of € 60 000 000 per insurance claim. Run-off liability may not be excluded or limited. If the space activity is in the public interest, the Minister for Transport, Innovation and Technology may determine a lower sum or release the operator from the insurance requirement by administrative decision, taking into account the risks connected to the activity and the operator’s financial capacity. Space activities are in the public interest if they serve science, research or education. Taking out insurance is not necessary if the Federal State itself is the operator.”

Pursuant § 11, Austria would demand recourse if Austria were to be held liable to compensate damage caused by any space activity on the surface of the Earth or to aircraft in flight. Austria obliges the “space operator”, which is according to § 2 para 3 “*a natural or juridical person that carries out or undertakes to carry out space activities*” to buy an unlimited insurance covering a minimum amount of € 60,000,000 (§ 4 (4)).

However, exoneration and relaxation are made for space activities that are “in the public” interest. Paragraph 4 (4) defines the public interest as being research, scientific or educational purposes. In the view of the author, this enumeration is intentionally closed. Thus, space activities for cultural or artistic aims are excluded from the definition of the public interest provided in this paragraph.

As a consequence, small satellites which are not “in the public interest” according to § 4 (4) for instance small satellites launched for merely artistic aims rather than scientific, research and educational purposes cannot obtain an exoneration or a relaxation under § 4 (4).

In order to obtain exoneration or relaxation additionally to the public interest, the risk connected to the activity has to be very low and the operator needs a financial capacity (§ 4(4)). A risk can be considered very low, if it can be assured by experts that the space object will burn-up during re-entering Earth atmosphere.¹²¹

In the view of the author, all three factors (public interest, low risk, sufficient financial capacity) are cumulative. Nevertheless, those factors have to be weighed against each other,¹²² for instance even though the financial capacity is low but the activity is in the predominant public interest (science, research, education) exoneration or relaxation may be granted.

¹²¹ See *Marboe*, The new Austrian Outer Space Act, 2012, 48.

¹²² *Ibid.* 35.

Concerning the obligation to maintain a national registry of space objects launched into outer space the AOSA states:

§ 9 (1) “The Minister for Transport, Innovation and Technology maintains a registry for space objects.”

(2) “(...) all space objects for which Austria is considered to be the launching State according to Art I of the Convention on Registration of Objects Launched into Outer Space (BGBl. Nr. 163/1980) shall be entered into this registry.”

This provision refers to the international obligation to establish a national registry where all space objects including small satellites regardless of their size, weight and harm potential have to be registered (Art II REG). This regulation is in line with Art VIII OST and does not hinder small satellites to realise their benefits.

To sum up: The AOSA can be considered as a well-structured, modern and dynamic piece of national space legislation. It is basically in the favour of small satellite missions, which are carried out “in the public interest” (research, scientific and educational purposes) since those missions benefit from a relaxation of the insurance obligation. In contrast, small satellites launched by natural or legal persons with rather cultural or artistic aims still have to afford the full amount of insurance, which is probably unaffordable for them. The reference to the internationally recognised space debris mitigation guidelines may become an obstacle for several types of small satellites, which may hinder the realisation of a “democratised” space.

Digression:¹²³ The absence of cultural and artistic purposes in the autonomous definition of a “public interest” does not reflect the full potential of small satellites to “democratise” space. It would be appreciated if space activities for mere artistic purposes could also benefit from the relaxation laid down in § 4 (4) AOSA since the freedom of science laid down in Art 17 of the Austrian Basic Law¹²⁴ (Staatsgrundgesetz) is followed by the freedom of arts in Art 17a. Both freedoms are enshrined in the same document at the same national level.

3.3.4 Harmonisation of national space legislation in favour of small satellite missions?

This chapter deals with the issue of non-harmonised national space legislation, and in particular, the consideration of small satellites. Many small satellite missions are cross-border activities such as the future planned QB50 project, which engages numerous entities all around the world. The main purpose of this project is to launch about 40 double-Cube-

¹²³ This paragraph reflects a discussion conducted with Professor emeritus Dr. Christian Brünner during the elaboration process of this thesis.

¹²⁴ Staatsgrundgesetz über die allgemeinen Rechte der Staatsbürger, RGBL 1867/142 idF BGBl 1988/684.

satellites in the LEO at an altitude of about 320 km in order to examine the lower thermosphere (90-320 km). These satellites will only remain in orbit about three months. After their orbital life-times, they will naturally decay and burn up while re-entering the atmosphere.¹²⁵

Since the OST virtually provides a framework, national space legislation varies which may challenge international small satellite projects.

National space acts like AOSA, and FSOA stipulate an obligatory minimum insurance amount of € 60,000,000 (§ 4(4) AOSA; Art 16 and 17 FSOA in conjunction with the French Finance Act). As already mentioned above in the AOSA, some exceptions are made for space activities which are in the autonomously defined “public interest”. In contrast, the British Outer Space Act¹²⁶ (Section 5 para 2 lit. f) and the Netherlands Space Activities Act¹²⁷ (§ 1 Section 3 para 4) include a mandatory insurance cover, but does not regulate a fixed amount.

Since (small) satellites can be registered by one of the four launching states provided in Art I REG, diverging registration practices may arise. However, some states have enacted clear regimes in order to register small satellites (e.g. §§ 9, 10 AOSA) whereas others have not (e.g. U.S. Commercial Space Act¹²⁸). There are also states which have not ratified the REG and which are thus merely bound by Art VIII OST when they have ratified the OST.

As regards space debris mitigation the AOSA explicitly refers to the internationally recognised guidelines in § 5 in order to obtain a licence.

In addition to that, diverging intellectual property rights as well as technology (export) control restrictions raise significant uncertainties. As a consequence, the missions costs are blowing up (e.g. penalties for non-compliance with export control provisions) and further time delays are expected (for details on technology (export) control in general see chapter 3.7.3).

Different national space legislations may lead to “flag of convenience” situations, which is a common state practice in the High Seas, meaning that the most favourable country of tax law and tort law is chosen. Thus, if launching states (Art I REG) commit to registering, a small

125 For a project description see <https://www.qb50.eu/> (25.03.2013).

126 United Kingdom of Great Britain and Northern Ireland Outer Space Act 1986.

127 Rules Concerning Space Activities and the Establishment of a Registry of Space Objects (Dutch Space Activities Act).

128 U.S. Commercial Space Act 1998.

satellite under the most favourable law among those states which have the capacity to carry out launches, the undesirable situation of “launching state shopping” occurs.¹²⁹

To sum up: Diverging national space legislation concerning licencing, insurance policies, registration, as well as the reference to space debris mitigation guidelines, might hinder small satellites activities to realise the benefits of low cost and short production time. Differences in space legislation concerning licencing procedures may lead to various time delays, which become an obstacle when dozens of countries such as in an international small satellite constellation are involved need to book a joint piggyback launch.

Can national space legislation be harmonised by the European Union as a supra-national organisation in order to tackle the problem of diverging space legislation?

The TFEU¹³⁰ (Treaty on the Functioning of the European Union) provides the answer in Art 4 para 3 in conjunction with Art 189 (1) second sentence in conjunction with

“To contribute to attaining the objectives referred to in paragraph 1, the European Parliament and the Council, acting in accordance with the ordinary legislative procedure, (...) excluding any harmonisation of the laws and regulations of the Member States.”

This provision explicitly does not allow any competence of the European Union to harmonise national space legislation.

Nevertheless, UNIDROIT is *inter alia* working on the adaptation of intellectual property rights and commercial contract provisions. It successfully contributed to the drafting of the Cape Town Convention on International Interests in Mobile Equipment and to the adoption of the Space Protocol.

Although no harmonised rules on public national law exist so far, the EU Draft for a Code of Conduct (revised draft 2010)¹³¹ in Chapter 2 contains “General Measures” *inter alia* common measures on space debris control and mitigation. It further stipulates in Chapter 3 “Cooperation Mechanisms” the notification of outer space activities and the registration of space objects.¹³² Those measures are designed to also ease (small) satellite joint venture projects with diverging space legislation within the subscribing states. Member states will

129 See *Gerhard*, 2009, 124 recital 86. It would go beyond the discussion to focus on the issue of ‘flag of convenience’ in depth.

130 Treaty on the Functioning of the European Union (Consolidated version), 2012/C 326/01.

131 Draft for a Code of Conduct 2008, revised 2010, Council of the European Union, Brussels.

132 For explanations on the European Code of Conduct in general see *Mayence*, 2012, 343ff.

contribute on a voluntary basis (“soft law”), which is to strengthen transparency and confidence-building measures (Preamble). Notably, all states, not only European Union member states, are invited to subscribe to the Code of Conduct when adopted (item 1.2 in conjunction with the preamble).

To sum up: Many small satellite projects are composed of different participants from several states with diverging national space legislations. As a consequence, divergences in national space acts, such as deviations in licencing, insurance and registration obligation may be an obstacle for small satellite missions intending to realise a joint venture. Although the EU has no competence to harmonise national space legislations, the promotion of small spacecraft requires, at least, the adaptation of existing provisions in order to realise the benefits of small satellites. Hence, the harmonisation, or at least adaptation, of national space legislations is in favour of small satellite missions.

3.4 International liability for space objects launched into outer space

3.4.1 General aspects

One of the main principles in outer space legislation is the principle of “state liability”, which is laid down in Art VII OST:

“Each State Party to the Treaty, that launches or procures the launching of an object into outer space, including the Moon and other celestial bodies, and each State party from whose territory or facility an object is launched, is internationally liable for 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 airspace or in outer space, including the moon and other celestial bodies.”

Article VII OST was further developed in the Liability Convention in 1978 (hereinafter cited as LIAB).¹³³ The LIAB can be considered as *lex specialis* to the OST.¹³⁴

The term “damage” is autonomously defined by Art. I (a) LIAB as “(...) *loss of life, personal injury or other impairment of health; or loss of or damage to property of states or of persons, natural or juridical, or property of international intergovernmental organizations;*”

As already mentioned above in Art VII OST, Art I (c) LIAB defines a launching state as “(...) (i) *A State which launches or procures the launching of a space object;* (ii) *A state from*

¹³³ See *supra* fn 77.

¹³⁴ See Kerrest/Smith, 2009, 129 recital 5.

whose territory or facility a space object is launched.” Therefore, the concept of a launching state offers four possibilities.

1. A “state which launches” is the state that in fact launches the space object (Art I (c) LIAB).¹³⁵
2. The English term “procuring” refers to the respective entity that “purchases” the launch.¹³⁶ Space activities are quite complex matters and may be involving many actors. Thus in many cases, the mission operator is not identical with the launching operator and user of the mission.¹³⁷ The operator in fact controls the missions. Furthermore, a satellite mission may be “used” by a third party not involved in the launch and operational process. For instance, a university buys meteorological data for scientific purposes. However, Art I (c) LIAB only refers to the entity which “procures” the launch and not the entire mission.
3. Launching territories can be “hired”. A state from whose territory an object is launched shall be considered as a “launching state” and may be held liable in case of damage (Art I (ii) LIAB). Problems with the term “territory” may arise when satellites are launched from non-territorial space ports such as from the High Seas.¹³⁸
4. Facilities such as launch pads as well as piggyback launches on foreign launch vehicles can be “booked”.¹³⁹ Therefore, a state from whose facility an object is launched shall be considered as a launching state (Art I (ii) LIAB).

Notably, under Art V LIAB, all launching states are jointly and severally liable if damage has been caused by a space object. The Liability Convention provides a closed regime, of state liability in case damage occurs on the surface of the Earth, in air space or in outer space where at least one state remains a launching state.¹⁴⁰

Moreover, it is important to know that Arts II and III LIAB in conjunction with Art IV LIAB distinguish between two different concepts, namely absolute liability and fault-based liability.

Article II LIAB defines *absolute* liability as follows:

¹³⁵ See *Soucek*, International Law, 2011, 341 “If I am the state which launches, then I press the button (and the rocket goes off)”.

¹³⁶ See *Kerrest/Smith*, 2009, 137 recital 37.

¹³⁷ See *Bovet et al.*, 2002, 438 One can distinguish between the “operator”, the “procurer” and the “user”.

¹³⁸ See *Kerrest/Smith*, 2009, 138 recital 41.

¹³⁹ See *Soucek*, International Law, 2011, 341 “If I am the state from whose facility it is launched, the rocket takes off from my launch pad (which could be mounted somewhere outside my territory).”

¹⁴⁰ See *Kerrest/Smith*, 2009, 138, recital 45.

“A launching State shall be absolutely liable to pay compensation for damage caused by its space object on the surface of the Earth or to aircraft in flight.”

The concept of absolute liability is only applicable if a third innocent party, which is a party that is not participating in an outer space activity, is involved. It has only been applied once when the Russian Cosmos 954 satellite crashed over Canada and contaminated a vast part of land in 1978.¹⁴¹ Absolute liability is not based on fault. It means to pay damage indemnification regardless of any fault.

On the contrary, the concept of fault-based liability based on Art III LIAB states the following:

“In the event of damage being caused elsewhere than on the surface of the Earth (...) shall be liable only if the damage is due to its fault (...).”

Therefore, damage in outer space occurring among participants of space activities always relies on fault-based liability. Virtually, if the author of damage has acted on fault, damage indemnification has to be paid.

The scope of application of the LIAB always requires an international element. If damage occurs among victims of the same launching state(s), international law is not applicable (Art VII LIAB). This situation has occurred several times in the past, such as in the case of the Challenger crash over U.S. territory in 1986.¹⁴²

It is noteworthy to say that the two concepts laid down in the OST (Art VII) and in the LIAB are independent from each other.¹⁴³ Thus, the LIAB is not applicable if a launching state as a non-state party to the Convention is involved in a space activity when damage occurs.¹⁴⁴

The main difference between the concept stated in Art VII OST and the LIAB is that Art VII OST does not make any distinction between absolute and fault-based liability. It only refers to state parties to the treaty, which shall be “internationally liable”. According to the opinion of some authors in the legal literature, this may in case of doubt mean absolute liability.¹⁴⁵

Basically, both concepts always refer to states and not to other (governmental or non-governmental) entities. As a matter of fact, only states, and without exception, no non-governmental entity or individual has ever been held internationally liable due to this regime.

141 For the Cosmos 954 incident see http://en.wikipedia.org/wiki/Kosmos_954 (25.03.2013).

142 See *Kerrest/Smith*, 2009, 143 recital 62.

143 Ibid. 142 recital 59.

144 Ibid. 135 recital 31.

145 Ibid. 142 recital 60.

However, the LIAB will also be applicable to international intergovernmental organisations if they declare its acceptance. Currently only the ESA and the European Telecommunication Satellite Organisation (EUTELSAT) have done so.¹⁴⁶

Finally, claims of damage can be pursued under Arts VIII-XXI LIAB. The OST, however, has no specific regime in order to pursue claims. Pursuant to Art VIII LIAB, any damage caused by a space object to a third party victim can only be pursued by the state to which the victim belongs, since only states are entitled by the treaties (Art VIII LIAB). Hence, natural persons can only activate the state to pursue liability under the international regime in their name. However, if the state of the victim remains inactive or if the entire procedure is of long duration (this situation is very likely since states initially try to solve a problem by means of negotiations and diplomatic consultations according to Art IX LIAB), a third party victim can also try to enforce damage compensation under appropriate domestic law provisions (Art XI para 2 LIAB).

3.4.2 Specific aspects focusing on small satellite missions

The core question concerning small satellites is “Which entity is liable in case of damage?”

According to the wording of Article VII OST and Art I LIAB, it is always the launching state that is internationally liable in a case of damage caused by its space object irrespective of whether the activity is carried out by a non-governmental entity or by individuals.

However, non-governmental entities and individuals cannot be held internationally liable under the space treaties. The rationale for making only states liable is that absolute liability implies unlimited damage indemnification. Consequently, non-governmental entities and individuals may become bankrupt.¹⁴⁷

During the launch phase, the greatest danger originates from the launch vehicle itself, since a rocket is of course much bigger, heavier and carries explosive propulsion in comparison with small satellites on its piggyback transport. Hence, the realistic harm that a small satellite causes during the launch phase is negligible in comparison with the harm potentiality of the launch vehicle.

¹⁴⁶ See Resolution of the Council of the European Space Agency on the Agency's Legal Liability, ESA/C/XXII/Res.5, 13 December 1977.

¹⁴⁷ See *Kerrest/Smith*, 2009, 136 recital 35.

Nonetheless, the OST and the LIAB do not refer to the size and weight of space objects. Hence, even in the case of small satellites, though depending on their shape, size and material, it is unrealistic that they would crash on “top of our heads” or “land on our roofs” when re-entering the Earth’s atmosphere, and that they would fall under the existing international concepts concerning liability. Small satellites would burn up (still depending on the size, material, payload, as well as on many other factors) when they re-enter the atmosphere. Hence, Nano-, Pico-, Cube-, or Ultra-small satellites certainly would not cause harm to property or persons on the surface of Earth or in airspace, while re-entering the atmosphere.

Although small satellites, for instance those which are smaller than a shoebox, are still able to damage space stations or other objects in space. Thus, all spacecraft, even though some of them might be smaller than a child’s hand (e.g. Femto-satellites) and weighing less than 1 kg, are considered as ultra-hazardous activities.¹⁴⁸

However, the most critical phases that might raise third-party liability are always the launch phase and the re-entry phase. The in-orbit phase raises the question of fault-based liability which might become significant due to the increasing number of space debris.

The following questions A-E shall demonstrate the question of international liability, notably concerning small satellites launched piggyback.¹⁴⁹

- A) Would the launching state of the launch vehicle (launch service provider) or facility (e.g. launch pad) be liable for third party damage caused by a foreign space object (small satellite) during the launch or re-entry phase?
- B) Would the launching state of the primary payload be liable for third party damage caused by a foreign small satellite during the launch or re-entry phase?
- C) Would the launching state of the small satellite be held liable for third party damages caused by the launch vehicle during the launch or re-entry phase?
- D) Would the LIAB be applicable if the small satellite hit the primary payload during the launch phase?
- E) Imagine, a small satellite constellation consisting of dozens of small satellites. Are the launching states jointly liable in a case of third party damage caused by one satellite during the launch or re-entry phase?

148 For the attempt in general to describe the wording “ultra-hazardous activity” see *Soucek*, International Law, 2011, 342.

149 The following cases were not described in the literature used by the author. However, it shall not assert a claim that these cases have not been treated by other authors.

F) What kind of liability is applicable if a small satellite had become space debris and subsequently caused a collision with another space object in space (in the orbit phase)?

A) The state that provides the launch vehicle (which is a space object) shall be considered as “launching state” by Art I (i) LIAB. According to Art II LIAB, a launching state shall be absolutely liable in a case of damage caused by its space object. However, a small satellite cannot be considered as component part of the rocket (see chapter 3.2). Since the damage was caused by the small satellite, which is not a component part of the rocket, the damage was not caused by its space object. Hence, the launching state of the launch service provider is not absolutely liable in case of damage caused by the small satellite. Evidence to this notion is also provided by Art V LIAB (*“Whenever two or more States jointly launch a space object, they shall be jointly and severally liable for any damage caused”*).

In addition to that, the state which provides the facility (launch pad) shall also be considered as a launching state according to Art I (ii) LIAB. In this case, the state which provides the facility would be absolutely liable since it has launched both space objects, the small satellite and the launch vehicle. However, Art V para 3 LIAB states *“A State from whose territory or facility a space object is launched shall be regarded as a participant in a joint launching.”* This statement may be considered as an indication that the launching state(s) of the ground facilities and territory are merely “participants”. Under Art V para 2 LIAB, the participants in a joint launch event may conclude agreements so as to pass the liability in case of damage to the state that launches or procures the mission.

To sum up: Due to the fact that the state that merely provides the facility is jointly liable in case of damage caused by the small satellite (Art I LIAB in conjunction with Art V) agreements on allocating international liability among the parties are recommended.

B) A small satellite which is launched alongside the primary payload (piggyback) cannot be considered as a component part of the primary payload (see chapter 3.2).

Therefore, the primary payload and the small satellite shall be considered as two separate space objects. The launching state of the primary payload is not jointly liable for damages as the damage is not caused by its space object pursuant to Art II LIAB. Since the launching state of the primary payload neither launches, nor procures the small satellite launch, it cannot be considered as a “launching state” under Article I LIAB. Hence, the launching state of the

primary payload is not liable in a case of damage caused by the small satellite launched alongside the primary payload.

C) According to Art I (i) the state which hosts the operator of the small satellite shall be considered as a “launching state” if it “launches” or “procures” the launch. Moreover, according to the wording of Art I (d) *“The term “space object” includes (...) its launch vehicle (...)”*. This means that in this launch event, the small satellite and its launch vehicle may be considered as one space object. As regards this opinion, the damage was caused by the space object of the launching state of the small satellite mission as well.

Therefore, in a case of damage, all four launching states, namely the launching state of the small satellite and the launching state of the launch service provider, as well as the state which provides the facility and the state which provides the territory, are jointly and severally liable in case of damage (Art I in conjunction with Art V LIAB). However, Art VI LIAB states cases of exoneration from absolute liability to a launching state due to gross negligence of another launching state. This might be applicable if the launch service provider had acted on gross negligence (e.g. not all pre-launch safety checks had been fulfilled).

Thus, it is highly recommended to launching states which launch, or procure a small satellite launch to waive the liability for damages caused by the launch vehicle itself and to make sure that the launch vehicle is sufficiently insured for third party damages (for cross-waivers of international liability in general see chapter 3.4.3).

D) Article VII LIAB states the following:

“The provisions of this Convention shall not apply to damage caused by a space object of a launching State to: (...) (b) Foreign nationals during such time as they are participating in the operation of that space object (...).”

In a case of impairment to the primary payload caused by the small satellite during its transport, the LIAB is not applicable, due to the participation in the same operation (Art VII b LIAB). Thus, it would be highly recommended for both parties in the same operation to a) make sure that no payload may harm the other one (e.g. safety check), b) to conclude a transport insurance¹⁵⁰ or c) agree upon a cross-waiver of liability concerning internal damage indemnification.

150 See Lyall/Larsen, 2009, 110.

E) Small satellite constellations may become very prominent in the future. Such constellations consisting of dozens of small satellites (mainly Nano-, Pico-, Cube- or Ultra-small satellites) may be launched by different launching states. In case of damage, all participating states may be considered as launching states (since each satellite of the constellation is a separate space object). Hence, in case of damage all launching states are jointly and severally liable (Art I in conjunction with Art V LIAB). Thus, the risk shall be adequately allocated among all participants for instance through cross-waivers of liability (for risk allocation in general see chapter 3.4.3).

F) To provide an adequate answer to this case, one has to scrutinise whether space debris can be considered as a space object.¹⁵¹ If one submits to this assumption then the accident happened in outer space and was caused by one space object to another space object. Hence Art III in conjunction with Art IV (b) LIAB shall be applicable. This provision refers to the concept of fault-based liability where the launching state(s) of the small satellite are only liable due to its fault. With the increasing number of small satellites in the LEO the concept of fault-based liability might become important. However, it is still technically difficult to find out whose fault it was in case of damage occurred in outer space.

Summing up, the character of the LIAB considers all space objects as ultra-hazardous objects, irrespective of their size, mass or technological capacity. The core element of Art VII OST and the LIAB is that only states and never non-governmental entities or individuals are internationally liable.

Regularly, multiple actors are involved in a small satellite piggyback launch, such as the launching state(s) of the small satellite, or the launching state(s) of the primary payload and the launching state(s) of the launch vehicle, as well as the facility and territory. Due to Art V LIAB all of them are jointly and severally liable in a case of damage, when caused by its space object. Therefore, a small satellite piggyback launch generally does not release a launching state from liability in case of damage caused by the launch vehicle itself.

3.4.3 Risk allocation - challenges for small satellites?

As already mentioned above, one can distinguish between several hazards occurring in a small satellite launch: a) third-party damage, b) damage to foreign space actors (in outer

¹⁵¹ For the discussion of qualifying space debris as "space object" in general see *Schmidt-Tedd/Mick*, 2009, 154 recital 33.

space) and c) damage caused to participants in the same launching event. Hence, accident risk allocation is directly linked with financial risk allocation.

a) The major accident risk for third-party damage is actually the launch-phase, when damage may be caused by the rocket failures. However, as already mentioned, the launching state(s) of a small satellite may become liable even in case of damage caused by the rocket by virtue of Art I in conjunction with Art V LIAB.

Since space activities are increasingly carried out by non-governmental entities, launching states are indeed intended to pass the “hot potato” for third party damage indemnification to concerned entities through “recourse” provisions specified in national space legislations.

As already mentioned in chapter 3.3.3, the AOSA stipulates in § 11 (1) the states’ right of recourse in a case where Austria was held internationally liable for third-party damages. Occasionally, § 11 (2) AOSA states that the government can pursue the non-governmental entity virtually up to the amount of the insured risk which is a minimum sum of € 60,000,000 (§ 4 (4)).¹⁵²

Basically, each space activity to which the AOSA applies has to afford this minimum sum. However, exoneration may be granted if the activity has a low harm potential. The AOSA does not determine appropriate methods to find out the actual risk connected to the space activity. Hence, the absence of standardised accident risk evaluation systems of small satellite projects in general impairs states in estimating the actual risk potentiality of a small satellite, which can make it difficult for the state to decide upon exoneration, especially if it is not experienced in space-faring matters. As a consequence, standardised risk evaluation sheets, in particular for small satellites expected to have a low harm potential depending on their size, weight, material, orbital position and so forth, should be generally endorsed for universal application in order to assist states with less space experience.

However, launching states are also aware of passing the burden of liability in case of damage among them. Accordingly, Art V para 2 LIAB states:

“The participants in a joint launching may conclude agreements regarding the apportioning among themselves of the financial obligation in respect of which they are jointly and severally liable.”

¹⁵² Instead, the FSOA contains a “state guarantee” in Art 16 where damages exceeding the insured risk sum are taken by the French Government.

Hence, risk can also be allocated by *cross-waiver* of liability clauses in an international agreement or in space contracts where each party bears its own costs and does not pursue the other party in case of damage. The term cross-waiver of liability is enshrined for instance in Art 16 of the International Space Station (ISS) Intergovernmental Agreement (ISS-IGA)¹⁵³ when it states in para 3a:

“(...) Partner State agrees to a cross-waiver of liability pursuant to which each Partner State waives all claims against any of the entities or persons listed in subparagraphs 3(a)(1) through 3(a)(3) below based on damage arising out of Protected Space Operations.”

Such cross-waivers of liability may become crucial in international small satellite missions where several foreign states are involved in a launch event.

In summary, as already mentioned only states can be held internationally liable due to the existing regimes under the LIAB and Art VII OST. However, states are aware to pass the “hot potato” onto the non-governmental entity concerned which in fact carries out a space activity through recourse clauses and mandatory insurance obligations in national space legislation. However, states are also aware of the possibility to pass international liability among themselves (launching states) through “cross-waivers” of liability.

b) As regards damage caused by foreign space actors in outer space, national space law has not implemented mandatory on-orbit insurance regimes so far. It is therefore currently not mandatory to insure the satellite for in-orbit risks (e.g. collisions).

This situation is in favour of small satellites, since universities or individuals could probably not afford the required minimum insurance amount for on-orbit accidents, additionally to existing mandatory insurance obligations for third-party damage. However, it is still questionable how insurance companies would find out on whose fault an accident in space was caused, which is of course, a pre-condition for most insurance coverage.

c) There are several risks remaining which may occur among the participants in the same launch event. For instance, ground operator failures or transportation failures such as a small satellite that was brought into a wrong inclination and so forth. Since the LIAB is not applicable when damage is inflicted by a national of the same launching state (Arts VII a),

¹⁵³ Intergovernmental Agreement on the ISS, signed 29 January 1998 (hereinafter cited as: IGA).

contractual damage insurance coverage might become significant. However, national space legislation has not required any damage insurance except third-party claims so far.¹⁵⁴

In conclusion: Risk allocation may challenge small satellite missions. High mandatory insurance requirements (when exoneration is not granted) may be an obstacle for small satellite projects. Thus, one has to think about new insurance models exclusively for small satellites which are taking into particular account the smaller harm potential of small spacecraft to third parties in general¹⁵⁵ and which therefore require a lower insurance amount, regardless of whether the activity serves a public interest.

However, the absence of mandatory in-orbit or other insurance obligations is still in favour of small satellites as additional costs may stress small satellite missions which are subjects to budget constraints.

3.5 Digression: Non-territorial, non-fixed facility and non-terrestrial small satellite launches

Apart from conventional launching sites, small satellites may even be launched from non-territories such as the high sea or from a non-fixed facility such as an airplane. The term “facility” in this chapter relates to Art I LIAB “*A state from whose (...) facility a space object is launched*”. However, the term “facility” in the LIAB does not refer to a specific type of facility, such as a space facility (e.g. launching pad). Hence, even an airplane can serve as a facility under Art I (ii) LIAB when launching a space object. Typically, one can distinguish between fixed and mobile facilities (see Part 2 ASAA definition “launch facility”). Notably, this chapter refers to non-fixed (mobile) facilities such as an airplane.

Since some types of small satellites tend to be very compact (e.g. Nano-, Pico-, and Cube-satellites), they are likely also to be launched non-terrestrially, from the ISS, in the near future. Moreover, even if it seems very futuristic, it is nevertheless highly possible that small satellites will be launched from the surface of the Moon or the planet Mars into the orbits of Moon or Mars or even beyond.

154 See *Montpert*, 2011, 283ff. For instance, one can distinguish between faulty design, ground operator mistake, and inadequate testing or performance reduction. It would go beyond the scope of discussion to further elaborate on the issue of space insurances in the present thesis.

155 This issue was discussed among the panelists in the symposium “Small is beautiful? Potentials and Risks of Small Satellite Projects”, Nov 27, 2012, Juridicum, Vienna.

In order to provide more details about the various (future) launching methods, the author tries to differentiate between:

- A) Non-territorial, but terrestrial launches such as from the High Sea;
- B) Non-fixed facility launches such as from an airplane;
- C) Non-terrestrial but territorial launches such as from the ISS;
- D) Non-terrestrial and also non-territorial small satellite launches such as from celestial bodies.¹⁵⁶

A) As regards High Sea launches¹⁵⁷ there is no territory a state is launching from (Art I UNCLOS¹⁵⁸). However, the state which in fact launches or procures the launch (Art I (i)), or the state which provides the facility, for instance the launch pad (Art I (ii) LIAB), still remain as an indicator for international liability. In fact, the absence of the state which provides the territory (Art I (ii) LIAB) can lead to minimising international liability if the remaining state which in fact launches or procures or provides the facility (Art I LIAB) is the very same state and no other launching states are involved.¹⁵⁹

B) Another possibility of launching small satellites would be from airplanes. Airplane launches have been carried out several times in the past. The benefits of airplane launching can be cost reduction in general (the operational costs for an airplane are less expensive than for a rocket) as well as flexibility in launching opportunities (e.g. an airplane launch does not need as much preparation time as a rocket). However, the main disadvantages are limitations in size and mass. Moreover, various adaptations to the aircraft may have to be made which would finally increase the launch cost.¹⁶⁰

Concerning small satellite airplane launches, two main legal issues have to be examined:¹⁶¹ a) Do such airplanes reach outer space and must they therefore be considered as “space objects”? b) Shall the airplane and the airport be considered as a facility which applies the LIAB?

¹⁵⁶ The author discussed small satellite launches from the planet Mars in particular with Mag. *Alexander Soucek*, MSS, ESA who contributed to raising this idea. Furthermore, the issue of liability concerning small satellite launches from celestial bodies was discussed with Professor *Armel Kerrest*, University of Brest and Professor *Lesley-Jane Smith*, Leuphana University. Issues concerning the registration of small satellites launched from celestial bodies were discussed with *Niklas Hedman*, UNOOSA, Vienna.

¹⁵⁷ A company which offers sea launches <http://www.sea-launch.com/> (25.03.2013).

¹⁵⁸ United Nations Convention on the Law of the Sea of 10 December 1982.

¹⁵⁹ For legal considerations in general concerning the absence of a territory see *Kerrest/Smith*, 2009, 138 recital 41.

¹⁶⁰ For the benefits of airplane launching see *Kleef/Oving*, conference proceedings, 2012, 3.

¹⁶¹ This paragraph was in particular discussed with Professor *Armel Kerrest*, University of Brest during the ECSL Summer Course 2012, Pafos, Cyprus.

a) Those airplanes fly at very high altitudes, though still in airspace. Some of them may even reach outer space if they are on a sub-orbital flight. Art II REG refers to the term of a space object as “*an object launched into Earth orbit or beyond*”. However, if an airplane is not intended to reach outer space, it should not be considered a “space object”.¹⁶² Thus, an airplane carrying out a small satellite piggyback launch shall not be considered as a space object.

b) However, an airplane and the airport may still be a “*facility a space object is launched*” under Art I (ii) LIAB. There are two possible ways of approaching legal issues concerning airplane launches: b₁) The ignition of the small satellite shall be considered as the moment when being separated from the aircraft or b₂) The ignition of the small satellite launch starts already at the airport when the rocket leaves the launch pad.

Referring to b₁) The ignition of the small satellite legally starts in airspace and therefore the state of the flag of the airplane as well as the state of the territory (which retains sovereignty in space) may be considered as launching state pursuant to Art I (ii) “*(...) from whose territory or facility a space object is launched*”. The small satellite was launched from a mobile facility, hereinafter an airplane. As a consequence, the state which has registered the airplane as well as the state which retains sovereignty of the airspace would be considered as launching states.

Referring to b₂) If the ignition of the launch is legally induced at the airport, when the airplane leaves the launch pad, the state that operates the airport from which the small satellite is launched shall even be considered as a launch facility and launch territory according to Art I (ii). As a consequence, the state which hosts the airport would be considered as a launching state as well.

It can be assumed that a state that hosts an airport operator would entreat for the ignition that starts in airspace. This would definitely not extend the victim-orientated character of the LIAB that would even make the host state of the airport liable in case of damage caused by a launched space object.

Moreover, the *telos* of Art VII and the LIAB cover ultra-hazardous activities.¹⁶³ Since operating an airport is not an ultra-hazard activity anymore (ten-thousands of flights are

¹⁶² See Kerrest/Smith, 2009, 141 recital 54. For another opinion see Gerhard, 2009, 108 recital 24.

¹⁶³ Ibid. 129 recital 6.

carried out every day all over the world), the ignition of the launch shall – due to the opinion of the authors - start when the small satellite is about to be separated from the aircraft. Hence, the state which hosts the airport shall not be considered as a launching state pursuant to Art I LIAB.

Summing up, according to Art I LIAB, an airplane which launches a small satellite, although not considered a space object under normal conditions, may serve as (mobile) facility. Thus, the LIAB is applicable and the launching state of the airplane (state that has registered the airplane), as well as the state which retains sovereignty of the airspace when the small satellite is separated from the airplane are jointly and severally liable in case of damage (Art V LIAB). Anyway, according to the author's opinion, applying the LIAB even to the territory and facility of an airport operator may lead to an unfruitful extension of the victim-orientated character of the LIAB. Hence, the launching state which hosts the airport operator shall not be made liable in case of damage.

C) As regards non-terrestrial small satellite launches from the ISS, the main question is whether the space treaties (e.g. LIAB) are applicable as well. This question again raises the issue of timing of the ignition of a small satellite launched from a facility already placed in outer space.

A Recent example for a small satellite which was launched from the ISS is a Nano-satellite in honour of Yuri Gagarin during a spacewalk in 2011.¹⁶⁴

The question is whether a small satellite was launched at the time when it was brought to the ISS together with other payloads or at the time when it was released from the ISS. If small satellites were to be constructed on-board of the ISS, then doubtlessly they would be launched when being released from the ISS. As a consequence, the launch may be considered as a non-terrestrial small satellite launch. However, this does not automatically mean that it is a non-territorial small satellite launch as well.

Although space is not subject to national appropriation (Art II OST) on-board of the ISS, Canada, the European Partner States, Japan, Russia, and the United States retain criminal jurisdiction over their flight elements according to Art 22 ISS-IGA. In addition to that, Art 21 para 2 refers to “state territory” when stating:

¹⁶⁴ Yuri Gagarin was a Russian cosmonaut and was the first human in space. He reached the Earth orbit on 12 April 1961. The launch of a Nano-satellite from the ISS http://www.space-travel.com/reports/Russians_abort_satellite_launch_during_space_walk_999.html (25.03.2013).

“(….)for purposes of intellectual property law, an activity occurring in or on a Space Station flight element shall be deemed to have occurred only in the territory of the Partner State of that element's registry, (…).”

The notion of a launching state (Art I LIAB) does not refer to a spacecraft launched from the ISS. However, by virtue of Art 21 ISS-IGA, states of registry of the modules shall become launching states even in a case of small satellite launches from the ISS. In contrast, if damage to another state party on-board of the ISS during the launch-phase occurs, the LIAB shall not be applicable in this planned launching event because foreign nationals are involved in the same space activity (Art VII (b) LIAB).

D) Another considerable aspect in the future might be the possibility of launching small satellites from celestial bodies, such as from the planet Mars or the Moon. The question is whether small satellites launched from celestial bodies are space objects. Due to a wide interpretation of the *telos* of the LIAB, small satellites are also to be considered as “space objects” even when being launched from the Moon or the planet Mars into the Moon or Mars orbit.¹⁶⁵ Hence, the LIAB is even applicable for non-terrestrial and non-territorial small satellite launches from celestial bodies.

However, the concept of *absolute liability* will not be applicable for damages caused on the surface of celestial bodies during the launch phase, since Art II and IV (a) cover damage on the surface of the Earth, or to aircraft in flight only. Therefore, damage caused by small satellites during the launch phase from celestial bodies falls under Art III in conjunction with Art IVb LIAB, where fault-based liability is applicable.

Furthermore, Art I REG states: *“When a space object is launched into Earth orbit or beyond (…).”*¹⁶⁶ Almost certainly the REG, when it was adopted in 1974, did not foresee the possibility of launching small spacecraft from celestial bodies. Although the title of the REG states “Convention on Registration of Objects Launched into Outer Space”, small satellites launched from outer space shall be covered by wide interpretation of the REG.¹⁶⁷ Since the *telos* of the REG is to identify space objects in space, even space objects launched from outer

¹⁶⁵ This notion was in particular discussed with Professor Dr. Lesley-Jane Smith, Leuphana University Lüneburg in October 2012.

¹⁶⁶ See *Contant-Jorgenson et al.*, 2006, 22 Definition “Earth orbit”: “It refers to the orbit of the Earth around the sun. But in astrodynamics “Earth orbit” means orbit “around the Earth”; See *Soucek*, International law, 2011, 349 “Beyond” is to be understood in the “geographic” sense of space missions leaving the Earth’s gravity field on interplanetary trajectories, with whatever final destination.”

¹⁶⁷ In contrast to this, *Schmidt-Tedd/Mick*, 2009, 151, recital 20 state: „Consequently, objects that have not reached earth orbit in principle do not fall under the scope of REG.”

space have to be registered in both a national registry under Art VIII OST and the international registry maintained by the Secretary General (Art III REG).¹⁶⁸

Furthermore, when launching small satellites from celestial bodies, the Moon Agreement shall be applicable (for those states which ratified the Moon Agreement) with regard to Art 12 para 1 where it states that

“States Parties shall retain jurisdiction and control over their personnel, vehicles, equipment, facilities, stations and installations on the Moon (...)”. Due to Art 1 “The provisions of this Agreement relating to the Moon shall also apply to other celestial bodies within the solar system, other than the Earth (...)”

Since the Moon Agreement also applies to other celestial bodies, the launch of small satellites from Mars has to be in compliance with the Moon Agreement as well.¹⁶⁹

To sum up: The most important fact towards small satellite launches from the Moon or the planet Mars is that the concept of fault-based liability virtually applies in case of damage during the launching phase. Due to the *telos* of Art VIII OST and Art II REG, even small satellites launched from outer space into the Moon or Mars orbit have to be registered. Therefore, the state of registry also retains jurisdiction and control over small satellites launched from celestial bodies.

3.6 Registration of space objects

3.6.1 General aspects

According to Art VIII OST “A State Party to the Treaty on whose register an object launched into outer space is carried shall retain jurisdiction and control over such object (...)” This single provision contains two significant aspects. On the one hand, a launching state has to register a space object. On the other hand, the state of registry retains jurisdiction and control over the registered object. Art VIII OST was further developed in the Registration Convention (REG).¹⁷⁰ These circumstances raise a few general questions:

- A) What kind of registry is meant by Art VIII OST and by Art III REG?
- B) Which state is the “state of registry”?
- C) What do “jurisdiction” and “control” mean?

¹⁶⁸ This notion was discussed in particular with Niklas Hedman, UNOOSA during the ECSL Summer Course, 27.8.-7.9. 2012, Cyprus.

¹⁶⁹ Only for the states which have ratified the Moon Agreement (14 states by 2012).

¹⁷⁰ See *supra* fn 80.

A) The space treaties (Art VIII OST and Arts II-IV REG) contain two independent registration systems. According to Art III REG, each space object has to be registered in an international register furnished by the UN Secretary-General. In fact, the registry has been maintained by the UN Office for Outer Space Affairs (UNOOSA).¹⁷¹

Moreover, pursuant to Art II REG, each space object launched into space shall even be entered on a national registry maintained by the state of registry. National space legislation such as the AOSA furnishes a national registry in § 9 and specifies in § 10 what kind of information shall be registered at the national level.

If a state is not party to the REG, one has to prove whether Art VIII OST is applicable in the given case. However, Art VIII OST merely states: “(...) *on whose registry an object launched*” and does not further determine any obligation to states in order to maintain a registry. However, for states which have not registered for the REG, Res 1721 A and B (XVI) of 20 December 1961 still remains applicable where relevant information about the launched space object shall be furnished to the UN Secretary-General.

The main function of registering a space object is to identify space objects and to find out which state retains jurisdiction and control over the space activity. Consequently, there is a direct link between Arts VI, VII and VIII OST.¹⁷² Since the obligation to “authorise” and to “supervise”, laid down in Art VI OST, can be virtually fulfilled if a state knows exactly what has to be supervised, the registration of a space object is essential. In order to identify space objects pursuant to Art IV REG, each state has to provide information such as *inter alia* the name of the launching state(s), date and territory or location as well as general function of the space object.

B) As regards the question which state might become the state of registry, Art I REG, taken out of Art I LIAB states that a launching state would be (i) “*a state which launches or procures the launch*” or (ii) “*a state from whose territory or facility a space object is launched.*” In addition, Art II para 1 REG states “(...) *the launching state shall register the space object by means of an entry in an appropriate registry which it shall maintain.*”

171 See <http://www.oosa.unvienna.org/oosa/en/SORegister/index.html> (25.03.2013).

172 See Gerhard, 2009, 115 recital 50.

The notion of “the” launching state indicates that only a single launching state can be entered on a registry.¹⁷³ This is in contrast to the LIAB where several launching states may be held jointly and severally liable (Art V). Consequently, only one launching state shall retain jurisdiction and control.¹⁷⁴ If a space activity is a joint venture, launching states may conclude an agreement on which state is going to be registered (Art II para 2 REG).

C) By Art VIII OST: *“A State Party to the Treaty on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object (...).”* Neither Art VIII OST nor the REG defines the terms “jurisdiction” and “control”. In contrast, Art 91 UNCLOS defines “jurisdiction” and “control” as follows *“(...) exercise its jurisdiction and control in administrative, technical and social matters over ships flying its flag.”*

In fact, jurisdiction can be virtually retained by states. Although even international or inter-governmental organisations such as the ESA and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) have declared their acceptance of Art VII REG, international organisations do not retain jurisdiction.¹⁷⁵

However, the term “control” shall not only be understood as an obligation. It even enables the state of registry to enact specific rules which may affect the entire mission.¹⁷⁶ Furthermore, “control” of a space object does not end if a space object becomes dysfunctional and turns into space debris.¹⁷⁷

3.6.2 Specific aspects focusing on small satellite missions

The following paragraphs refer again to the legal nature of a small satellite and raise three main questions.

A) Shall small satellites be registered? If yes, at what time should they be entered on a registry?

B) Which registries have to be considered and which entity shall register a small satellite?

A) Since the existing space treaties do not refer to the size and weight of space objects Art VIII OST and Art II REG also applies to small satellites. The main aim of the REG is to

¹⁷³ See *Schmidt-Tedd/Mick*, 2009, 147 recital 2.

¹⁷⁴ Ibid. 147 recital 2.

¹⁷⁵ The declarations can be found under <http://www.oosa.unvienna.org/oosa/SORegister/regist.html> (25.03.2013).

¹⁷⁶ See *Schmidt-Tedd/Mick*, 2009, 158 recital 52.

¹⁷⁷ Ibid. 154 recital 33f for the discussion on the legal nature of space debris in general.

identify space objects.¹⁷⁸ Therefore, even the tiniest spacecraft has to be registered. Small satellites carried piggyback into space are not to be considered as component parts of the primary payload and should thus be registered separately.¹⁷⁹

Referring to the question when a space object has to be registered (timeframe), the wording of Art II REG states “*When a space object is launched into Earth orbit or beyond (...)*.” It might refer to a point of time after its launch or according to *Schmidt-Tedd/Mick* “*at the beginning of its stay in outer space.*”¹⁸⁰ Indeed, § 9 AOSA does not require a pre-launch notification. It proves sufficient to register the space object shortly after its launch.

B) As far as the regulatory registration procedure of small satellites is concerned, only a launching state can register a small satellite (Art I (i)). Thus, non-governmental entities cannot register small satellites (according to Art VII REG only “international intergovernmental organisations” can declare acceptance of the REG).

A (small) satellite has to be entered on both the international registries, maintained by UNOOSA on behalf of the UN Secretary-General (Art III REG) and a national registry (Art VIII OST; Art II REG). After reporting a space object at the UNOOSA, each space object gets a specific document number that can be accessed online by each internet user. As an example: the document number for the Nigerian small satellite Nigeriasat-1 is A/AC.105/INF.411¹⁸¹ and it is noted in the document that “*Information Furnished in Conformity with General Assembly Resolution 1721 B (XVI) by States Launching Objects into Orbit or Beyond.*”

Many launching states with less experience are not aware of having to register a (small) spacecraft properly. Thus, the UN General Assembly has enacted a resolution called “Recommendations on enhancing the practice of States and international intergovernmental organisations in registering space objects.”¹⁸² This resolution aims at encouraging states to register objects and provides them with sufficient guidelines.

Due to a lack of national space legislations, not many countries maintain a national space registry. Austria has enacted a registration obligation in §§ 9, 10 AOSA. In contrast to this,

178 See *Schmidt-Tedd/Mick*, 2009, 154 recital 34.

179 See UNGA Res 62/101 of 17 December 2007 para 3(c) “In cases of joint launches of space objects, each space object should be registered separately (...)”, available under www.unoosa.at (25.03.2013).

180 See *Schmidt-Tedd/Mick*, 2009, 155 recital 39.

181 The document is available under <http://www.oosa.unvienna.org/oosa/Reports/inf411.html> (25.03.2013).

182 See supra fn 180.

some domestic space legislation ties its national registration obligations to its national system of granting licenses, such as the FSOA (Art 1-3 in conjunction with Art 12).

The REG only refers to “a launching state” that has to register “a space object”. Given the fact that only a single launching state can enter on a registry, the question which state registers the small satellite in a joint venture project may arise. It is highly recommended that the state that in fact retains jurisdiction and control over the mission also registers the small satellite.¹⁸³

The launching state of the launch vehicle may register both the upper stage and the small satellite. Since the launching state of the launch service provider probably does not retain jurisdiction and control over the foreign small satellite, it is not recommended that it registers both the upper stage¹⁸⁴ and the payload (small satellite).¹⁸⁵

The current notion of a launching state does even allow for a more favourable launching state (e.g. a state which offers better legal conditions under domestic law), which is either the state that launches or procures or the state that provides the facility or territory (Art I REG), to be entered on the registries, which would lead to a “flag of convenience” situation.¹⁸⁶

In summary: The main aim of Art VIII OST and the Articles laid down in the REG is to identify space objects regardless of their size, weight or harm potentiality. Thus, even small satellites shall be registered by a single state of registry. However, non-space faring states are often not aware of this obligation. Hence, non-space faring nations which intend to launch or procure a small satellite launch for the first time have to be informed about their legal obligation to register small spacecraft.

3.7 Property in space in particular consideration of small satellites

3.7.1 Ownership in space

Although no state (even no non-governmental entity and no individual)¹⁸⁷ can claim sovereignty in space by virtue of Art II OST,¹⁸⁸ property *per se* still exists in space. The most

¹⁸³ For the question which entity shall register a space object see *Schmidt-Tedd/Mick*, 2009, 151 recital 24.

¹⁸⁴ Ibid. 151 recital 24.

¹⁸⁵ See Res 62/101 of 17 December 2007, para 3 (d) states that “States should encourage launch service providers under their jurisdiction to advise the owner and/or operator of the space object to address the appropriate States on the registration of that space object;”

¹⁸⁶ For the problem of “flag of convenience” in general see chapter 3.3.4.

¹⁸⁷ See an extract of the case of Gregory W Nemitz, who claimed ownership of asteroid 433 in *Freeland/Jakhu*, 2009, 55f recital 49ff.

¹⁸⁸ See Art II OST: “Outer space, including the Moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means.”

significant statement hereof is provided by Art VIII OST “(...) *Ownership of objects launched into outer space (...) is not affected by their presence (...).*” Space objects, devices, platforms, computers, electronics launched into or developed in outer space do not fall under the concept of *res nullis*, since those items belong to a natural or juridical person. Therefore, property in space does exist and will not be lost just by the fact that an object is going to be launched into an area of *terra nullis*.¹⁸⁹

However, property (hereinafter a small satellite) cannot only be demised on the surface of the Earth, it can also be sold in outer space.¹⁹⁰ The space treaties do not regulate a transfer of ownership in orbit. Therefore, Arts VI-VIII OST does not explicitly forbid any transfer of ownership in space. Three possibilities of transfer of ownership (hereinafter of a small satellite) in orbit are thinkable:¹⁹¹ It should be noted, that it would go beyond the discussion to elaborate on the issue of transfer of ownership in space in depth. Therefore, diverging opinions have not been considered.

A) Transfer of ownership within the (same) launching state: This situation does not involve the relations of the outside world, since liability, jurisdiction and control remain with the same launching state.

B) Transfer of ownership among different launching states: a transfer of ownership which may *de facto* include a transfer of jurisdiction and control from the launching state to the purchasing state, which is also a launching state is not excluded by Art VIII.¹⁹²

However, the “old” launching state, which is the state of registry, should be aware that the “new” purchasing state does not automatically take over liability as well as jurisdiction and control according to Art VIII OST and Art II REG. These duties remain with the “old” launching state. This situation could be solved by both launching states agreeing upon internal arrangements in order to organise liability and control in-house.¹⁹³

C) Transfer of ownership from a launching to a non-launching state: Art VIII OST and the REG neither forbids nor encourages a transfer of ownership to a non-launching state. However, the registration of a satellite is directly linked to the concept of a launching state

189 See *Schmidt-Tedd/Mick*, 2009, 163 recital 78.

190 Ibid. 164 recital 81.

191 All three possibilities were described by *Trögeler*, Practice of States and international organisations in registering the transfer of ownership of space objects, 2012, available under <http://www.unoosa.org/pdf/pres/lsc2012/symp-02E.pdf> (25.03.2013).

192 See *Schmidt-Tedd/Mick*, 2009, 155 recital 40.

193 Ibid. 155, recital 41.

(Art I REG). Only a launching state can register a space object and retain jurisdiction and control over a satellite (Art II REG).

In this case the launching state still retains liability, jurisdiction and control over the satellite. A change from a launching state to a non-launching state could result in disadvantages for third parties. It can minimise the liability for third parties in case of damage, since a non-launching state cannot be held liable under Art VII OST and Art I LIAB. This situation might undergo the victim-orientated character of the LIAB.¹⁹⁴ It should be mentioned that, this situation has not been solved yet. There is an on-going discussion about the legal nature of a transfer of property to a non-launching state in orbit. It would go beyond the discussion in this thesis to further elaborate on this issue.

One must also consider the situation when a small satellite, belonging to a non-governmental entity, is transferred (sold) in orbit to another space operator without informing the launching state(s) or the state(s) of registry. Therefore, the state of registry still remains significant in terms of identifying the small satellite and the attribution of the satellite to a launching state. A launching state remains liable in case of damage and a state of registry still retains jurisdiction and control, despite the transfer of ownership of a small satellite in-orbit from one launching state to another launching state.

It is quite difficult for launching states to continuously supervise any contractual agreements of non-governmental entities without having legal norms to apply. Therefore, § 8 AOSA stipulates *“A change of the operator requires the authorisation of the Minister for Transport, Innovation and Technology. The change of the operator shall be authorised under the conditions set out under § 4.”*

Thus, Austria is aware of the specific situation which arises with the emergence of non-governmental entities engaged in space activities, namely that the operator might be changed in orbit without prior authorisation. However, Austria virtually refers to the conditions set out under § 4 (e.g. insurance obligation, space debris standards) and does not refer to any specific type of transfer of ownership. Hence, under the AOSA a transfer of ownership to a non-launching state is not explicitly forbidden.

194 Speech of *Armel Kerrest*, University of Brest, France: Legal aspects of transfer of ownership of space objects: issues of responsibility, liability and registration, organised by the IISL and ESL, March 19 2012, Vienna International Centre.

Moreover, it has been strictly distinguished between “transfer of ownership” and “in-orbit delivery”. In-orbit delivery (IOV) means that a launching agreement also includes the in-orbit delivery service. In such a case, property will never be transferred from one entity to another.¹⁹⁵

To sum up: Small satellite missions carried out by non-governmental entities or individuals might be transferred after launch, without prior state notification or approval. Since responsibility (Art VI), liability (Art VII) and the duty to retain jurisdiction and control (Art VIII) remain with the state that authorises, launches or registers a space object, states are interested in becoming informed when space operators are changed. As a consequence, national space legislation may require prior state approval by non-governmental entities and individuals before property (space object) will be transferred in space.

3.7.2 Intellectual property rights

Intellectual property rights (IPR) refer to business-related protection, whereas technology transfer and export control refers to the protection of governmental interests.¹⁹⁶ The field of IPR is very complex and encompasses artistic, scientific, literary and industrial investigations.¹⁹⁷ Notably, this chapter focuses on IPR applicable to inventions made in outer space. It should also be considered as an extract and it would go beyond the discussion of the present thesis to elaborate on the issue of IPR in depth.

The situation in space is specific and intricate since national laws are usually not extra-territorial. Thus, national legislation concerning IPR in Austria, such as the Austrian Patent Law¹⁹⁸ (Patentgesetz) is virtually applicable in Austria and cannot be extended. However, Art VIII OST states that a launching state has to carry out national jurisdiction and control over its space objects even in space.

At the ISS the main document that refers to IPR is the ISS-IGA. In Art 21 this document establishes that each state which registers a module on board of the ISS retains jurisdiction and sovereignty over its module as well as IPR.¹⁹⁹ Article 21 might become important for future small satellite missions designed and manufactured on board and launched from the

¹⁹⁵ See *Schmidt-Tedd/Mick*, 2009, 156 recital 42.

¹⁹⁶ See *Hertzfeld/Jones*, 2011, 638.

¹⁹⁷ See Art 2 para VIII of the Convention of the World Intellectual Property Organisations.

¹⁹⁸ Patentgesetz 1970, StF: BGBl. Nr. 259/1970.

¹⁹⁹ Art 21 of the ISS-IGA „(...) Subject to the provisions of this Article, for purposes of intellectual property law, an activity occurring in or on a Space Station flight element shall be deemed to have occurred only in the territory of the Partner State of that element's registry, except that for ESA-registered elements any European Partner State may deem the activity (...)”

ISS (this may become true weight for Nano-, Pico-, or Cube-satellites due to their small size and). Thus, the applicable law concerning IPR depends on the module in which the small satellite would be designed and developed.

Some national space laws contain rules concerning IPR in outer space (e.g. Art 22 FSOA). France explicitly extends national rules concerning IPR to inventions made in outer space. However, national space laws vary widely as far as IPR are concerned. For instance, the AOSA does not refer to IPR at all. This non-uniformity due to a lack of adaptation of national provisions theoretically might prove to be an obstacle for future small satellite missions which involve international actors with diverging national laws, when inventions in space are made.

Property in space including IPR is also an area of interest for mobile equipment, hence UNIDROIT assisted the drafting process of the Convention on International Interests in Mobile Equipment in 2001 (Cape Town Convention).²⁰⁰ One of the three protocols adhered to is the Space Protocol (Berlin Protocol) that was recently adopted in March 2012.²⁰¹ It envisages states to maintain a national property-related register including IPR of assets in outer space in order to maintain security interests. In addition to that, it comprises necessities for space asset sales such as creditor rights (Art XIV) and provides a legal framework in case of contract breach (Art XVII ff).

The issue of intellectual property rights is directly linked to the state of registry by virtue Art VIII OST). Thus, a transfer of ownership in space also affects the issue of intellectual property rights regardless of whether the invention was made on the surface of the Earth or in outer space. The use of IPR can be even concluded in space contracts. However, those clauses have to be in line with national and international obligations (for space contracts in general see chapter 3.7.5).

Summing up, property in space (Art VIII OST) also encompasses intellectual property, thus, the state that retains jurisdiction over a small satellite also retains jurisdiction over intellectual property invented in space. On-board of the ISS the applicable law concerning IPR refers to the state of registry of the module (Art 21 ISS-IGA). As a consequence, future small satellites that will be developed on board of the ISS have to be in accordance with the IPR law of the module where the small satellite was designed.

²⁰⁰ See *supra* fn 81.

²⁰¹ Protocol to the Convention on International Interests on Mobile Equipment On Matters Specific To Space Assets, adopted on 9 March 2012.

3.7.3 Technology (export) control

This chapter deals with the control of industrial know-how.²⁰² Since it is the sovereign right of states to control the dissemination of technology, three main questions arise in regard to technology (export) control even in the context of small satellite missions.

A) What is technology (export) control?

B) What kind of legal system does exist in order to control the transfer of technology?

C) What is the main effect on small satellite missions?

A) “Technology” can be defined as *“the branch of knowledge that deals with the creation and use of technical means and their interrelation with life, society, and the environment, drawing upon such subjects as industrial arts, engineering, applied science, and pure science.”*²⁰³ The term “technology” is not universally defined in a legal context. The United States International Traffic in Arms Regulations²⁰⁴ (ITAR) for instance talk about *“personal knowledge including technical data”* (§ 120.17 para 1, CFR 120-130).

In a commercial market, environment technology is usually considered a good and therefore transferable. Technology can be transferred from a natural or legal person to another natural or legal person within the same entity, to another entity in the same country or to another entity in a foreign country.²⁰⁵ Typically, the latter one is the most restricted as far as export control is concerned since national technology, which often includes security interests, will be released to a foreign entity.

However, governments usually do not appreciate it when technology is transferred, notably to foreign entities even if good prices may be achieved. There are simple reasons for that, such as security issues and economic competitiveness.²⁰⁶ Many space technologies, even small satellites or items, may be used “dually”, which means military and civilian use at the same

202 The present chapter also relates to international trade and competition law. It would go beyond the scope of the discussion to be dealing with those aspects as well.

203 This definition is available under www.dictionary.com (25.03.2013).

204 The United States International Traffic in Arms Regulations, official version published April 1, 2012 can be downloaded from http://pmddtc.state.gov/regulations_laws/itar_official.html (25.03.2013).

205 See Regulation setting up a Community regime for the control of exports, transfer, brokering and transit of dual-use items. Regulation (EC) 428/2009 of 5 May 2009. Art 2 para 3 “exporter” shall mean any natural or legal person or partnership. The term “export” is also defined in § 120.17, 22 CFR 120-130 International Traffic in Arms Regulations (ITAR).

206 See Hertzfeld/Jones, 2011, 639.

time (Art 2 para 1 (EC) 428/2009).²⁰⁷ On this occasion, states do not want to transfer any sensitive or strategically significant technology to foreign government.

B) Technology (export) control can be considered as *lex specialis* of international trade law.²⁰⁸ At the international level, *The Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies* established in Vienna in 1996, has to be mentioned. It is the replacement for the *Coordinating Committee for Multilateral Export Controls (CoCOM)* that comprises 41 member states including Austria. Interestingly enough, not a single developing country is a member state to this arrangement.²⁰⁹ According to the *Wassenaar Arrangement*, state parties autonomously decide whether they admit a technology transfer to the member states or not however, they have to notify any transfer of technology or goods which have a “dual-use” character (e.g. chapter IV. Procedures for the General Information Exchange).

Accordingly, as small satellite technology could be used “dually”, state approval is a prerogative in most domestic laws in order to legally transfer small satellite technology to foreign entities such as, for instance, developing countries. In addition to that, the EU has enacted proper export control rules for security and economic reasons. The most important provision is the Council Regulation No 428/2009 of 5 May 2009, setting up a Community regime for the control of exports, transfer, brokering and transit of dual-use items.

In the context of domestic laws, the national U.S. export control system will be presented briefly. In the past, the U.S. have enacted several documents referring to space export control, such as the Export Control Act²¹⁰ of 1949 (ECA), the Mutual Defence Assistance Control Act²¹¹ of 1951, the Export Administration Act²¹² of 1979 (EAA), and the Arms Export Control Act²¹³ of 1976 (AECA). The provisions laid down in the AECA are defined as International Traffic in Arms Regulations (ITAR).

A regulation system set up by the U.S. ITAR encompasses the U.S. Munitions List (USML) of 21 classes of defence articles and services. There are two separate categories referring to space activities, namely Category IV “Launch vehicles (...)” and XV “Spacecraft Systems

207 See *supra* fn.205.

208 See *Creydt/Hörl*, 2011, 291.

209 See <http://www.wassenaar.org/participants/index.html> (25.03.2013).

210 United States congress, Export Control Act of 1949.

211 United States congress, Mutual Defense Control Act of 1951.

212 Export Administration Act of 1979.

213 Arms Export Control Act of 1976.

and Associated Equipment”. Notably, the latter one contains all types of satellites in lit (a) USML. Thus, even small satellites fall under the USML.

Moreover, the U.S. government claims universal validation for its technology control regulations. This system encompasses dual-use technology and explicitly refers to space technology and satellites (Category XV USML). This means that any international cooperation with the U.S. or its national space agency NASA is subject to this control regime.

C) Due to budget constraints, many small satellite missions depend on foreign component parts or commercial-off-the-shelf (COTS) components. Those parts may be imported from foreign countries such as the United States. Thus, small satellite missions are facing national regulations concerning export control systems.

The ITAR regulations are very complex and frequently changing. A lack of knowledge of the complex and time consuming regulatory procedures consequently lead to delays and additional cost.²¹⁴ Moreover, ITAR regulations are extra-territorial, which means that for the re-export of any component part an additional licence is needed (§ 121.1 Category XV in conjunction with § 127.1 USML). As a consequence, the ITAR regulations most likely decide on the launching site.

To provide an example: A single item (e.g. camera) is urgently needed for a small satellite mission and therefore imported from the U.S. to state X. If state X wanted to launch its small satellite including the imported camera from a foreign spaceport (e.g. piggyback launch from state Y), state X would have to apply for an additional re-export license from the U.S. State Department. Moreover, the project solicitor has to be registered with the Directorate of Defense Trade Controls (Part 122 – Registration of Manufacturers and Exporters, §122.1 USML).

In fact, the U.S. has a very strict exportation policy concerning China, which makes a cost-effective small satellite piggyback launch from a Chinese rocket for U.S. exported satellite items nearly impossible.²¹⁵ This situation challenges small satellite missions, since small

²¹⁴ See *Hertzfeld/Jones*, 2011, 645.

²¹⁵ There are existing embargoes *inter alia* against China from June 1989 and July 1993 available under http://www.pmddtc.state.gov/embargoed_countries/index.html (25.03.2013).

satellite launching opportunities are rare and China offers dedicated piggyback launches for fair prices on its Long March rocket family.²¹⁶

In general, acting against export control systems may lead to severe civil or criminal penalties (e.g. Part 127 – Violations and Penalties, § 127.1 in conjunction with § 127.3 USML). As a consequence, many subcontractors offer ITAR-free proposals; which cannot always be fully trusted. ITAR regulations are changing frequently and a component part bought ITAR-free might require a license at launching time nonetheless due to subsequent law amendments.²¹⁷

Moreover, the small satellite industry also faces strict export control systems. If a foreign customer buys a satellite from the space industry, national technology will coincidentally be transferred and released. Thus, the EC Regulation 428/2009 regarding “dual-use items” might become a challenge for the small satellite industry concerning the transfer of space technology and sub-systems listed in the Annex.

To sum up: Small satellites cannot follow a low budget approach when being restricted by tight laws, notifications and costly state approvals. At the same time, the European small satellite industry is challenged by strict European export control systems when purchasing satellites in foreign countries. To be aware of the complex ITAR regime, experts and legal advisors are needed who can hardly be afforded by small satellites missions with budget constraints. Hence, a pool of legal experts is needed to advise small satellite operators and non-space faring countries on affordable cost in order to avoid pitfalls with ITAR and other national regulations as regards technology (export) controls.

3.7.4 Space data

“Space data” in this thesis is the sum of any information gathered by a small satellite mission, in particular images of the Earth and the universe, as well as mission data concerning the spacecraft for educational purposes or technology demonstration.²¹⁸

Space data are purchasable and tradable, and therefore, valuable. An example of the high commercial value of space data acquired by small satellite missions is the DMC International Imaging operated *inter alia* by SSTL, which is a platform that provides customers with data,

²¹⁶ Chinese Long March Rocket family offers competitive prices for piggyback launches. See Zhiheng/Fei, conference proceedings, 2012.

²¹⁷ See Creydt/Hörl, 2011, 298ff.

²¹⁸ See Soucek, Space science data, 2011, 665. Notably this chapter provides an extract about space data in the context of small satellite missions. Hence, it would go beyond the discussion to further elaborate on different data typologies.

mainly acquired from the DMC, which can be bought or sold.²¹⁹ However, space data can also be used for free, e.g. such as Earth observation data based on the INSPIRE directive (Directive establishing an Infrastructure for Spatial Information in the European Community).²²⁰ This directive enables a European coherent concept in order to share free space data among the member states (Art 14 INSPIRE).

Reasons for keeping rather than releasing data for free are economic interests as well as security and military concerns. This approach might be in contrast to the principle of “Freedom of Information” (FOI). This principle is laid down in Art 19 Human Rights Charta as well as in Art 10 European Convention on Human Rights and in Art 19 (IPBR). It states that everybody is allowed to obtain information, regardless of national territories. However, this right can be limited due to national sovereignty.²²¹

National space legislation such as the FSOA contains specific provisions concerning “primary space data” (Arts 23-25). It refers to the prohibition of distributing primary space data, which are further defined by a decree for security purposes. Those space data are not allowed to be re-used. In contrast, the AOSA does not contain any provision relating to space data.

A prime example for a respective law concerning space data is the German Satellite Data Security Act²²² (“Satellitendatensicherheitsgesetz”). It refers to the distribution and re-use of remote sensing data gathered by German citizens or any legal institution based in Germany (§ 1). The distribution of thus acquired remote sensing data requires either an authorisation (§§ 11, 12) or a notification (§ 13). Basically the use and re-use of data can be concluded in space contracts.

The political question still remains “Shall we share data in favour of developing countries?” Accordingly, some representatives from developing countries have expressed the need for Art I OST “(...) *all States without discrimination of any kind, on a basis of equality and in accordance with international law*” to be of “binding character.”²²³ According to this approach, space-faring countries may share data and benefits with developing countries.²²⁴

219 See <http://www.sssl.co.uk/divisions/earth-observation-science> (25.03.2013). Further involved in the DCM are Nigeria, Algeria, China and Spain.

220 Directive 2007/2/EC of 14 March 2007, Brussels, European Union.

221 For instance Convention on the Protection and Promotion of the Diversity of Cultural Expressions 2005 available under http://portal.unesco.org/en/ev.php-URL_ID=31038&URL_DO=DO_TOPIC&URL_SECTION=201.html (25.03.2013).

222 Gesetz zum Schutz vor Gefährdung der Sicherheit der Bundesrepublik Deutschland durch das Verbreiten von hochwertigen Erdfernerkundungsdaten „Satellitendatensicherheitsgesetz“ vom 23. November 2007, BGBl. I S. 2590.

223 For further details on the binding character of Art I para 1 OST see *Hobe*, 2009, 40 recital 56ff.

224 See *Hobe*, 2009, 41 recital 63.

This assumption has not been universally accepted.²²⁵ The UNGA Declaration on Space Benefits (1996) made a clear statement that no obligations on space faring-nations can be derived from Art I para 1.²²⁶ The core of this Resolution is rather to encourage international cooperation. However, states cannot even be obliged to cooperate.²²⁷

As far as remote sensing of the Earth from outer space is concerned, attention has to be drawn to the following principles of the UNGA Res 41/65 1986. This Resolution contains straight forward provisions and principles which might not be in favour of space faring countries.

Principle IX states that

“(...) a State carrying out a programme of remote sensing (...) shall, moreover make available any other relevant information to the greatest extent feasible and practicable to any other State, particularly any developing country that is affected by the programme, at its request.”

This principle states a clear claim, namely that, upon request, a country remote sensed by foreigners shall have the right to gain the acquired data. However, the resolution is virtually applicable to few remote sensing activities laid down in Principle I. Any small satellite mission which observes the universe and not the surface of the Earth would not be affected by the Resolution (Principle I).

The scope of Principle I is narrow because it only refers to the necessity of improving natural resource management, use of landscape the protection of the environment. It is still questionable whether small satellites missions, serving dual use purposes, such as monitoring refugee spreading or harvest deficiency in underprivileged sub-Saharan regions and illegal deforestation surveillance, fall under the scope of this Resolution in order to benefit from its data sharing grant.

Nonetheless, strict data policies followed by governmental entities affect small satellite missions in various matters. Since there is no legal distinction between small and conventional satellites, even small satellites are bound by data policies and laws concerning space data. Thus, a small satellite operator has to be in line with national legislation concerning space data. Different national laws concerning the dissemination and re-use of space data (e.g. Art 23-25 FSOA or the German Satellite Data Security Act) challenge cross-border small satellite projects.

225 Ibid 42 recital 69.

226 Declaration on international co-operation in the exploration and use of outer space for the benefit and in the interest of all States, taking into particular account the needs of developing countries, UNGA Res 51/122 (13 December 1996).

227 See Hobe, 2009, 42 recital 68f.

Since space data can be considered as a product, it is also protectable through IPR.²²⁸ It is highly recommended to assist small satellite operators with legal advice in order to avoid pitfalls and financial penalties for non-compliance laws regarding the protection of space data (e.g. acting against Art 23 FSOA shall be fined € 200.000 pursuant to Art 25).

To sum up: Each small satellite operator should be aware of the existing legal framework concerning data security and IPR in order to protect their own data, and to avoid significant penalties for unauthorised use and re-use of space data.

3.7.5 Space contracts

Although the procurement process for small satellites, in particular for university or student satellites, is usually less intricate than for conventional satellites as even small spacecraft meet contractual provisions. In particular, small satellite missions may be faced with satellite purchase contracts if they purchase a finished product.

Moreover, each small satellite mission when intended to be launched piggyback faces launch contracts (Launch Service Agreements).²²⁹ Most likely small satellites are also concerned with contractual provisions concerning risk allocation or as intellectual property rights and data dissemination clauses.

One has to draw particular attention to international small satellite missions, where several entities are involved in a joint venture. Such missions would have to face a set of different legal layers such as international commercial law (WTO rules), European law (directives, regulations) and national law (IPR, data protection laws etc.). Thus, in an international (small) satellite mission, various laws might be applicable. As this chapter also relates to domestic contract law, dealing with all those aspects would go beyond this discussion.

The small satellite industry has fully emerged and small spacecraft can be bought on demand. For example, a small satellite can be ordered under a contract of sale.²³⁰ A contract of sale regularly includes design and development and possibly the launch (in-orbit delivery) as well as operation of the satellite. In such case, a contract of sale plus a contract of service will be

²²⁸ See *Smith/Doldirina*, 2011, 337.

²²⁹ For LSA in general see *Ravillon*, 2011, 161ff.

²³⁰ Ibid. 161f. For a contract of sale in general.

concluded.²³¹ However, a mere contract of sale only guarantees that the satellite is free of defects whereas an in-orbit delivery also guarantees that the satellite works in orbit.²³²

Typically, a contract of sale also includes provisions concerning IPR. A set of clauses refer to the question whether the manufacturer keeps all IPR (e.g. for the distribution of remote sensing data) or licences or gives some of them to the customer.²³³ However, all clauses have to be in line with superior law such as domestic, supra-national and international provisions.

A prominent example of a space contract for small satellites might be a launch service agreement (LSA). An LSA is always a contract of service, which means that laws concerning liability for product deficiency are not applicable (e.g. *Produkthaftungsgesetz*).²³⁴ Any LSA describes the service in detail as well as the price and conditions.²³⁵ An LSA, even for small satellites, is usually concluded in strict confidence. However, an LSA for small satellites would also include the price of the piggyback launch, as well as the payment for necessary launch adaptations. A typical LSA contains a set of clauses in case the primary payload or the launch provider consumes launch postponing.²³⁶

However, a small satellite piggyback launch contract often lacks guarantee clauses in case of delays caused by the primary payload(s). A piggyback launching contract would hardly be concluded if the small satellite operator demanded guarantees. This situation significantly affects small satellite missions since they have no legal remedies for launch postponing.

Moreover, space contracts may contain clauses concerning risk allocation such as third-party liability in case of damage (cross-waivers of liability) and also concerning requisite export and launch licences.²³⁷ Another example of a contractual risk allocation is an insurance contract.

In cases where no obligatory liability insurance cover is demanded by the national space legislation, such as the Swedish Space Act, a contractual insurance shall be voluntarily concluded, since the launching state still has the right of reimbursement in case of damage (section 6).

²³¹ Ibid. 162.

²³² Ibid. 163.

²³³ For IPR concerning the use and the distribution of remote sensing data in general see *Smith/Doldrina*, 2011, 337ff.

²³⁴ See *Du Parquet*, 2011, 386.

²³⁵ Ibid. 386.

²³⁶ Ibid. 389f.

²³⁷ See *Smith*, 2011, 55.

To sum up: Even a small satellite mission faces various types of contracts. Notably, contractual provisions strongly vary between countries, which may challenge international small satellite missions, in particular when being carried out by universities or other non-governmental entities with less legal advice. Due to an unawareness of superior provisions, certain pitfalls may arise which can further lead to severe penalties. Therefore, legal experts who are familiar with contract law are highly appreciated with a view to assist small satellite missions with a lack of legal advice (e.g. student satellites). Moreover, the conventional launcher industry often considers piggyback launchers rather as non-essential than as serious customers of their service. Small satellites launched piggyback usually do not achieve contractual warranties for delays. This situation can only be changed if a reliable commercial small satellite launcher industry emerges.

3.8 Sustainable use of outer space in particular consideration of small satellites

The term sustainability represents an ecological approach and was widely accepted at the Rio Conference in 1992 (Rio Declaration, Principle 1).²³⁸ It means that the society of today has to act in favour of the generation of tomorrow (Rio Declaration, Principle 3). However, the Rio Declaration is considered as a “soft law” document, which merely refers to the global (Earth) environment, rather than to the space environment. Nonetheless, the wording “sustainable use of outer space” is a rather new concept,²³⁹ which has not been universally defined so far.

Nevertheless, the space environment has to be protected as well. Art IX OST refers to the avoidance of “harmful contamination”. Other document, such as the Principles Relevant to the Use of Nuclear Power Sources in Outer Space (Principle 3 (a)) also states the imperative of non-contamination of outer space.

The following sub-chapters address the main issues concerning a sustainable use of outer space with particular consideration of small satellites, namely space debris mitigation, frequency management and space traffic management systems in order to avoid future collisions. Notably, the entire “Chapter 3.8” is to be considered under the aspect that small satellites contribute positively to outer space “democratisation”.

²³⁸ The document is available under <http://www.unep.org/documents.multilingual/default.asp?documentid=78&articleid=1163> (25.03.2013); for further description of the term “sustainability” in general see *Soucek*, Space and sustainability: improving life on Earth, 2011, 570ff.
²³⁹ See *Schrogl*, 2011, 604.

3.8.1 Space debris

When speaking to laypersons, one gets the impression that it usually does not seem plausible to them that even outer space has already been contaminated. Indeed, space debris has a direct impact on the outer space environment.²⁴⁰ As a consequence, the following issues arise concerning space debris in general:

- A) What is the definition and legal nature of space debris?
- B) How much space debris is already contaminating the orbit?
- C) Which provisions are relevant to space debris mitigation?
- D) How could space debris actually be mitigated?

A) Mitigation of space debris is catered for by the Inter-Agency Space Debris Coordination Committee (IADC) Space Debris Mitigation Guidelines,²⁴¹ item 3.1: *“Space debris are all man made objects including fragments and elements thereof, in Earth orbit or re-entering the atmosphere, that are non-functional.”*

An advanced definition is given by the Technical Report on Space Debris of the Committee on the Peaceful Uses of Outer Space, A/AC.105/720 as the following:

*“Space debris are all manmade objects, including their fragments and parts, whether their owners can be identified or not, in Earth orbit or re-entering the dense layers of the atmosphere that are non-functional with no reasonable expectation of their being able to assume or resume their intended functions or any other functions for which they are or can be authorized.”*²⁴²

Space debris is nothing that would be launched into space directly.²⁴³ It is the consequence of any space activity. After its operational time, each space object becomes space debris. Space debris encompasses launcher stages, as well as break-ups and retired satellites.²⁴⁴ From a legal point of view, the duty to control a space object is laid down in Art VIII OST. However, can a piece of space debris actually be considered as a “space object”?

The space treaties do not define the term “space debris”. According to Art I (d) LIAB and Art I (b) REG, *“The term “space object” includes component parts of a space object as well as its launch vehicle and parts thereof.”* Accordingly, in many cases space debris can be

²⁴⁰ See Smith/Valic, 2012, 5f.

²⁴¹ Inter-Agency Space Debris Coordination Committee, Space Debris Mitigation Guidelines, 2002 (revised 2007), IADC-02-01 available under <http://www.iadc-online.org> (25.03.2013).

²⁴² Available under URL: www.unoosa.at (25.03.2013).

²⁴³ See Schmidt-Tedd/Mick, 2009, 154 recital 34.

²⁴⁴ See Item 5 IADC Space Debris Mitigation Guidelines.

considered as a “component part” or “parts thereof”²⁴⁵ for instance, an upper stage of a launch vehicle.

In contrast, if space debris had been considered as an “independent” space object, it would have been identified and registered properly (Art II REG) which, in fact, might be challenging since lost fragments usually cannot be identified.²⁴⁶ Referring to the aforementioned UNCOPUOS Scientific Report on Space Debris, space debris must not necessarily be considered as space objects “(...) *whether their owners can be identified or not* (...)”

To sum up: Due to the lack of a legally binding definition of the term “space debris”, it is still unclear whether space debris shall be considered as a “space object”. As a consequence of qualifying space debris as space objects, states would be responsible for space debris under Art VI OST and liable in case of damage due to Art VII OST and the LIAB, and it would be their duty to register the object under Art VIII OST and Art II REG.

B) In 2007, a dreadful event shocked space operators all around the world. China shut one of its own Earth observation satellites for an anti-satellite missile test, which in turn caused the uncontrollable release of countless small pieces of space debris to its orbit.²⁴⁷ Another remarkable event occurred in 2009, when the inactive Russian communication satellite COSMOS-2251 and the U.S. communication satellite Iridium-33 collided in space at an altitude of about 780 km. This was at an altitude with the highest collision risk prospected in future.²⁴⁸

Numerous graphics show the amount of uncontrollable and broken pieces buzzing in outer space.²⁴⁹ The total number of artificial objects in space has not been clearly figured out, but it is estimated that about 22,000 space objects or fragments larger than 10 cm were tracked by the U.S. Space Surveillance network in 2012.²⁵⁰ Very tiny pieces of space debris may be highly dangerous, based on the fact that they can hardly be tracked.²⁵¹ Hence, the international community draws particular attention to this issue of utmost urgency. In 2009 for instance, the

245 See *Schmidt-Tedd/Mick*, 2009, 154 recital 33.

246 For the discussion on the practical limitations of registering space debris in general see *Schmidt-Tedd/Mick*, 2009, 154f recital 34f.

247 See http://en.wikipedia.org/wiki/2007_Chinese_anti-satellite_missile_test (25.03.2013).

248 See *Wiedemann*, 2012, 323.

249 For instance, ESA provides graphics on space debris http://www.esa.int/Our_Activities/Operations/Space_debris_environment (25.03.2013).

250 See http://www.stratcom.mil/factsheets/USSTRATCOM_Space_Control_and_Space_Surveillance/ (25.03.2013).

251 Pieces which are smaller than 10 cm usually cannot be tracked. See http://www.nasa.gov/audience/forstudents/5-8/features/what-is-orbital-debris-58_prt.htm (25.03.2013).

ESA initiated the Space Situational Awareness (SSA), a European independent programme in order to secure safe access to and utilisation of space.²⁵² This programme monitors space debris and space objects in the Earth orbit.

C) Currently there are no internationally binding rules concerning space debris mitigation. By Art IX OST “(...) *States Parties to the Treaty shall pursue studies of outer space (...) so as to avoid their harmful contamination (...).*” Indeed, space debris induces a “harmful contamination” of outer space.²⁵³

Legal strategies that have been developed so far are the 2003 Inter-Agency Space Debris Coordination Committee Guidelines (hereinafter IADC Guidelines) as well as the 2007 Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space²⁵⁴ (hereinafter UNCOPUOS Guidelines). The IADC committee is composed of well-established space agencies from all over the world. The UNCOPUOS Guidelines are based on the IADC Guidelines (provision 6) and both guidelines are non-binding and can be fulfilled voluntarily by the member States and international organisations (provision 3).

The main targets of the Space Debris Mitigation Guidelines are the limitation of debris released during normal operations, the minimising of on-orbit break-ups, and the prevention of on-orbit collisions (provision 1 IADC Guidelines; provision 4 UNCOPUOS Guidelines). Moreover, national space legislation can also contain specific provisions in order to mitigate space debris or to refer to the internationally recognised guidelines (e.g. § 5 AOSA).

Furthermore, the “Safety Framework for Nuclear Power Source Applications in Outer Space”²⁵⁵ considers “end-of-service phases” of space objects using Nuclear Power Sources in outer space in order to mitigate space debris (“Risk assessments”). One example for debris mitigation carried out by other non-territorial regimes is the UNCLOS which stipulates in Art 192 that the marine environment has to be protected and preserved by the states.

D) The physical phenomena that let space objects stay in orbit for years are the result of a lack of sufficient air friction in space. Another factor is the non-existence of germs in the

252 For further details on SSA see http://www.esa.int/Our_Activities/Operations/Space_Situational_Awareness2 (25.03.2013).

253 See *Marchisio*, 2009, 177, recital 29.

254 Space Debris Mitigation Guidelines of the United Nations Committee on the Peaceful Uses of Outer Space, Report. Official Records of the GA, 62nd session, 2007, Supplement No 20 (A/62/20).

255 See *supra* fn 87.

greater heights of the Earth's atmosphere that could decompose a launched space object.²⁵⁶ The farther the distance between the Earth and the object's orbit, the smaller the gravitational force. Thus, an object placed at considerable altitude can remain in space for decades. For example, a satellite positioned in the GEO (~36.000 km) would last several hundred years in space until it re-enters.²⁵⁷ Therefore, scientists and engineers are called upon to develop new systems triggering the de-orbiting process of space objects or to find innovative ways to limit the number of items and component parts that cause space debris during a mission.

De-orbiting means to navigate a satellite shortly before the end of its life time to a higher orbit or to any lower orbit, where it would burn up while re-entering Earth's atmosphere.²⁵⁸ However, those are technically complicated and complex matters. Achieving such manoeuvres is based on the existence of an effective propulsion system. Various types of small satellites, however, carry no propulsion for active de-orbiting manoeuvres in order to limit the weight to a minimum.²⁵⁹

As an approach to the technical challenges of developing low-budget de-orbiting methods, numerous student programmes working on this task have been established. They design de-orbiting systems by applying physical phenomena. One example developed by PhD students is a self-conducted inflatable system designed to de-orbit objects.²⁶⁰ New mission integrated-technologies such as electric thrusters and lasers represent possible future de-orbiting systems.²⁶¹

Space debris – a real issue concerning small satellites?

With regard to small satellites, the following aspects are closely examined. A) Do small satellites cause space debris? B) Do existing rules whether binding or non-binding affect small satellites?

A) One has to consider the fact that the Low Earth orbits are currently the most “polluted” orbits and will certainly still be in the future. In LEO, at a height of about 900 km in the polar and sun-synchronous orbit, the highest concentration of spacecraft and therefore also the

256 ESA provides very informative answers to FAQ concerning space debris on its webpage http://www.esa.int/Our_Activities/Operations/Space_debris_-_Frequently_asked_questions (25.03.2013).

257 See Contant-Jorgenson et al., 2006, 33f.

258 See item 3.4.2 IADC Space Debris Mitigation Guidelines.

259 See UN/ESA Symposium Report, 2011, para 49.

260 See Lücking et al., conference proceedings, 2012.

261 See Pergola et al., conference proceedings, 2012, 1.

highest risk of future collisions exist.²⁶² Moreover, the amount of space debris is located in lower orbits above 2,000 km²⁶³ which is exactly the area where the majority of small satellites missions are carried out, due to the bond of operating distance. Additionally, the ESA is constantly working on the ESA MASTER-Model and the ESA DELTA-Model, which deliver a rather accurate outline of future space debris fragmentation.²⁶⁴

When bringing the issue of space debris in conjunction with small satellite missions, one has to bear in mind that small satellites mainly use LEO orbits. Since small satellites are space objects which become dysfunctional after a certain period of time, they cause space debris like conventional satellites. An increasing concentration of small satellites in LEO leads to an accumulation of space debris.

Many small satellites are smaller than 10 cm (e.g. Pico-satellites) and are therefore hard to track, which constitutes additional threats to other space activities. In addition, various types of small satellites are typically not laid out in a way to carry propulsion systems for the de-orbiting process. Especially small satellite constellations, consisting of dozens of small space objects, may contaminate the orbit after their lifetime.²⁶⁵

Furthermore, international space stations such as the ISS are placed at an altitude of approximately 400 km. Any object being placed higher or at the same altitude as space stations is an inherent threat. Space objects which are de-orbiting from high altitudes may harm space stations.²⁶⁶ Thus, space debris is a “real” issue regarding small satellite missions.

B) Due to the fact that each spacecraft causes space debris, small satellite missions, in particular considering the high “democratisation” potential of small satellites, would also be affected by space debris mitigation policies. Currently, no legally binding and internationally enforceable documents (“hard law”) concerning space debris mitigation exist. However, the IADC and the UNCOPUOS endorsed so-called “Space Debris Mitigation Guidelines”.

Item 5.3.2 of the IADC states that

“This IADC and some other studies and a number of existing national guidelines have found 25 years to be a reasonable and appropriate lifetime limit. If a space system is to be disposed of by re-entry into the atmosphere, debris that survives to

262 See Wiedemann, 2012, 323.

263 See graphics available on the NASA webpage <http://orbitaldebris.jsc.nasa.gov/photogallery/beehives.html> (25.03.2013).

264 For further information on the ESA Maser Model see the ESA webpage http://www.esa.int/Our_Activities/Operations/Space_debris_modelling (25.03.2013).

265 See Sandau, 2006, 43.

266 For the risks of de-orbiting from higher altitudes in general see Wiedemann, 2012, 318.

reach the surface of the Earth should not pose an undue risk to people or property.”

This rule stipulates that 25 years after the mission had been completed a spacecraft has to be either de-orbited so as to re-enter the atmosphere or brought farther up to a “graveyard” orbit.

A 25-year in-orbit limit mainly affects the high “democratisation” potential of small satellite missions, in particular those carried out by developing and smaller countries. Usually, small satellites do not carry enough fuel or other expensive systems for de-orbiting due to their cost-constraint approach.²⁶⁷ Small satellites without active de-orbiting systems such as additional fuel would stay in LEO for over 25 years (depending on other factors such as payload and material etc.).²⁶⁸

In contrast, the UNCOPUOS report 2010, para 163 states

„Some delegations were of the view that the work on the long-term sustainability of outer space activities should not be limited to the safety and security interests of States with advanced space activities, but should also focus on ensuring equitable and rational access to outer space, which was a limited resource and at risk of saturation.”²⁶⁹

One may argue that the UNCOPUOS pleads for a less restrictive regime in order to mitigate space debris on the back of less developed countries. It might foresee the impact of strict guidelines on developing countries and the resulting limited access to outer space. In comparison to the regulation of the IADC Space Debris Mitigation Guidelines, the UNCOPUOS Guidelines do not set up a certain time limit after the end of mission in orbit.

However, national space legislation has enacted space debris mitigation provisions, which are of course binding rules. An example is § 5 AOSA which refers to the “internationally recognised guidelines”. Due to the materials of the AOSA, those guidelines are primarily the IADC Space Debris Mitigation Guidelines and the UNCOPUOS Space Debris Mitigation Guidelines. As a consequence, in order to get an authorisation under the AOSA, the applicant has to be in line with the “25-years-limit-on-orbit rule”.

Summing up, considering the high “democratisation” potential of small satellites, the international community should refrain from regulations limiting the total number of space

²⁶⁷ See Report on the third United Nations/Austria/European Space Agency Symposium on Small Satellite Programmes for Sustainable Development: “Implementing small satellite programmes: technical, managerial, regulatory and legal issues”, Graz, Austria, 13.-16. September 2011, UN/AC.105/1005, para 49.

²⁶⁸ See Smith/Valic, 2012, 7.

²⁶⁹ Report of the Committee on the Peaceful Uses of Outer Space, fifty-third session, 9-18 June 2010, UN A/65/20, page 22, para 163.

objects such as measures establishing certain in-orbit time restrictions which affect all types of small satellites equally. A non-differentiation of different types of small satellite application is capable to hinder outer space “democratisation” in general. Small satellites, which must necessarily be placed at high altitudes are just as much affected by time limits as typical “student satellites”. Those satellites naturally have a very short life-time and do not necessarily go to higher orbits, whereas small satellites used for scientific and research purposes may require higher orbits as well. Small satellites for mere technology demonstrations should be placed in very low orbits such as below ~330 km (which is below the ISS) by binding rules.

Hence, developing and smaller countries, or universities, since they mostly rely on budget-constrained small satellite missions, are mainly affected by the current space debris mitigation guidelines, in particular when national space legislation has incorporated them.

3.8.2 Frequency management

Due to the fact that a satellite placed in orbit is remote from its ground station, the only way to communicate is by using radio frequencies. This raises a few practical and legal issues:

- A) Why do we need frequency management?
- B) How does the current regime affect small satellites?

A) The main aim of space communication is to obtain (harmful-) interference-free communication when giving commands and receiving data and images from a satellite (see Art 45 ITU Constitution). If two or more operators use the same or almost the same frequency at the same time, harmful interference may occur. The term “harmful interference” is defined by Art 1.169 Radio Regulations (RR)²⁷⁰ as

“Interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with Radio Regulations.”

Accordingly, the ITU considers frequencies as a “limited resource” and allocates and coordinates the international frequency spectrum rationally, efficiently and economically according to Art 44 (2) ITU Constitution.²⁷¹

270 Radio Regulations (RR) adopted at the World Radio Conference (WRC) Geneva 1995, last amended WRC Geneva, 2012.

271 Constitution of the International Telecommunication Union (ITU), 22 December 1992, entered into force 1993, 1825 UNTS 1 (hereinafter cited as: ITU Constitution).

B) Since all regulations also apply to small satellites, regardless of their short development time and low budget possibilities, it is usually small satellite projects (in particular Nano-, Pico-, and Cube-satellites) that use amateur frequencies for space communication²⁷² which are generally free of charge and much easier to obtain as far as the regulatory procedure is concerned.

Pursuant to Art 1.56 RR an “amateur service” is defined as the following:

“A radiocommunication service for the purpose of self-training, intercommunication and technical investigations carried out by amateurs, that is, by duly authorized persons interested in radio technique solely with a personal aim and without pecuniary interest.”

According to this definition, a small satellite operator that intends to sell its data and images would strictly not fall under the current definition of an “amateur”. Moreover, § 2 Z 1 in conjunction with Z 2 of the Austrian Amateur Radio Act (Amateurfunk-Gesetz) contains the same definition as the one laid down in the RR.²⁷³ However, intentions are changing as a university may fulfil the tight criteria of a radio amateur at the advent of the mission; in fact, that status might change during the mission, as the university could start selling the mission’s data in order to be financially sustainable.

In order to obtain amateur frequencies, the project solicitor has to apply to the national authority in charge, which according to § 26 Austrian Amateur Radio Act in conjunction with § 113 Austrian Telecommunication Act²⁷⁴ (Telekommunikationsgesetz) in Austria is the Telecommunication Office (Fernmeldebüro). A radio amateur has to be authorised by the authority in charge (§§ 3, 4 AARA). At the national level, frequency plans co-exist and determine certain frequencies as “amateur frequencies” (in Austria pursuant to Frequency Range Allocation Ordinance “Frequenzbereichszuweisungsverordnung” and Frequency Range Utilisation Ordinance “Frequenzbereichsnutzungsverordnung”).²⁷⁵ The national

272 See Resolution COM6/10 (WRC-12) lit g.

273 Bundesgesetz betreffend den Amateurfunkdienst (Amateurfunkgesetz 1998 - AFG) StF: BGBl. I Nr. 25/1999 BGBl. I Nr. 32/2002.

274 Bundesgesetz, mit dem ein Telekommunikationsgesetz erlassen wird (Telekommunikationsgesetz 2003 - TKG 2003) StF: BGBl. I Nr. 70/2003 BGBl. I Nr. 102/2011.

275 Verordnung des Bundesministers für Verkehr, Innovation und Technologie betreffend die Frequenzbereichszuweisung (Frequenzbereichszuweisungsverordnung 2005 - FBZV 2005) StF: BGBl. II Nr. 306/2005 BGBl. Nr. 67/2011; Verordnung des Bundesministers für Verkehr, Innovation und Technologie betreffend die Frequenznutzung (Frequenznutzungsverordnung 2005 - FNV 2005) StF: BGBl. II Nr. 307/2005, BGBl. II Nr. 68/2011.

amateur frequencies are coordinated by the IARU, which is legally based on the IARU Constitution.²⁷⁶

In comparison to the international frequency management, the amateur frequency management is not as complex and less problematic and time-consuming when it comes to obtaining a licence. Since amateur frequencies are usually free of charge and easier to apply for, small satellite missions, in particular for scientific and educational purposes, often use the amateur bands. However, legally speaking, many small satellite missions do not fall under the definition of a radio amateur (Art 1.56 Radio Regulations). Those that cannot legally use the amateur frequencies are thus facing very complex and time-consuming procedures at the ITU level, which will be described briefly in the following paragraphs.

The main body that coordinates and allocates the international radio frequency spectrum is the ITU, based in Geneva.²⁷⁷ The ITU is the oldest international organisation, established in 1865, as the former International Telegraph Union. This organisation is divided into three sectors, pursuant to Art 7 of the ITU Constitution: the radio communication sector (ITU-R), the telecommunication development sector (ITU-D) and the ITU standards (ITU-S). Currently, the ITU has a membership of 193 countries (by 2012) which, makes that UN specialised organisation a universal organisation.

According to Art 4 of the ITU Constitution, the main legal documents are the International Telecommunication Constitution (ITU Constitution), the International Telecommunication Convention (ITU Convention) and the Administrative Regulations, containing *inter alia* the RR. Being explicitly defined in Art 4, all of them are binding and enforceable rules (“hard law”).

The legal procedure in order to apply for international radio frequencies, with particular consideration of the situation in Austria, is the following: According to Art 9.1 RR the project solicitor has to apply for radio frequencies “(...) *preferably not later than 2 years before the planned date of bringing into use of the network or system.*” The wording “preferably” is not the same as “mandatory” or “obligatory”. However, the ITU practice is very restrictive on this issue, which reveals it to be a real challenge for small satellite projects (e.g. Nano- and Pico-

²⁷⁶ See the IARU webpage <http://www.iaru.org> (25.03.2013).

²⁷⁷ See the ITU webpage <http://www.itu.int> (25.03.2013).

satellites) with an overall development time (from manufacture to launch) of less than 2 years.²⁷⁸

Basically, only (member) states can apply for international frequencies due to Art 9 RR at the Radio Communication Bureau, which acts on behalf of the ITU (Art 12 ITU Convention). The ITU rules do not define any national organisation or authority. Therefore, § 112 in conjunction with § 54 Austrian Telecommunication Act stipulates that the project solicitor must approach the authority in charge (in Austria: Ministry for Transport, Innovation and Technology) with the planned frequencies. As the Austrian authority in charge has only once been confronted with the application for an international frequency, specific rules concerning a national procedure for application do not exist yet.

After this national application, the authority in charge will initiate the so-called Advanced Public Information (API) procedure at the ITU pursuant to Art 9 RR. According to the same article, the Radio Communication Bureau has to inform all relevant states that may be affected, and will publish the frequency in the International Frequency Information Circular. During a period of six months (Art 9 RR) all concerned member states have the opportunity to write letters of clarifications to the applicant state. The state has to answer all letters on behalf of the project solicitor. When all questions are settled, the frequency has to be registered in the Master Frequency Information Register under to Art 8 RR.

To sum up: Although small satellite missions are widely congenial to the use of amateur frequencies, those which are not falling under the definition of an “amateur” are faced with very complex ITU regulations. The main issue which challenges small satellite mission in particular is the fact that satellite operators have to apply at the ITU for a certain frequency two years in advance due to Art 9.1 RR. As a matter of fact, many small satellite missions do not even have an entire mission time of two years. It is thus rather difficult for the operators to plan in advance.

The application for an international frequency implies careful planning of the entire missions, including experts and legal advisors as well as financial assistance. The current frequency management rules may hinder small satellites to realise their benefits as positively contributing to outer space “democratisation”. Therefore, rules and procedures at the international level would be favourable in order to facilitate the access to the ITU frequency

²⁷⁸ See Resolution COM6/10 (WRC-12) lit. b.

management for small satellites with short development times and a low budget for investment.²⁷⁹

3.8.3 Space traffic management

The number of functional and non-functional space objects in orbit has significantly increased since the launch of the first artificial satellite Sputnik-1. As already mentioned, the highest concentration of space objects can be found in the LEO in particular at heights of 800, 1000, 1400, and 1500 km.²⁸⁰ In addition to that, most small satellite missions, in particular Nano-, Pico and Cube-satellites for technology demonstration and verification, are operating in LEO. The main harm in the near future is illustrated by the crowdedness²⁸¹ of LEO orbits where space stations are placed and human spaceflight (e.g. space tourism) continues to be carried out.

Space traffic management can be defined by a

“(...) 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.”²⁸²

Currently there is no specific internationally agreed regime on a space “traffic management” system. The three phases of a future space traffic management may be the launch phase, the in-orbit phase and the re-entry phase.²⁸³ Referring to these three phases, the following provisions sound particularly promising: A) “Pre-launch notification” B) “End-of life-operations rules” C) “Zoning”

A) “Pre-launch notification”:²⁸⁴ Recently, any small satellite mission has to enter on a national registry at the time of the launch (Art II REG). Since the REG only refers to (after) launch registration, a space traffic management system should encompass pre-launch notification. Considering everything, registration and notification are prerogatives for any effective collision warning and avoidance system. A striking number of missions do not even provide information after launch because of security concerns. Hence, pre-launch or pre-

279 See Resolution COM6/10 (WRC-12) lit h.

280 See Contant-Jorgenson et al., 2006, 32.

281 See Report on the third United Nations/Austria/European Space Agency Symposium on Small Satellite Programmes for Sustainable Development, 2011, para 45.

282 Contant-Jorgenson et al., 2006, 10.

283 Ibid. 59ff.

284 Ibid. 64. For the idea of pre-launch notification in general.

manoeuvre and re-entry notifications should be established at international level.²⁸⁵ Small satellites, however, are not negatively affected by a pre-launch notification system.

B) “End-of-life operations rules”,²⁸⁶ lay down lifespan limits without taking into account any specific space application (e.g. item 5.3.3. IADC Space Debris Mitigation Guidelines). Hence, small satellites which necessarily need to be placed in an overcrowded area to realise their mission target would be totally banned by life-time limits. Several types of small satellites e.g. Nano-satellites placed in high LEO orbits would take decades to re-enter the atmosphere. Due to budget and mass constraints, most of those Nano-satellites cannot be equipped with active de-orbiting systems.²⁸⁷ Thus, general life-limitations rules clearly challenge small satellite missions, in particular from a perspective of outer space “democratisation”. The main challenge is to find life-limit rules which do limit the use of outer space but do not hinder outer space “democratisation”.

C) Finally, special “zones”²⁸⁸ in LEO or MEO can exclude certain types of spacecraft, for instance very tiny satellites like Nano-, Pico or Femto-satellites. At first sight, such rules would challenge small satellites at an utmost level. However, a significant number of Nano-, Pico-, and Cube-satellites serve technology demonstration and verification purposes. Those satellites purposely have a short life-span. Such classical “student satellites” can also be placed in very low Earth orbits below the zone where space stations typically are placed.²⁸⁹ Reserving zones particularly for small educational satellites in low altitudes of the LEO would, on the one hand be a huge contribution to tackling the issue of space debris mitigation (placing a satellite at a very low orbit drastically reduces the in-orbit stay), and to minimising the risk of harmful accidents with the space stations and other precious Earth observation satellites and, on the other hand, a major contribution towards the process of outer space “democratisation” through small satellites.

Examples for existing frameworks in other realms concerning traffic management are the Convention on the International Regulations for Preventing Collisions at Sea (COLREG)²⁹⁰ and the Chicago Air Convention. The ITU also approaches space traffic management issues

285 See Report of the Committee on the Peaceful Uses of Outer Space, Fifty-third session, 9-18 June 2010, A/65/20, page 15, para 105.

286 See *Contant-Jorgenson et al.*, 2006, 68, see also *Schrogl*, 2011, 610.

287 See Resolution COM6/10 (WRC-12) lit. h.

288 For “zoning” in general see *Contant-Jorgenson et al.*, 2006, 69ff, see also *Schrogl*, 2011, 610.

289 See *Contant-Jorgenson et al.*, 2006, 69 “One approach to ensuring that key orbits remain useful for current and future space activities is to regulate the type of activities that can be conducted in each orbital regime.”

290 Convention on the International Regulations for Preventing Collisions at Sea, 20 October 1972.

since frequencies and orbits are considered to be a limited resource (Art 44 para 2 ITU Constitution) and are therefore allocated and coordinated. Whereas the orbital slots in GEO are strictly allocated by the ITU, other orbits are rather coordinated than allotted.²⁹¹ As a result, each satellite operator can choose any orbital position under international cooperation rather than authorisation procedures.

On a “soft law” basis, the revised draft of an EU Code of Conduct addresses all types of space activities (governmental and non-governmental) so as to better coordinate even private space activities.

Further, the ESA has been working on its Space Situational Awareness, which is a system pendant to the American Space Surveillance System.²⁹² This autonomous system is intended to *inter alia* track and supervise space debris in order to prevent potential collisions.

Space traffic management is closely linked to Transparency and Confidence Building Measures (TCBMs).²⁹³ Although, there is no precise definition of TCBMs, they encompass *inter alia* all actions that secure a peaceful use of outer space.²⁹⁴ For instance, Art XI OST states that State Parties to the Treaty shall provide the Secretary-General of the UN with relevant information about the location of any space activity. In turn, the Secretary-General shall disseminate such information immediately in order to avoid harm.

To sum up: The increasing number of small satellite missions, in particular in the LEO regions, requires an effective traffic management system to secure a sustainable use of outer space. However, tight regulations which de facto exclude small satellites from using space negatively influence an outer space “democratisation” process through small satellites.

291 Pre-notification through API procedure. See chapter 3.8.3.

292 For the ESA Space Situational Awareness see http://www.esa.int/Our_Activities/Operations/Space_Situational_Awareness2 (25.03.2013).

293 See *Schmidt-Tedd/Mick*, 166f, recital 94.

294 See <http://www.geneva.mid.ru/disarm/d-01.html> (25.03.2013).

4 Political aspects

4.1 Outer space “democratisation” – what does it mean?

Are small satellites a new approach towards outer space “democratisation”? This is one of the main questions posed in the present thesis. Since many types of small satellites can be produced at low costs, shorter production times and fewer (financial) risks, small satellites may enable non-governmental entities to enter outer space.

Elon Musk, the founder of SpaceX made the following statement referring to the test launch of “Falcon 9” in 2010: *“This is a momentous moment and one that will ensure the democratization of space. This will increase the ease of access to space.”*²⁹⁵

The term “outer space democratisation” is defined in this thesis as a process where an increasing number of multiple actors actively participate in outer space activities (quantitative approach). Moreover, outer space “democratisation” means the capability, in particular, to build up technological, scientific and educational capacities in developing and small countries as well as the enhancement of international cooperation in general. One should also bear in mind that small satellites are able to face other dimensions such as cultural aims, e.g. when small spacecraft are launched for artistic purposes. All those aspects are subsumed under the qualitative perspective of an outer space “democratisation” process through small satellites.

To answer the aforementioned statement by *Elon Musk* when he refers to the capability of certain types of launchers to “democratise” space: It is true that privately financed launch vehicles may allow broader access to space; however, the launch sector *per se* still depends on either large capital that can be invested or on affluent people.²⁹⁶ Eventually, a satellite which is produced at low cost and shorter production time actually allows multiple actors access to space. It is rather the invention of small and low-cost spacecraft than the privatisation of the launch sector *per se* that has been enabling non-governmental entities and individuals to enter outer space on a large scale. As a result, small satellites must be considered as a new approach towards outer space “democratisation”.

Why do we need a “democratised” outer space, though? One interpretation is that the desire to “democratise” outer space has already been formulated in Art I OST

²⁹⁵ http://www.thaindian.com/newsportal/sci-tech/paypal-millionaires-rocket-launch-could-herald-a-new-epoch-for-space-exploration_100375974.html (25.03.2013).

²⁹⁶ The starting price for a space ticket booked with Virgin Galactic is \$ 200,000
<http://www.virgingalactic.com/overview/space-tickets/> (25.03.2013).

“The exploration and use of outer space (...) shall be carried out for the benefit and in the interests of all countries irrespective of their degree of economic or scientific development, and shall be in the province of all mankind.”

For decades, only large space-faring countries had access to space as sufficient money was available for investment. These countries were able to advance their technological, scientific and educational capacities. However, in order to promote capacity-building processes in developing and small countries, even non-space faring countries and non-governmental entities should participate in outer space activities.

The reasons for a quantitative “democratisation” process in space are manifold. Access to space educates staff, generates work force and therefore may even positively contribute to strengthening the national economies. Small satellite missions may ensure a faster return of science and therefore lead to a multiplication of investment.²⁹⁷ Moreover, by virtue of Art I OST, a balanced access to space between all players (industrialised and developing countries) is desirable, and an outer space “democratisation” through small satellites, which can deliver this approach, would thus be widely appreciated.

Moreover, the “Space Millennium: Vienna Declaration on Space and Human Development” provides further evidence that space will be “democratised”:

(v) “To encourage all States to provide their children and youth, especially females, through appropriate educational programmes, with opportunities to learn more about space science and technology and their importance to human development and to participate fully in activities related to space science and technology, as an investment in the future;”

Small satellites may contribute to such an “investment in the future” since the low cost approach of several types of small satellites will encourage states to carry out programmes, to enable multiple to actors learn about the opportunities in space and to let them fully participate in space activities.

The following subchapters highlight what is further meant by the author’s notion of a “democratised” outer space through small satellites. Although small satellites are also used for military purposes, military considerations are not covered by the author.

²⁹⁷ See Sandau, 2010, 84.

4.2 Actors in a “democratisation” process through small satellites – a quantitative perspective

4.2.1 Governmental entities

Most space-faring nations have established governmental space agencies such as the National Aeronautical Space Administration (NASA), the Russian Federal Space Agency (ROSCOSMOS), the French Centre National d'Etudes Spaciales (CNES) or the Japanese Space Agency (JAXA), all of which carry out space activities. Further, governments can be members of inter-governmental space agencies such as the European Space Agency (ESA).

As far as small satellite missions are concerned, governmental entities (or space agencies) still play an important role when it comes to the operation of small spacecraft. Governments (or space agencies) have been the main customer of all small spacecraft launched (35%) over the last 10 years.²⁹⁸

In contrast, as regards the manufacturing of small spacecraft, governments (or space agencies) have been in the last position (only 7%) over the past 10 years.²⁹⁹ This unbalanced figure shows that governments mainly “procure” or order and operate small satellite missions instead of developing and manufacturing them within their own capacities.

However, the fact that governments are the major customer of small spacecraft with 35% (followed by university or academia with 24% and other entities with 19%)³⁰⁰ shows that governments are still dominating the sector in terms of procuring and operating small satellite missions.

4.2.2 Non-governmental entities and the significant role of universities

Small satellites have a commercial potential, and therefore, constitute a new business. This is *inter alia* reflected by the successful European-based company Surrey Satellite Technology Ltd company, which is of course not the only example for the commercialisation of the small satellite business. The company, with Sir Martin Sweeting as its head, has long been focussing on small satellite development. Surrey Ltd. can today be considered as a leading European small satellite manufacturer. Examples are the manufacture of NigeriaSat-1 and 2

²⁹⁸ See Focus of the year/Small spacecraft in: ASD-Eurospace, 10.

²⁹⁹ Ibid. 10.

³⁰⁰ Ibid. 10.

(Micro-satellites), or the RapidEye Constellation (Mini-satellite).³⁰¹ Those examples demonstrate that even the space industry can benefit from small spacecraft.

Further examples for a European industry which also focuses on small satellites are: Astrium, Thales Alenia Space, Luxspace or Berlin Space-Tech which often serve as prime contractors. Examples for subcontractors (which deliver component parts, for instance) are RUAG Space, Vectronic Aerospace GMBH or Rockwell Collins Deutschland GmbH. This list is not exclusive as there are many more prime- and subcontractors focusing on small satellites.

Universities and various specialised research centres play a role of utmost importance in developing, manufacturing and operating small satellite missions. Universities show balanced figures. During the last ten years, about 24% of all small spacecraft have been procured by universities. Considering manufacture, 27% of all small spacecraft over the past 10 years have been manufactured by universities or academia.³⁰²

A total figure shows that the space industry has manufactured 94% of all conventional satellites (> 500kg). Notably, only 6% out of the total manufacture rate of space industry were small satellites over the last ten years.³⁰³ However, when it comes to small satellites, space industry has still manufactured 58% of all small spacecraft over the last ten years. In contrast, academia, universities or research centres for instance have manufactured 35% of all small spacecraft over the last 10 years.³⁰⁴ These figures show the significance of universities and non-governmental entities when it comes to the manufacture of small spacecraft.

There are simple reasons why non-governmental entities such as universities (whether run by public or private institutions) are interested in small satellite projects: Small satellites can be designed and manufactured with low production cost, short developing time and limited financial risk. Hence, small satellites are a useful application for scientific and educational purposes.³⁰⁵ Students or young research fellows can be part of a small satellite project from the beginning of its development phase. They may carry out experiments and use the small spacecraft for training.

Further evidence reflecting the trend to engage academia in space activities is provided by the following project carried out by master students at the International Space University (ISU) in

301 See <http://www.sstl.co.uk/Missions> (25.03.2013).

302 See Focus of the year: Small spacecraft in: ASD-Eurospace, 2012, 10.

303 Ibid. 10.

304 Ibid. 10.

305 See UNISPACE III, *Small Satellite Missions Background paper 9*, 10ff.

July 2012. A group of four students organised a fundraising campaign in order to launch a small satellite to ensure “*affordable and open access to a satellite in space*”.³⁰⁶ The intention of the students was to design a small satellite which delivers satellite images on individual demand and at affordable costs. The motivation behind this project is directly linked to the topic of the thesis and mirrors the phenomenon that small satellites are a new approach towards outer space “democratisation”.

4.2.3 Individuals - you and me in outer space?

There are predictions that even individuals might conduct their own small satellites in space in the near future.³⁰⁷ An example which provides evidence to this notion is the fact that one can already buy a Nano-satellite in the U.S. offered by the company “Interorbital Systems” for about \$ 8,000, including the piggyback launching cost.³⁰⁸ Additionally, one can order and buy a Cube-satellite online using a credit card as a method of payment.³⁰⁹

A small satellite project carried out by individuals is the Austrian mur.sat project.³¹⁰ A group of people will launch a small satellite mainly for cultural and artistic purposes into LEO by 2013. The satellite is a Pico-satellite and weighs about 0,75 kg. The small spacecraft was bought from Interorbital Systems. The price includes the launch cost with an American rocket, also operated by Interorbital Systems.

Mur.sat will only stay in orbit for a few weeks. The satellite is operated individually by the mur.sat team, composed of about 30 people ranging from technicians to artists. The satellite sends signals to individual users who can leave online messages for the satellite. This cultural and artistic project even provides evidence that small satellites serve as new instruments towards outer space “democratisation”, with even cultural aspects becoming visible in space. Notably, “culture” already physically entered space when *Richard Kriesche* carried out a cultural project called “Artsat” during the “AUSTROMIR 91” mission in 1991.³¹¹

Another example for individuals who virtually take part in outer space activities via using space applications delivered by small satellites are users of smart phone applications. A major

306 For the project description see <http://www.isunet.edu/news-and-events/1095-isu-masters-students-launch-a-fundraising-campaign-to-offer-affordable-and-open-access-to-a-satellite-in-space> (25.03.2013).

307 See *Janson*, 2008, 66.

308 See http://interorbital.com/TubeSat_1.htm (25.03.2013).

309 See http://www.clyde-space.com/cubesat_shop?gclid=CI-Q94LwgrQCFUm-zAod-1kAeA (25.03.2013).

310 For the project description see <http://sat.mur.at/> (accessed 04.03.2013). All further information was provided by Reni Hofmüller who actively participates in the project.

311 See *Besser*, 2009, 185.

example is the STRaND-1 Smart Phone Nano-satellite, manufactured by SSTL and launched on 25th February 2013 together with the Austrian small satellites from India where individuals can track and monitor the small satellite.³¹² This satellite enables individual users to order data about the actual position or to receive images from the satellite via different apps.

In short, the question still remains whether it is theoretically possible for everyone to afford and operate their own satellite in space. From a legal point of view, the space treaties do not exclusively limit the ring of subjects who are allowed to access space. They solely refer to the state parties to the treaty. Art I para 2 OST stipulates that “(...) *outer space (...) shall be free for exploration and use by all States (...)*.” As only states are parties to the OST, it is only states that are bound by the provisions laid down in the treaty. As a consequence, individuals cannot directly derive any rights or obligations from Art II OST.³¹³

However, many states are not aware of the fact that individuals are able to buy small satellites at very low cost and launch them on a piggyback basis. Indeed, government representatives do not bear in mind that although a small satellite is bought in, and launched from, a foreign territory, state parties to the treaty may carry out national space activities due to Art VI OST. Accordingly, national space legislation is crucial in order to authorise and continuously supervise (Art VI OST) space activities carried out by individuals.

To sum up: As a matter of fact, individuals are able to buy and launch small satellites for individual purposes. Although this development may not be welcomed by many other space actors, it fully realises the notion of outer space “democratisation”.

4.3 Capacity building – a qualitative perspective through small satellite missions

The term capacity building is a widely used and recognised term in economic science and development policies. The United Nations Development Programme (UNDP), for example, maintains human development programmes in order to achieve the UN Millennium Development Goals (MDG's).³¹⁴ Capacity building has various meanings, ranging from strengthening weak populations, maintaining economies, training staff, and enhancing scientific and research capacities etc. The meaning of capacity-building in the present thesis is not closed. It focuses *inter alia* on scientific, research and educational capacities which can be built-up in general through small satellites.

312 See <http://www.sstl.co.uk/Divisions/Earth-Observation-Science/Science-Missions/STRaND-nanosatellite> (25.03.2013).

313 See Hobe, 2009, 35 recital 39.

314 See <http://www.undp.org> (25.03.2013).

Capacity building has also been recognised by the “Space Millennium: Vienna Declaration on Space and Human Development”, stating that

*“(d) Enhancing education and training opportunities and ensuring public awareness of the importance of space activities: action should be taken: (i) To enhance capacity-building through the development of human and budgetary resources, (...).”*³¹⁵

An organisation that is working on capacity building in space is the Committee on Space Research (COSPAR). Furthermore, COSPAR organises workshops in order to support developing countries in building up their capacities.³¹⁶

The BSTI (Basic Space Technology Initiative), which is within the framework of the United Nations Programme on Space Applications, also faces the need for capacity building in basic space technology in particular towards small satellites.³¹⁷

The following subchapters further describe the author’s notion of capacity building as a qualitative output in an outer space “democratisation” process through small satellites.

4.3.1 A new approach for developing countries

Art I para 1 OST states one of the most significant sentences regarding small satellite missions:

“The exploration and use of outer space, (...) shall be carried out for the benefit and in the interests of all countries irrespective of their degree of economic or scientific development, and shall be the province of all mankind.”

One could interpret the sentence in a way that space-faring countries shall enable non-space faring countries to participate in outer space activities.³¹⁸ However, it is highly controversial whether Art I stipulates any obligation to space-faring countries.³¹⁹ It can be argued that Art I

315 The Space Millennium: Vienna Declaration on Space and Human Development*

The States participating in the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), held in Vienna from 19 to 30 July 1999 www.oosa.unvienna.org/pdf/.../viennadecIE.pdf (25.03.2013).

316 See <http://cosparhq.cnes.fr/Meetings/Workshops.htm> (25.03.2013).

317 See Report on the third UN/Austria/European Space Agency Symposium on Small Satellite Programmes for Sustainable Development, UNGA A/AC.105/1005, 2011, I. Introduction.

318 See *Hobe*, 2009, 38 recital 51; see also *Schmidt*, 2011, 700f concerning the enforceability of the freedom of exploration and use of outer space in general.

319 See UNISPACE III, *Small Satellite Missions Background paper 9*, 15, para 67 “(...) each country has the right to have opportunity to participate in space activities. In addition, each country has the obligation to cooperate in those efforts and to share existing information and adequate technology in order to help others to plan, develop, launch and operate satellites.”

at least emphasises the fact that countries, irrespective of their degree of economic or scientific development, will benefit from the results of space activities.³²⁰

In fact, low-budget small satellite missions may encourage countries irrespective of their degree of economic development to take part in space activities. Hence, the high concessive wordings of Art I OST are no longer merely theoretical expressions, but lead to “independence” of non-space faring countries to conduct their own space activities through small satellites. Small satellites which can be produced at low cost may put aside the question whether space-faring countries should be obliged under Art I OST to assist non-space-faring countries in building up their own space capacities.³²¹

When talking about capacity building, the need for “bridging the digital divide” also emerges.³²² There is no universal definition of the term “digital divide”, but it means that in fact not everybody in the world has access to digital communication (e.g. Internet, social media) or digital media (e.g. direct broadcasting satellite facilities).³²³ Typically, developing countries (due to an absence of infrastructure), have no or little access to digital communication whereas a vast number of people in industrialised and even in emerging countries do.

Small satellites may contribute to the bridging of the digital divide.³²⁴ Small telecommunication-satellites constellations in LEO or MEO may deliver broadcasting facilities at affordable cost. However, plans have in the past been delayed or stopped and have not been successfully implemented yet. The technical disadvantages of LEO small satellite communication constellations (the need for dozens of small spacecraft which display less reliability inter alia due to their insufficient mass and less nominal life-time) have prevailed to date. Nevertheless, the investment in such a market niche might become a future success for developing countries.

Notably, developing countries are affected by the global climate change, which results in water and nutrition insecurity. Natural disasters strike weak economies in particular. Thus, low-budget Earth observation satellites which are affordable for developing countries would

320 See *Hobe*, 2009, 38 recital 51. For details on Art I as an enforceable right see *Schmidt*, 2011, 692ff.

321 For the benefits of small satellites for developing countries in general see *Dhanji*, 2002, 307ff.

322 See the Millennium Development Goals <http://www.un.org/millenniumgoals/> (25.03.2013).

323 For the description of the term „digital divide“ see http://en.wikipedia.org/wiki/Digital_divide (25.03.2013).

324 For the importance of bridging the digital divide with space communication application in general see *Schmidt*, 2011, 704ff.

be highly appreciated in assisting the process of predicting disasters and preventing people from severe aftermaths.

Small land monitoring satellites operated by developing countries would represent a significant contribution to tackling current and future challenges. A prime example is the African Resource Management Constellation (ARMC), a small satellite constellation in LEO within the cooperation between Algeria, Nigeria and South Africa.³²⁵ Its main aim is to share data among the participants.

Another example for a disaster management constellation which involves developing and emerging countries with a view to fulfilling the goals of the Vienna Declaration on Space and Human Development is the DCM. This constellation was established by SSTL, which contributed a satellite to the constellation.³²⁶ Further participants are Nigeria (NigeriaSat-1), Algeria (ASAL), China and Spain. Nigeria and Algeria launched a Micro-satellite each for this constellation.

Small satellites used in the field of research and education may also enable developing countries to build their own capacities and national infrastructure.³²⁷ One example for scientific and research capacity-building in developing countries is the Nigerian National Space and Research and Development Agency (NASRDA).³²⁸ The NASRDA, in cooperation with SSTL, developed NigeriaSat-2 and NigeriaSat-X, two Micro-satellites, and launched them in 2011. Those small Earth observation satellites monitor Nigerian land mainly to tackle food insecurity.

Through the emergence of small satellite technologies and with the budget constrained approach of various types of small satellites, developing and emerging countries such as Nigeria, Algeria, South Africa, Thailand, Vietnam, Indonesia, Brazil, Argentina and Venezuela (this list is not exhaustive) were able to enter outer space during the past decade.³²⁹

325 See *Venet*, 2011, 88.

326 For details see <http://www.sstl.co.uk/News-and-Events?story=2058> (25.03.2013).

327 See *Sweeting*, 2002, 13.

328 For details see <http://www.nasrda.gov.ng/> (25.03.2013); see Report on the third United Nations/Austria/European Space Agency Symposium on Small Satellite Programmes for Sustainable Development, 2011; para 29; for further details on the Nigerian engagement in space through small satellites see Chizea, 2002, 301ff.

329 See *Venet*, 2011, 84ff.

4.3.2 Chances for small countries

Many small but industrialised countries do not carry out large space programmes. Small national economies are not able to fund launching sites or to develop rockets and complex spacecraft. Nowadays many small industrialised countries are being faced with the global economic crisis. As a result, cuts in national space programmes have been made.

Small satellites are new chances for small industrialised countries, a finding which was reflected by the Symposium “Small is beautiful? Potentials and Risks of Small Satellite Projects”, organised by the European Centre for Space Law and Space Policy (ECSL) National Point of Contact Austria (held by Associate Professor Dr. Irmgard Marboe) at the Juridicum Vienna in November 2012. Academics, practitioners, government and industry as well as other interested people are to get in touch with technical as well as with legal, political and economic aspects of small satellite missions. The symposium, which was well attended by representatives from all fields mentioned before, had shown that small but industrialised countries like Austria are interested in new approaches such as participating in space activities at affordable costs.³³⁰

With the increase of small satellite missions, the importance of space law in industrialised countries has also risen. Thus, small satellite missions make a high contribution to legal and political capacity-building even in small industrialised countries. With the commissioning of the Austrian BRITE mission in 2005 and the intended launch of TUGSAT-1 and UniBRITE, the government realised the need for national space legislation and sought the draft of a legal document.³³¹ Hence, small satellite projects proved to be the initiator for certain legal considerations.³³²

To sum up: Industrialised but small countries also suffer from cuts in national space programmes. Hence, many small countries have not yet entered space. However, small satellites can serve as a persuasive instrument to enter outer space even for small but industrialised countries at affordable costs.

³³⁰ Details on the symposium and the presentations are available under http://www.spacelaw.at/index.php?option=com_content&view=category&layout=blog&id=40&Itemid=73 (25.03.2013).

³³¹ See *Marboe*, The New Austrian Outer Space Act, 2012, 27.

³³² See Report on the third United Nations/Austria/European Space Agency Symposium on Small Satellite Programmes for Sustainable Development, 2011, para 52.

4.4 Small satellites and international cooperation - changes on the skyline

In the early days of space-faring, international cooperation was actually not on the agenda.³³³

In fact, the launch of the first artificial satellite Sputnik-1 in 1957 initiated the so-called “space race” followed by further historic undertakings into space. However, the OST does acknowledge the principle of international cooperation in Art III:

“States parties to the Treaty shall carry on activities in the exploration and use of outer space, including the Moon and other celestial bodies (...) in the interest of maintaining international peace and security and promoting international cooperation and understanding.”

Hence, the so-called “cooperation clause” promotes international cooperation and mutual understanding. It should be noted those principles were adopted during difficult times in 1967 when international cooperation was not considered at all.

In the 1990s, after settling the disputes between “East” and “West” (fall of the iron curtain), the need for international cooperation in space became apparent. A prime example for collaboration between the hostile space faring nations U.S.A. and the former USSR at this time was the cooperation in the MIR project, which was realised in 1995 when the first U.S. astronaut entered the space station MIR.³³⁴ Nowadays, a prime and still vibrant example for international collaboration is the ISS.³³⁵

The cooperation principle was recalled in several realms of the OST, highlighting its significance and necessity for the peaceful use of outer space, e.g. Art IX OST: “(...) *States Parties to the treaty shall be guided by the principle of cooperation and mutual assistance (...).*” The importance of international cooperation in the field of exploration and utilisation of outer space was even recalled in the *Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of all States, Taking into Particular Account the Needs of Developing Countries* (1996).³³⁶

Nonetheless, small satellite undertakings are vital examples for international cooperation. On the one hand, the low-budget approach of various types of small satellites may lead to

³³³ See *Cheli*, 2011, 178f.

³³⁴ See <http://spaceflight.nasa.gov/history/shuttle-mir/history/h-mir.htm> (25.03.2013).

³³⁵ The main partners of the ISS are U.S. (NASA), Russia (Roscosmos), Japan (JAXA), Canada (CSA) and ESA; See http://www.esa.int/Our_Activities/Human_Spaceflight/International_Space_Station/International_Space_Station_Legal_Framework (25.03.2013).

³³⁶ Paragraph 3, Annex stipulates that “All States, (...) should contribute to promoting and fostering international cooperation on an equitable and mutually acceptable basis.” In addition, para 5 “(...) international cooperation (...) should aim (...) rational and efficient allocation of financial and technical resources (...)”

“independence”³³⁷ in space so that space operators are able to develop their own technology and to acquire their own data instead of depending on crucial technology and data from foreign operators.

However, on the other hand, the low-budget approach might even tie countries to stronger cooperation, starting from the design and development (e.g. technology transfer programmes³³⁸ and the use of standardised items imported from foreign countries) to the launch (e.g. piggyback launch) and to the operation of a small spacecraft (e.g. shared³³⁹ ground stations).

Technology transfer is one of the most striking forms of international cooperation. The UNISPACE III, Small Satellites Background paper 9 in para 70 defines the importance of technology transfer in the realm of international cooperation as follows:

“A successful technology transfer in the development of small satellite activities implies a process by which a team acquires sufficient momentum to be able to produce the next generation of a small satellite. There are several mechanisms whereby technology transfer can be achieved, but, to be successful, the transfer of understanding, not the transfer of technology package (“know-why” as well as “know-how”).”

Programmes such as the Basic Space Technology Initiative (BSTI) successfully carry out small satellite technology transfer activities and therefore positively contribute to large-scale international cooperation. A few small space industries focusing on small satellite technologies have already been following this approach, when offering technology transfer on a commercial basis.³⁴⁰

Two practical examples of international cooperation within the small satellite industry are the approaches offered by SSTL namely the principle of Shared Satellite Ownership and International Partnership. Shared Satellite Ownership means that several small satellite operators share one specific small satellite in its use (mainly used in the field of Earth observation) e.g. by sharing images or data. Additionally, International Partnership defines a

337 See UNISPACE III, *Small Satellite Missions Background paper 9*, 6 para 7.

338 See UNISPACE III, *Small Satellite Mission Background paper 9*, 4.

339 A model for a shared ground station is the GENSO ground station network, a successful project initiated by the ESA. Software, which is available for free, enables low-budget small satellite missions to obtain access to shared ground station facilities. For further details see <http://www.genso.org/> (25.03.2013).

340 See Berlin Space Tech GmbH <http://www.berlin-space-tech.com/index.php?id=7> (25.03.2013).

system where collaboration takes place between the owner of a small satellite and its customers, e.g. by sharing data and technology with developing countries or third parties.³⁴¹

To sum up: On the one hand, small satellites ensure “independence” in space as small satellites allow multiple actors to operate their own mission. On the other hand, the low-budget approach of some types of small satellites needs international cooperation when it comes to the design, development, launch and operation of a small satellite. Hence, small satellite missions may realise the major targets of the international community, namely international cooperation and mutual understanding, which is laid down several times *inter alia* in the OST. As a consequence, the low-budget approach of several types of small satellites contributes to a change on the skyline when it realises both “independence” and the need for stronger (international) cooperation.

4.5 A “democratised” outer space through small satellites – spin-offs to society

The word “spin-off” is a common term used not only in the field of space technology. It also appears in other scientific and non-scientific fields and means a derivation of a certain technology or of a product.³⁴² The wording “spin-offs to society” in this chapter shall point out the positive effects of a “democratised” outer space through small satellites to the economy and politics as well as to society and culture.

Concerning economic spin-offs, small satellite missions, which are successfully carried out may have a multiplier effect such as the capability to enlarge local industries.³⁴³ In addition to that, “independence” in space can be considered as a key element, in particular, for developing countries.³⁴⁴ Those countries are able to use small satellites for agricultural land use management (e.g. land monitoring and drought prediction as well as irrigation and crop spraying coordination) and they, therefore, do not depend on the willingness of space-faring nations to share or sell crucial data gathered exclusively by them.³⁴⁵ Due to their flexibility in mission, small satellites meet societal and human needs such as positively contributing to

341 See SSTL <http://www.sstl.co.uk/divisions/earth-observation-science> (25.03.2013).

342 See <http://en.wikipedia.org/wiki/Spin-off> (25.03.2013). For example NASA Spin-off report, available under <http://spinoff.nasa.gov/> (25.03.2013).

343 See UNISPACE III, *Small Satellite Missions Background paper 9*, 14 para 62f.

344 Ibid. 6 para 7.

345 Ibid. 14 para 60f.

realising independent food security programmes as well as drinking water detection and climate change observation missions.³⁴⁶

As far as political spin-offs are concerned, small satellite missions can positively contribute to state stability. As the National Space Policy of the United States of America states in its introductory words “*Satellites contribute to increased transparency and stability among nations and provide a vital communications path for avoiding potential conflicts.*”³⁴⁷ This sentence especially fits small satellites. Moreover, acting at the international level has a clear peace-keeping function. Therefore, the anticipation and integration of numerous states in small satellite programmes helps to maintain a peaceful use of outer space and promotes international peace and security. Due to the fact that various types of small satellites depend on a greater international involvement in order to make such missions feasible, small satellite missions initiate dialogues which may prevent entities from engaging in disputes.

Relating to societal spin-offs, small satellite engagement should be considered as an “edge technology”, which brings national or regional consciousness to the citizen. Citizens could develop another kind of pride when launching a small satellite, namely; the kind of pride that is included in the sentence “We are small, less developed and lacking money – but we did it anyway.” These emotions could enable further scientific interest and would maintain capacity building.

However, a striking example of strengthening national identities through small satellite engagement is the city of Graz/Austria, which was given the epithet *Graz – City of Space*, because of its on-going space projects.³⁴⁸ Indeed, the first Austrian small satellite TUGSAT-1 was developed by the Graz University of Technology. From 2009 to 2011, Graz was the place where the UN/ESA Small Satellite Symposium took place.³⁴⁹ Moreover, Graz might be considered as the city of “Small Satellites” in the future, due to a further small satellite engagement known as mur.sat, which is currently in progress.

The project, which briefly described below, shows that small satellites can also stimulate cultural and artistic dimensions. The initiative is called “mur.sat”, which is also a small satellite project.³⁵⁰ A number of artists and technicians use that platform for launching a small

346 Ibid. 14 para 60f.

347 National Space Policy of the United States of America, June 28, 2010.

348 See Brünner, 2007, 14.

349 See UN/ESA Symposium <http://www.oosa.unvienna.org/oosa/SAP/act2011/graz/index.html> (25.03.2013).

350 All information is provided by Reni Hofmüller and is available online under sat.mur.at (25.03.2013).

satellite mainly for cultural and artistic purposes. The satellite realises several programmes. For instance, under a programme by the name of “Poor People’s Space Travel” people can leave a hair which will be stored in the satellite. Hence, a person’s hair “travels” to space on behalf of the person. The “LIS – Led in Space von Hannes Fiechtner” will provide people with access to the Internet, with a chance to actively participate in outer space activities through conducting mur.sat in a virtual environment. People can leave messages or operate the satellite via Web interfaces, e.g. by giving virtual commands such as “switch on the satellite’s light”. In cooperation with the small satellite mission, several workshops were carried out, and a special radio programme was broadcast on a monthly basis, drawing people’s attention to the cultural aspect of the universe.³⁵¹

4.6 The need for a sustainable approach towards outer space “democratisation”

Regarding the promotion of ways to encourage developing, emerging and small countries as well as universities and individuals to access outer space through small satellites, the question arises as to whether outer space “democratisation” also has factual and legal limits. A “sustainable outer space democratisation” is defined in the present thesis as a process which regulates the use of outer space but does not hinder small satellite activities above all to enter outer space and realise their benefits.

Art IX OST formulates that “(...) *States Parties to the Treaty shall (...) conduct exploration of them so as to avoid their harmful contamination (...).*” The imperative to “avoid harmful contamination” is not further defined in the OST. Nevertheless, one can assume that space debris can be considered as a kind of harmful contamination.³⁵² Article IX also serves as a restriction of the “space freedoms” granted in Art I OST.³⁵³ As a consequence, Art IX OST can be interpreted as a legal limitation to “democratise” outer space.

In acknowledging sustainability of outer space activities, the EU has endorsed a draft for a Code of Conduct for Outer Space Activities in 2008, which was revised in 2010.³⁵⁴ The document is open to voluntary ratification by states and non-governmental entities. Its purpose and scope are the following according to Chapter 1: “*The purpose of this Code is to enhance the security, the safety and sustainability of all outer space activities.*” Chapter 5 of

351 See Radio Helsinki, Neues aus dem Orbit, on Tuesday once a month <http://helsinki.at/programm/shows/mursat-space-art-project> (25.03.2013).

352 See *Marchisio*, 2009, 177, recital 29; see also *Hobe*, 2009, 39 recital 55.

353 Ibid. 175 recital 23.

354 The draft Code of Conduct can be downloaded http://eeas.europa.eu/non-proliferation-and-disarmament/outer-space-activities/index_en.htm (25.03.2013).

these Guidelines draw particular attention to space debris mitigation. Although this document will have a “soft law” character when it finally is formally endorsed, it provides evidence of the author’s notion that outer space “democratisation” is legally limited.

Moreover, Art I para 2 OST stipulates the so-called “space freedoms”, an enumeration of rights not only granted to state parties to the treaty.³⁵⁵ In recapitulation, the “space freedoms” encompass “free access to all areas of celestial bodies”, free “exploration” and “use” of outer space as well as the “freedom of scientific investigation”. “Use” of outer space means both economic and non-economic usage of space as well as including the exploitation of space.³⁵⁶

The most important notion for small satellite missions, carried out by private entities, is that private entities are not directly entitled to the OST according to public international law (OST Art I).³⁵⁷ Only states are parties to the OST and may therefore directly exercise the “space freedoms”. However, both Art I para 2 and Art III OST state that the freedom of “use” shall be “*in accordance with international law*”. Thus, the legal limit to use outer space is international law itself.

Furthermore, states are legitimised to authorise private space activities (Art VI OST) and they also retain jurisdiction and control over (private) space activities (Art VIII OST). Thus, states may also limit access to the exploration, use and scientific investigation of space.³⁵⁸ Moreover, according to Art VI OST, space activities have to be authorised, which gives evidence that the “space freedoms” can be limited.³⁵⁹

Nevertheless, if certain areas of the LEO are overcrowded to an extreme extent, the freedom of “use” of outer space, as a consequence, might actually be restricted.³⁶⁰ Furthermore, the freedom of access to all areas of celestial bodies (Art I para 2 OST) explicitly refers to “areas of celestial bodies” and not to outer space itself since access to outer space can be legally restricted.

Another limitation of the freedom of use of outer space is laid down in the same article as a granted right. Art I para 1 OST stipulates in the “province of all mankind” clause namely that

355 See *Hobe*, 2009, 35 recital 39.

356 See *Hobe*, 2009, 35 recital 36.

357 Ibid. 35, recital 39.

358 Ibid. 35, recital 39.

359 See *Gerhard*, 2009, 104, recital 1; see also *Hobe*, 2009, 39 recital 55.

360 See *Lyall/Larsen*, 238 “(...) there has been concern that a state might in effect permanently retain the use of a particular orbit by the placement and replacement of a satellite”; See also *Soucek*, 2011, 380 “Pollution of the near-Earth environment with space debris is not in the interest of all, and it constraints the freedom of use (e.g. certain orbits may become too crowded with debris).”

“The exploration and use of outer space (...) shall be the province of all mankind”. This clause can be seen as a specific target comparable with the “common heritage of all mankind” clause.³⁶¹ The latter is stated in the Antarctic Treaty, in the UNCLOS (Art 136) as well as in the Moon Agreement (Art 11). Although this principle has not been defined any further, the ideological notion of “the province of all mankind” has fostered numerous space engagements, even of non-space faring nations.³⁶²

Back in the 1960s, only two superpowers had access to space, and “the province of all mankind” should therefore secure the notion of several interests and not only a view of ideological opinions of a limited number of space-faring nations.³⁶³ The increasing number of small satellite launches all over the world reflects the idea that small satellites enable developing countries to participate in outer space activities.

However, “the province of all mankind” does not only have a programmatic character, but also serves as a limitation of the “space freedoms”.³⁶⁴ This means that a right to access, explore, use or investigate outer space virtually exists, but it can be limited if the activity is not in line with the common interest and thus against “the province of all mankind”.³⁶⁵ As a consequence, very short-term small satellite missions might not be in “the province of all mankind”. Moreover, ultra-small satellites that cannot be tracked in order to avoid collisions may also not be in “the province of all mankind” and may not fulfil the requirement of non-harmful contamination (Art IX OST).

Another question is whether small satellite constellations consisting of dozens of small spacecraft are in “the province of all mankind” and meet the requirement to avoid “harmful contamination” since they produce an increasing number of space debris after the mission has expired. Plans to establish small satellite swarms and constellations in LEO, consisting of hundreds of small spacecraft, may in fact limit a harmless passage of the Low Earth Orbits for other spacecraft.

In addition to that, the *Trail Smelter Case* (USA-Canada, arbitration court 11.3.1941) acknowledged that national jurisdiction is limited in such a manner that no national actions

³⁶¹ See *Hobe*, 2009, 38 recital 52.

³⁶² See *Hobe*, 2009, 38f recital 52f “(...) it shall be the interest of all mankind to enable the participation on non-space-faring and developing States in the exploration and use of outer space.”

³⁶³ Ibid. 38 recital 52f.

³⁶⁴ Ibid. 38 recital 52.

³⁶⁵ Ibid. 32, recital 25; Ibid. 39, recital 54 “It is the idea that all space activities shall be undertaken to the advantage of all mankind, which is clearly expressed in Article I paragraph 1 of the Outer Space Treaty, a provision that insofar has general importance for Article 1 as well as for the entire Outer Space Treaty.”

can be conducted if they cause damage to another state's property.³⁶⁶ Thus, outer space has to be "democratised" through small satellites in such a manner that it does not harm other states' properties (space objects).

However, the Report of the Committee on the Peaceful Uses of Outer Space 2010, A/65/20, recognises in chapter 10 "Long-term sustainability for outer space activities" para 163 (...) *the work on the long-term sustainability of outer space activities should not be limited to the safety and security interests of States with advance space activities (...).*" Hence, legal norms have to be considered against the background of tight budgets of various types of small satellites.

To sum up: The notion of outer space "democratisation" also has its limitations. Thus, taking into consideration several limitations, outer space has to be "democratised sustainable" through small satellites. As a consequence, states are entitled to limit the use of outer space. However, the utmost importance has to be drawn on finding effective and sustainable solutions concerning space debris and space traffic management which limit but do not hinder an outer space "democratisation" process through small satellites.

4.7 Institutional aspects concerning small satellite missions

4.7.1 The role of the United Nations

The United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) was first established as an ad hoc and later as a permanent committee, e.g. one year after the first small satellite had been launched into space in 1959.³⁶⁷ UNCOPUOS and its two subcommittees (legal and scientific/technical) have their annual sessions usually in March and June at the United Nations Centre in Vienna. Decisions made in the UNCOPUOS legal subcommittee are in line with the "consensus" principle.³⁶⁸ The UNCOPUOS plays a significant role concerning

366 Trail Smelter Case (USA-Canada, arbitration court 11.3.1941) "(...) no State has the right to use or permit the use of its territory in such a manner as to cause injury by fumes in or to the territory of another or the properties of persons therein, when the case is of serious consequence and the injury is established by clear and convincing evidence." This case is printed in Neuhold et al., *Materialienteil*, 2004, 464.

367 UNCOPUOS currently maintains 71 members with additional appliance of Armenia, Costa Rica and Jordan in 2012.

368 See Lyall/Larsen, 2009, 21. "Consensus" principle means no formal vote but any objections. Abstentions may not hinder "consensus".

in preparing several resolutions addressing the specific needs of developing countries, which were adopted by the General Assembly.³⁶⁹

From a legal and regulatory point of view, international attention to small satellite missions first came from the United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III) held in 1999 in Vienna. This conference, in particular, drew attention on small satellite missions as it endorsed the Small Satellite Missions Background paper 9.³⁷⁰

In addition, UNOOSA (United Nations Office for Outer Space Affairs), together with UNCOPUOS, provides a platform for small satellite missions. It has established the BSTI, which is an initiative within the UN Programme on Space Applications.³⁷¹ It has drawn particular attention to small satellite missions in the near past. The main aim of BSTI is to enable developing and emerging countries to participate in outer space activities and to provide assistance with capacity-building.³⁷²

A prime example of UN small satellite engagement was the organisation of three symposia in a row in 2009-2011, known as UN/Austria/ESA Symposium on Small Satellite Programmes for Sustainable Development in Graz, Austria.³⁷³ Another series of small satellite technology symposia has been held annually all around the world addressing various technical, political as well as legal issues concerning small satellites.³⁷⁴

In addition to that, the BSTI, in cooperation with the ISU, recently published a Guidebook on small satellite programmes. This book provides assistance in particular for non-space faring nations and non-governmental entities that want to launch a small satellite for the first time. It faces the benefits as well as the challenges of small satellite programmes from a technical as well as a managerial and political point of view.³⁷⁵

369 E.g. Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries, adopted by the GA in its Res 51/122 of 13 December 1996.

370 See UNISPACE III, Vienna, 19-30 July 1999. UNISPACE III was the latest United Nations Conference on the Peaceful Uses of Outer Space in 1999. The first (UNISPACE I) conference took place in 1969 and the second (UNISPACE II) in 1982. All three conferences were held in Vienna. Small Satellite Missions Background paper 9, A/CONF. 184/BP/9 26 May 1998, <http://www.un.org/events/unispace3/> (accessed 05.03.2013).

371 See <http://www.unoosa.org/oosa/en/sapidx.html> (25.03.2013).

372 For further details on BSTI see <http://www.unoosa.org/oosa/en/SAP/bsti/index.html> (25.03.2013).

373 Documents relating the conference are available under <http://www.oosa.unvienna.org/oosa/SAP/act2011/graz/index.html> (25.03.2013).

374 For a list of venues see <http://www.unoosa.org/oosa/en/SAP/bsti/japan2012.html> (25.03.2013).

375 The Guidebook is available under <http://gossip.isunet.edu/index.php?a=addextable> (25.03.2013).

4.7.2 ESA and the European Union

These days Europe has to tackle several problems, especially of a financial and economic nature. The current political issues and economic challenges affect European space programmes in every respect. As far as small satellite missions in Europe are concerned, despite the fact that small budgets are needed, they rely on a healthy economic development because governments, space industry and academia need content investors. Small satellite development in Europe requires a liberal working environment in order to be able to expand.

Any small satellite mission procured by the ESA may benefit from provisions stated in the ESA Convention.³⁷⁶ Any ESA member state would benefit from the grant stipulated in Art IX para 1 of the ESA Convention in a way that the ESA “(...) *shall make its facilities available*”. Especially for future VEGA launches this could mean that, as far as it is technologically possible to carry small satellites on board, it has an obligation to make its facilities available (of course, not for free).

Furthermore, Art IX para 3a states the so-called “fair return” principle. Concerning small satellites missions, “*Products developed under a programme of the Agency shall be supplied to any Member State that has taken part in the funding of the programme (...)*.” However, it is expressed in para 3a that funding small satellites programmes gives a fair return in order to obtain the assignment to produce the facility. This may enhance the economy and avoid brain drain in a certain member state as well as ensuring a closer engagement within the ESA.

Currently, the ESA is working on the PROBA-3 Mission which consists of five Micro-satellites to monitor Earth’s vegetation.³⁷⁷ Furthermore, ESA has invented and has continuously been involved in the GENSO ground station network, which provides standardised and cheap ground facilities for small satellite operators. Eventually, the ESA carries out the European Student Earth Orbiter, which is a Micro-satellite that enables students to participate in the project.³⁷⁸

The EU is to be engaged in a prominent small satellite project, namely by funding the QB50 small satellite constellation described above. This is the first small satellite project that is primarily funded by the EU. This international project also reflects the fact that the EU

376 Convention for the Establishment of a European Space Agency, currently 14 full member states and a cooperative agreement between ESA and Canada.

377 For mission details see http://www.esa.int/Our_Activities/Technology/Proba_Missions/Proba-3_precision_formation-flyer_takes_next_step_to_space (25.03.2013).

378 See http://www.esa.int/Education/European_Student_Earth_Orbiter (25.03.2013).

promotes small satellite development and encourages international cooperation as well as the involvement of universities, other institutions and local space industry through small spacecraft.

Small satellite missions also fit in with the EU/ESA space policies. The communication document “Towards a Space Strategy for the European Union that benefits its Citizens” COM (2011) 152 states in item 5.2 that “*the EU should gather and identify the users’ needs in full.*” Item one defines three types of needs, which range from combating climate change to generating new knowledge and products to creating jobs and economic competitiveness. Item 3.2 of the Strategy explicitly refers to the requirement of “*Boosting Research and Innovation*”. Indeed, small satellites, in particular for scientific and educational purposes, may meet those ambitious targets.

To sum up: Recent developments provide evidence that both, the ESA and the EU are promoting small satellite projects. With less money being invested in small satellites, it is easier for both organisations to support ambitious projects. Nonetheless, since two major organisations are encouraging small satellite activities, one would say “let small satellite projects step out of the shadow and let the light shine on them”.

4.7.3 Other institutions

Further institutions which pay attention to small satellites are the International Astronautical Federation (IAF),³⁷⁹ the International Academy of Astronautics (IAA)³⁸⁰ and the International Institute of Space Law (IISL)³⁸¹. For instance, the IAA supports a series of symposia concerning small satellites for Earth observation missions.³⁸² In addition to that, the IAA also upholds a Permanent Committee on Small Satellites.³⁸³ This committee supports the annual symposia on small satellites for Earth observation as well as organising symposia at the International Astronautical Congress (IAC). Further, the IAA has furnished a study group on “Small Satellite Missions for Earth Observation”.³⁸⁴

379 See the IAF webpage http://www.iafastro.com/index.html?title=Main_Page (25.03.2013).

380 See the IAA webpage <http://www.iaaweb.org/> (25.03.2013).

381 See the IISL webpage <http://www.iislweb.org/> (25.03.2013).

382 See the 9th IAA Symposium on Small Satellites for Earth Observation April 08 - 12, 2013 Berlin, Germany: URL: <http://www.dlr.de/iaa.symp/desktopdefault.aspx/tabid-4802/> (25.03.2013).

383 For the committee on small satellites see <http://iaaweb.org/content/view/397/555/> (25.03.2013).

384 See Sandau, 2010, 35.

The European Space Policy Institute (ESPI),³⁸⁵ based in Vienna, is an international space-related think tank that advises both customers and decision makers. The institute provides strategies, informs about different space policies and carries out studies and research projects on different space-related topics, such as, *inter alia* on small satellites.

Other institutions dealing with small satellites are the World Meteorological Organisation (WMO) and COSPAR. The United Nations Educational, Scientific and Cultural Organization (UNESCO) uses small satellite missions and programmes in order to detect and preserve historical sites.³⁸⁶

Finally (however, this list is not exhaustive), just to mention a national organisation, the ECSL Austrian National Point of Contact, in cooperation with its Subpoints, organised a Symposium on Small Satellites as mentioned above in 2012. Those engagements show that small satellites have already reached the level of national institutional considerations.

4.8 Instruments that support sustainable outer space “democratisation” through small satellites

In order to support a sustainable outer space “democratisation” process, diverse measures ranging from legal to technical to political and economic actions have to be taken. This chapter highlights the main instruments as already mentioned in order to support a sustainable outer space “democratisation” through the implementation of small satellites.

As far as legal measures are concerned, new and amended “hard” law provisions at the international and national levels, referring to the availability of low-budgets and to a shorter production time, need to be enacted. Binding provisions that facilitate state approval for small satellites would be highly appreciated. In addition to that, rules which simplify the ITU procedure for small spacecraft would also be welcomed. Less tight ITAR provisions would ease access to foreign COTS and would further enable developing countries and non-governmental entities to enter space.

As mentioned above, high insurance obligations hinder the realisation of small satellite projects. Mandatory insurance exonerations or specific insurance policies for small satellites are thus instruments that support outer space “democratisation”.

385 See the ESPI webpage <http://www.espi.or.at/> (25.03.2013).

386 See *Hernandez*, 2012, 1ff.

Contractual issues can also pose a challenge to small satellites. Typically, no warranties for launch postponing or defects caused by the primary payload are concluded in small satellite launch agreements. This issue might only be solved with the wide emergence of commercial launching opportunities dedicated to smaller spacecraft.

The existing framework concerning space debris mitigation (in orbit limits without reference to specific space application), although consisting of voluntary guidelines, may be an obstacle for small satellites. When establishing general time limits applicable to all types of small satellites, the benefits of small satellites can hardly be realised. Accordingly, specific orbits below the area where space stations are usually placed should be dedicated to small satellites. Higher orbits above the ISS might be open for small satellites used for scientific and research purposes, whereas small satellites for mere technology demonstration and verification or so-called “classical” student satellites might be restricted.

Nevertheless, beside “hard” law provisions, “soft” law³⁸⁷ in terms of voluntarily concluded guidelines is still a persuasive instrument to promote outer space democratisation through small satellites as well.³⁸⁸

However, in order to support a sustainable outer space “democratisation”, governments and research institutions have to invest in active de-orbiting systems. Future small satellite constellations placed in higher orbits than space stations will have to assure that they are able to de-orbit after their life time.

In addition, light has to be shed on LEO communication satellites again in order to “democratise” space when enabling developing countries to enter the field of telecommunication. Further, small satellites for Earth observation shall strengthen unprivileged areas, due to their capacity to monitor and predict droughts or other natural disasters. Student projects have to be financially supported to train staff and to build up capacities in developing and small industrialised countries.

Moreover, strengthening cooperation within the small satellite community is highly appreciated. Establishing a worldwide platform for technology transfer and transparency among small satellite actors would further enable outer space “democratisation” through small satellites.

387 For the role and implementation of soft law instruments in outer space in general see *Marboe*, *Soft Law in Outer Space*, 2011.

388 See also *Contant-Jorgenson et al.*, 2006, 38.

Additional launching opportunities for small satellites are urgently required. Not only do small satellite operators need technical and legal assistance, but they also need financial assistance. Thus, pools of experts need to be established to assist small satellite projects with a lack of financial resources.

5 Economic aspects

5.1 The economic value of small satellites and their assigned orbits

The third United Nations Conference on the Exploration and Peaceful Uses of Outer Space Small Satellite Missions background paper 9 (UNISPACE III) proposes to differentiate between direct and indirect economic benefits of small satellites. Of course, those benefits can even be achieved by conventional satellites. However, even small satellites with a low-budget approach might have the following economic benefits:³⁸⁹

Direct benefits are derived from the field of Earth observation such as the improvement of agriculture productivity, advancements in the identification of soil characteristics and in natural disaster detection. Furthermore, amendments could be achieved in the communication of settlements in rural areas far from central infrastructures through small communication satellites as well as in the establishment of educational programmes in remote areas etc.³⁹⁰

On the contrary, indirect economic benefits would refer to developing and smaller non-space faring countries which want to get engaged in space activities.³⁹¹ Basically, it has turned out that investments in space may have a multiplier effect on the gross national product.³⁹² Therefore, the indirect economic value of small satellite missions in general can be roughly determined by the fact that those missions would be able to create and maintain jobs. Moreover, new markets may be established and small satellites can minimise the overall financial risk, making such engagements attractive for universities and private engagements.

The present global economic crisis and budgetary constraints in the U.S. and Europe have restricted innovation and inhibited economic investigation. Conventional satellite missions and costly space activities are negatively affected too. Thus, small satellites could deliver an edge-technology even for narrow budgets. An investment in small satellite technology could have a multiplier effect and increase scientific, research and educational capacities.

As already mentioned, small satellite missions may create new jobs and train staff properly. Especially in the private space industry many jobs have been created that have resulted from small satellite engagements. Graduates and under-graduates have the chance to participate in research programmes and projects, which often pave the way for future careers.

389 See UNISPACE III, *Small Satellite Missions Background paper 9*, 14 para 60ff.

390 Ibid. 14 para 60.

391 Ibid. 14 para 61ff.

392 Ibid. 14 para 61.

The space sector can further be roughly divided into an upstream and a downstream sector.³⁹³ The upstream sector encompasses the hardware or launching opportunities as well as the requisite insurances for any mission.³⁹⁴ The downstream sector, on the contrary, includes all fields of space application such as telecommunication, navigation and remote sensing.³⁹⁵ The upstream sector is more costly and the economic value is slight whereas the downstream sector has a tremendous economic and capitalistic outcome.³⁹⁶ Small satellite missions are primarily orientated to serve the downstream sector as they have a wide range of satellite applications.

The rather long time before a satellite becomes operational is very challenging. Various issues could be encountered during a comprehensible design and development phase. Manufacturing may be put on hold, technical problems may arise, investors may disembark, and a lack of money could as easily occur as other negative events that could compromise the entire mission.³⁹⁷ Hence, it is the low-budget approach and the significantly small financial risk of several types of small satellites that lead developing countries as well as small national economies, universities and privately financed research programmes to draw attention to their being engaged in space missions.³⁹⁸

However, small satellites may also have positive effects on the upstream sector as far as satellite development (e.g. design of commercial of the shelf technology), cheap launching opportunities and the space insurance market are concerned.

Even the assigned satellite orbits play an important role. A satellite orbit is defined by “(...) *trajectories, mostly periodical, of satellites around the primary body, in our case the Earth, under the influence of natural forces.*”³⁹⁹

The term LEO refers to all orbits below about 2000 km from the Earth’s surface.⁴⁰⁰ Small satellite missions mainly use orbits in the LEO, because in many cases it is the easiest orbit to reach especially when being booked on a piggyback ride.

393 See Venet, 2011, 64ff.

394 Ibid. 64f.

395 Ibid. 67f.

396 Ibid. 66f.

397 For the risks of the space markets in general see Venet, 2011, 61ff.

398 See also Venet, 2011, 61 when he stipulates the main challenges of the space economy, namely the high launch prices per kg and the long development cycles which lead to market risks.

399 Contant-Jorgenson et al., 2006, 21.

400 Ibid. 21.

The MEO is located between 2,000 km above the surface of the Earth and the GEO (~36,000 km).⁴⁰¹ Small satellites in this orbit benefit from a longer lifetime (the natural decay time is shorter) and a better traffic situation. The higher a satellite can be placed, the longer it can stay and the better the communication rate will be (satellites are visible longer on the ground station) which makes the mission more valuable. This area would be served by Micro- and Mini-satellites since they are more massive and more reliable.

A space object which is placed at the GEO is located at an altitude of close to 35,786 km and with zero inclination (above the equator).⁴⁰² The GEO is the most valuable orbit as far as telecommunication or meteorology is concerned, since this orbit over the equator has a permanent communication rate and ensures rather long-term mission sustainability. The biggest revenues in the commercial space industry will be achieved through the GEO in the field of telecommunication and direct broadcasting TV. The main disadvantage for small satellite mission is that due to their small mass (fewer payloads, no or fewer fuel, less required component parts etc.) they are less reliable in comparison to the very high launch cost.

To sum up: The most valuable orbit for small satellite missions, such as Nano- Pico- and Cube-satellites, is the LEO. For more massive small satellites such as Micro- and Mini-satellites the MEO can be interesting too, due to its advanced communication rate and long-term sustainability. The GEO as the most valuable orbit to get the biggest revenues from has so far been factually undesirable for small satellites.

5.2 Financing small satellite missions

Financing small satellite missions primarily leads to the question “Who orders a small satellite from whom?” and “Who is going to pay for the venture”?

As to the question who orders a small satellite from whom: Satellite customers may be governments, universities, private entities and even individuals. They may order the (small) satellite from the industry or manufacture several parts on their own.

As to the question who is going to pay for the venture: In a liberalised environment there might come a situation where different actors have to act in concert. It might be the operator of a small satellite mission which is different from the manufacturer of the spacecraft and even different from the entity that is merely going to fund the venture.

⁴⁰¹ Ibid. 21.

⁴⁰² See *Contant-Jorgenson et al.*, 2006, 22.

Actually, financing issues of small satellite missions are sometimes equated with a narrow sense of small satellite “procurement”, which may mean “purchasing”.⁴⁰³ The term “procurement” has been used in several international documents without providing a definition, which sometimes leads to misinterpretations. The main notion should be that by virtue of Art II LIAB a state (including private entities located in the launching state) which is purchasing, financing or even authorising a launch by using foreign facilities shall be considered as a launching state with all legal consequences such as state responsibility and liability since it might “procure” the launch. A state that “procures” a piggyback launch of a small satellite might also become a state of registry. Therefore, “financing” or merely “authorising” the launch of a small satellite might also lead to legal impacts that governmental entities should be aware of.

5.2.1 Private Finance Initiatives (PFI)

Due to the fact that (small) satellite procurement in central Europe has been more and more liberalised, this chapter starts with the most liberal way of financing, namely private finance initiatives. PFI means financial procurement (of projects often with public interest, e.g. Earth observation missions) virtually by private initiatives. One can characterise PFI in central Europe by a so-called “award of contracts” or “call for tenders”.⁴⁰⁴

Private investment has been increasing over the last decades. The entire European space industry can be considered as a prime example for a vital PFI which designs, manufactures, launches and operates small satellite missions. Nevertheless, many private investors also expect revenues which mean that small satellite missions undertaken for mere scientific and educational purposes rather than for their commercial potential may not be funded by private investors due to a lack of profit gained.⁴⁰⁵

5.2.2 Public Private Partnerships (PPPs)

A significant financial instrument, not only when it comes to small satellite missions, are PPPs. The acronym PPP itself already reveals the concept behind it. PPPs typically work out with projects which have both a public interest and a commercial potential.⁴⁰⁶

403 See *Kerrest/Smith*, 2009, 137 recital 37.

404 *Brünner/Walter*: Space Transportation in the Future, 2008, 67.

405 See *Kreisel*, 2002, 191ff.

406 *Ibid.* 194.

One can find PPPs even in ground-based traffic procurement, which means that hence, PPPs are not only space-related. Nowadays, a strong shift away from the public sector is observable. This has various reasons in general: state liberalism, state budgets that are tight and the emergence of a competitive private sector. In most cases, both the public (states or governmental organisations) and the private sector (mainly industry) benefit from each other: While the public sector may assume the financial risk and liability, the private investor may provide his or her competitive knowledge to a (small) satellite mission.⁴⁰⁷

PPPs in general are a very complex matter and comprise a set of public, private, international, and domestic rules such as economic law, competition law, intellectual property rights and so forth.⁴⁰⁸ In practice, two different models are common: the operator model and the concessive model. The main difference between those models is that the latter lets the private sector operate at their own cost and duty.⁴⁰⁹

As against that, the operator model has the private sector act on behalf of their government and institutions, e.g. at public cost and duty.⁴¹⁰ Concerning small satellite missions, the concessive model may become more favourable for the financing government. For instance, if the non-governmental entity does not merely supply a “product” but rather supplies a “service”, it might become the operator which in fact controls the mission.⁴¹¹

However, in most of the liberalised western state systems the public sector generally still has the duty to provide so-called “services of public interest”, which are usually not-for-profit. In contrast, the private sector in general is rather rational and economically orientated and therefore wants to gain revenues from a project. The private sector even wants to acquire a fast return on investment and is therefore cost-benefit orientated.

As a consequence, PPP would basically be in the interest of both the public sector and the private sector since various small satellite applications serve a public interest and provide a fast return on investment. However, small satellites are often not profitable or do not have a commercial aim, as in the case of missions for educational and scientific purposes. Hence,

407 For the definition of PPP's in general see *Brünner/Walter*, 2008, 65ff.

408 Ibid. 68.

409 Ibid. 68.

410 Ibid. 68.

411 See *Ravillon*, 2011, 163.

PPP as a finance model might be virtually interesting concerning small satellite missions with a public interest plus a pecuniary aim.⁴¹²

5.2.3 Public sector procurement

The strongest engagement of states towards financing is public sector procurement. This exclusive type of public funding is not very common in small satellite procurements, at least in central Europe, which is represented by a flourishing small satellite industry. Due to the fact that a significant number of small satellite missions are carried out for civil purposes (about 40% of all small spacecraft by 2011), the exclusive engagement of public institutions has gone.⁴¹³

One must strictly distinguish between public sector procurement and public funding. The latter is exemplified by governments that mainly fund scientific, educational or academic projects. One such example is the Austrian Tugsat-1, which is funded by the Austrian government. Public funding is considered to grant financial assistance without being involved in the operation and management of the mission, or taking over any financial risks. Nonetheless, public funding of small missions mainly without pecuniary interest (e.g. scientific, research or educational purposes) has become most prominent.

5.3 Further economic and financial considerations concerning small satellites

5.3.1 Standardised items – a cost minimiser

Placing this topic under economic and financial considerations should show how significant and economically valuable standardised component parts for small satellites are. However, this chapter must not be mixed up with general rules of space standardisation.⁴¹⁴

One of the most time-consuming and costly stages of satellite development is the manufacture of non-standardised component parts or platforms.⁴¹⁵ Standardisation in the context of space technology means to standardise or adapt component parts in order to use them in manifold ways. Some of those items can also be produced off-the-shelf. Standardised or off-the-shelf

⁴¹² See *Kreisel*, 2002, 194.

⁴¹³ For the figure see Focus of the year: Small spacecraft in: ASD Eurospace 2011.

⁴¹⁴ For space standardisations see in general http://ec.europa.eu/enterprise/policies/space/esp/industrial-policy/standardisation/index_en.htm (25.03.2013). It would be out of the scope to deal with space standardisation which might additionally challenge small satellite missions.

⁴¹⁵ See Report on the third United Nations/Austria/European Space Agency Symposium on Small Satellite Programmes for Development, 2011, para 28.

items are significant for small satellite missions because they are based upon low cost and short developing time.⁴¹⁶

Standardised component parts for Nano- or Cube-satellites are already available for costumers, which has opened a new market. One can even buy standardised Cube-satellites or items on the internet.⁴¹⁷ Standardised Cube-satellites for sale offer new market opportunities and enable a broader community to step into space. Therefore, standardisation of small spacecraft contributes positively to the notion of outer space “democratisation”.

However, there is still no platform for small satellites that provides a coordination of standardised items. Small satellite operators would benefit from such a platform and could share experiences. Although the European Cooperation for Space Standardisation is acting on behalf of this issue, closer co-operation among the small satellite community will be sought.⁴¹⁸

In recapitulating, countries with constrained space budgets or less know-how are particularly dependent on off-the-shelf items in order to successfully carry out small satellite missions.⁴¹⁹ Using non-standardised and expensive components for small satellites highly increases the overall mission cost.⁴²⁰ In some cases, it would never pay off due to the short lifetime. However, many standardised component items are still imported from the United States. These circumstances, as already mentioned, confront small satellite operators with strict national ITAR regulations.

Summing up, the lack of standardisation of small satellite items and components, in particular for student missions, can prove to be a financial challenge for the entire mission. Standardised items for small satellite missions can thus be considered as a cost minimiser. Therefore, coordination platforms at the international level and experts that will assist small satellite operators are highly needed in order to realise the benefits of small spacecraft.

5.3.2 Launching opportunities

416 See UNISPACE III, *Small Satellite Missions Background paper 9*, 14 para 66.

417 Standardised Cube-satellites for purchase <http://www.cubesatkit.com/> (25.03.2013).

418 See <http://www.ecss.nl/> (25.03.2013).

419 See Sandau, 2010, 84.

420 See Janson, 2008, 69.

With the wide emergence of Nano, Pico, and Cube-satellites, the need for dedicated launching opportunities has risen.⁴²¹ In accordance with a low-cost approach, affordable launching opportunities are urgently needed. This includes “piggyback” launching opportunities or launches from smaller and less expensive rockets⁴²² or other affordable opportunities, as already described, from airplanes or from the ISS. This chapter refers to the economic aspects of small satellite “piggyback” launching and “dedicated launches” on smaller launch vehicles.

Piggyback launching, where a small satellite is stored alongside the primary payload and pushed out at its dedicated orbit which is on the way of the primary payload, seems to be a very cost-effective way to launch small satellites.⁴²³

However, when facing a small satellite “piggyback” launch, many things have to be considered. Firstly, a dedicated launching company must be found. Secondly, the primary payload must almost go into the same “direction” as the secondary payload is intended to go.⁴²⁴ Finally, most of the launch vehicles have to make certain adaptations in order to secure a safe separation process of the small satellite during the ride. This would cost additional money. Last but not least, most launchers limit the in-orbital mass to carry along as secondary payload. Therefore, most piggyback launchings are only carried out for Nano-, Pico-, and Cube-, and other smaller and lighter types of small satellites.

In general, the launch of a space object is one of the major cost drivers and, thus, the total amount of cost for the launch depends on the mass of the object.⁴²⁵ One may think that it should not be a problem to carry very small spacecraft like Nano-satellites with a weight of no more than 10 kg piggyback as a secondary payload but, in fact, such operations rely on large technical adaptations applied to the spacecraft in order to store a small satellite and to properly release it on its ride.

Looking into the past, Ariane-4 contained a special structure named Ariane Structure for Auxiliary Payloads (ASAP) in order to deploy small satellites. The limit of its piggyback launching capacity was about 7 small spacecraft with a limit of 50 kg per each payload.⁴²⁶ Currently, Ariane 5 is able to successfully carry out “piggyback launches” with up to 100 kg

421 See Resolution COM6/10 (WRC-12) lit. e.

422 For low-cost launching opportunities for small satellites in general see UNISPACE III, *Small Satellite Missions Background paper 9*, 11f para 44ff.

423 Ibid. 12 para 48.

424 Ibid. 12 para 49.

425 See Kleef/Oving, conference proceedings, 2012, 1.

426 See UNISPACE III, *Small Satellite Missions Background paper 9*, 1998, 12, para 50.

per each payload and primarily serves the geostationary transfer orbits and the low polar orbits.⁴²⁷ Accordingly, piggyback launching methods in combination with pre-adapted launching systems have radically revolutionised small satellite development. With such systems multiple small satellites (predominantly Nano, Cube- and Pico-satellites) can be jointly launched. Some launch operators offer piggyback launching at low cost, in particular when new launch vehicles are being tested.⁴²⁸

Usually, small satellite operators also pay travel fees, but in most cases these are silent conditions. It is therefore not easy to say how much a mission costs in total. A list of prices does not exist and the costs are often negotiated. Typically, the launching cost of one kg launched into LEO is about € 20,000.⁴²⁹ However, this amount may be fairly reduced when launching “piggyback”.

At the moment, there are only a few “piggyback” launching opportunities for small satellites worldwide.⁴³⁰ One has to bear in mind that piggyback launches are not really lucrative for the conventional launching business. Nevertheless, a cheaper price can be achieved in India on the national PSLV or in China on its Long March Rocket family that is even used for commercial purposes.⁴³¹

Piggyback launches, as provided in India and China, could indeed be a competitive future market. In comparison to that situation, the collapse of the former USSR in 1991 had Russia also step into the global competitive economy. This has created cheaper launching opportunities for small satellite missions even in Russia and has damaged predominant contractors.⁴³²

Nonetheless, small satellites can be even launched as primary payloads in groups on dedicated smaller launch vehicles.⁴³³ Recently, a new European launch vehicle specialised in smaller payloads has been developed. This launch vehicle is called the VEGA (Vettore Europeo di Generazione Avanzata)⁴³⁴ rocket and is entirely a European project. On its first test flight in February 2012, VEGA successfully carried nine small satellites (seven Nano-satellites) into outer space. VEGA is to cover the European demand for small satellite launchers and

427 Ibid. para 50.

428 Ibid. para 47.

429 See Koudelka, 2009, 53.

430 See Kleef/Oving, conference proceedings, 2012, 1 f.

431 Ibid. 1ff.

432 See Janson, 2008, 64.

433 See *Small Satellite Missions Background paper 9*, 1998, 12 para 47.

434 Vega is part of the Ariane family http://www.arianespace.com/launch-services-vega/vega_overview.asp (25.03.2013).

therefore, should fill the gap in the European space policy, e.g. by providing autonomous small satellite launches. VEGA is able to lift up small satellites of about 300 kg – 2,000 kg and also offers very small satellite launches for Nano-, Pico-, and Cube-satellites, which are intended to go to low polar orbits.⁴³⁵

VEGA should also be able to launch several small satellites in order to install small satellite clusters or swarms (e.g. Nano-satellite constellation).⁴³⁶ However, VEGA could seriously compete with Chinese and Indian launching facilities for small satellites in the future. Therefore, VEGA launches should be affordable for several small satellite missions carried out by governments, universities, or individuals.

Fully private launching operators, such as SpaceX,⁴³⁷ also provide small satellite launches for commercial purposes under conditions comparable to those mentioned above. Therefore, (smaller) private launching operators may become competitive in comparison to state (or governmental and inter-governmental space agency) launchers⁴³⁸ as they can launch small satellites in groups as primary payloads. Moreover, Virgin Galactic, which is already planning its new spaceship LauncherOne,⁴³⁹ also intends to launch small satellites at an affordable cost. What is also worth mentioning is Interorbital Systems (IOS), a company based in Mojave that sells and launches Cube-satellites with a low-cost approach.⁴⁴⁰

However, there might still be a lack of attractive launching opportunities in order to successfully carry out small satellite missions in the future. The following example may illustrate this: Austria had to wait for its launching opportunity for Tugsat-1 and UniBRITE, witnessing repeated postponements of the launch because of the non-readiness of the primary payload.⁴⁴¹

Various types of small satellites are based on low cost and therefore low financial risk, but in any worst-case scenario repeatedly required postponements could kill any mission due to a loss of investors and money flow. Moreover, small satellites launched “piggyback” can also

435 See *Barbera*, 2002, 253.

436 Ibid. 252.

437 For more information on SpaceX see <http://www.spacex.com/> (25.03.2013).

438 See *Jankowitsch*, 2007, 31.

439 See <http://www.virgingalactic.com/launcherone> (accessed 19.08.2012); also <http://www.space.com/7065-virgin-galactic-deal-targets-small-satellite-launches.html> (25.03.2013).

440 For information on Interorbital Systems in general see <http://www.interorbital.com/> (25.03.2013).

441 See *derStandard*, 23. Februar 2012, online version: <http://derstandard.at/1329870151527/Auf-Sommer-verschoben-Oesterreichische-Satelliten-starten-noch-spaeter-als-geplant> (25.03.2013).

be brought into a wrong orbit.⁴⁴² A classic “student satellite” does not afford a space insurance to cover such a defect. In most cases, small satellite operators are considered as “suers” rather than serious customers when applying for a piggyback launch. This notion has been reflected upon as piggyback customers frequently do not have any contractual warranty against launch postponement and/or defective delivery.

To sum up: The major challenge of small satellite launches is the lack of adequate launching opportunities. Small satellites on a piggyback ride have to be assigned to nearly the same orbit and inclination as the primary payload. As pointed out earlier, it should become a real challenge to find a launch vehicle for small satellite operators that is going in the same direction at nearly the same time and at fair travel expenses, and that is willing to carry a secondary payload. Additionally, several adaptations on the launching vehicle have to be completed in order to deploy a small satellite properly.

Moreover, small satellites launched piggyback strongly depend on the readiness of the primary payload. Several cases in the past have shown that small satellites were negatively affected by a postponement of the launch. Therefore, the increase of availability of piggyback launching opportunities may be decisive for the realisation of a “democratised” outer space.⁴⁴³

5.3.3 Small satellites – a future prospect on outer space “democratisation”

The field of small satellite activities must be divided into two different fields, namely in high and weak potential fields of outer space “democratisation”. Weak potential fields are believed to have less capability to “democratise” space. In contrast, high potential fields show a strong capability to enable non-governmental entities or developing and small countries to enter outer space.

Traditionally, the launcher segment as well as human spaceflight and space exploration have been reserved for privileged space-faring nations. Even conventional space applications such as navigation and telecommunication still count toward the field of weak “democratisation” potential of small satellites. Due to budget constraints, small satellites are not able to carry enough fuel to serve the GEO. Hence, due to the lack of appropriate propulsion systems and

⁴⁴² Such a defect for instance happened in 2012 <http://www.space.com/17984-spacex-private-rocket-glitch-satellite.html> (25.03.2013).

⁴⁴³ See Smith/Valic, 2012, 10.

further technical and economic reasons such as the short life-time (which does not reach at least 15 years) they will most likely not even be present in GEO in the future.⁴⁴⁴

However, the need for communication is still increasing. A growing number of developing countries are about to enter the field of telecommunication. The latest technological advancements have shown that communication can also be served by small satellite constellations in LEO.⁴⁴⁵ In the past, several companies have tried to establish LEO communication constellations but ORBCOMM Low Earth Orbit satellite communication systems are the only ones which have survived so far.⁴⁴⁶

In contrast, activities such as space education as well as space technology demonstration, space science and Earth observation have become important areas for small satellite missions. Education, science and technology have the highest potential to “democratise” outer space through small satellites. Universities, private research centres and individuals have been engaged and trained in small satellite activities.

Electronic miniaturisation is still on-going and, consequently, generates valid expectations for further development in small satellite technology. It is a fact, however, that small satellites will not replace conventional satellites in the near future, since both have different purposes and aims. Instead, small satellites will complement bigger missions.⁴⁴⁷

As far as legal prospects are concerned, however, expectations are that, if technology advances to a point where more and more entities and individuals launch their own satellite into space, restrictive space debris mitigation guidelines and traffic management rules will be enacted in order to limit the number of small spacecraft in response to an unsustainable use of outer space.

However, at this point the author simply acknowledges a major and distinctive trend – the “sustainable democratisation” of outer space. The author stresses the urgent need for rules which do regulate but do not hinder outer space “democratisation” through small satellites in the near future.

⁴⁴⁴ See Lewin, 2002, 167.

⁴⁴⁵ Ibid. 168.

⁴⁴⁶ For details on Orbcomm in general see <http://www.orbcomm.com/our-network-overview.htm> (25.03.2013); see above Lewin, 169.

⁴⁴⁷ See UNISPACE III, *Small Satellite Missions Background paper 9*, 1998, 7 para 13.

6 Conclusions

Can small satellites serve as new instruments toward outer space “democratisation”? This is the main question posed in the present thesis. The answer to this question is unequivocal: “Yes, they can.” Since several types of small satellites can be produced at low cost, shorter production time, and less financial risk, they allow non-governmental entities, such as universities, research centres as well as other private institutions and even individuals, to enter outer space.

Moreover, developing and small countries clearly benefit from small, low-budget satellite missions in order to advance their technological, scientific and research capacities. Small satellites may meet human and societal needs such as water detection and land management through Earth observation and may be able to bridge the digital divide through satellite constellations.

Small satellites may ensure “independence” in space but at the same time they rely on cooperation, when it comes to foreign “piggyback” for instance, which is a clear change on the skyline. One should not forget to mention the cultural and artistic potential that small satellites are facing. Thus, outer space “democratisation” contributes positively to quantitative developments such as the increase in the numbers of space actors as well as to qualitative aspects such as promoting international cooperation through cross-border small satellite projects. Hence, although being small and only able to carry a limited number of payloads, small satellites cannot depreciatively be considered as “toys”, for they are serious space objects which meet societal and human needs.

Legally, a small satellite mission when becoming operational is still considered a “space activity” (Art VI OST). The space treaties do not refer to the size and weight of a given space activity. Thus, the space treaties and other relevant provisions are also applicable to small satellites. No specific rules have been enacted so far which specifically refer to small satellites. This lack of distinction between conventional expensive satellites and smaller affordable satellites eventually lead to factual challenges that small satellites will be faced with.

Indeed, time-consuming frequency management procedures in conjunction with strict and complex export control regimes and unaffordable, high insurance requirements for third-party liability, undermine the various political-economic benefits offered by small satellites. One

must take into account, in particular, the tight budgets and the lack of legal advisors for universities, research centres, developing and small countries. Small spacecraft need at least adequate adaptations of existing provisions. It is evident that for cross-border missions we need further adaptations of national space laws.

However, small satellites cause space debris like any other conventional satellites. In particular small satellite constellations, consisting of dozens of small spacecraft, contaminate outer space when becoming space debris and having no means to de-orbit. Various types of small satellites are unable to actively de-orbit after their end of lifespan. Since small satellites are usually launched to LEO, regions in these orbits tend to be particularly overcrowded. This renders the issue of space debris mitigation and traffic management increasingly important. Currently, restrictive space debris mitigation guidelines, even when not binding, limit the number of small satellites, since many types are currently unable to fulfil the tight criteria. Rather selective space debris mitigation rules hinder outer space “democratisation” through small satellites.

In order to realise the benefits of small satellites, small spacecraft require modified regulations concerning frequency management, transfer of technology, as well as space debris mitigation and insurance policies. These changes will have to be considered against the background of tight budgets as well as a lack of legal advisors for universities, research centres, and developing and small countries. The main challenge will be to find legal and technical solutions which regulate, but do not hinder outer space “democratisation” through small satellites.

List of Abbreviations/Acronyms

AARA	Austrian Amateur Radio Act
AECA	Arms Export Control Act
AOSA	Austrian Outer Space Act
API	Advanced Public Information
ARMC	African Resource Management (Satellite) Constellation
ARRA	Agreement on the Rescue of Astronauts, and the Return of Astronauts and Return of Objects launched into Outer Space
Art.	Article
Arts	Articles
ASIM	Application Specific Integrated Micro-instruments ASIM
ASAA	Australian Space Activities Act
BRITE	Bright Target Explorer
BSTI	Basic Space Technology Initiative
cm	centimetre
CNES	Centre National d'Etudes Spaciales
CoCOM	Coordinating Committee for Multilateral Export
COLREG	Convention on the International Regulations for Preventing Collisions at Sea
COSPAR	Committee on Space Research
COTS	Commercial off-the-shelf
DLR	Deutsches Zentrum für Luft- und Raumfahrt
DMC	Disaster Monitoring Constellation
DoS	U.S. Department of State
DSAA	Dutch Space Activities Act
EAA	Export Administration Act
EC	European Council
ECA	Export Control Act
ECSL	European Centre for Space Law
ed.(s)	editor(s)
e.g.	exempli gratia (for example)
EO	Earth Observation
ESA	European Space Agency
ESPI	European Space Policy Institute
EU	European Union
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
EUTELSAT	European Telecommunication Satellite Organisation
FFG	Forschungsförderungsgesellschaft (Österreich)
FOI	Freedom of Information
FSOA	French Space Operations Act
GEO	Geostationary Orbit
GENSO	Global Educational Network for Satellite Operations

IAA	International Academy of Astronautics
IAC	International Astronautical Congress
IADC	Inter-Agency Space Debris Coordination Committee
IAF	International Astronautical Federation
IARU	International Amateur Radio Union
ICCPR	International Covenant on Civil and Political Rights
ICJ	International Court of Justice
IGA	Intergovernmental Agreement
IGY	International Geophysical Year
IISL	International Institute of Space Law
INSPIRE	Infrastructure for Spatial Information in the European Community
IOS	Interorbital Systems
IOV	In-orbit delivery
IPR	Intellectual Property Rights
ISS	International Space Station
ISU	International Space University
ITAR	International Traffic in Arms Regulations
ITU	International Telecommunication Union
JAXA	Japanese Space Agency
kg	kilogram
LEO	Low Earth Orbit
LIAB	Liability Convention
lit.	literal
LSA	Launch Service Agreements
M	Million
MDG's	UN Millennium Development Goals
MEMS	Micro-Electromechanical Systems
MEO	Medium Earth Orbit
mg	milligram
NASA	National Aeronautics and Space Administration
NASRDA	National Space and Research and Development Agency
OST	Outer Space Treaty
p./pp.	page(s)
para	paragraph
PFI	Private Finance Initiatives
PPP	Public Private Partnership
PSLV	Polar Satellite Launch Vehicle
REG	Registration Convention
ROSCOSMOS	Russian Space Agency
RR	Radio Regulations
SHAR	Satish Dhawan Space Centre
SSA	Space Situational Awareness

SSTL	Surrey Satellite Technology Ltd.
TCBMs	Transparency and Confidence-Building Measures
TFEU	Treaty on the Functioning of the European Union
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNCOPUOS	United Nations Committee for the Peaceful Uses of Outer Space
UNDP	United Nations Development Programme
UNESCO	The United Nations Educational, Scientific and Cultural Organization
UNGA	United Nations General Assembly
UNIDROIT	United Nations International Institution for Unification of Private Law
UNISPACE	United Nations Conference on the Exploration and Peaceful Uses of Outer Space
UNOOSA	United Nations Office for Outer Space Affairs
U.S.	United States (of America)
USML	U.S. Munitions List
USSR	Union of Soviet Socialist Republics
VEGA	Vettore Europeo di Generazione Avanzata
WMO	World Meteorological Organization
WTO	World Trade Organisation
vol.	volume

Bibliography

References

Barbera, R.: VEGA: the European Initiative for Launching Small Satellites in: *Rycroft, Michael/Crosby, Norma* (ed.): *Smaller Satellites: Bigger Business? Concepts, Applications and Markets for Micro/Nanosatellites in a New Information World*, Space Studies Vol.6, International Space University, Kluwer Academic Publishers, Dordrecht/Boston/London, 2002, 249-255.

Baumann, Ingo/Dodel, Hans: The ITU Filing of Satellite Systems in: *Smith, Lesley Jane/Baumann, Ingo* (eds.): *Contracting for Space/Contract Practice in the European Space Sector*, Ashgate, 2011, 367-382.

Besser, Bruno P.: Österreichs Weg in den Weltraum, Beauchesne, Paris, 2009.

Bovet/Hair/Kennedy/Milani/Pavek/Schingler: The International Space University's Small Satellite Interdisciplinary Survey (ISIS) in: *Rycroft, Michael/Crosby, Norma* (ed.): *Smaller Satellites: Bigger Business? Concepts, Applications and Markets for Micro/Nanosatellites in a New Information World*, Space Studies Vol.6, International Space University, Kluwer Academic Publishers, Dordrecht/Boston/London, 2002, 429-49.

Brünner, Christian/Walter, Edith: Space Transportation in the Future: Public-Private Partnership in: *Arnold, K./Bundschuh-Rieseneder, F./Kahl, A./Müller, T./Wallnöfer, K.* (eds.) *Recht Politik Wirtschaft Dynamische Perspektiven*, Festschrift für Norbert Wimmer, SpringerWienNewYork, 2008, 65-85.

Brünner, Christian/Walter, Edith: Prolog/Raumfahrt und Recht in: *Brünner, Christian/Walter, Edith* (ed.): *Raumfahrt und Recht/Faszination Weltraum. Regeln zwischen Himmel und Erde*, Studien zu Politik und Verwaltung Vol. 89, Böhlau Verlag Wien – Köln – Graz, 2007, 9-20.

Cheli, Simonetta: Cooperation in Space in: *Brünner, Christian/Soucek, Alexander* (eds.): *Outer Space in Society, Politics and Law*, Studies in Space Policy Vol.8, edited by the European Space Policy Institute, SpringerWienNewYork, 2011, 178-197.

Chizea, F.D.: Small Satellites in Developing Countries – An Integral Part of National Development in: *Rycroft, Michael/Crosby, Norma* (ed.), *Smaller Satellites: Bigger Business?*

Concepts, Applications and Markets for Micro/Nanosatellites in a New Information World, Space Studies Vol.6, International Space University, Kluwer Academic Publishers, Dordrecht/Boston/London, 2002, 299-306.

Clerc, Philippe: Consequences of the French Space Law on Space Operations (FSOA) on CNES's Mission as a Contracting Space Agency in: *Smith, Lesley Jane/Baumann, Ingo* (eds.): Contracting for Space/Contract Practice in the European Space Sector, Ashgate, 2011, 117-131.

Contant-Jorgenson, Corinne/Lála, Petr/Schrogl, Kai-Uwe (eds.): Cosmic Study on Space Traffic Management, published by the International Academy of Astronautics, printed by the German Aerospace Centre (DLR), France, 2006.

Creydt, Matthias/Hörl, Kay-Uwe: Export Control Issues in Space Contracts in: *Smith, Lesley Jane/Baumann, Ingo* (eds.): Contracting for Space/Contract Practice in the European Space Sector, Ashgate, 2011, 291-302.

Dhanji, N.: Prospects for Involvement in Space Activities in Developing Countries via Small Satellites in: *Rycroft, Michael/Crosby, Norma* (ed.): Smaller Satellites: Bigger Business? Concepts, Applications and Markets for Micro/Nanosatellites in a New Information World, Space Studies Vol.6, International Space University, Kluwer Academic Publishers, Dordrecht/Boston/London, 2002, 307-314.

Du Parquet, Claude-Alain: Specific Clauses of Launch Service Agreements in: *Smith, Lesley Jane/Baumann, Ingo* (eds.): Contracting for Space/Contract Practice in the European Space Sector, Ashgate, 2011, 385-392.

Freeland, Steven/Jakhu, Ram: Article II in: *Hobe, Stephan/Schmidt-Tedd, Bernhard/Schrogl, Kai-Uwe* (ed.): Cologne Commentary on Space Law, Outer Space Treaty, Carl Heymanns Verlag, 2009¹, 44-63.

Freeland, Steven: The Role of 'Soft Law' in Public International Law and its Relevance to the International Legal Regulation of Outer Space in: *Marboe, Irmgard* (ed.): Soft Law in Outer Space/The Function of Non-binding Norms in International Space Law, Studien zu Politik und Verwaltung Vol. 102, 2012, 9-30.

Gerhard, Michael: Article VI in: *Hobe, Stephan/Schmidt-Tedd, Bernhard/Schrogl, Kai-Uwe* (ed.): *Cologne Commentary on Space Law/Outer Space Treaty*, Carl Heymanns Verlag, 2009¹, 103-125.

Hertzfeld, Henry R./Jones, Raymond L.: International aspects of technology controls in: *Brünner, Christian/Soucek, Alexander* (Eds.): *Outer Space in Society, Politics and Law*, Studies in Space Policy Vol. 8, edited by the European Space Policy Institute, SpringerWienNewYork, 2011, 638-663.

Hobe, Stephan: Article I in: *Hobe, Stephan/Schmidt-Tedd, Bernhard/Schrogl, Kai-Uwe* (ed.): *Cologne Commentary on Space Law/Outer Space Treaty*, Carl Heymanns Verlag, 2009¹, 25-43.

Jankowitsch, Peter: International Relations during the Days of Cold War and Today: The situation within COPUOS in: *Brünner, Christian/Soucek, Alexander/Walter, Edith* (eds.) *Raumfahrt und Recht/Faszination Weltraum/Regeln zwischen Himmel und Erde*, Studien zu Politik und Verwaltung Vol. 89, Böhlau Verlag Wien – Köln – Graz, 2007, 21-34.

Janson, Siegfried W.: The History of Small Satelites in: *Helvajian, Henry/Janson, Siegfried, W.*(eds.): *Small Satellites: Past, Present and Future*, The Aerospace Press El Segundo, California, American Institute of Aeronautics and Astronautics, Virginia, 2008, 47-94.

Kerrest, Armel/Smith, Lesley Jane: Art VII in: *Hobe, Stephan/Schmidt-Tedd, Bernhard/Schrogl, Kai-Uwe* (ed.): *Cologne Commentary on Space Law/Outer Space Treaty*, Carl Heymanns Verlag, 2009¹, 126-145.

Koudelka, Otto: The technical dimension of space in: *Brünner, Christian/Soucek, Alexander* (eds.): *Outer Space in Society, Politics and Law*, Studies in Space Policy Vol. 8, edited by the European Space Policy Institute, SpringerWienNewYork, 2011, 46-54.

Koudelka, Otto: Tugsat-1: The first Austrian Satellite in: *Brünner, Christian/ Walter Edith* (ed.): *National Space Law/Development in Europe – Challenges for Small Countries*, Studien zu Politik und Verwaltung Vol. 89, Böhlau Verlag Wien – Köln – Graz, 2008, 133-147.

Kreisel, J.: Some Problems Specific to Small Satellite Project Financing in: *Rycroft, Michael/Crosby, Norma* (ed.): *Smaller Satellites: Bigger Business? Concepts, Applications and Markets for Micro/Nanosatellites in a New Information World*, Space Studies Vol. 6,

International Space University, Kluwer Academic Publishers, Dordrecht/Boston/London, 2002, 185-195.

Lewin, A.: Market Growth Potential for Small Satellites: An Industry View in: *Rycroft, Michael/Crosby, Norma* (ed.): *Smaller Satellites: Bigger Business? Concepts, Applications and Markets for Micro/Nanosatellites in a New Information World*, Space Studies Vol. 6, International Space University, Kluwer Academic Publishers, Dordrecht/Boston/London, 2002, 165-171.

Lyall, Francis/Larsen, Paul B.(eds.): *Space Law/A Treatise*, Ashgate, 2009.

Maeda, K.: Small Satellites in the Future Space Infrastructure in: *Rycroft, Michael/Crosby, Norma* (ed.): *Smaller Satellites: Bigger Business? Concepts, Applications and Markets for Micro/Nanosatellites in a New Information World*, Space Studies Vol. 6, International Space University, Kluwer Academic Publishers, Dordrecht/Boston/London, 2002, 119-126.

Marboe, Irmgard (ed.): *Soft Law in Outer Space/The Function of Non-binding Norms in International Space Law*, Studien zu Politik und Verwaltung Vol. 102, Böhlau Verlag Wien – Köln – Graz, 2012.

Marchisio, Sergio: Art IX in: *Hobe, Stephan/Schmidt-Tedd, Bernhard/Schrogl, Kai-Uwe* (ed.): *Cologne Commentary on Space Law/Outer Space Treaty*, Carl Heymanns Verlag, 2009¹, 169-182.

Mayence, Jean-Francois: The European Union`s Initiative for a Code of Conduct on Space Activities: A Model of Soft Law for Outer Space in: *Marboe, Irmgard* (ed.): *Soft Law in Outer Space/The Function of Non-binding Norms in International Space Law*, Studien zu Politik und Verwaltung Vol. 102, Böhlau Verlag Wien – Köln – Graz, 2012, 343-360.

Montpert, Philippe: Space Insurance in: *Smith, Lesley Jane/Baumann, Ingo* (eds.): *Contracting for Space/Contract Practice in the European Space Sector*, Ashgate, 2011, 283-289.

Moore, Gilbert, R.: The first Small Satellites: Sputnik, Explorer, and Vanguard in: *Helvajian, Henry/ Janson, Siegfried* (eds.): *Small Satellites: Past, Present and Future*, The Aerospace Press El Segundo, California, American Institute of Aeronautics and Astronautics, Virginia, 2008, 1-46.

Neuhold, Hanspeter/Hummer, Wademar/Schreuer, Christoph (eds.): Österreichisches Handbuch des Völkerrechts, Band 1, Textteil, Manzsche Verlags- und Universitätsbuchhandlung, 2004⁴, 133-134.

Neuhold, Hanspeter/Hummer, Wademar/Schreuer, Christoph (eds.): Österreichisches Handbuch des Völkerrechts, Band 2, Materialienteil, Manzsche Verlags- und Universitätsbuchhandlung, 2004⁴.

Ravillon, Laurence: Typology of Contracts in the Space Sector in: *Smith, Lesley Jane/Baumann, Ingo* (eds.): Contracting for Space/Contract Practice in the European Space Sector, Ashgate, 2011, 161-168.

Radcliffe, T./Summerer, Leopold: Master of Space Studies 2001/Views and Visions in: *Rycroft, Michael/Crosby, Norma* (ed.): Smaller Satellites: Bigger Business? Concepts, Applications and Markets for Micro/Nanosatellites in a New Information World, Space Studies Vol. 6, International Space University, Kluwer Academic Publishers, Dordrecht/Boston/London, 2002, 127-132.

Sandau, Rainer: Small Satellite Missions in: *Contant, Jean-Michel* (ed.): Celebrating 50 years of Excellence/ Space for Humanity, International Academy of Astronautics, Paris, 2010, 84-85.

Sandau, Rainer (ed.): International study on Cost-Effective Earth Observation Missions, IAA Commission IV Study Group: System Operation & Utilisation, International Academy of Astronautics, October 2005, A.A. Balkema Publishers Talyor & Francis Group, London *et al.*, 2006.

Schmidt-Tedd, Bernhard/Mick, Stephan: Article VII in: *Hobe, Stephan/Schmidt-Tedd, Bernhard/Schrogl, Kai-Uwe* (ed.): Cologne Commentary on Space Law/Outer Space Treaty, Carl Heymanns Verlag, 2009¹, 146-168.

Schmidt Yvonne: International space law and developing countries in: *Brünner, Christian/Soucek, Alexander* (eds.): Outer Space in Society, Politics and Law, Studies in Space Policy Vol. 8, edited by the European Space Policy Institute, SpringerWienNewYork, 2011, 690-725.

Schrogl, Kai-Uwe: Space and its sustainable uses in: *Brünner, Christian/Soucek, Alexander* (eds.): *Outer Space in Society, Politics and Law, Studies in Space Policy Vol. 8*, edited by the European Space Policy Institute, SpringerWienNewYork, 2011, 604-615.

Smith, Lesley Jane: The Principles of International Space Law and their Relevance to Space Industry Contracts in: *Smith, Lesley Jane/Baumann, Ingo* (eds.): *Contracting for Space/Contract Practice in the European Space Sector*, Ashgate, 2011, 45-58.

Smith, Lesley Jane/Doldirina, Catherine: Intellectual Property Issues in the Use and Distribution of Remote Sensing Data in: *Smith, Lesley Jane/Baumann, Ingo* (eds.): *Contracting for Space/Contract Practice in the European Space Sector*, Ashgate, 2011, 337-348.

Soucek, Alexander: International Law in: *Brünner, Christian/Soucek, Alexander* (eds.): *Outer Space in Society, Politics and Law, Studies in Space Policy Vol. 8*, edited by the European Space Policy Institute, SpringerWienNewYork, 2011, 294-405.

Soucek, Alexander: Reasons for space activities: some thoughts in: *Brünner, Christian/Soucek, Alexander* (eds.): *Outer Space in Society, Politics and Law, Studies in Space Policy Vol. 8*, edited by the European Space Policy Institute, SpringerWienNewYork, 2011, 15-19.

Soucek, Alexander: Space science data policies in: *Brünner, Christian/Soucek, Alexander* (eds.): *Outer Space in Society, Politics and Law, Studies in Space Policy Vol. 8*, edited by the European Space Policy Institute, SpringerWienNewYork, 2011, 665-673.

Soucek, Alexander: Space and sustainability: improving life on Earth in: *Brünner, Christian/Soucek, Alexander* (eds.): *Outer Space in Society, Politics and Law, Studies in Space Policy Vol. 8*, edited by the European Space Policy Institute, SpringerWienNewYork, 2011, 569-600.

Sweeting, Martin N.: Keynote Address Micro/Nanosatellites – The new World in: *Rycroft, Micheal/Crosby, Norma* (Eds.): *Smaller Satellites: Bigger Business? Concepts, Applications and Markets for Micro/Nanosatellites in a New Information World, Space Studies Vol.6*, International Space University, Dordrecht/Boston/London, Kluwer Academic Publishers 2002, 1-19.

Venet, Christophe: The economic dimension in: *Brünner, Christian/Soucek, Alexander* (eds.): *Outer Space in Society, Politics and Law, Studies in Space Policy Vol. 8*, edited by the European Space Policy Institute, SpringerWienNewYork, 2011, 55-72.

Wiedemann, Carsten: Space Debris Mitigation in: *Marboe, Irmgard* (ed.): *Soft Law in Outer Space/The Function of Non-binding Norms in International Space Law, Studien zu Politik und Verwaltung Vol. 102*, Böhlau Verlag Wien – Köln – Graz, 2012, 315-324.

Tables

Table 1: Classification of satellites according to mass and typical cost: removed from: *Sweeting, Martin N.*: Keynote Address Micro/Nanosatellites – The new World in: *Rycroft, Michael/Crosby, Norma* (Eds.): *Smaller Satellites: Bigger Business? Concepts, Applications and Markets for Micro/Nanosatellites in a New Information World, Space Studies, International Space University, Dordrecht/Boston/London, Kluwer Academic Publishers 2002*, 1-19.

Table 2: removed from http://centaur.sstl.co.uk/SSHP/sshp_classify.html (25.03.2013).

Table 3: removed from Focus of the year: Small Spacecraft/Growing interest for smaller spacecraft worldwide in: ASD-Eurospace Space Trends Report on Global Space Activities, an overview 1986-2011, 1st Edition May 2012, <http://eurospace.org/space-trends.aspx> (25.03.2013).

Table 4: removed from Focus of the year: Small Spacecraft/Growing interest for smaller spacecraft worldwide in: ASD-Eurospace Space Trends Report on Global Space Activities, an overview 1986-2011, 1st Edition May 2012, <http://eurospace.org/space-trends.aspx> (25.03.2013).

International Treaties

Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space, 22 April 1968, 672 UNTS 119 (hereinafter cited as: ARRA).

Convention on International Interests in Mobile Equipment, Cape Town, 2001, A/AC.105/C.2/2002/CRP.3 (hereinafter cited as: Cape Town Convention).

Protocol to The Convention on International Interests on Mobile Equipment On Matters Specific To Space Assets, adopted on 9 March 2012 (hereinafter cited as: Berlin Protocol).

Convention on International Civil Aviation, adopted in Chicago on 7 December 1944 (hereinafter cited as: Chicago Convention).

Convention on the Protection and Promotion of the Diversity of Cultural Expressions 2005.

Convention on the International Regulations for Preventing Collisions at Sea, 20 October 1972 (hereinafter cited as: COLREGS).

Convention of the World Intellectual Property Organisations, <http://www.wipo.int/treaties/en/convention/> (25.03.2013).

Convention for the Establishment of a European Space Agency, entered into force on 30 October 1980, latest amended in 2009 (ESA C (2009)/73), consolidated version in force as of 1 January 2010.

Intergovernmental Agreement of the ISS, signed 29 January 1998 (hereinafter cited as: IGA), <ftp://ftp.hq.nasa.gov/pub/pao/reports/1998/IGA.html> (25.03.2013).

Statute of the International Court of Justice, San Francisco, 26.06.1945, <http://www.icj-cij.org/documents/?p1=4&p2=2&p3=0> (25.03.2013).

Constitution of the international Amateur Radio Union (hereinafter cited as: IARU).

Constitution and Convention of the International Telecommunication Union (ITU), 22 December 1992, entered into force 1993, 1825 UNTS 1 (hereinafter cited as: ITU Constitution and ITU Convention), <http://www.itu.int/net/about/legal.aspx> (25.03.2013).

Convention on International Liability for Damage Cause by Space Objects, 29 November 1971, 24 UST 2389, TIAS 7762, 961 UNTS 187 (hereinafter cited as: LIAB).

Agreement Governing the Activities of States on the Moon and other Celestial Bodies, 5 December 1979.

Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies of 19 December 1966, 610 UNTS 205 (hereinafter cited as: OST).

Convention on Registration of Objects launched into Outer Space of 12 November 1974, 1023 UNTS 15 (hereinafter cited as: REG).

The Antarctic Treaty 1959, <http://www.ats.aq/e/ats.htm> (25.03.2013).

Charter of the United Nations, 26 June 1945 (hereinafter cited as: UN Charter).

United Nations Convention on the Law of the Sea of 10 December 1982, 1833 UNTS 3 (hereinafter cited as: UNCLOS), http://www.un.org/Depts/los/convention_agreements/convention_overview_convention.htm (25.03.2013).

Other international documents

Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries, adopted by the GA in its resolution A/RES/51/122 of 13 December 1996, <http://www.un.org/documents/ga/res/51/a51r122.htm> (25.03.2013).

Inter-Agency Space debris Coordination Committee (IADC), Space Debris Mitigation Guidelines, 2002 (revised 2007), IADC-02-01, http://www.iadc-online.org/index.cgi?item=docs_pub (25.03.2013).

Principles Relating to remote Sensing of the Earth from Outer Space, 3 December 1986, A/RES/41/65 (hereinafter cited as: Remote Sensing Principles), <http://www.un.org/documents/ga/res/41/a41r065.htm> (25.03.2013).

Principles Relevant to the Use of Nuclear Power Sources in Outer Space, adopted by the GA in its resolution 47/68 of 14 December 1992, <http://www.unoosa.org/oosa/SpaceLaw/nps.html> (25.03.2013).

Radio Regulations (RR) adopted at the World Radio Conference (WRC) Geneva 1995, last amended WRC Geneva, 2012, <http://www.itu.int/pub/R-REG-RR> (25.03.2013).

Report on the third United Nations/Austria/European Space Agency Symposium on Small Satellite Programmes for Sustainable Development: “Implementing small satellite programmes: technical, managerial, regulatory and legal issues”, Graz, Austria, 13.-16. September 2011, UN/AC.105/1005, http://www.oosa.unvienna.org/pdf/reports/ac105/AC105_1005E.pdf (25.03.2013).

Report of the Committee on the Peaceful Uses of Outer Space, Fifty-third session (9-18 June 2010), A/65/20, http://www.oosa.unvienna.org/pdf/gadocs/A_65_20E.pdf (25.03.2013).

Resolution COM6/10 (WRC-12), Regulatory aspects for nano- and picosatellites, The World Radiocommunication Conference (Geneva, 2012), http://www.itu.int/en/ITU-R/space/AmateurDoc/RES-COM6_10.pdf (25.03.2013).

Resolution concerning the use of the geostationary orbit, adopted by the Legal Subcommittee at its thirty-ninth session (A/AC.105/738, annex III).

Recommendations on enhancing the practice of States and international intergovernmental organizations in registering space objects, RES 62/101 of 17 December 2007.

Resolution of the Council of the European Space Agency on the Agency's Legal Liability, ESA/C/XXII/Res.5, 13 December 1977.

Rio Declaration on Environment and Development, The United Nations Conference on Environment and Development, Rio de Janeiro from 3 to 14 June 1992, <http://www.unep.org/documents.multilingual/default.asp?documentid=78&articleid=1163> (25.03.2013).

Resolution 1721 A and B (XVI) of 20 December 1961, http://www.oosa.unvienna.org/oosa/SpaceLaw/gares/html/gares_16_1721.html (25.03.2013).

Safety Framework for Nuclear Power Source Application in Outer Space, endorsed by the Committee on the Peaceful Uses of Outer Space at its fifty-second session and contained in A/AC.105/934.

Technical Report on Space Debris of the Committee on the Peaceful Uses of Outer Space, A/AC.105/720, http://www.oosa.unvienna.org/pdf/reports/ac105/AC105_720E.pdf (25.03.2013).

The Space Debris Mitigation Guidelines of the United Nations Committee on the Peaceful Uses of Outer Space, Report. Official Records of the GA, 62nd session, 2007, Supplement No 20 (A/62/20), http://www.oosa.unvienna.org/pdf/gadocs/A_62_20E.pdf (25.03.2013).

Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), Small Satellite Missions Background paper 9, 1998, A/CONF.184/BP/9, <http://www.un.org/Docs/journal/asp/ws.asp?m=A/CONF.184/BP/9> (25.03.2013).

Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), The Space Millennium: Vienna Declaration on Space and Human

Development, 30 July 1999,
<http://www.oosa.unvienna.org/pdf/reports/unispace/viennadecle.pdf> (25.03.2013).

Declaration of Legal Principles of Governing the Activities on States in the Exploration and Use of Outer Space”, 13 December 1963, A/RES/181962.

Information Furnished in Conformity with General Assembly Resolution 1721 B (XVI) by States Launching Objects into Orbit or Beyond, UNGA Res 62/101 of 17 December 2007.

National Space Policy of the United States of America, June 28, 2010,
http://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf
(25.03.2013).

EU laws and documents

Council of the European Union Regulation setting up a Community regime for the control of exports, transfer, brokering and transit of dual-use items. Regulation (EC) 428/2009 of 5 May 2009, ABI L143/1

Draft for a Code of Conduct 2008, revised 2010, Council of the European Union, Brussels,
<http://www.consilium.europa.eu/uedocs/cmsUpload/st14455.en10.pdf> (25.03.2013).

Treaty on the Functioning of the European Union (Consolidated version 2012), 2012/C 326/01 (hereinafter cited as: TFEU).

Towards a Space Strategy for the European Union that benefits its Citizens, COM (2011) 152,
http://ec.europa.eu/enterprise/policies/space/files/policy/comm_pdf_com_2011_0152_f_communication_en.pdf (25.03.2013).

National Laws

The United States International Traffic in Arms Regulations, official version published April 1, 2012 (hereinafter cited as: ITAR),
http://pmddtc.state.gov/regulations_laws/itar_official.html (25.03.2013).

Austrian Federal Law on the Authorisation of Space Activities and the Establishment of a National Space Registry (Austrian Outer Space Act), adopted by the National Council on 6 December 2011, entered into force on 28 December 2011, unofficial translation (hereinafter cited as: AOSA), BGBl. I Nr. 132/2011,

<http://www.oosa.unvienna.org/pdf/spacelaw/national/austria/austrian-outer-space-actE.pdf>
(25.03.2013).

The French Act relating to space operations, Loi n° 2008-518 due 3 Juin 2008 relative aux operations spatiales, unofficial translation (hereinafter cited as: FSOA).

Gesetz zum Schutz vor Gefährdung der Sicherheit der Bundesrepublik Deutschland durch das Verbreiten von hochwertigen Erdfernerkundungsdaten „Satellitendatensicherheitsgesetz“, (German Satellite Data Security Act), 23 Nov 2007, BGBl. I S. 2590.

Verordnung des Bundesministers für Verkehr, Innovation und Technologie betreffend die Frequenzbereichszuweisung (Frequenzbereichszuweisungsverordnung 2005 – FBZV 2005), Frequency Range Allocation Ordinance, StF: BGBl. II Nr. 306/2005, BGBl. II Nr. 67/2001.

Verordnung des Bundesministers für Verkehr, Innovation und Technologie betreffend die Frequenznutzung (Frequenznutzungsverordnung 2005 – FNV 2005), Frequency Range Utilisation Ordinance, StF: BGBl. II Nr. 307/2005; BGBl. II Nr.68/2011.

Bundesgesetz, mit dem ein Telekommunikationsgesetz erlassen wird (Telekommunikationsgesetz 2003 – TKG 2003), Austrian Telecommunication Act, StF: BGBl. I Nr. 70/2003; BGBl. I Nr. 102/2011.

Bundesgesetz betreffend den Amateurfunkdienst (Amateurfunkgesetz 1998 – AFG), Austrian Amateur Radio Act, StF: BGBl. I Nr. 25/1999, BGBl. I Nr. 32/2002 (hereinafter cited as: AARA).

United States Commercial Space Act 1998,
<http://www.nasa.gov/offices/ogc/commercial/CommercialSpaceActof1998.html> (25.03.2013).

Australian Space Activities Act 1998 Act No. 123 of 1998 as amended of Act No.8 of 2010 (hereinafter cited as: ASAA).

Belgium Law on the Activities of Launching, Flight Operations or Guidance of Space Objects, http://www.belspo.be/belspo/space/doc/beLaw/Loi_en.pdf (25.03.2013).

Österreichisches Staatsgrundgesetz über die allgemeinen Rechte der Staatsbürger, RGBl 1867/142 idF BGBl 1988/684.

United Kingdom of Great Britain and Northern Ireland Outer Space Act 1986,
<http://www.legislation.gov.uk/ukpga/1986/38/introduction> (25.03.2013).

Rules Concerning Space Activities and the Establishment of a Registry of Space Objects
“Dutch Space Activities Act” (hereinafter cited as: DSAA),
http://www.oosa.unvienna.org/oosa/en/SpaceLaw/national/netherlands/space_activities_actE.html (25.03.2013).

Patentgesetz 1970 (Austrian Patent Law), StF: BGBl. Nr. 259/1970, BGBl. I Nr. 135/2009.

Swedish Act on Space Activities,
http://www.oosa.unvienna.org/oosa/en/SpaceLaw/national/sweden/act_on_space_activities_1982E.html (25.03.2013).

United States Export Administration Act of 1979.

United States Arms Export Control Act of 1976.

United States Congress Mutual Defense control Act of 1951.

United States Export Control Act of 1949.

Judicial Decisions

Trail Smelter Case (USA-Canada, arbitration court 11.3.1941) printed in: *Neuhold et al.*, 2004, 464.

Journals

Marboe, Irmgard: The New Austrian Outer Space Act in: *Zeitschrift für Luft- und Weltraumrecht/German Journal of Air and Space Law*, Carl Heymanns Verlag, 61. Jg. 1/2012, 25-61.

Focus of the year: Small Spacecraft/Growing interest for smaller spacecraft worldwide in: ASD-Eurospace Space Trends Report on Global Space Activities, an overview 1986-2011, 1st Edition May 2012, <http://eurospace.org/space-trends.aspx> (25.03.2013).

Presentations

Balogh, Werner: Small Satellite Projects Capacity Building & Legal and Regulatory Aspects: Symposium: Small is beautiful? Potentials and Risks of Small Satellite Projects, Juridicum Vienna, 27 Nov 2012.

Koudelka, Otto: The BRITE Nanosatellite Constellation: Symposium: Small is beautiful? Potentials and Risks of Small Satellite Projects, Juridicum Vienna, 27 Nov 2012.

Conference Proceedings

Hernandez, Mario: Satellites Helping to Protect World Heritage, 4S Symposium on Small Satellites Systems and Services, Portoroz, June 4-8 2012.

Trögeler, Mildred: Practice of States and international organizations in registering the transfer of ownership of space objects: Symposium: Transfer of ownership of space objects: issues of responsibility, liability and registration, organised by the IISL and ECSL, UNCOPUOS Legal Subcommittee, Vienna International Centre, March 19 2012.

Kleef/Oving: Affordable launch opportunities for small satellites, 4S Symposium on Small Satellites and Services, Portoroz, June 4-8 2012.

Lücking, Charlotte/Colombo, Camilla/McInnes, Colin: Solar Radiation Pressure Augmented Deorbiting from High Altitude Sun-Synchronous Orbits, 4 SS Symposium on Small Satellites and Services, Portoroz, June 4-8 2012.

Pergola, P./Ruggiero, A./Finocchietti, C./Andrenucci, M.: Overview and Comparison of Small Satellites Deorbiting Methods, 4S Symposium on Small Satellites Services and Systems, Portoroz, June 4-8 2012.

Smith, Lesley Jane/ Valic, Ziga: A Regulatory Roadmap for Small Satellites, 4S Symposium on Small Satellites and Services, Portoroz, June 4-8 2012.

Zhiheng/Fei: Long March for Small Satellite Launches, 4S Symposium on Small Satellites Systems and Services, Portoroz, June 4-8 2012.

Miscellaneous Sources

<http://www.cansat.eu/european-competition.html> (25.03.2013).

http://www.thaindian.com/newsportal/sci-tech/paypal-millionaires-rocket-launch-could-herald-a-new-epoch-for-space-exploration_100375974.html (25.03.2013).

<http://eurospace.org/> (25.03.2013).
<http://helsinki.at/programm/shows/mursat-space-art-project> (25.03.2013).
http://en.wikipedia.org/wiki/Digital_divide (25.03.2013).
<http://history.nasa.gov/sputnik/igy.html> (25.03.2013).
<http://www.genso.org/> (25.03.2013).
<http://en.wikipedia.org/wiki/Satellite> (25.03.2013).
http://www.esa.int/SPECIALS/ECSL/SEMT9MMKPZD_0.html (25.03.2013).
<http://centaur.sstl.co.uk/SSH/orbterm.htm> (25.03.2013).
http://www.ee.surrey.ac.uk/SSC/profiles?s_name=Martin_Sweeting (25.03.2013).
http://centaur.sstl.co.uk/SSH/ssh_classify.html (25.03.2013).
<http://www.spacex.com/dragon.php> (25.03.2013).
<http://www.sstl.co.uk/> (25.03.2013).
<http://www.tugraz.at/der-satellite> (25.03.2013).
<https://www.qb50.eu/> (25.03.2013).
<http://www.oosa.unvienna.org/oosa/en/SpaceLaw/national/state-index.html> (25.03.2013).
<http://www.esa.int/Education/CubeSats> (accessed 05.03.2013 (25.03.2013)).
http://www.dmcii.com/about_us_constellation.htm (25.03.2013).
<http://www.brite-constellation.at/> (25.03.2013).
<http://www.sea-launch.com/> (25.03.2013).
http://www.space-travel.com/reports/Russians_abort_satellite_launch_during_space_walk_999.html (accessed 25.03.2013).
http://pmddtc.state.gov/regulations_laws/itar_official.html (25.03.2013).
www.dictionary.com (25.03.2013).
<http://www.wassenaar.org/participants/index.html> (25.03.2013).
http://www.pmddtc.state.gov/embargoed_countries/index.html (25.03.2013).
<http://www.unep.org/documents.multilingual/default.asp?documentid=78&articleid=1163> (25.03.2013).
<http://centaur.sstl.co.uk/SSH/micro/micro60s.html> (25.03.2013).
<http://centaur.sstl.co.uk/SSH/index.html> (25.03.2013).
http://centaur.sstl.co.uk/SSH/list/list_gps.html (25.03.2013).
http://centaur.sstl.co.uk/SSH/ssh_technology.html (25.03.2013).

<http://www.oosa.unvienna.org/pdf/spacelaw/national/austria/austrian-outer-space-actE.pdf> (25.03.2013).

<http://www.ris.bka.gv.at> (25.03.2013).

http://www.parlament.gv.at/PAKT/VHG/XXIV/I/I_01466/index.shtml (25.03.2013).

http://en.wikipedia.org/wiki/Kosmos_954 (25.03.2013).

<http://www.oosa.unvienna.org/oosa/en/SORegister/index.html> (25.03.2013).

<http://www.oosa.unvienna.org/oosa/Reports/inf411.html> (25.03.2013).

<http://www.unoosa.org/pdf/pres/lsc2012/symp-02E.pdf> (25.03.2013).

<http://www.sstl.co.uk/divisions/earth-observation-science> (25.03.2013).

http://portal.unesco.org/en/ev.php-URL_ID=31038&URL_DO=DO_TOPIC&URL_SECTION=201.html (25.03.2013).

www.unoosa.at (25.03.2013).

http://www.esa.int/Our_Activities/Operations/Space_debris_environment (25.03.2013).

http://www.stratcom.mil/factsheets/USSTRATCOM_Space_Control_and_Space_Surveillance/ (25.03.2013).

http://www.esa.int/Our_Activities/Operations/Space_Situational_Awareness2 (25.03.2013).

http://www.esa.int/Our_Activities/Operations/Space_debris_-_Frequently_asked_questions (25.03.2013).

<http://orbitaldebris.jsc.nasa.gov/photogallery/beehives.html> (25.03.2013).

http://www.esa.int/Our_Activities/Operations/Space_debris_modelling (25.03.2013).

<http://www.iaru.org/> (25.03.2013).

<http://www.itu.int> (25.03. 2013).

http://www.msnbc.msn.com/id/5287945/ns/technology_and_science-space/t/where-does-outer-space-begin/ (25.03.2013).

<http://www.geneva.mid.ru/disarm/d-01.html> (25.03. 2013).

<http://www.virgingalactic.com/overview/space-tickets/> (25.03.2013).

<http://www.isunet.edu/news-and-events/1095-isu-masters-students-launch-a-fundraising-campaign-to-offer-affordable-and-open-access-to-a-satellite-in-space> (25.03.2013).

http://interorbital.com/TubeSat_1.htm (25.03.2013).

http://www.clyde-space.com/cubesat_shop?gclid=CI-Q94LwgrQCFUm-zAod-1kAeA (25.03.2013).

<http://sat.mur.at/> (25.03.2013)

<http://www.un.org/millenniumgoals/>

http://www.spacelaw.at/index.php?option=com_content&view=category&layout=blog&id=40&Itemid=73 (25.03.2013).

<http://www.berlin-space-tech.com/index.php?id=7> (25.03.2013).

<http://www.sstl.co.uk/divisions/earth-observation-science> (25.03.2013).

<http://en.wikipedia.org/wiki/Spin-off> (25.03.2013).

<http://spinoff.nasa.gov/> (25.03.2013).

http://www.esa.int/Education/European_Student_Earth_Orbiter (25.03.2013).