

The Governance of Space Situational Awareness: Revolution not Evolution

Ralph “Dinz” Dinsley, Sqn Ldr (Retd)

Northern Space and Security/Reflecting Space

Professor Christopher Newman

Northumbria University/Reflecting Space

1. Introduction

The rapid expansion of industrial activity in space is presenting a considerable challenge to the traditional governance mechanisms of human space activity. With technology and engagement from a wide group of stakeholders, robust governance has fallen behind this rapid pace of development. This has seen the space environment become ever more congested, competitive and usage contested. Resolution through space situational awareness (SSA) services, which observe and predict object collision for instance, is crucial. Yet this vital part of the industry has been left to languish. Rectification has recently enjoyed greater attention, but the results are an unsatisfactory, piecemeal quality. So confusing is the result that it would be simpler and more effective to construct entirely new governance for SSA to make it fit-for-purpose to the newfound intensity of space activity. This article will review and evaluate existing frameworks and governance that have previously been employed, examining the potential impact of a new structure. It is concluded that the disregarded nature of the Outer Space Treaty 1967¹ (OST) possesses both the flexibility and core principles to provide open and active oversight as well as insight into the sector’s needs and growth.

2. The Struggles of SSA

Space, and especially the orbit around Earth, is enjoying a new era of participation regarding the increasing number of actors involved, from States to private investors for military and commercial purposes. The growing availability and ease of access has also expanded with rapidity. Parties including governments, academics alongside private entities are ‘launching more satellites than ever before as advances in technology lower the technical and cost barriers’². The addition of human-generated space objects alongside those naturally occurring in space further complicates orbit due to the significant issue caused by debris resulting from both intentional and non-intentional collisions. Former space activity’s remains, including flecks of paint orbit the Earth resulting in a ‘significant hazard to operational space craft’³. Control through the removal of defunct satellites and other debris, including the creation of guidelines⁴ to mitigate additional debris⁵ has been unable to accommodate this rate of expansion. Furthermore, it does nothing to serve the removal of retired objects and debris due to a professional atmosphere in space exploration that is so driven by accomplishment of mission objectives that the consequences to space’s finite environment are unconsidered. Therefore, the importance of SSA services to space activity cannot be understated. SSA is enabled through the monitoring of the space environment including space weather, space surveillance and tracking, and, understanding the operational and geopolitical nuances involved to predict the locations of space objects within orbit.

SSA services have primarily been the remit of the USA’s Department of Defence (DOD) which possesses the most extensive Space Surveillance Network capability worldwide. Yet even the extensive capacity of the USA cannot provide coverage of the whole Earth⁶. Current US governance and the subsequent reaction by commercial and foreign

¹ Treaty on Principles governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies 1967

² K. Tanaka, “Applicability of remote sensing policies to space situational awareness” (2017) 42 *Space Policy*, 83-91, 84

³ Brian Weeden, “Overview of the legal and policy challenges of orbital debris removal” (2011) 27 *Space Policy*, 38-43, 38

⁴ Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space as annexed to UN do. A/62/20, Report of the UNCOUOS (2007)

⁵ Jeff Foust, “International partnerships to address orbital debris in absence of broader accord.” Space News, 24 September 2017. Available at <http://spacenews.com/international-partnerships-to-address-orbital-debris-in-absence-of-broader-accord/> accessed on 21 August 2018

⁶ K. Tanaka, “Applicability of remote sensing policies to space situational awareness” (2017) 42 *Space Policy*, 83-91, 84

entities (CFE) is neither safe for continued space activity nor sustainable. Whilst the USA enjoys the greatest capability and use of SSA services in the protection of its national security, it gains a greater level of understanding of foreign space activities through the exchange of information in return for collision warnings. Use of incentive by trading information is inherently problematic for its focus on trade, straying from the peaceful purposes and unity that the OST 1967 sought to instil in space exploration⁷. The commercialisation of safety and awareness has been perpetuated by the commercial entities which sell and plan to sell data to governments and satellite operators⁸ who use the information to supplement and improve their own information. After the Iridium-Cosmos collision resulted in over 2,000 pieces of debris, longer than 10cm in a significantly congested area⁹, the USA freely provided collision warnings to anyone regardless of CFE framework membership¹⁰. However, this freedom is conditional and the current status quo of SSA services as a result is untenable for providing effective space traffic management.

3. Models of SSA services

As the majority industry stakeholder in SSA services, the USA's policy is of direct and vital importance to the course of SSA's future. Analysis of the USA's developing policy demonstrates that an industry led model of operation is susceptible to significant issues that outweighs the prospective benefits unless proportionate regulation is developed. In June 2018, President Trump signed Space Policy Directive-3, cementing SSA capability as a US priority, 'to maintain US leadership in space'¹¹. Despite the confirmed intention 'to support safe, stable and sustainable space activities'¹², the policy's execution fails to complete this. As both the primary supplier and consumer of SSA¹³, the US' reliance has grown into an unsubstantiated degree of concern for its own national security. This is evident from President Trump's announcement at the SPD-3 signing that American space dominance, required the establishment of 'a Space Force as the sixth branch of the armed forces'¹⁴.

In transferring SSA responsibility and space traffic management (STM) from the DOD to the Department of Commerce, the USA is, to some extent, removing the troublesome shadow cast by military involvement. Even though the US military no longer wishes to be the face of SSA services¹⁵, the USA's global hegemony is undisturbed in that SSA remain US-centric as illustrated by the replacement STM strategy intended to provide 'benchmark standards for the whole world'¹⁶. Yet Commerce will have to supplement information regarding its own country from elsewhere because it will not collect SSA, receiving a subset of information, presumably void of military information¹⁷ from the DoD. The accuracy of the public SSA database overall becomes suspect by the fact that Commerce will have no transparent access to over 6,000 objects less than the internal military database¹⁸. It is precisely this lack of transparency regarding its own activity which has bred such mistrust about the military's intimate SSA involvement, encouraging independent attempts at SSA services. Without informed reporting on its own space movements, the USA military's movements cannot be deemed stable and risks damage and debris to its own instruments as well as those of its neighbours for the sake of national security. Anti-satellite attacks are an understandable concern for the wider effects which they carry. Nevertheless, the potential risk must be balanced against the greater probability of damage

⁷ Treaty on Principles governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies 1967, Art. I

⁸ M. Borowitz, "Strategic Implications of the proliferation of space situational technology and information: lessons learned from the remote sensing sector" Space Policy 2018 <https://doi.org/10.1016/j.spacepol.2018.05.002>, accessed 20 August 2018, 1

⁹ Brian Weeden (2010) "2009 Iridium-Cosmos collision fact sheet, Secure World Foundation" https://swfound.org/media/6575/swf_iridium_cosmos_collision_fact_sheet_updated_2012.pdf, accessed 21 August 2018

¹⁰ T. Chow, Space Situational Awareness Sharing Program: an SWF Issue Brief, (Sep. 2011).

¹¹ Space Policy Directive-3, National Space Traffic Management Policy, 18th June 2018

¹² Ibid, Article 2 (a)

¹³ K. Tanaka, "Applicability of remote sensing policies to space situational awareness" (2017) 42 *Space Policy*, 83-91, 84

¹⁴ President Trump in J. Foust, "Managing Space Traffic Expectations", *The Space Review*, 25th June 2018

<http://www.thespacereview.com/article/3521/1>, accessed 20th August 2018.

¹⁵ Air Force General John Hyten in J. Foust, "Managing Space Traffic Expectations", *The Space Review*, 25th June 2018

<http://www.thespacereview.com/article/3521/1>, accessed 20th August 2018.

¹⁶ Commerce Secretary Wilbur Ross in J. Foust, "Space Commerce Traffic Management", *The Space Review*, 30th April 2018

<http://www.thespacereview.com/article/3521/1>, accessed 20th August 2018

¹⁷ J. Foust, "Managing Space Traffic Expectations", *The Space Review*, 25th June 2018 <http://www.thespacereview.com/article/3521/1>, accessed 20th August 2018

¹⁸ M. Borowitz, "Strategic Implications of the proliferation of space situational technology and information: lessons learned from the remote sensing sector" Space Policy 2018 <https://doi.org/10.1016/j.spacepol.2018.05.002>, accessed 20 August 2018, 2

that can be done to all space activity from one accident which could be avoided provided proper situational awareness information. Indeed, the persistent refusal to divulge any military information to preserve not only national security but also its global hegemony has left the USA with a prevailing paranoia. The style of governance the USA aims to follow is more concerning for its desire of a rapid solution¹⁹. Yet international deliberations are already ongoing in the form of the UN Committee on the Peaceful Uses of Outer Space (UNCOPUOS) Working Group on the long-term sustainability of space²⁰ with an expert group concerned with collaborative SSA²¹ and may provide a ready template for legislation. However, time is of the essence and the UN processes take an inordinately long time to discuss, agree and promote with little or no means to enforce.

Whilst UNCOUOS is to be lauded for its efforts and the suggested guidelines are still in the preparatory stage, the agreed proposal thus far is not promising for dealing with the current reality of STM and SSA. Following in the footsteps of its predecessor²², although focusing on international co-operation necessary to make SSA and STM fit-for-purpose, the Working Group's guidelines are purely voluntary and not legally binding²³. Additionally, even if the guidelines were to be obeyed, the language used involves a significant degree of flexibility in application, when 'practicable'²⁴ or 'appropriate'²⁵. Caution is natural given potential sensitive data²⁶, but without definition, individual parties may determine their own sensitivity rather than conforming to an established standard to promote STM development and shared SSA. The intention is to facilitate and develop national structures and international co-operation for space sustainability²⁷ beyond the present US-centric system.

Yet the UNCOUOS Guidelines have made no significant attempt to remove the military involvement from SSA, nor mitigate the mistrust and lack of information this causes. Little has been said about SSA beyond the need to develop more innovate technology to aid with SSA sensing capability²⁸ and the fact that some states were co-operating with the European Union and ESA tracking and surveillance framework²⁹. But the ESA's SSA Programme, established in 2009 is also purely optional, focusing on 'an autonomous European SST capability in close cooperation with national SST initiatives'³⁰ for the observation and prevention of debris including avoidance capability. It enjoys some degree of success, though this is most likely due to the desire of both spacefaring and non-spacefaring European countries desire to have knowledge and involvement with space activity. This flexibility³¹ effectively prohibits the universal desire for transparency, instead simply confirming US dominance in a fractured industry. The strength of military involvement and concern for the impact of open SSA upon the USA's national security, even as the largest stakeholder has been well illustrated as overzealous and unnecessary. As Borowitz highlights via comparison to previous concern over remote sensing, the risk to USA national security is in fact very low risk due to the exorbitant cost of attacking space assets possessed by a 'very small number of nations' as well as the repercussion of damage from debris³². With the above issues rife within the current and developing industrial structure due to national politics governing

¹⁹ Scott Pace, Executive Secretary of the US National Space Council in J. Foust, "Managing Space Traffic Expectations", *The Space Review*, 25th June 2018 <http://www.thespacereview.com/article/3521/1>, accessed 20th August 2018.

²⁰ For more information see 'Long-term sustainability of space activities', <http://www.unoosa.org/oosa/en/ourwork/topics/long-term-sustainability-of-outer-space-activities.html>, accessed 21st August 2018

²¹ Report of the Working Group on the long-term sustainability of outer space activity, Working Paper by the Chair of the Working Group, COPUOS, Vienna 20-29th June 2018, 27th June 2018 A/SC.105/2018/CRP.22 p.4

²² Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space as annexed to UN do. A/62/20, Report of the UNCOUOS (2007)

²³ Report of the Working Group on the long-term sustainability of outer space activity, Working Paper by the Chair of the Working Group, COPUOS, Vienna 20-29th June 2018, 27th June 2018 A/SC.105/2018/CRP.22 p.6

²⁴ Ibid p.5

²⁵ Ibid P.6

²⁶ Defining sensitive data in relation to space activities is further complicated by the 'over classification' of space tracking data associated with the historical military contribution to SSA.

²⁷ Ibid, C.1.

²⁸ (N.28) p. 22, para 135

²⁹ Ibid, p.20 para 119

³⁰ 'SSA Programme Overview', ESA website

<http://www.esa.int/Our_Activities/Operations/Space_Situational_Awareness/SSA_Programme_overview>, accessed 23rd August 2018

³¹ Ibid p.5-6

³² M. Borowitz, "Strategic Implications of the proliferation of space situational technology and information: lessons learned from the remote sensing sector" Space Policy 2018 <https://doi.org/10.1016/j.spacepol.2018.05.002>, accessed 20 August 2018 p.3

international relations, it is of little surprise that alternative models of operation have gathered momentum to the potential detriment of a successful international SSA policy if correctly incorporated³³.

4. Commercial Competition

The second largest SSA operation is commercial enterprise, and in recent years companies such as AGI³⁴, LEOLabs³⁵ and ExoAnalytic Solutions³⁶ have made considerable advances in this field, selling SSA information and creating support opportunities due to the natural competition within the industry. Commercial space has the innate advantage of being the only sector that can rapidly deploy capabilities needed for current and future space operations. This, in turn, has created a disparity between governmental and commercial data. For instance, the Commercial Space Operations Centre aims to compete with the US government over the number of objects detected³⁷ for profit. Overall, commercial activity has moved beyond both government capability and regulation, and the practical implementation of the OST 1967. The negative possibilities of this development is the risk to sensitive data due to its status as a commodity in influencing the international realm. Yet not even the USA, with the largest SSA commercial market, govern sensitive data sales³⁸. By insisting upon global hegemony, the US government perpetuates danger and debris in the name of national security, prompting other countries to supplement their knowledge via commercial means. The area's development via the US' draft Space Commerce Act³⁹ is worrisome. The Act intends to end regulatory uncertainty by essentially allowing free reign⁴⁰, ignoring due diligence. Yet it forbids 'new' private space activities without permission/ supervision⁴¹ keeping SSA and STM control firmly with the government and their contracted suppliers without the competence nor responsiveness of commerce. An extended repercussion of an international community schism into separate national SSA services such as USA, Russia, China and the ESA is the further destruction of credibility and disregard for accepting liability for collisions. Despite concerns of commercial impact on security, safeguards are already embedded within practise. Not only does the USA possess SSA state and commercial dominance but even if sensitive data was accessed by CFE, respective governments possess oversight capability to prevent exploitation of sensitive data⁴². Additionally, preventing further debris and the congestion of space due to satellite attack is a primary interest of commercial parties to continue investing in space exploration. Therefore, open SSA access, even to sensitive data, is necessary to develop a healthier environment in both space and international relations. By increasing transparency, the USA will both better international relations and remove commercial demand, further decreasing any threats rather than pursuing profit.

Another option for the improvement of SSA information sharing could be the formation of an autonomous civilian organisation to handle this service. Civilian space activity is growing and their contribution to the effective management could be invaluable. Indeed, civilian involvement has already proven successful with the creation of several organisations⁴³ devoted to specific causes via remote sensing and its imagery technology. The development of a civilian organisation for the regulation of SSA could allow for a wider international distribution network. This would remove the care of SSA from the military into civil governance, a move already under way by the transfer of USA

³³ For the on-going genesis of these discussion see Brown and Gleason et al, s109 'Orbital Traffic Management Study' available at <http://www.spacepolicyonline.com/pages/images/stories/Orbital%20Traffic%20Mgmt%20report%20from%20SAIC.pdf>

³⁴ Analytical Graphics Inc., <http://www.agi.com/home>

³⁵ "LeoLabs", <https://www.leolabs.space/>.

³⁶ ExoAnalytic Solutions, <https://exoanalytic.com>

³⁷ Paul Welsh, AGI Blog, 18 March 2014 <<http://blogs.agi.com/agi/2014/03/18/introducing-the-commercial-space-operations-center-comspoc/>>, accessed 24th August 2018

³⁸ M. Borowitz, "Strategic Implications of the proliferation of space situational technology and information: lessons learned from the remote sensing sector" Space Policy 2018 <https://doi.org/10.1016/j.spacepol.2018.05.002>, accessed 20 August 2018 p.4

³⁹ Bill, American Space Commerce Free Enterprise Act of 2017, HR 2809, available at: <https://science.house.gov/sites/republicans.science.house.gov/files/documents/2017%2006%2001%2023%20Free%20Enterprise%20Act%20HR%20Blank.pdf>, accessed 24th August 2018

⁴⁰ House Science Committee chairman Rep. Lamar Smith in J. Foust, "Space Commerce Traffic Management", *The Space Review*, 30th April 2018 <http://www.thespacereview.com/article/3521/1>, accessed 20th August 2018

⁴¹ H. Lui & F. Tronchetti, 'The American Space Commerce Free Enterprise Act of 2017: The last step in regulating the space resources utilisation industry or something else?', Space Policy 2018, P.3

⁴² M. Borowitz, "Strategic Implications of the proliferation of space situational technology and information: lessons learned from the remote sensing sector" Space Policy 2018 <https://doi.org/10.1016/j.spacepol.2018.05.002>, accessed 20 August 2018 p.4

⁴³ For more information see: M. Borowitz, "Strategic Implications of the proliferation of space situational technology and information: lessons learned from the remote sensing sector" Space Policy 2018 <https://doi.org/10.1016/j.spacepol.2018.05.002>, accessed 20 August 2018 p.5

capability from the DoD to the Department of Commerce (DoC). The USA is transferring responsibility from one state department to another, rather than allowing for greater international involvement. However, suggestion of supplying uncensored information to civilian hands is unrealistic. There is currently no guarantee of civilian expertise or organisation, nor will the military wish to endanger sensitive information gained through SSA in such a way. The difficulties of the alternative models of operation suggested highlights the obstacle to progress that sensitive data's vulnerability represents. Concern given the strength of organised crime and terrorism in the modern day, particularly the increasing number of attacks perpetrated by lone individuals rather than criminal groups, is understandable. Nevertheless, the current civilian access, whilst widespread is not sufficient or advanced enough to genuinely cause concern or any significant damage⁴⁴. Any expansion of access however, would be unwise due to the performance issues outlined above as well as the fact that any state with SSA services would be uneasy, preventing their support.

The predicted issues in adopting civilian or commercially led resolutions to the current problems proves that rather than evolving the situation, where issues are dealt with on an ad hoc basis, a revolutionary new programme would be more beneficial overall. Therefore, it is submitted here that an overarching international organisation be formed for SSA regulation. Beginning anew recognises the important role that SSA has within space exploration and its management while enabling resolution of the existing problematic framework grounded in legacy practises no longer suitable to support present and future needs. This is already being achieved somewhat through the work of the UNCOPUOS Working Group and its guidelines, albeit too slowly and also the voluntary, unbinding nature of this device once it is complete will do little, if anything, to resolve the issues. A new, independent organisation is therefore necessary to provide the much needed 'insight as well as oversight'⁴⁵. Establishing an overarching international body would enable the inclusion of experts like UNCOPUOS, but on a permanent basis as well as allowing for all affected CFE to have representatives onboard. The present is the prime opportunity since the transfer of SSA to the US DoC is not yet finalised⁴⁶. Difficulties persist in the US' approach and refusal of a separate international organisation due to their impatience with the regulatory process of any new treaty, instead pursuing a quicker route⁴⁷. The growing capacity of other CFE renders this decision problematic and isolationist. It is also highly unrealistic for the needs of the space environment.

Although it is a significant task to monitor and analyse the movement of all space objects, both natural and human-made in correspondence to each other, such regulation cannot be rushed. One way in which an overarching organisation could assist in properly developing effective policy is to instigate a principle of necessity. Some foundations already exist in the DoC planned reform to review space objects based on their capabilities⁴⁸. Stricter regulation will minimise strain on resources and streamline information, mitigating new debris creation in keeping with the existing UNCOPOUS guidelines⁴⁹. This could be said to infringe on free access to outer space⁵⁰, yet when that provision was created, space was the sole purview of State. The growth and direction of space exploration continues to be unexpected but for anyone to have access at all, the space environment must be properly regulated. It would also promote access to sensitive data, thus bettering international relations. Openness in sensitive data is vital to make SSA fit-for-purpose. Furthermore, a new overarching organisation would not necessitate a new treaty, which the USA refuses to wait for⁵¹, but rather could be built from the existing terms of the OST 1967.

⁴⁴ For more information see: Tom Wilson, Threats to the United States Space Capabilities, The Commission (2001)

⁴⁵ Commerce Secretary Wilbur Ross in J. Foust, "Space Commerce Traffic Management", *The Space Review*, 30th April 2018 <http://www.thespacereview.com/article/3521/1>, accessed 20th August 2018

⁴⁶ Scott Pace, Executive Secretary for the US National Space Council in J. Foust, "Managing Space Traffic Expectations", *The Space Review*, 25th June 2018 <http://www.thespacereview.com/article/3521/1>, accessed 20th August 2018

⁴⁷ Ibid

⁴⁸ J. Foust, "Space Commerce Traffic Management", *The Space Review*, 30th April 2018 <http://www.thespacereview.com/article/3521/1>, accessed 20th August 2018

⁴⁹ Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space as annexed to UN do. A/62/20, Report of the UNCOPUOS (2007)

⁵⁰ Outer Space Treaty 1967, Art. I

⁵¹ Scott Pace, Executive Secretary for the US National Space Council in J. Foust, "Managing Space Traffic Expectations", *The Space Review*, 25th June 2018 <http://www.thespacereview.com/article/3521/1>, accessed 20th August 2018

5. The endurance of the Outer Space Treaty

The OST 1967 has been subject of some criticism across the space sector for being archaic and not reflecting the modern space environment⁵². Yet in the case of SSA services, the OST could provide the underpinning legal authority for establishing effective governance. It is both flexible enough in endowing states with responsibility for on-going supervision⁵³ and well accepted in the space-faring community. The acceptance of the OST as the continuing primary authority for the governance of outer space means that the USA's Space Commerce Act 2017 will be compliant with international law by virtue of Article VI of the Treaty⁵⁴.

The challenges to the traditional legal framework for outer space activity is clear. The Commerce Act 2017 states that outer space is not a global commons⁵⁵. This does not necessarily clash with academic or established opinion on this area⁵⁶. Indeed, in the 2017 Act, the USA confirmed its commitment to the OST 1967⁵⁷ and this interpretation still operates under the umbrella of the OST 1967. As such, provided the interpretation of the OST 1967 in relation to SSA is explicitly worded and strict for application to prevent misuse there is no reason that the treaty should not endure to govern a new age of SSA. As Article VI outlines, all space sector parties must comply, including an international organisation and States participating in that organisation⁵⁸. The interplay between the OST 1967 and SSA services are clear. There is an obligation for considering 'on a basis of equality any requests by other State Parties...an opportunity to observe the flights of space objects' both for and beyond the purpose of collision warnings. This could also be readily amended to allow for observation of foreign space objects⁵⁹. Although the practical details such as operational rules of the road arising from SSA, the provisions of Space Traffic Management and the enforcement of such an alteration of SSA practises, a ready-made backbone exists in the form of the OST 1967.

6. Conclusion

In conclusion, it is apparent upon assessment that without a radical realignment of attitudes towards SSA, both in its governance and usage across the entire space sector, SSA will struggle in its designed purpose. Although multiple avenues are available and are being employed to combat the resident difficulties, success is elusive. It is for this reason that an entirely new structure has been proposed above to stabilise SSA services. A new system will ensure that the vital usage of SSA continues in a robust and effective manner that protects critical infrastructures and the people who rely upon them. Without such alterations, the increasingly fractious SSA's nature will only expand vulnerability until services grind to a halt entirely.

⁵² See, for example, J. Stuart, "The Outer Space Treaty has been remarkably successful – but is it fit for the modern age?", *The Conversation*, 27 January 2017 available online at <https://theconversation.com/the-outer-space-treaty-has-been-remarkably-successful-but-is-it-fit-for-the-modern-age-71381>

⁵³ States are made responsible for national space activities, whether undertaken by government or non-governmental actors according to Article VI of the OST.

⁵⁴ H. Lui & F. Tronchetti, 'The American Space Commerce Free Enterprise Act of 2017: The last step in regulating the space resources utilisation industry or something else?', *Space Policy* 2018, P.3

⁵⁵ American Space Commerce Free Enterprise Act of 2017, Chapter 803, Administrative provisions related to certification and permitting, § 80309. Global Commons.

⁵⁶ H. Hertzfeld, B. Weeden, C. Johnson, "How simple terms mislead us: The pitfalls of thinking about Outer Space as a Commons" IAC-15-E7.5.2 x 29369 available online at <https://swfound.org/media/205390/how-simple-terms-mislead-us-hertzfeld-johnson-weeden-iac-2015.pdf>

⁵⁷ Senate Committee on Commerce, Science and Transportation Hearings – Reopening the American Frontier: Exploring How the Outer Space Treaty Will Impact American Commerce and Settlement in Space, May 23, 2017. The transcripts of the hearing is available at: <https://www.commerce.senate.gov/public/index.cfm/hearings?ID=5A91CD95-CDA5-46F2-8E18-2D2DFCAE4355>, accessed 24th August 2018

⁵⁸ Article VI OST 1967

⁵⁹ *Ibid*, Article XV