A DELICATE BALANCE: REGULATING MICRO SATELLITE TECHNOLOGY IN A BIG SATELLITE WORLD

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ABSTRACT

The development of space-related technology since the dawn of the space age in 1957 has given rise to many new and exciting possibilities. It has also meant that space activities continue to evolve, facilitating the participation of a variety of space 'actors' other than States. One of the potentially most significant developments in this regard has been the increasing use of small satellites. These are in general cheaper and less complex to develop, build and launch than conventional satellites, and have thus enabled groups such as university students and non-profit organisations to become involved in space. More significantly, the possibilities now exist for 'traditional' users of outer space to also utilise this technology for existing as well as new commercial and other purposes. This may represent a pivotal moment towards the development of a new space paradigm. Yet, despite the tremendous potential offered by small satellites, it is important to recognise that, like other space objects, they are subject to the regulatory requirements specified in the international space treaties, as well as other instruments and national legislation. This article discusses a number of the more significant regulatory requirements and analyses how they might apply to space activities involving small satellites now and into the future.

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I THE CHANGING NATURE OF SPACE TECHNOLOGY

October 1957 witnessed the launch of the first human-made space object to orbit the Earth, Sputnik 1. Since that time, there has been a breathtaking and seemingly endless development of space-related technology. Humankind is now engaged in a multitude of space activities far beyond the contemplation of those involved at that time. The utilisation of space technology now forms a crucial part of everyday society in all parts of the globe – irrespective of the (geo)political, economic and cultural characteristics of any one country. Simply put, our reliance on space technology is such that the world would cease to function in many respects without constant and unimpeded access, and this imperative is likely to become even more pronounced for future generations. This has primarily been driven by the increasing 'commercialisation' of outer space.

Yet, as is well known, there remains a vast gulf between the space capabilities of the relatively small number of space 'powers' compared with the rest of the world. It has been estimated that approximately up to 60 States now have some form of direct space capability,[1] although the extent to which they are able to utilise space for their own development (and other) purposes varies quite significantly. Of course, this also means that perhaps up to 140 States thus far do not realistically have *any* independent capability to directly access space themselves. This is despite their reliance on space-related technology for many aspects of their functioning and development. These countries are instead totally dependent on others for their space access, which therefore impacts upon their space 'security' and impedes opportunities for creativity, innovation and progress among their citizens. The reality is that their access to satellite data and the ability to utilise vital space technology in a crisis would be largely dependent on, and subject to, the strength and enforceability of their existing contractual relationships and political ties.

It is in this context that the recent development and adaptation of so-called 'small' satellite technology potentially represents a paradigm shift in the way humankind accesses space. These satellites are usually cheaper and less complex to develop, build and launch than conventional satellites. They therefore open the possibilities for a significantly greater degree of space access to a much larger range of space 'actors'. Already, groups such as university students and non-

[1] See, for example, Ram S Jakhu, 'Global Space Governance System: Evolution and Sustainability' (2015) *Annals of Air and Space Law* (forthcoming) 3.

profit organisations in both developed and developing countries have increasingly been able to become involved in space through these means.[2] The development of this technology may represent an important precursor to the establishment of indigenous and independent space programs in States that previously could not have considered such activities. In effect, by eliminating some significant barriers to entry, small satellite technology may facilitate capacity building, broader collaborative opportunities and education/training programs, as well as bridging (some) technology gaps, for hitherto 'non-space faring' States. It will also open up even more diverse commercial opportunities for a much broader range of potential service providers and, generally, 'bring space to more people.'

Significantly, as the technology develops even further, it may also open the door to traditional users of outer space – both States and private commercial entities - to utilise it for existing as well as new purposes, thus expanding the scope of their capability at a significantly lower relative cost. Of course, this may also require a mind-shift on the part of existing space actors as they grapple with whether, and how, to adapt to this relatively new technology and adjust their activities to react to the challenges posed by the potential for new market entrants.[3]

As a consequence, the increasing advent of this technology could potentially redefine the landscape of many activities in space. This new space paradigm will not see the end of more traditional satellite technology since, naturally, small satellite technology will not quench our insatiable demand for all that space can provide. However, it does open up a plethora of possibilities, many of which we are simply not in a position to comprehend or even imagine at this point. In this regard, one might liken the potential of small satellites to the way that mobile phones have revolutionised terrestrial communications activities. We simply do not know where this technology might ultimately lead and what it will allow us to do. However, we can confidently expect that it will open the door to an even more expansive array of commercial opportunities.

Thus, from a technological perspective at least, small satellite technology most likely represents a 'win-win' possibility that enhances the momentum for change and further promotes commercial space activities. Indeed, in many respects, this has been the singular

[2] See, for example, below n 11.

[3] See, for example, Adriana Martin, 'Is There a Kodak Moment or a Bubble? Analysis of the Threat of New Entrants to the Existing Firms in the Space Industry' (Research Paper for the SIRIUS Chair, University of Toulouse, September 2014) (copy with author).

motivation for both developers and users thus far. As with many aspects related to the exploration and use of outer space, the technology continues to move forward at a rapid pace without sufficient attention being paid to the regulatory consequences and requirements. It is therefore important not to be too caught up in this wave of optimism and innovation, without at least also considering how these developments coexist with the current regulatory framework, which has largely been designed with 'big' satellite technology in mind.

The purpose of this article is therefore to take pause and reflect on various regulatory requirements and challenges posed by the existing international legal regime in relation to the use of small satellite technology. While many of the users of this technology are no doubt cognisant of these requirements, it is probably fair to say that many are not; or, put another way, they do not consider the regulatory issues with the same degree of attention as they do the technical factors.

What this discussion will highlight is the fact that the existing legal framework was not designed with small satellite technology specifically in mind. Moreover, there are significant political, legal and logistical realities giving rise to difficulties in amending the existing international legal regime. As a result, at least in the short-medium term, further regulation will be required – particularly at the national level – and this will necessitate a balancing of sometimes competing interests between protecting the State now and into the future from potentially very significant liability on the one hand, and encouraging innovation and research and development on the other. Although the discussion below focuses on the current regulatory requirements, it leads to the conclusion that the design of future legal regimes to deal specifically with small satellite technology will necessitate some fundamental policy decisions by national lawmakers and regulatory bodies.

II THE CURRENT INTERNATIONAL LEGAL FRAMEWORK AND REGULATORY REQUIREMENTS

The international regulation of the exploration and use of outer space is primarily based upon a series of five United Nations Space Treaties[4]

[4] These are: (i) *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and other Celestial Bodies*, opened for signature 27 January 1967), 610 UNTS 205 (entered into force 10 October 1967) (*Outer Space Treaty*); (ii) *Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects*

and several General Assembly Principles.[5] The Treaties in particular set out a number of fundamental rules, imposing various obligations on States Parties, some of which are also regarded as representing customary international law.[6] More and more States have come to recognise the need to promulgate national space laws to transform these international obligations into their respective domestic legal spheres.[7] Given that the advent of small satellite technology presents opportunities for hitherto non-space faring States to engage in space activities, it may well be that the development of such technology in a particular country may pre-date any specific applicable national laws. Thus, the possibilities of greater access to this technology may be a driving force in the enactment of a further wave of national space law in various countries – for example, as was the case in Austria, which enacted its national space law in late 2011.

It should be noted that, in addition to these various instruments, there have recently been an increasing number of 'soft-law' guidelines concluded that also relate to the conduct of particular activities in outer space.[8] This has been for several reasons, partly related to the strategic

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Launched into Outer Space, opened for signature 22 April 1968, 672 UNTS 119 (entered into force 3 December 1968) (*Rescue Agreement*); (iii) *Convention on International Liability for Damage Caused by Space Objects*, opened for signature 29 March 1972, 961 UNTS 187 (entered into force 1 September 1972) (*Liability Convention*); (iv) *Convention on Registration of Objects Launched into Outer Space*, opened for signature 14 January 1975, 1023 UNTS 15 (entered into force 15 September 1976) (*Registration Agreement*); and (v) *Agreement Governing the Activities of States on the Moon and other Celestial Bodies*, opened for signature 18 December 1979, 1363 UNTS 3 (entered into force 15 September 1984) (*Moon Agreement*).

[5] See, in particular: (i) *Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space*, GA Res 1962(XVIII), UN GAOR, 1st comm, 18th sess, 1280th mtg, Agenda Item 28a, UN doc A/RES/18/1962 (13 December 1963); (ii) *Principles Governing the Use by States of Artificial Earth Satellites for International Direct Television Broadcasting*, GA Res 37/92, UN GAOR, 100th plenary mtg, UN Doc A/Res/37/92 (10 December 1982); (iii) *Principles Relating to Remote Sensing of the Earth from Outer Space*, GA Res 41/65, UN GAOR, 95th Plenary mtg, UN Doc A/Res/41/65 (3 December 1986); (iv) *Principles Relevant to the Use of Nuclear Power Sources in Outer Space*, GA Res 47/68, UN GAOR, UN Doc A/Res/ 47/68 (14 December 1992); and (v) *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*, GA Res 51/122, UN GAOR, 83rd Plenary mtg, UN Doc A/Res/51/122 (13 December 1996).

[6] See, generally, Stephan Hobe, Bernhard Schmidt-Tedd and Kai-Uwe Schrogl (eds), *Cologne Commentary on Space Law, Volume I – Outer Space Treaty* (Heymanns Verlag, 2009); Stephan Hobe, Bernhard Schmidt-Tedd and Kai-Uwe Schrogl (eds), *Cologne Commentary on Space Law, Volume II – Rescue Agreement, Liability Convention, Registration Convention, Moon Agreement* (Heymanns Verlag, 2013).

[7] See United Nations Office for Outer Space Affairs, *National Space Law Collection* <http://www.unoosa.org/oosa/en/ourwork/spacelaw/nationalspacelaw/index.html.

[8] For a discussion of the increasing trend towards the conclusion of non-binding instruments in the realm of outer space, and an overview of the most significant of these instruments, see Irmgard Marboe (ed), *Soft Law in Outer Space: The Function of Non-*

and political nature of space, which has made the finalisation of internationally binding treaties more difficult to achieve.

This article will refer primarily to existing 'hard-law' regulatory requirements that flow from the Space Treaties – although reference will be made to one important set of voluntary guidelines – from the perspective of how they may relate to the use of small satellites, and seek to raise some pertinent questions that arise from their applicability. It is not intended in this article to be exhaustive in this regard, or comprehensive as to all the precise details, but rather to raise the more significant issues and the challenges they pose. This will also serve to highlight the importance of properly addressing this issue by way of specifically directed regulation, given that the use of small satellite technology will most likely continue to grow exponentially into the future.

A *International Responsibility – Authorisation and Supervision*

The regime for space activities is structured on the basis that States bear international responsibility for 'national activities in outer space', including when such activities are carried on by non-governmental entities.[9] Whilst there is no precise definition in the *Outer Space Treaty* as to what constitutes a 'national' activity, the terms of the domestic space law of a particular State will clarify the scope of activities to which it refers – in essence, representing an interpretation by the drafters of that legislation of what they regard to be 'national activities in outer space', at least for the purposes of the specific domestic law.

A review of existing national space law indicates that, in most cases, States have legislated for the regulation of space activities based on the 'territoriality' of the activity (ie where an activity, for example a launch, involves the territory of that State), in accordance with general international law principles of jurisdiction. In addition, many States that have national space law also regulate space activities based on the nationality of the space actor (ie the person/entity engaged in the space activity). For example, the *Space Activities Act 1998* (Cth) provides that certain space activities carried out in Australia, or by an Australian national outside Australia, are subject to regulation under the legislation and require an appropriate approval under the licensing

binding Norms in International Space Law (Böhlau, 2012); Steven Freeland, 'For Better or For Worse? The Use of 'Soft Law' within the International Legal Regulation of Outer Space' (2011) 36 *Annals of Air and Space Law* 409.

[9] *Outer Space Treaty*, art 6.

system it establishes.[10] Thus, a launch of a small satellite in Australia by an Australian University will engage the international responsibility of that State under the *Outer Space Treaty*. Likewise, so will the involvement of that University in a small satellite program – for example, the QB50 program[11] – where the satellites are to be launched from another State. In these circumstances, therefore, (international) responsibility under the *Outer Space Treaty* extends to extra-territorial activities.

Article 6 of the *Outer Space Treaty* goes on to require that the 'appropriate State' – which is generally regarded to mean the State whose national activity it is – undertake the 'authorisation and continuing supervision' of such activities. Typically, the authorisation of space activities is implemented by way of a licensing regime established under national law (at least for those States with specific domestic space legislation).[12] This can be through the creation of a comprehensive 'one size fits all' licence regime or, more likely, via the establishment of different forms of licence, depending upon the particular space activity for which authorisation is being sought. For example, the *Space Activities Act 1998* (Cth) creates a number of different licences to deal with specific space (launch-related) activities, including a 'Launch Permit' for launches from Australian territory,[13] and an 'Overseas Launch Certificate' for launches of a space object by an Australian national from launch facilities outside of Australia.[14]

In relation to the use of small satellites, there is little conjecture that their launch and use does, indeed, constitute a space activity. Moreover, the satellite itself would in most circumstances be a space object for the purposes of international space law – including for the purposes of the *Liability Convention* (see below), as well as the domestic law of most countries. Activities involving small satellites therefore would typically fall within the scope of article 6 of the *Outer Space Treaty*. This in itself is not surprising – what is, however, is that this is

[10] See *Space Activities Act 1998* (Cth), pt 3.

[11] The QB50 mission involves the launching in 2015 of a network of 50 'CubeSats' built by Universities all over the world as a primary payload, with the aim of performing various scientific experiments in the lower thermosphere at an altitude of approximately 320 kilometres: See *QB50 an FP7 Project*, 'Mission Objectives' <https://www.qb50.eu/index.php/project-description-obj>.
Australian universities are involved in this project: Australian Centre for Space Engineering Research, UNSW, Australia, *QB50 – an International Network of 50 CubeSats* <http://www.acser.unsw.edu.au/QB50/index.html>.

[12] See Steven Freeland, 'Matching Detail with Practice: The Essential Elements of National Space Legislation' (2010) *Proceedings of the International Institute of Space Law* 540.

[13] *Space Activities Act 1998* (Cth), sections 11 and 26(1).

[14] Ibid section 12(a).

not necessarily understood by the users of small satellites, particularly with respect to experimental projects. The reality is that those seeking to engage in small satellite activities, irrespective of where those satellites might be launched, should take careful note of the relevant national laws and apply for the requisite licence (where applicable). As noted below, this might also have added consequences in terms of financial and liability concerns, as well as other aspects of conditionality.

Moreover, the requirement of continuing supervision on the part of the State may be quite complex. There is, for example, some uncertainty as to how, in practice, the need for continuing supervision might be undertaken in circumstances where the relevant space activity is a cooperative venture between institutions in a number of States. Internal arrangements between the cooperating States should be put into place to allow for each State to, in some way, exercise a degree of supervision, at least in relation to those aspects of the activity (and over its nationals who may be involved in its ongoing operation) in which it has a specific interest. Yet, even this pre-supposes that the institutions or persons engaged in the small satellite activity have informed the relevant Government agency of their involvement, and have provided specific details as to the scope of the program, design, issues of control etc.

Adding to the complexity is the fact that most small satellites are not designed with control systems, and therefore cannot be manoeuvered once they are launched and operative. As soon as they are placed in orbit, their position cannot be altered from Earth. This may also explain why this requirement may often have been disregarded, leaving the responsible State in a difficult position in terms of its obligations under the *Outer Space Treaty*.

B *International Liability – National Indemnity Requirements*

The general international liability provisions found in the *Outer Space Treaty*[15] and the more detailed regime specified in the *Liability Convention*[16] impose liability on a 'launching State' for certain damage

[15] Article 7 of the *Outer Space Treaty* prescribes the general terms giving rise to international liability for damage caused by an object launched into outer space. The scope of international liability is then elaborated in the *Liability Convention*. However, even if it is not a State Party to the *Liability Convention*, a State would still be subject to the liability provisions in the *Outer Space Treaty*, as well as any other potential claims based on the general public international law principles of State responsibility.

[16] The identity of the relevant launching State(s) is determined at the time of launch, with article 1(c) of the *Liability Convention* defining a launching State as:

caused by a space object. There are no time limitations or caps on the amount of this liability under the *Liability Convention*, as long as it represents 'damage'[17] by a 'space object' as those terms are defined for the purposes of that Treaty.[18] In the absence of specific indemnities in relation to claims by third parties, or where the various exceptions and exonerations contained in the *Liability Convention* do not apply, a launching State will bear this international obligation of liability[19] even in circumstances where the space activity is undertaken by a non-Government entity and perhaps also even where the State may not be aware of the activity at all.[20]

This represents one compelling incentive for States to pass domestic space law. The enactment of national space law enables States to formalise domestic legal processes that would allow them to pass on financial responsibility to, and recover from their national non-governmental entities the full amount (or part thereof) of the damages for which the State may be liable at the international level. Of course, this does not remove the international obligation of liability of a launching State under the *Liability Convention* – this contingent liability remains in place in relation to any space object for which a particular State is deemed to be a launching State. However, it does enable the State to put in place a domestic mechanism by which it can transfer the financial risk associated with this potential international liability for third party claims. Indeed, this is precisely what a number of States have done in their national laws in relation to traditional satellite technology. For example, in Australia, one of the objectives of the *Space Activities Act 1998* (Cth) is: 'to provide for the payment of adequate

'(i) A State which launches or procures the launching of a space object;
(ii) A State from whose territory or facility a space object is launched'.

[17] Article 1(a) of the *Liability Convention* defines 'damage' 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'.

[18] As noted, it would be difficult to argue that an operating small satellite was *not* a space object for the purposes of the *Liability Convention*, even if it is not manoeuvrable whilst in operation.

[19] For a detailed analysis of the *Liability Convention*, see Steven Freeland, 'There's a Satellite in my Backyard! – Mir and the Convention on International Liability For Damage Caused by Space Objects', (2001) 24(2) *University of New South Wales Law Journal* 462.

[20] On this point, there may be an argument that, where the only possible relevant mode by which a State could be a launching State in a specific case is by 'procuring' the launch, there is a minimum threshold test to demonstrate such procuring, at least based on knowledge of the particular activity. However, it is unclear whether such an argument reflects the correct legal position.

compensation for damage caused to persons or property as a result of space activities regulated by [the legislation]'.[21]

As a consequence, national space legislation often attaches conditionality to the issue of a licence to engage in a specific space activity, the practical effect of which is to require the applicant to provide or somehow procure an indemnity to the Government for damage, although the amount may be subject to specific caps under particular national law. Although it would be relatively straightforward to simply require the applicant in these circumstances to take out appropriate commercial insurance against third party claims to the extent of the specified (maximum) damage, this would often be impractical (given the relative lack of depth of the international space insurance market) and, more specifically in the case of many small satellite operators, disproportionally costly.[22] Indeed, such a requirement might make the planned small satellite activity unaffordable, thus preventing it from going ahead at all.

This gives rise to difficult considerations that would require a balancing between the protection of the State from potential financial liability and the desirability of encouraging expertise, research and development, perhaps as a precursor to more profitable and commercial opportunities down the track. Such potentially conflicting interests between a need for regulation on the one hand and the provision of incentives for new innovation on the other are not unique to the situation of small satellite operators – similar arguments have been raised in relation to the requirement for the 'equitable sharing of benefits' derived from the exploitation of natural resources under the *Moon Agreement*. However, unlike the *Moon Agreement*, virtually every space-faring State is a party to both the *Outer Space Treaty* and the *Liability Convention* – and, in any event, the liability regime they establish arguably also reflects customary international law. It is therefore incumbent on all States with an (potential) involvement in space to somehow address this issue.

The ideal scenario would be for the small satellite operator to negotiate with the relevant launch service provider for the provision of insurance cover and/or an indemnity by that provider (and perhaps also the Government standing behind that provider) to the launching State and the payload owner (for example, the University that has built the small

[21] *Space Activities Act 1998* (Cth), section 3(b).
[22] Section 47 of the *Space Activities Act 1998* (Cth) envisages that, in certain circumstances, rather than procure insurance, an applicant could instead demonstrate 'direct financial responsibility' as an alternative.

satellite(s)), at least in relation to certain elements of potential third party claims (again most likely subject to a cap). This is often the case in commercial launch service contract arrangements for large satellites. Some small satellite operators contend that the position is more complicated in the case of a collaborative small satellite program such as the QB50 project, involving Universities from several countries (and thus potentially a considerable number of launching States). However, the point remains that many such programs have proceeded without the issue even being raised with either the launch service provider or the intermediary arranging the launch.

Once again, this is something that should be negotiated coincidentally with the development of the technical aspects of such a program. A failure to do so potentially not only places the launching State in a difficult position, but might also expose the institution supporting the small satellite operators to a real and unacceptable risk of liability. Obviously, this should be of practical concern to those involved.

C *Registration – National and United Nations Registers*

The *Registration Convention* creates a two-pronged regime of registers that are relevant in respect of space objects that are launched inter alia 'into earth orbit'.[23] The State of Registry (as defined) is to maintain a national register in which such space objects are to be included and, in addition, shall provide certain specified information in relation to those objects to the United Nations, which itself maintains a central register.[24] In accordance with the terms of the *Outer Space Treaty*, the registration of a space object within a State's national register also has implications with regard to the 'jurisdiction and control' of that object.[25]

In situations where a State, has not, for example, previously been involved in launching activities, it may not have in place a national register, nor a mechanism for the furnishing of the required information to the United Nations. There may be a time lag associated with the establishment of the national register, which in most circumstances could only be implemented under national space legislation.[26] Once again, this will require consultation and information flows between the small satellite operator and the relevant Government agency (if indeed such an agency exists).

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[23] *Registration Convention*, art 2(1).
[24] Ibid art 4(1).
[25] *Outer Space Treaty*, art 8.
[26] See *Space Activities Act 1998* (Cth), pt 5.

In addition, with widespread cooperative small satellite programs that may potentially involve institutions from many countries, there will be need for careful coordination between the various launching States as to who should be the State of Registry – it can only be one of the launching States.[27] It may not, for example, make practical sense that each launching State would seek to be the State of Registry for its specific small satellites in the context of a joint program involving a large constellation of objects launched simultaneously from the one launch vehicle.

D *Sustainability of the Space Environment – Space Debris Mitigation*

One of the major challenges for the future exploration and use of outer space is the growing proliferation of space debris. Much has been written about the exponential growth of pollution in outer space and the hazards that it poses.[28] These discussions are indicative of the many views that exist as to how the problems should be addressed, given that the whole issue of the environment of outer space is a complex one, with many interconnecting variables at play. As noted above, these variables, and the enormous financial implications that would arise from setting in motion binding requirements, have meant that, to date, only soft-law guidelines, rather than hard law treaty regulation, have been agreed to address this issue. Nonetheless, these guidelines,[29] although voluntary and expressed in general terms, are significant in that they reflect the existing practices as developed by a number of States and international organisations and set (minimum) standards towards which space-faring nations should strive.

The principles underpinning the debris mitigation guidelines are that care should be taken to minimise the risk of debris creation in the conduct of space activities.[30] The importance of space for all aspects of

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[27] *Registration Convention*, art 1(c).

[28] See, for example, Ulrike M Bohlmann and Steven Freeland, 'The Regulation of Space Activities and the Space Environment' in Shawkat Alam, Md Jahid Hossain Bhuiyan, Tareq MR Chowdhury and Erika J Techera (eds), *Routledge Handbook of International Environmental Law* (Routledge, 2013) 375.

[29] See Inter-Agency Space Debris Coordination Committee, *Space Debris Mitigation Guidelines* (IADC Debris Mitigation Guidelines, 2007), which is found in *IADC Document Registration List* <http://www.iadc-online.org/index.cgi?item=docs_pub>; *International Cooperation in the Peaceful Uses of Outer Space*, GA Res 62/217, UN GAOR, UN Doc A/Res 62/403 (1 February 2008), which (in paragraph 26) endorsed the Space Debris Mitigation Guidelines agreed by the United Nations Committee on the Peaceful Uses of Outer Space (UN Guidelines)
<http://orbitaldebris.jsc.nasa.gov/library/Space%20Debris%20Mitigation%20Guidelines_COPUOS.pdf>.

[30] The UN Guidelines recognise two broad categories of space debris mitigation measures: those that curtail the generation of potentially harmful space debris in the near

our lives necessitates a diligent adherence to these standards to the greatest extent possible. It is generally recognised that it is in the interests of all space-faring States to follow these guidelines, and this is, as noted, increasingly reflected in their practices. The long-term sustainability of outer space activities is a matter of interest and importance for the international community as a whole, and is now one of the principal focal points for the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS).[31]

There are some potentially significant environmental challenges that arise from the use of small satellite technology. Growing demand and the expanding range of functions and, ultimately, commercial services they can provide points to rapid increases in the numbers of small satellites that will be placed into Earth orbit. In order to utilise this technology to achieve global coverage, very large constellations of small satellites will be required, and are being planned.[32] Whilst these satellites will primarily be placed into a low Earth orbit, projects such as these will populate important orbits with a significant number of space objects and increasingly pose a potential collision risk.

Even with respect to the current low-cost small satellite programs, the issue still remains. Many experimental satellite programs have been exactly that – experimental. They have often utilised existing off-the-shelf components, and the expectations of mission success for any significant period of time have not necessarily been high. It is fair to say that such circumstances give rise to lower perceptions of risk and a higher tolerance towards failure. For many such programs, at least in the relatively early phases of small satellite development, the process has largely been about the journey (to space) rather than delivery of services – though of course this is now changing. Many of these programs have relied on 'piggy-back' launches, which has meant that

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term – minimisation of the production of mission-related space debris and the avoidance of break-ups (Guidelines 1-5); and those that limit their generation over the longer term – end-of-life procedures that remove decommissioned spacecraft and launch vehicle orbital stages from regions populated by operational spacecraft (Guidelines 6-7).

[31] See, for example, United Nations Information Service, 'Long-term Sustainability of Outer Space Activities Among the Key Topics of Scientific and Technical Subcommittee at its 51st Session' (Press release, UNIS/OS/432, 7 February 2014) <http://www.unis.unvienna.org/unis/en/pressrels/2014/unisos432.html>.

[32] See, for example, Ellie Zolfagharifard and Sarah Griffiths, 'Elon Musk's New Mission Revealed: SpaceX Founder Confirms Plans for Tiny Satellites that will Provide Cheap Internet Worldwide' *Daily Mail* (Online), 12 November 2014 <http://www.dailymail.co.uk/sciencetech/article-2830263/Elon-Musk-s-new-mission-revealed-SpaceX-founder-confirms-plans-tiny-satellites-provide-cheap-internet-worldwide.html>. This article reports that SpaceX plans to launch 700 satellites (each weighing 113 kilograms), and Google 180 satellites, both in an effort to provide internet services for the 4.8 billion people of the world who are still without online access.

the satellites have been placed in orbits significantly higher than the very low orbits that would allow them to decay relatively quickly. For many small satellites, therefore, there is a potentially very long period (perhaps in excess of the 25 years cap suggested by the IADC Debris Mitigation Guidelines) before orbital decay, even though the satellite itself will have been functioning for only a short timeframe.

Moreover, as is well known, there are several variants of small satellite technology. Whilst it is too simplistic to categorise them solely on the basis of their size and weight, the so-called 'pico' (0.1-1 kilogram) and 'femto' (less than 100 gram) satellites may be too small to be picked up by conventional tracking systems. Yet, as is also well known, even such low mass objects can cause catastrophic damage in certain circumstances. The potential consequences, and therefore the potential risks, would, of course, be greatly magnified should the development of a large-scale commercial human spaceflight industry, despite recent setbacks, ultimately come to fruition.[33]

Of course, these issues are relevant to the question of potential liability raised above. They also point to the need to carefully consider how, and to what extent, the future implementation of small satellite programs can and will be undertaken, so as to be, as much as possible, consistent with the overarching goal of managing the long term sustainability of outer space activities in such a way as to maximise the (commercial) benefits that can be derived, whilst maintaining appropriate and acceptable safety standards, particularly for missions involving humans.

In some senses, therefore, the environmental consequences relating to small satellite programs have not really been properly factored into the regulatory framework. This is also a question of education and awareness, but is a highly important factor to take into account when designing the future legal regime to apply to such programs.

[33] See, for example, Andrea Peterson, 'Manned commercial space flight: The final unregulated frontier' *The Washington Post* (Online), 6 November 2014 <http://www.washingtonpost.com/blogs/the-switch/wp/2014/11/06/ manned-commercial-space-flight-the-final-unregulated-frontier/>. For a discussion of the relevant legal issues related to the proposals to establish a commercial human spaceflight industry, see Steven Freeland, 'Fly Me to the Moon: How Will International Law Cope with Commercial Space Tourism?' (2010) 11(1) *Melbourne Journal of International Law* 90.

E *Other Regulatory Considerations – Frequency Allocation and Traffic Management*

As noted, these brief comments do not purport to be comprehensive as to the relevant regulatory factors associated with this new commercial space paradigm featuring large-scale small satellite programs. However, the primary regulatory issues that ultimately stem from the principal requirements under the United Nations Space Treaties have been raised. There are, of course, other equally relevant considerations that also arise. For example, as more such programs emerge, particularly offering commercial services, the issue of radio frequency usage becomes all important. The existing use of the amateur band frequencies will no longer be applicable and appropriate. The regulatory framework of the International Telecommunications Union (ITU) will become even more relevant. Whilst the ITU operates effectively to manage the use of radio spectra, it is highly bureaucratic. Decisions about allocations of valuable (commercial) frequencies take significant periods of time, and are sometimes highly political. The coordination of frequencies so as to minimise harmful interference is complex. This lengthy process does not necessarily sit comfortably with the shorter timeframes associated with small satellite programs, and procedures will need to be established to accommodate this technology without compromising the important work of the ITU. This will not be an easy task.

In addition, the introduction of large numbers of small satellites will highlight even more the imperatives to consider the development of international traffic management systems involving space traffic, as well as its intersection with air traffic. Once again, while some initial steps are being taken to consider these issues,[34] there is much work to be done by all stakeholders.

III CONCLUDING REMARKS

These comments have served to highlight the fact that the current international legal framework continues to apply to new and developing technologies – such as small satellites – that will contribute to the further evolution of commercial space activities. Of course, the business case for those large programs that have been announced is yet to be proven and, whilst it is clear that small satellites will form a

[34] For example, from 18-20 March, 2015, the United Nations Office for Outer Space Affairs (UNOOSA) and the International Civil Aviation Organization (ICAO) jointly sponsored an 'AeroSPACE' symposium where some of these issues were discussed.

(significant) part of the future dimension of space, there may be some false starts along the way as to the most appropriate approach to be undertaken by those entities seeking to utilise the technology to develop very significant commercial businesses.

That said, the existing law and the technology, at least at the international level, do not represent a natural fit. The international regulatory framework was not designed specifically to deal with the advent of this technology, nor for the expansive range of new space actors. Moreover, these new actors in particular may not be completely aware of, or understand, the relevance and implications of the existing framework.

The United Nations is therefore conscious of the imperative to explore the potential dynamics of the small satellite industry, and promote the need to address both the challenges and the opportunities posed by small satellites. It has, for example, established the Basic Space Technology Initiative (BSTI),[35] which seeks to support capacity building in fundamental space technology, and also to promote the use of space technology and its applications for sustainable development. This has partially been guided by the growth of small satellites technology and the increasing access to them of universities and smaller institutions, in countries along the full spectrum of economic development. The BSTI represents a useful international cooperative attempt to better understand the dimensions of the issues that will arise. Despite these initiatives, however, it seems unlikely that binding international frameworks will be put in place anytime soon to effectively deal with this technology.

Yet, even putting these initiatives aside, it is clear that such shifts in space technology require the development of appropriate regulatory standards in a relatively short timeframe. Small satellite entrepreneurs are anxious that any real (or perceived) barriers to entry posed by national regulatory requirements are removed. Many of these entities believe that, if they are not able to develop and implement their plans in the short-term, then the opportunity will be lost, since someone else will do it instead, perhaps in a more 'user friendly' domestic regulatory environment.

Whether or not these fears are justified in every case, what seems increasingly likely is that, in some respects, small satellite technology will become a mainstream methodology for utilising space for

[35] See UNOOSA, *Basic Space Technology Initiative (BSTI)* <http://www.unoosa.org/oosa/en/ourwork/psa/bsti/index.html>.

commercial purposes. Attempting to regulate this 21st century technology solely by reference to 20th century regulation is therefore likely to create difficulties and uncertainties, and perhaps deter some who would otherwise consider engaging in the space industry.

In the meantime, however, there is no doubt that small satellite technology can offer great opportunities, but it also poses some significant challenges to the broader perspective of the exploration and use of outer space. The need for clear regulation to specifically address this technology is clear and it thus falls on national lawmakers to provide what is required within a more expedient timeframe. Pressure is already being exerted by industry associations and representatives in various States seeking clarification of the regulatory requirements in relation to this new technology.[36]

In the end, therefore, clear domestic policies must be formulated. National legislatures have to come to grips with the ever-changing range of space technology, particularly if they wish to become increasingly involved in space activities. Some Governments are already attempting through their legislation to deal specifically with the issues that arise through the advent of small satellite technology,[37] but there is a long way to go. Whatever rules are put in place must find the right balance between, on the one hand, the need for regulation of the financial and technical elements, so as to minimise the risks to an acceptable level, and the facilitation of research and innovation to allow for greater and more efficient access to space, and the potential for commercial returns, on the other.

Public policy questions arise as to whether, for example, to exempt (non-commercial?) small satellite operators from several of the existing national regulatory requirements that apply to their large satellite 'brethren'. Yet, to do so may have the ultimate effect of minimising the incentives or motivation of these operators to engage in best practices, or to take simple, inexpensive steps to ensure that their local stakeholders are covered by existing protections. Naturally, this may not necessarily be the case when it comes to commercial small-satellite enterprises; however, it is suggested that the industry as a whole

[36] See, for example, Space Industry Association of Australia, 'Discussion Paper on the Regulatory Requirements for Launches of Small Satellites for Scientific and Educational Purposes', February 2015 (copy with author).

[37] See, for example, Irmgard Marboe and Karin Traunmuller, 'Small Satellites and Small States: New Incentives for National Space Legislation' (2012) 38 *Journal of Space Law* 289, where the authors describe how the national laws of Austria, Belgium and The Netherlands have been structured to deal with the possibility of future small satellite programs involving those countries.

would not necessarily be unduly stifled by the requirement that, in all circumstances, they take proper and appropriate risk management steps. Any relaxation of the rules for the users of this technology will bring with it added risk for the regulators and the relevant State, even though in many cases these might be quite small.

These are difficult choices and States will take differing paths depending upon their specific circumstances. This will, unfortunately, mean that there is unlikely to be established a uniform international set of rules to address the complexities of small satellites, at least in the short-medium term. Perhaps we might see the emergence of a soft-law code of conduct at the international level, but this may not provide a sufficient base to determine the conduct of those new actors in the space paradigm.

This again points to the strong role that national law and lawmakers have to play, which will require close consultation between all stakeholders, and emphasises the need for regulators, the scientific community, the entrepreneurs and the lawyers to all talk to each other to a far greater degree than has thus far been the case.