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Global Space Governance: Key Proposed Actions

(Key Findings and Recommendations of the forthcoming Book on Global Space Governance: An International Study, Springer, 2017)

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Chapter 1: Introduction to the Global Space Governance: An International Study

At Second Manfred Lachs Conference held at the Institute of Air and Space Law at McGill University in May 2014, the Montreal Declaration (see Appendix) calling for an international and interdisciplinary study on Global Space Governance issues, concerns, and recommended actions for the future was unanimously endorsed. Since that time more than eighty scholars, governmental and regulatory officials, scientists and engineers, and space entrepreneurs have collaborated from all over the world to carry out this comprehensive and wide ranging study. The results of the study are being published as book entitled, *Global Space Governance: An International Study*, is being published by Springer Press in 2017. Appendix I of the Book contains the names of all the contributors to the study. This document "Global Space Governance: Key Proposed Actions," edited by Dr. Md Tanveer Ahmad, is an executive summary of the key findings and recommendations of the Book.

The hope is that electronic copies of this Study will be made widely available to the international space law and policy community, to governmental regulators, to space industry officials, and to representatives of States members and permanent observers to the Committee on the Peaceful Uses of Outer Space (UNCOPUOS). This is key to aid in preparations for the sixty-first session of UNCOPUOS, in June 2018, when the Committee will celebrate the fiftieth anniversary of the first UN Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE+50).

The UNCOPUOS, at its fifty-ninth session in 2016, agreed to the following thematic priorities: 1) Global partnership in space exploration and innovation; 2) Legal regime of outer space and global space governance: current and future perspectives; 3) Enhanced information exchange on space objects and events; 4) International framework for space weather services; 5) Strengthened space cooperation for global health; 6) International cooperation towards low-emission and resilient societies; and 7) Capacity-building for the twenty-first century (see UNCOPUOS report A/71/20, para. 296). Preparations are now being carried out under the respective thematic priorities in accordance with their defined objectives.

It is the wish of the editors, contributors, and reviewers that the findings and recommendations as summarized here in this Executive Summary can lead to new innovations and reforms in Global Space Governance in the years and even decades ahead. Many of the recommendations, if they were implemented, could also assist in the achievement of the UN Goals for Sustainable Development in 2030. These recommendations, if agreed and carried out, could aid in such areas as telecommunications , remote sensing and meteorological services, space navigation, space-based solar power, space navigation, environmental services, space traffic management, and more. These space-based activities can be critical to the long-term sustainability of our planet—both on the ground and in space.

This executive summary follows the structure of the book and includes the various summary tables that listed problems and issues considered followed by recommendations for possible reforms and innovations in Global Space Governance. These tables, which were separately copyrighted by the Institute, are only a modest recap of the much more thorough analysis that is provided in the book. It is hoped that the materials that follow will, nevertheless, highlight some of the most important

points covered in the full international study. It is also hoped that a high-level review team, scheduled to meet just before the Fifth Manfred Lachs Conference, would identify any key issue of global space governance and any possible reform effort that might have been overlooked in the study and add insights as to new actions that might be taken with regard to improved Global Space Governance. It is also hoped that this review team might also assist in drafting a 2017 Montreal Declaration that commends to the UNISPACE+50 anniversary celebrations realistic research and collaborative efforts, processes, and actual reform efforts that might be considered within the international community regarding Global Space Governance.

There are no grand proposals for a comprehensive new space treaty contained in the pages that followed, but there are many recommended ways forward in terms of new technical or safety standards, international codes of conduct, transparency and confidence building measures (TCBM), possible national or regional model laws, and collaborative efforts within governmental and nongovernmental bodies. The goal of the study and its recommendations has been to move international cooperation and enhanced space regulatory actions in the area of Global Space Governance forward.

This has been especially true for areas related to the UN Sustainable Development Goals (UNSDG) and especially in areas related to space education and health, space applications, space commerce and economics, space transportation, space security-related issues, the environment, and planetary defense related activities. We invite you to consider the brief summary presentation of the chapters contained in the book and ask us by noting issues or recommendations that might be refined, other actors or initiatives that might be included or where additional innovations in the area of Global Space Governance might produce positive results.

President John F. Kennedy famously said as he launched the Apollo Program to go to the Moon in 1961 “We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard.” Formulating and agreeing on successful Global Space Governance is an incredibly hard objective. However, it is also a worthwhile goal to strive to accomplish. Today, with more than 80 nations in the UNCOPUOS, a wide range of new commercial space ventures seeking to engage in totally new activities, such as on-orbit servicing, providing private flights into space by ordinary citizens, and space mining, and with rising international tensions around the world, agreement on new Global Space Governance arrangements and processes will not be easy. Nevertheless, the effort must be made.

This two-year long international effort has helped to clarify and more specifically identify problems. Its purpose has been to seek new solutions that are equitable and just for all concerned. It has accordingly involved scores of dedicated people from around the world. We hope that it can provide a useful input to the UNISPACE+50 anniversary activities and shine a light on a more hopeful and sustainable future in space. We also hope that, at the end of the Fifth Manfred Lachs Conference, this study effort might be endorsed and formally transmitted to the 2017 session of the UNCOPUOS.

Chapter 2:
Overview of the Existing Mechanisms of Global Space Governance

This chapter provides an overview of the existing mechanisms that are now available with regard to global space governance and provides some analysis as to current problems, issues, possible solutions, and future actions that could improve global space governance. This includes not only formal treaty organizations, but also nongovernmental organizations that assist with the development of standards, codes of conduct, and other useful means to coordinate activities in space.

Chart 1

Existing Major Space Governance Mechanisms				
Existing Governance Mechanisms	**Member Categories (Formal/ Informal)**	**Decision-making (Actor/ Participant)**	**Strengths**	**Limitations**
Five core UN space treaties	Formal	States	Created the core principles of access to and use of space, liability for damage due to space activities, registration obligations, and return and rescue obligations. Some of these principles are considered to be customary law, binding on all States and governing all space activities	Product of the Cold War. Geopolitical power is more complex today and there are more space actors, including non-State actors. Therefore, it is difficult to uphold these principles when they are challenged. Limited enforcement mechanisms. Moon Agreement has very low participation and very low impact
UN General Assembly	Formal (intergovernmental)	UN Member States	Universal participation. Resolutions represent the positions of Member States, as can be seen in vote counts	Resolutions are politically, not legally, binding
UN Office for Outer Space Affairs (UNOOSA)	Formal (intergovernmental)	UN Member States	Centralizes space activities within the UN, through cooperation with many specialized agencies. Discharges the responsibilities of the UN Secretary-General under the UN treaties and principles on outer space, including by maintaining the Register of Space Objects as well as other databases, which are made available to Member States as well as private entities. Conducts capacity-building activities and disseminates knowledge through training programs. Serves as Executive Secretariat for ICG and Permanent Secretariat to SMPAG	Limited funding, need for growing human resource complement
UN Committee on the Peaceful Uses of Outer Space (UNCOPUOS)	Formal (intergovernmental)	UN Member States being members of the Committee (currently 80 members)	Specific focus on peaceful uses of outer space means global public interest is central. Five core space law treaties were produced by UNCOPUOS. Current focus on long-term space sustainability and transparency and confidence-building measures as well as GNSS,	Consensus decision-making means everything is compromised, and UNCOPUOS has had limited ability to reach broad agreement on new space-related subjects nor produced

			space weather, exploration and innovation, planetary defence, and sustainable development	any new binding legal norms, although at the same time it has been successful in "soft law" development of principles, resolutions, and guidelines supplementing the set of space law treaties
Conference on Disarmament	Formal (intergovernmental)	UN Member States	Specific focus on disarmament allows global public interest to remain a high priority. Links with other (non-space) disarmament issues	Consensus decision-making means there has been little progress in this politically sensitive area
International Civil Aviation Organization (ICAO)	Formal (intergovernmental)	UN Member States	Has produced much binding law on air law matters. Has recently started cooperation with UNOOSA to consider overlap between air and space safety and traffic management activities	To what extent does it have the jurisdiction and mandate to deal with space governance as far as commercial space transportation and suborbital activities are concerned? Individual State interests dominate law-making
World Health Organization (WHO), World Meteorological Organization (WMO), and UN Environment Programme (UNEP)	Formal (intergovernmental)	Member States	Provide recommendations and standards in terms of radiation and environmental concerns	Only those space-related governance issues are addressed that are limited to the main mandates of these organizations
International Telecommunication Union (ITU)	Formal (intergovernmental with some nongovernmental participation)	States, "sector members" including regional organizations, commercial entities, and academics	Successfully regulated allocation of radio frequencies and orbital slots. Has near-universal participation	Has very few enforcement mechanisms, and no strong ones. Breaches can be noted, but no real penalties
Committee on Earth Observation Satellites (CEOS)	Formal	National space agencies	Coordination of satellite Earth observation policies, standards, and other operational aspects	Membership limited to some space agencies, non-binding decisions
Interagency Operations Advisory Group (IOAG)	Formal (intergovernmental)	National space agencies	Provides recommendations to Interoperability Plenary on issues of coordinating space communications policies and technologies. Centralized and neutral. Has broad participation	Recommendations are not binding. Depends upon participation by national space agencies, which excludes developing nations that do not yet have active space programs
Group of Governmental Experts (GGE)	Informal (ad hoc) intergovernmental	Individuals selected for their expertise	Produced reports on transparency and confidence-building measures in accordance with UN General Assembly resolutions. Similar groups have also been formed for cyber security and	Non-binding norms, dependent on States or other bodies to implement them. No enforcement or incentive mechanisms

			telecommunications. The 2013 GGE-report on TCBM in outer space activities paved the way for considerations in UNCOPUOS of the broader perspective of space security	
UNISPACE I, II, and III	Informal (Intergovernmental and nongovernmental events)	UN Member States; international organizations; space-related industry members (on invitation of their governments)	Served as important fora for almost all stakeholders to discuss almost all aspects of space exploration, use, and exploitation of space	Limited and only indirect influence in the formulation of global space governance
International Astronautical Federation (IAF)	NGO	Companies and organizations working in space-related fields	Creates a global network of private entities involved in space activities on a large-scale. Dissemination of knowledge and technological advances contributes to international cooperation, especially through annual meeting with Members of Parliament	Produces no applicable governance documents or guidelines
International Institute of Space Law (IISL)	NGO	Individuals with expertise in space law	Brings together international experts in their personal capacities, rather than as State representatives, to consider issues of space law. Produces "proceedings" and academic publications	No general guidelines or applicable governance documents and no significant and direct input to global space governance
International Association for the Advancement of Space Safety (IAASS)	NGO	Individuals with expertise in space. IAASS is itself a member of IAF and has observer status at UNCOPUOS	Produces reports, academic publications/proceedings, as well as recommendations that it presents to UNCOPUOS, develops international standards	
International Law Association (ILA) Space Law Committee	Formal NGO	Individuals who are members of their national branch of the ILA and have expertise in space law	Brings together international experts in their personal capacities, rather than as State representatives, to consider issues of space law	Produces reports and academic publications, but no general guidelines or applicable governance documents; not very strong on dissemination
Consultative Committee on Space Data Systems (CCSDS)		National space agencies, other governmental agencies, NGOs, private scientific and commercial entities	Develops standards to enhance governmental and commercial interoperability and cross-support, while also reducing risk, development time, and project costs	
NOTE: There are numerous other regulatory instruments and institutions that play role to a varied degree in global space governance. They are too many to be discussed in this chapter and listed in this chart, though some of them are referred to in other chapters.				

Chapter 3:
Global Space Governance from Regional Perspectives

This chapter reviews regional mechanisms and governance systems related to the outer space arena. In Europe, due to the strength of the regional programs conducted by the European Space Agency and the European Union, in terms of their governance and financial arrangements, these governance capabilities for regional space programs are relatively strong and effective. In the rest of the world, this is much less the case. Nevertheless, there are regional systems and capabilities worthy of note and these are addressed in this chapter. The following four charts provide an assessment of the strengths and limitations of regional space organizations. The full text of Chapter 3 of the *Global Space Governance: Key Proposed Actions* also discusses other regional organizations and entities that operate on a regional basis. Thus, there is some discussion and analysis of Arabsat, the Regional African Satellite Communication Organization (RASCOM), the Organization for Andean Telecommunication by Satellite (OATS), and proposals to create an African Satellite Agency, a Pan-Arab Space Agency, and a Latin American Space Agency. These organizations are or will become more important to regional space governance in coming years.

Chart 1: European Union

Strengths and Limitations of the European Union's Space Activities					
Strengths			**Limitations**		
Participation	**Governance Structure**	**Projects and Implementation**	**Participation**	**Governance Structure**	**Projects and Implementation**
• Treaty-based, hence more certainty • Three-phase membership process can increase joining State's overall capability • Includes most States in the European continent	Joint decision-making by the European Parliament and the Council of the EU helps to reconcile potential conflicts of interests with regard to the EU, ESA, and Member States	• Centrally funded flagship projects (GALILEO and Copernicus) • Research and innovative funding by *7th Framework Programme for Research and Technological Development* and Horizon 2020 • The "best value for money" principle for the benefit of cost-efficiency	• Only open to States • Time-consuming and difficult to join	• Still limited centralization of space policy and activities of Europe	• Heavily reliant on national and ESA space capability • The "best value for money" principle can conflict with the "fair return" principle for EU-United States cooperative programs
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Chart 2: European Space Agency

Assessment of the Strengths and Limitations of the European Space Agency

Strengths			Issues or Limitations		
Participation	**Governance Structure**	**Projects and Implementation**	**Participation**	**Governance Structure**	**Projects and Implementation**
▪ Treaty-based, thus more certainty ▪ Three-phase membership process that contributes to capacity-building and the formation of a supply chain prior to joining ▪ Includes most States within the West European continent ▪ Associate membership allows participation of non-European States, such as Canada	▪ Decision-making by majority, two-thirds majority, or unanimity depending on importance ▪ Joint Secretariat with the European Commission ▪ Coordination at program level	▪ Mandatory projects, optional projects, and operational activities provide flexibility ▪ Possible contribution reduction for a limited period in special circumstances ▪ The "fair return" policy as an incentive for investment (This can also be considered disadvantage)	▪ Only open to States ▪ Time-consuming to join	▪ Non-EU State Members (Norway, Switzerland) can have key influence on crucial votes ▪ Lack of institutional coordination mechanism with the EU	▪ Some new Member States are at disadvantage ▪ More benefits for States with greater concentration of space industry ▪ Increasing involvement in military and dual-use projects, with possible conflicts with the national competence ▪ The "fair return" policy is not necessarily cost-efficient
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Chart 3: Asia-Pacific Space Cooperation Organization (APSCO)

Analysis of the Asia-Pacific Space Cooperation Organization					
Strengths			Issues or Limitations		
Participation	**Governance Structure**	**Projects and Implementation**	**Participation**	**Governance Structure**	**Projects and Implementation**
○ Treaty-based, hence more certainty ○ Sharing of China's space expertise as an incentive ○ Associate membership and observer status allow broader participation	Decision-making by consensus allows unity within the Organization	○ Basic activities and optional activities ○ The "return on investment" as an incentive for investment ○ China makes great contributions to the projects ○ Teaching and training help to spread China's space expertise ○ Activities not constrained by MTCR	○ Only open to States ○ Decision on membership by consensus can be time-consuming ○ Lack of gradual membership process that contributes to capacity-building ○ Potentially impeded by MTCR ○ The dominance of China potentially discourages other major space powers to join	Decision-making by consensus can be slow	○ Lack of sufficient financial and technical capabilities in some participating States ○ Chinese dominance and its foreign policy influences

Chart 4: Asia-Pacific Regional Space Agency Forum (APRSAF)

Assessment of the Asia-Pacific Regional Space Agency Forum (APRSAF)					
Strengths			**Issues or Limitations**		
Participation	**Governance**	**Programs and Implementation**	**Participation**	**Governance**	**Programs and Implementation**
• Open to non-State actors • Sharing Japan's space expertise as an incentive • Not treaty-based, allowing broad participation by non-State entities and from Asia-Pacific and beyond	• Open and flexible framework • Newly established Executive Committee	• Four Working Groups to share information with frequent meetings • International projects as solutions for common issues, such as Space Applications for Environment (SAFE)	• Not treaty-based, hence less certainty • The dominance of Japan potentially discourages other major space powers to join	• Decision-making mechanism unclear • Influence from Japan's foreign policy	Japan constrained by export control mechanisms

Chapter 4:
National Space Policies and Laws and Global Space Governance

There can be no doubt that the strongest and most effective source of governance of space programs comes at the level of national space policy and law. A growing number of States have established statements of national space policy that cover commercial, civil governmental, and national defence space programs and activities. In a number of cases, such as the case with the French Space Operations Act, there are explicit provisions to enforce international space agreements, conventions or even provisions, such as the UN Guidelines on Space Debris. This can be accomplished through such means as penalties, taxation, legal provisions, guidelines, policy objectives, and incentives.

The following brief exposition on selected States' space policies, laws, guidelines, and administrative regulations are summarized in brief fashion in Chapter 4 of *Global Space Governance: An International Study*. Clearly, this is not an entirely exhaustive list. Nevertheless, it does include a significant majority of States with well-established national space legislation and regulations. States covered include: Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, China, France, Germany, India, Indonesia, Iran, Ireland, Italy, Japan, Kazakhstan. Republic of Korea, the Netherlands, Nigeria, Norway, the Russian Federation, South Africa, Spain, Sweden, Ukraine, the United Kingdom, and the United States. Certainly, there are other States with space initiatives and space policies in place, such as Malaysia, Pakistan, Thailand, Israel, Mexico, Colombia, and indeed others. The purpose of this analysis was not to be entirely comprehensive, but sufficiently broad to provide perspective on the various national space governance approaches

that have been taken around the world. To the extent, if any errors in the summaries or information concerning the national space policies and governance and regulation of national space programs are not included in Chapter 4, the editors of the study would welcome such additional information. The Chart below summarizes key analysis found in this chapter.

Chart 1

National Space Policies and Laws and Global Space Governance				
Existing Governance Mechanisms	**Formal/ Informal**	**Decision-making (Actor/Participant)**	**Strengths**	**Limitations**
National laws, regulations, standards, policies, guidelines, and regulatory bodies	Formal	Mainly official law and policy-makers, administrative staff and, in some States, participation by the private sector and civil society	Very effective in creating and implementing national governance regimes, in shaping global space governance mechanisms, and often necessary in implementing global space governance system	Lack of national laws in some States (even in spacefaring States), divergent nature creates inconsistency, possibility of extraterritorial application of some national laws, national laws of certain States may impede the adoption of global space governance norms
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Chapter 5:
Private Commercial Space Enterprises and Global Governance System

This chapter addresses the rapid rise of commercial space enterprises and its likely future trajectory. It then significantly considers the fundamental question as to what are the existing mechanisms of global space governance, which will be compatible with the increasing trend of space commercialization, and which regulations might be a brake on commercial space products, services, and operations?

Chart 1: Key Issues

Key Elements and Issues Related to Private Commercial Space Enterprises			
Issues and Challenges	**Technical Challenges (Natural and Man-made)**	**Economic, Business, Demographic, Health, and Other Challenges**	**Risks/Threat Mitigation/Equity Issues**
Development of technology ahead of governance	Lack of regulation; potentially unsafe practices; no foresight to sustainable use of outer space	Business risk due to regulatory uncertainty; potential safety issues	Uneven national rules for licensing and approval
Low cost of launching nano/pico satellites	Lack of propulsion; difficulty in tracking; limited or no manoeuvrability	Launches can go unnoticed from a regulatory perspective; registration of such satellites is limited due to short flight duration	Lack of oversight can lead to violations of environmental, safety, liability, and other rules
Global development of private space industry	Technologies vary in safety and sustainability	Export controls and patchwork national regulations hinder development of international cooperation	Forum shopping; flags of convenience

State responsibility for private activities	Identification and tracking of space objects, including debris	Requirements are implemented at a national rather than international level	States unfriendly to space risks may stifle the development of space industry by their nationals
State liability for private activities	Identification and tracking of space objects, including debris	Entities must meet States' differing requirements for indemnification	Smaller States without financial requirements for space entities may be unable to pay for damage caused
Change of ownership of space objects	Transfer of radio frequency allocations	Business risk for both transferor and transferee regarding international recognition of ownership	Liability remains with launching States, regardless of ownership
Non-appropriation and free access and use principles	Development of innovative space mining technologies may be hindered	Legal uncertainty with respect to ownership of extracted resources	Investment in space resource extraction enterprises risky in uncertain legal environment
Orbital slot and frequency allocation	Harmful radio frequency interference; space object and debris tracking	Satellite operator business success relies on the ability to use specified radio frequencies and orbital slots; limited resources; paper satellites	Global governance through ITU ensures international cooperation; national mechanisms vary
Relationship of national legislation/bilateral agreements to global governance	Different technologies can be treated differently in different States	Economic, business, environmental, liability etc., rules may be treated differently in each jurisdiction	Forum shopping; flags of convenience
Formation of customary international law	Development of international law and development of technology are out of sync	Hard to determine exactly when customary law crystallizes	Legal uncertainty creates risk for investment
Use of soft law mechanisms	Technology develops faster than even soft law mechanisms are established	Technology developed in accordance with existing soft law mechanisms may be at an economic disadvantage to those developers who choose to ignore soft law mechanisms	Mechanisms are non-binding guidelines; do not ensure compliance
Registration requirements gap	Identification of space objects and tracking of space debris	Uncertainty of status of unregistered suborbital craft	Potential liability and ownership concerns
Export controls	Difficulty to share technological information between nationals of different States	Hindrance to the safe, sustainable development of the space industry globally	Stifling of national space industries; difficulty governing varying technologies globally
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Chart 2: Possible Actions

Proposed International Actions Related to Private Commercial Space Enterprises	
Proposed Action	**Entities to Take Proposed Action**
Development of comprehensive multilateral treaty, amendments to existing treaties, or supplemental protocols or implementing agreements to existing treaties	Some or all of: UN General Assembly First Committee, Fourth Committee, UNCOPUOS, CD, ITU, ICAO, World Meteorological Organization
Adoption of bilateral or limited multilateral agreements	Individual States, regional and international organizations (European Union, etc.)
Development of soft law instruments	Some or all of: UNCOPUOS, UN Disarmament Commission, ITU, ICAO

Implementation of industry-led rules	Space industry trade associations
Standards implemented by contract	Insurers and other space industry service providers
Encouragement of continued development of national legislation in those States still lacking	States must implement their own regulations, but can be encouraged by international organizations at the international level and lobbyists at the national level
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Chapter 6:
Satellite Telecommunications and Broadcasting

This chapter addresses all of the current issues facing the development of satellite communications and broadcasting systems that constitute the largest space industry. These issues include, among other topics, radio interference and jamming, coordination and technical standards related to the interface between satellite communications and terrestrial Internet and digital networking services, limited and contested spectrum allocations, and orbital locations in an increasingly congested environment. Additional issues relate to the deployment of large-scale constellations in low-Earth orbit (LEO), liability issues, impact of high throughput satellites, and concerns about orbital debris. These issues are outlined in Chart 1 below. In addition to addressing concerns and issues, possible actions that might be taken with regard to these issues were analysed as summarized in Chart 2.

Chart 1: Key Issues

Key Elements and Issues Related to Satellite Telecommunications			
Issues and Challenges	**Technical Challenges (Natural and Man-made)**	**Economic, Business, Demographic, Health, and Other Challenges**	**Risks/Threat Mitigation/Equity Issues**
Radio frequency interference (RFI) and electromagnetic interference (EMI)	Improved encoding systems; smart antenna systems	Increased enforcement and penalties for interference	Coping with government-sanctioned jamming
Need for better standards, coordination between ITU and Internet-based services (i.e. IETF)	Eliminate or reduce latency, IPsec "headers", and virtual private networking technical constraints for satellite services, where possible	Improve standards, and communications between telecommunications and IP networking mechanisms; utilize new ISO and IEC standards to make satellite networks and user terminals more easily updatable for blackbox, encryption, and data download updates	Remedial actions need to apply to civil and defence satellite networks
Demand for additional satellite frequencies to meet broadband services and competition for spectrum with terrestrial cellular broadband	Precipitation attenuation coping systems; dynamic power response to allocate power margin on demand	Development cost of higher frequencies in millimetre wave, terahertz, and above	Dominance of satellite systems from developed economies; needs of developing States; conflicting needs of terrestrial mobile users
Saturation of the GEO arc	Need for even better cooperation between satellite operators, including sharing of conjunction information; improve electronic	New licensing and auctioning techniques; economic incentives to use higher frequencies or more efficient satellite technologies,	Need to accommodate the access needs of developing States while

	ion positioning and pointing systems; autonomous control and artificial intelligence systems to avoid collisions	especially for station-keeping and collision avoidance	also meeting expanded service needs
Congestion of the LEO and polar orbit	Improved guidance and control systems; improved space situational awareness (S-band Radar Space Fence); technology to replace LEO and polar orbit satellite constellations by alternative satellite technology	New licensing and auctioning techniques; economic incentives to use higher frequencies or more efficient satellite technologies, especially for station-keeping and collision avoidance	Need to accommodate the access needs of developing States while also meeting expanded service needs
Orbital Debris build-up (particularly compounded by possible deployment of Mega-LEO systems)	New technology to allow cost-effective and reliable ways to remove debris or passive means to meet the 25-year rule; better active and passive de-orbit capability for satellites and upper stage rockets	Requirements for all new LEO systems launched to meet 25-year rule; need for new economic systems to incentivize debris removal; need to reform space liability provisions	Voluntary mitigation guidelines are not sufficient; we may need to evolve to mandatory space traffic management systems and find a means to finance active debris removal

Chart 2: Potential Actions

Proposed International Actions Related to Satellite Telecommunications	
Proposed Action	**Entities to Take Proposed Action**
Improve procedures to minimize RFI and EMI	ITU, UNCOPUOS, UNOOSA, UNODA, UN General Assembly, ISO, SIA, SDA, and Satellite Interference Reduction Group giving RRB powers to include physical investigation and verification of such abuses as interferences and questionable actions to retain orbital locations, and possibly, giving ITU authority to impose sanctions
Long-term planning process for satellite and wireless/cellular/HAPS/UAV systems and, especially, future spectrum allocation needs in millimetre, terahertz, infrared, and visible light frequencies; would also consider more efficient use of geosynchronous orbit and space traffic management. especially for global LEO and MEO constellations	ITU and national administrations to ITU, ICAO or other relevant international agency
Improved standards coordination between ITU and IETF and perhaps new relationship between ITU and ICAO related to space traffic management for application satellites	Coordination between ITU and IETF; ITU, concerned national administrations that license satellite networks, and ICAO jointly provide some form of space traffic management
Improved updating of satellite communications user terminals and facilities to reduce frequency interference to adjacent satellites	International Organization for Standardization (ISO) and International Electrotechnical Committee (IEC)
Campaign for new requirements via national laws that would follow “model laws” for de-orbit satellites to meet 25-year rule (or better) for satellites at end-of-life	National legislatures; UNOOSA upon mandate by UNCOPUOS could develop a model law as well as make available a wider number of national laws or national regulatory/administrative frameworks to global community; new international procedures for active space debris removal perhaps agreed via SDA or Inter-Agency Space Debris Coordination Committee (IADC)

Convening of an international coordination conference to consider a wide range of space-related issues, including the future of space applications and space traffic management	UN General Assembly, UNCOPUOS, ITU, ICAO or relevant international forum
Development of communications protocols between satellite operators with the aim of preventing physical collisions, including early sharing of conjunction information	SIA, SDA, UNCOPUOS, UNOOSA (under the framework of enhanced information exchange on space objects and events)
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Chapter 7:
Remote Sensing, Earth Observation, and Meteorological Satellites

This chapter analyses the continuing development of technologies, analytic techniques as well as the pertinent regulatory practices, and legal provisions related to all aspects of remote sensing. This analysis, thus, considers remote sensing for commercial purposes as well as civil governmental activities carried out for Earth observation, weather satellite service, including weather prediction and warnings, disaster management, search and rescue, and climate change and solar storm monitoring. Although remote sensing and Earth observation activities are not as large in terms of commercial markets as satellite communications, they do have a significant impact on many aspects of the global economy and touch upon almost every aspect of the UN Sustainable Development Goals. A recap of remote sensing activities and related issues and concerns that arise from these space services are provided in Chart 1. This is followed by Chart 2, which provides further analysis and proposals concerning actions that might be taken with regard to improved global governance reforms.

Chart 1: Key Issues

Key Elements and Issues Related to Remote Sensing, Earth Observation, and Meteorological Satellites				
Issues	**Technical Challenges (Natural and Man-made)**	**Economic, Business, Demographic, Health, and Other Challenges**	**Risks/Threat Mitigation/Equity Issues**	**Challenges**
Additional spectrum allocations	The rapid download of an increasing amount of sensed data	The high cost of processing data from satellites with higher resolution, greater spectral density, and more rapid temporal revisits	Accommodating new entrants to the field; more States and companies with higher performance satellites	Competing satellite applications require more spectrum, less interference, and orbital usage
Increased demand for usage of sun synchronous polar orbits and GEO	There are only limited orbital slots and the increasing density of use leads to radio frequency interference and risk of collision	Trade-offs between more data acquisition and end-product benefits	Curtailing vital governmental services to accommodate growth of commercial services	Lack of coordinated planning on global basis for future needs; difference in needs of governmental and commercial services
Increased orbital debris	Debris build-up in polar orbits is rapidly occurring because of heavy usage of these orbits – especially for new large	Currently, there are no cost-effective means to remove orbital debris; no financial incentives	Only a few States have caused the debris problem, but the risks to future use of space is global in nature	There is no current system in terms of incentives or penalties to prompt the cleaning up of orbital debris

	constellations			
Privacy of individuals, communities, and governments from unwanted surveillance	There is no effective mechanism to reduce unwanted surveillance from space or drones	The expanded commercial development of geographic displays and geographic information system data bases makes privacy even more difficult	The least economically developed States are most likely to suffer from unwanted surveillance	Need for new agreements about sharing of remote sensing data to protect economic interests of States with limited access to such data
Need for more effective and instantaneous global warning against violent storms and extreme solar events	With climate change, satellite warning of severe storms is a growing problem; also, more key infrastructure at risk from solar storms	There are no current financial or business incentives to provide needed warnings	States most at risk from global warming are not those that have most impacted climate change	There is a need for more coordinated action among World Meteorological Organization (WMO), UN Development Programme (UNDP), and International Bank of Reconstruction and Development
Effective use of remote sensing data to respond to disasters and effective recovery	Timing of response and detail of information	Excessive use of the Disasters Charter might undercut the business case for commercial remote sensing	Most developed economies are perhaps most likely to be able to use remote sensing data effectively	Global effective use of remote sensing data by all States
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Chart 2: Potential Actions

Proposed Actions Related to Remote Sensing, Earth Observation, and Meteorological Satellites	
Proposed Action	**Entities to Take Proposed Action**
Development of a long-term plan to accommodate the spectrum and orbital assignments needed for future remote sensing, Earth observation, emergency services, and meteorological and climate monitoring satellite system needs	ITU WRC, space agencies, UNCOPUOS, and CEOS
Development of a coordinated global plan for future use of various key Earth orbits against radio frequency interference and orbital congestion/collisions	ITU WRC, space agencies, UNCOPUOS, and CEOS
Development of a new globally agreed plan to not only minimize new space debris, but to actively remove the most dangerous large debris in LEO/polar orbits (note more detailed proposals in Chapter 6 on telecommunications)	UNCOPUOS (especially Scientific and Technical Subcommittee and Working Group on Long-Term Sustainability of Outer Space Activities), ITU, Inter-Agency Space Debris Coordination Committee
Improved warning systems against violent storms, solar storms, and significant climate change conditions; this might involve a new charter that is parallel to the Disasters Charter	WMO, UN Environment Programme, UNCOPUOS; specific extensions of the World Weather Watch to cover expanded weather, ocean, and solar hazards (this might include efforts related to climate change threats and efforts to create solar "shields" against coronal mass ejections); UNISPACE+50 thematic priority on international framework for space weather services
Revise and update the Disasters Charter to allow expanded use of remote sensing data for disaster recovery and in cases of significant impacts from climate change, droughts, and famines; coordination of regulations, policies, and standards, and sharing of	CEOS, UN Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER); expansion of the scope of the current Charter to cover more crises and with greater efficiency; UNISPACE+50 thematic priority on international cooperation toward low-emission and resilient

Earth observation information will expand the use of and the market for Earth observation data and applications	societies
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Chapter 8:
Global Navigation Satellite Systems and Services

This chapter analyzes the status and pending issues related to global navigation satellite systems and services (including space situational awareness), sometimes referred to as precise navigation and timing (PNT) services. It not only addresses the services but also pending issues and problems as well as possible actions that might be taken to improve global governance of these space-based services.

Chart 1: Key Issues

Key Elements and Issues Related to Global Navigation Satellite Systems			
Issues and Challenges	**Technical Challenges (Natural and Man-made)**	**Economic, Business, Demographic, Health, and Other Challenges**	**Risks/Threat Mitigation/Equity Issues**
Proliferation of national and regional GNSS systems	Proliferation of GNSS systems; increased complexity of GNSS systems and of multi-use receivers	Increased satellite investment, increased operational costs, and especially cost of multi-system user receiver units	Added complexity; possible inconsistencies and extra costs through national mandates to use localized GNSS; lack of interoperability
Radio frequency interference (RFI) and electromagnetic interference (EMI) and jamming	Improved encoding systems; smart antenna systems; spoofing	Increased enforcement related to interference and jamming	Coping with criminal or even government sanctioned jamming
Increasing demand for use of adjacent frequencies for communications or other applications	Technical difficulty of minimizing interference from applications in adjacent frequencies	Potentially higher cost user terminals	Potential denial of GNSS services, especially for vital services, such as aircraft take-off and landing, and maritime navigation and rescue
GNSS services may be increasingly needed for space and "Protozone" operations by spaceplane and stratospheric systems above commercial airspace	There are not sufficient safety systems in the area above commercial airspace up to low-Earth orbits	Potentially higher costs and lack of cost-effective equipment for these new markets	There are many new commercial systems, such as hypersonic transport, that might rely on GNSS services in the stratosphere. However, software or hardware for these areas are not optimized for this use
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Chart 2: Proposed Actions

Proposed International Actions Related to Global Navigation Satellite Systems	
Proposed Action	**Entities to Take Proposed Action**
Better coordination and integration of GNSSs around the world; Amendment of the 1998 Charter on the Rights and Obligations of States Relating to GNSS Services in order to mandate action by States to coordinate the use and better integration of GNSSs	ICG, ICAO, States

around the world	
Better coordinate the design and implementation of new and existing GNSSs and user terminals	UN General Assembly, UNCOPUOS, ICG
Improve procedures to minimize EMI and RFI either via deliberate jamming or adjacent use interference	ITU, UN General Assembly, UNCOPUOS, ICG
Better technical design to minimize interference to GNSS	Aerospace system designers, ICG
Better integration and cooperation in the design of multi-system user terminals and facilities as well as regional terrestrial systems, such as WAAS and EGNOS	International Organization for Standardization, International Electrotechnical Commission, US Federal Aviation Administration, European Aviation Safety Agency
Clarification of liability issues related to GNSS services	ITU, UN General Assembly, UNCOPUOS, ICG, ICAO, and, possibly, national laws
Protection from frequency loss at ITU to terrestrial applications	ITU, UN General Assembly, UNCOPUOS, ICG
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Chapter 9:
Space-Based Solar Power

This chapter addresses the topic of an emerging space service known as space-based solar power (SBSP), which is also referred to as solar power satellites (SPS). This analysis covers specific challenges related to launch systems, ground-based rectennas, and environmental and strategic concerns that will ultimately need to be addressed to realize viable SBSP systems. The prospect of SPS has been around now for a half century. However, it is now thought that the technology and economic competitiveness, coupled with environmental considerations, may actually mean that this type of new space-based service might become financially viable within the not too distant future. Chart 1 reports on issues and concerns related to the implementation of SBSP. Chart 2 considers possible actions that might be taken to improve the needed global space governance appropriate to providing a reasonable regulatory regime—both in space and on Earth—to implement this new type of space service.

Chart 1: Key Issues

Key Elements and Issues Related to Space-Based Solar Power			
Issues and Challenges	**Technical Challenges (Natural and Man-made)**	**Economic, Business, Demographic, Health, and Other Challenges**	**Risks/Threat Mitigation/Equity Issues**
Radio frequency interference and electromagnetic interference (EMI)	Modulation, multiplexing, and coding systems to help distinguish power transmission from orbit for telecommunication and other satellite applications; smart antenna systems	Need for increased enforcement and penalties for interference	Special protection for satellite systems for national systems, especially those from developing States using C-band networks, but indeed all telecommunication satellites as well as satellite navigation systems
Need for better standards coordination between ITU, energy industries, and national administrations responsible for the	New technical standards to undertake coordination and minimize interference to other space applications	Improve interference standards and processes for more effective communications and EMI issues affecting telecommunications, navigation, and electrical power networks; utilize new standards of	Fines or penalties for interference between communications and space power systems

regulation of electrical power grids		International Organization for Standardization (ISO), and International Electrotechnical Commission (IEC) as well as new ITU standards	
New frequency allocations	New allocations designed to best segregate power and telecommunication and navigation satellites and provide for higher rates of power throughput	Multi-billion assets could be at risk for various space industries, if not regulated properly	Potential financial losses for various space applications industries and commerce that relies on these services
Health standards for SBSP system related emissions	Research as to health implications of transmissions through the atmosphere as well as in proximity to rectennas	Agree on new health standards for space transmissions and ground rectennas	Risks to people in proximity to rectennas, to people in aircraft, and to migratory birds
Coordination of orbital assignments for SBSP systems vis-à-vis telecommunications and other application satellites	More efficient station-keeping and orbital manoeuvring systems	New licensing and auctioning techniques; more efficient satellite technologies, especially for station-keeping and collision avoidance	Risks to GEO-based satellites of all types; risks associated with the deployment in L1 Lagrange orbit or other orbits also require study
Orbital Debris Build-up	New technology to allow cost-effective and reliable ways to remove debris or passive means to meet the 25-year de-orbit rule; better active and passive de-orbit capability for satellites and upper stage rockets	Requirements for all SBSP systems launched to go into safe parking orbit or meet the 25-year de-orbit rule; new economic systems to incentivize debris removal; need to reform space liability provisions	Voluntary mitigation guidelines are not sufficient; may need to evolve to mandatory space traffic management systems and find a means to finance active debris removal
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Chart 2: Possible Actions

Proposed International Actions Related to Space-Based Solar Power	
Proposed Action	**Entities to Take Proposed Action**
Improve procedures to minimize EMI and radio frequency interference between all types of application and scientific satellites and SBSP systems	ITU, ISO, Satellite Industry Association (SIA), Satellite Interference Reduction Group; giving ITU and its Radio Regulations Board powers to investigate and verify EMI interference, abatement procedures, and authority to act on potential abuses
Health and safety standards for SBSP system transmission from space to ground-based rectennas	World Health Organization, ITU, Institute of Electrical and Electronics Engineers (IEEE), IAA, International Association for the Advancement of Space Safety (IAASS)
Allocation of new radio frequency spectrum for space to Earth transmission of power to ground rectennas	ITU, national telecommunication administrations
Improved updating of satellite communications user terminals to reduce interference and new standards for SBSP rectennas, including the issue of potential reflected energy back into space	ITU, SIA, ISO, and IEC
Campaign for new requirements via national laws that have to be consistent with space treaties to set new standards for active de-orbit of debris; the risks related to SBSP systems	National legislatures; UNOOSA could possibly circulate sample national laws or national regulatory/administrative processes or best practices to global community; new

presented by space debris is elevated because of the larger profile of these systems	international procedures for active space debris removal perhaps developed via the Space Data Association or the Inter-Agency Space Debris Coordination Committee, and brought to UNCOPUOS for consideration
Convening of international conference concerning the use of outer space for SBSP to examine the state of technology, frequencies, interference mitigation, space weapon issues, and energy and sustainable development, with the purpose of developing specific proposals on the above topics and timetable for implementation and specifically for creating an international joint venture (like the earlier INTELSAT) for developing and operating a global SBSP system	First, IAA study to set agenda; Second, UNCOPUOS to consider the topic with the participation of observers for UN entities, including Specialized Agencies, such as ITU, ICAO, and others as appropriate. UNOOSA to be mandated to develop the agenda further; Third, on this basis, the convening of an international conference under the auspices of UNOOSA

Chapter 10:
Space Launch Services

This chapter is concerned with future trends in the development of space launchers and launch services, including space elevators and other totally new technologies to provide access to Earth orbit that may develop in the future. It also relates to the development of new commercial launch capabilities and, thus, should be read in conjunction with Chapter 5 with regard to new space enterprise developments. Anticipating new technology is always difficult, especially if it involves break through inventions that are not simply extensions and improvements of conventional systems. Nevertheless, it is possible to establish strategic planning objectives for developing new space access technologies that involve important social or economic goals. These objectives for launch systems might include new systems that do not pollute the world's stratosphere or new launch capabilities that provide significant improvements in space safety. Such strategic goals can certainly help shape research objectives and produce truly new space launch systems in coming years. Chart 1 indicates key issues and concerns with regard to space launch systems. Chart 2 indicates the possible actions that should be taken.

Chart 1: Key Issues

Key Elements and Issues Related to Space Launch Services			
Issues and Challenges	**Technical Challenges (Natural and Man-made)**	**Economic, Business, Demographic, Health, and Other Challenges**	**Risks/Threat Mitigation/Equity Issues**
Better definition of basic concepts, such as "national air space", "Protozone", and outer space; perhaps, establish key zones involving launch zones, such as LEO, medium Earth orbit (MEO), and GEO	These areas and zones are not clearly defined in terms of precise technical parameters	These zones and areas have competing applications and their uses of varying levels of economic interest	The lack of clearly accepted international definitions for these concepts puts various space initiatives at risk; developing States might be placed at a disadvantaged position
Need for fuels that are cleaner and more environmental friendly launchers for the stratosphere	Phase out of solid and hybrid-fuelled launchers and spaceplanes, or otherwise find ways to cope with particulates	Dangers of depleted ozone layer at the top of stratosphere in terms of health and genetic mutations	Environmental impact is greatest in North and South polar regions
Development of launcher	New systems, such as EDDE	None of the current	If space debris issue is not

systems optimized for the cleaning up of orbital debris, as well as making the clean-up process more cost-effective; these systems could also possibly be used for addressing potentially hazardous asteroids	and other promising technologies; ground or space-based laser for heating, ablation or acceleration of solar sales is promising, but raises issues regarding space weapons	systems is cost-efficient; EDDE may also raise legal issues with the Outer Space Treaty and other space treaties	quickly addressed, the problem will worsen; the number of 1-cm debris may increase from 250,000 to 1 million in next 5 years
Developing reusable space launch systems	Lightweight structures, advanced propulsion systems, and reusable thermal protection systems	Investment in fully reusable vehicles of all types	Such systems might not only reduce costs, but also reduce risks
Development of small payload launch systems	Development of cheap and simple components	Global licensing and regulation of such systems	Unregulated use of small launch systems
Opportunities and difficulties associated with nuclear propulsion	Developing robust, reliable NTP propulsion systems	Strong political and societal antipathy toward nuclear systems	Risk mitigation, if used in launch systems or launched as a payload
Beamed energy systems	Energy beaming/conversion, tracking, and real-time control	Public concern about possible dangers; concerns about possible "weaponization"	
Tethers/orbital towers	Need to develop strong enough materials as well as control systems mechanisms to avoid potential collisions	Cost of such systems; if implemented, effect on existing launch infrastructure	Protection of ground terminals for space elevators from aggressive action
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Chart 2: Possible Actions

Proposed International Actions Related to Space Launch Services	
Proposed Action	**Entities to Take Proposed Action**
Seek within UNCOPUOS a general consensus statement that, as there are now many private-based activities, States should create "rules of the road", and/or national legislation setting forth expectations of space entities to meet international obligations, and should expand opportunities for liberalized trade in launch services to be made available on non-discriminatory basis and that minimize, where possible, trade and non-tariff barriers (like export control regulations, e.g., International Traffic in Arms Regulations of the US)	UNCOPUOS, UNOOSA, World Trade Organization, and national legislatures adopting space-related laws and pro-trade regulations to lower non-tariff barriers, etc.
Create a systematic survey and classification system for existing and future space launch technologies and systems within the UN system, which includes types of fuel and launching propulsion system, launch configuration for take-off and landing, air and space traffic management, air and stratospheric pollution levels, risks of creating orbital debris, and any other special considerations	UNCOPUOS, UNOOSA, and ICAO in cooperation with all spacefaring nations
Create flexible legal framework that can accommodate future developments in launch systems; this process should incentivize, to the maximum extent possible, the following objectives: (i) reusable launch systems; (ii) fuel systems that are not environmentally harmful to the stratosphere; and (iii) launch systems that can, in all senses, be optimized to assist with the orbital debris problems	UNCOPUOS, UNOOSA, national legislative actions, and national space policies to develop a forward looking approach and new technical launch capabilities to address key problems
Need to develop key definitions with respect to national airspace, the Protozone, and elements of orbital space	ICAO, UNCOPUOS, UNOOSA, and Inter-Agency Space Committee (i.e. expanded version of Inter-Agency Space Debris Coordination Committee) that can address issues identified in this chapter
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Chapter 11:
Human Space Flight

While Chapter 10 addresses new technology and new launch system capabilities, this chapter focuses on human space flights and issues and concerns that particularly relate to human space flight and related problems of governance, legal controls, and regulations. This involves the division of activities in this field between commercial human space flight activities and those involving civil governmental and military operations and development efforts. It also involves commercial space flight activities such as the so-called "space tourism" activities or commercial space station in low-Earth orbit versus activities involving deep space exploration where presumably national space agencies will likely continue to play a predominant role for some time to come. Chart 1 presents the key issues and concerns involving the future conduct of operations as well as systems and technology. Chart 2 presents the areas where future actions with regard to global space governance might be undertaken.

Chart 1: Key Issues

Key Elements and Issues Related to Human Space Flight Operations			
Issues and Challenges	**Technical Challenges (Natural and Man-made)**	**Economic, Business, Demographic, Health, and Other Challenges**	**Risks/Threat Mitigation/Equity Issues**
Lack of definitions as to where near-space (Protozone) and outer space begins and ends, and who has responsibility for traffic control and management	Systems for tracking and control in these areas are lacking from both a technical and regulatory perspective	Cost of new systems for tracking and control can be expensive and give rise to many issues as to how they might be implemented, controlled, and paid for globally	Liabilities related to accidents are large and without clear controls and oversights, which could lead to disputes and legal claims tied up in the courts
Increase in orbital debris and deployment of large constellations could make both State-based human space flight and commercial space and near-space travel higher risk	On-orbit servicing and active debris removal still in early technical development; no formal coordination between unmanned satellite networks and space safety for human space flight	Cost of developing needed capabilities are high and it is not clear who would pay for them and through what mechanism	Growing risks to satellite networks, commercial space travel, and most space and near-space operations; however, no clear governance and safety systems in place or planned
Rapid development of technology in areas related to near-space and suborbital systems ahead of governance, space traffic safety regulation, and environmental controls with regard to space plane operations	Lack of regulation, potentially unsafe practices, and stratospheric pollution	Business risk due to regulatory uncertainty; potential safety issues	Uneven national rules for licensing/certification and approval
Global development of private human space technology and different regulatory approaches in different nations	Safety technologies vary in safety and sustainability	Export controls and patchwork national regulations can hinder development of international cooperation	Shopping for States with lax regulations, flags of convenience
Uncertainties stemming from the US Commercial Space Launch Competitiveness Act	Development of innovative space technologies may be	Legal uncertainty with regard to ownership of extracted resources	Investment in space resource extraction enterprises risky in uncertain legal environment;

of 2015; long-range experimental licensing and use principles are now seemingly in flux due to the US legislation	hindered (such as for asteroid or Lunar mining); these may be robotic but involve humans at some point		requires cooperation internationally
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Chart 2: Possible Actions

Proposed International Actions Related to Human Space Flight Operations	
Proposed Action	**Entities to Take Proposed Action**
Better defining of zones and national oversight authority from 20 km to 36,000 km and what international governance mechanisms and controls might apply with regard to safety, traffic management, and environmental pollution	ICAO, UNCOPUOS, ITU, and UNOOSA in coordination with ICAO Secretariat, and with UNODA as far as military issues are concerned, and in coordination with national air traffic agencies, national space agencies, and Commercial Spaceflight Federation (CSF); additionally, UN Environment Programme (UNEP) and World Meteorological Organization (WMO) with regard to environmental pollution
Establishment of governance mechanisms via national laws and international agency coordination with respect to orbital debris control and de-orbit requirements	Spacefaring nations legislation and discussions involving Inter-Agency Space Debris Coordination Committee (IADC), UNCOPUOS and its Working Group on Long-Term Sustainability of Outer Space Activities (LTSOSA), and through UNISPACE+50 thematic priority on enhanced information exchange on space objects and events
Implementation of industry-led rules regarding commercial space travel involving human space flight and special concern with regard to future transcontinental Protozone flights	Space industry trade associations (i.e. CSF)/space safety industry/IAASS in cooperation with UNCOPUOS, UNOOSA, ICAO as well as UNEP and WMO
Amendments to existing treaties in relation to Moon/Mars missions and mining/extraction (including asteroids)	Some or all of: UNCOPUOS, UN General Assembly, ITU, ICAO
Standards implemented by contract and via guidance from space insurance industry (these would cover particularly near-space, LEO, but could also cover medium-Earth orbit and geostationary orbit)	ICAO, UNCOPUOS, space industry, IAASS, space insurance entities, UNOOSA and its Access to Space program
Safety requirements/targets	ICAO, space safety industry, IADC, UNCOPUOS and its LTSOSA
If progress is made in the above areas, it could lead to the adoption of bilateral or limited multilateral agreements; It is possible that SARPs could be developed under the existing authority of the Chicago Convention by the ICAO Secretariat	Individual States and international organizations (particularly EU, European Aviation Safety Agency, Federal Aviation Administration, etc.), ICAO Secretariat and UNOOSA, as well as consideration within UNCOPUOS and ICAO
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Chapter 12:
Global Governance of Space Security

This chapter analyses the evolution, current status, and emerging future trends in the development of military space activities and weapon systems. Its special focus is to assess the adequacy of current governance controls and limits concerning the deployment and use of space weapons and constraints on system, the use of force in space as well as efforts to undertake some degree of

militarization of outer space or near-space. Chart 1 presents the analysis of current issues and concerns, while Chart 2 presents possible new space governance systems.

Chart 1: Key Issues

Key Elements and Issues Related to Global Governance of Space Security			
Issues and Challenges	**Technical Challenges (Natural and Man-made)**	**Economic, Business, Demographic, Health, and Other Challenges**	**Risks/Threat Mitigation/Equity Issues**
Conflicting demand for radio frequency spectrum and orbital slots	Lack of adequate satellite spectrum or orbital locations for effective defensive systems	Unstable business and economic conditions	Conflicting demands for spectrum and orbital slots from military, government, and businesses; future needs of economically developing States
Increasing amount of dangerous orbital debris	Cost-effective and reliable method of debris removal	Lack of economic or, business incentive and potential liability issues for removal	Build-up of debris could threaten almost all space applications for defence, governmental, and business uses
Potentially conflicting uses of the Protozone both in a military context and from a safety or commercial use perspective	Area above commercial airspace and "below" outer space not regulated or subject to effective traffic safety control and management	Lack of safety or traffic management and control; no clear health standards either	Potential crashes between high-altitude platform stations, dark sky stations, robotic freighters, spaceplanes, and hypersonic transportation
Lack of international law applicable to military uses of outer space and the Protozone	Lack of technical systems to enforce a code related to military uses of outer space or the Protozone.	Liability claims from other users of outer space or the Protozone	Possible escalation of conflict to higher level of warfare
Increasing risk of critical space infrastructure as targets or of massive space weather event	Lack of protective systems from attack – i.e. frequency jamming, cyberattack or physical attack	Some systems, such as satellites for timing, navigation, and positioning, now critical to the Internet and global economy	Natural hazards or conflict-based attacks could represent a "black swan" event for global economy resulting in huge fatalities
Adequacy of space situational awareness (SSA) with regard to missile attacks, space weather, and space debris	The US has invested heavily in missile and debris tracking, and space weather monitoring (especially new S-band radar space fence), as have other States; there are still concerns about the technical adequacy and info sharing	Sharing of SSA data and space weather data key to many aspects of global economy	Failure of SSA systems could now put at risk the global economy
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Chart 2: Possible Actions

Proposed International Actions Related to Global Governance of Space Security	
Proposed Action	**Entities to Take Proposed Action**
Develop an internationally agreed longer-term plan for the use of higher frequency bands for all types of usage – commercial, governmental, and military	ITU Radio Conferences

Improved plan to control orbital debris increase; limits to large-scale LEO constellations and standards for improved debris removal systems; economic incentives for active debris removal	UNCOPUOS, IADC, ITU
Establishment of new safety standards and process to develop space traffic management and control, which also includes the Protozone, as well as a plan that might possibly provide for controls of air pollution from solid fuel particulates released in the stratosphere	International Civil Aviation Organization, ITU, World Meteorological Organization, UN Environment Programme, UNCOPUOS
Support the International Group of Experts that is preparing McGill Manual on International Law Applicable to Military Uses of Outer Space and the Protozone (MILAMOS) similar to those developed for land, sea, and airspace	UN Office for Disarmament Affairs in coordination with UNOOSA, relevant universities and foundations (especially those involved with the MILAMOS project)
Global assessment of vulnerabilities to world economy, if critical space infrastructure is lost and recommended systems or reforms to lessen these vulnerabilities – natural and military (including CME, EMP, jamming, cyberattacks, and physical attacks)	UN General Assembly, UNCOPUOS, International Academy of Astronautics (IAA), IAASS; UNISPACE+50 under thematic priority no 6
Development of improved global plan for sharing of SSA data related to space weather, changes to the Van Allen belts protective shielding, missile attacks (including terrorists), and orbital debris and satellite conjunctions	UNCOPUOS, UNOOSA in coordination with STSC Expert Group on Space Weather under UNISPACE+50, IAA, IAASS, SDA, and a dedicated neutral nongovernmental organization
Development of an enhanced global plan for planetary defence against severe space weather, asteroids and comets, EMPs, and other cosmic hazards	UN General Assembly, UNCOPUOS, SMPAG and IAWN (coordinated by UNOOSA as Permanent Secretariat of SMPAG), IAA, IAASS
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Chapter 13:
Space Traffic Management and Coordinated Controls for Near-Space

There have been increasing concerns about safety and potential collisions in outer space. There have been particular concerns about the lack of an effective global structure for space traffic management. This is especially linked to concerns related to space situational awareness and the effective tracking of missile launches, spacecraft launches, and other ascents to outer space as well as to near-space (or the so-called Protozone), where there is currently a lack of effective regulation and control. These concerns will only increase with time with more and more States becoming spacefaring nations, the launch of large-scale satellite constellations, and a continuing rise in orbital space debris. This chapter, thus, considers in some detail the relationship among space traffic management, orbital debris monitoring, active debris removal, on-orbit servicing, and orbital transfer of space objects. Chart 1 presents the analysis of current concerns and issues with regard to space traffic management. Chart 2 provides possible actions to improve global space governance with respect to these issues.

Chart 1: Key Issues

Key Elements and Issues Related to Space Traffic Management			
Issues and Challenges	**Technical Challenges (Natural and Man-made)**	**Economic, Business, Demographic, Health, and Other Challenges**	**Risks/Threat Mitigation/Equity Issues**
What is entailed by "Space Traffic Management"? Whether or not space traffic management should be integrated with air traffic	Technical tools required may involve upgraded software for Global Navigation Satellite Systems (GNSS), improved radar, such as S-	Space traffic management may involve different economic models from those applied to military	Need for risk assessment of efforts to "integrate" space traffic management with air traffic management versus segregate space

management?	band radar "space fence", and other tracking and positioning capabilities	and governmental systems	traffic management from air traffic management
Consideration as to whether the Protozone is part of air traffic control or space traffic control or part of an integrated system; would there be explicit zones of exclusion between air traffic control and space traffic control?	The largest challenge is that the systems and vehicles involved travel at vastly different velocities and from short to long durations and at varying altitudes	Economic systems for commercial systems different than those that apply to governmental and military systems	Addition of Protozone regulation and new zones may be difficult for lesser developed nations
Would the creation of a national airspace, contiguous zone, and a Strategic Stratospheric Economic Zone facilitate or complicate space traffic management efforts in terms of national acceptance?	States are not currently equipped to manage and control areas in the upper stratosphere; current levels of control extend to 20 km/21 km; the addition of the "Contiguous Zone" control may be possible for many spacefaring nations	The costs and complexity of controlling above 21 km may be quite expensive; the US S-Band radar "space fence" will cost more than US$ 7 billion	Addition of Protozone regulation and new zones may be difficult for lesser developed nations
Would focus on air traffic management versus space traffic management issues involving the Protozone, suborbital flights, and LEO detract from efforts to address strategic efforts related to structured use of the space, orbital debris build-up, and the management of medium Earth orbit and GEO?	Issues related to traffic management and control related to the Protozone and suborbital flights are technically quite different from those problems related to space traffic management in "true" outer space	The economic responsibility, frequency management, and health related issues are also quite different as between "true" outer space and the region above national airspace through the stratosphere to LEO	The risks of aviation crashes and Protozone safety concerns are more tangible and quantifiable than the risks of orbital debris collisions that are only one in 5 years to one in 10 years; yet, the consequences of debris collisions are much worse in the longer term
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Chart 2: Possible Actions

Proposed International Actions Related to Space Traffic Management	
Proposed Action	**Entities to Take Proposed Action**
Definition of the scope of what is "included" in and required for effective space traffic management (i.e. Protozone, LEO, suborbital, and high-altitude stratospheric flights)	ICAO, UNCOPUOS and recommended working group, and UN General Assembly
Preliminary consideration of whether a "Contiguous Zone" above national airspace up to 42 km and a Strategic Stratospheric Economic Zone (42 km to 160 km) with normal free passage should be established with specifically defined responsibilities after flight patterns have been coordinated (this would cover stratospheric balloons, dark sky stations, and high altitude platforms, among other issues)	UN General Assembly, ICAO, UNCOPUOS, and the proposed special working group in charge of space traffic management issues
Coordination plan of efforts at international level; this effort, led by ICAO Secretariat and UNOOSA, would involve consultation and coordination with ITU, UNEP, WMO, UNODA, and WHO as well as national/regional aviation safety agencies and space agencies (especially members of IADC)	UN General Assembly, ICAO, and UNCOPUOS, and other named intergovernmental bodies; national aviation safety agencies would need to designate representatives, not more than five, to discussions
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Chapter 14:
On-Orbit Servicing, Active Debris Removal, and Related Activities

The rapid development of on-orbit robotics and on-orbit servicing appears to open up a wide range of capabilities to do entirely new things in Earth orbit. This chapter thus explores the current status, emerging technical capabilities, and likely future trends in the development of space activities related to on-orbit servicing, active debris removal, and related space-based activities including the likely redeployment of satellites to new orbital locations and even the possibility of recycling parts of defunct spacecraft to create new space capabilities. Chart 1 indicates the current status of on-orbit servicing capabilities and related issues and concerns. Chart 2 examines possible new global space governance arrangements or regulatory provisions concerning on-orbit servicing.

Chart 1: Key Issues

Key Issues and Challenges Related to On-Orbit Servicing, Active Debris Removal, and Related Activities			
Issues and Challenges	**Technical Challenges (Natural and Man-made)**	**Economic, Business, and Other Challenges**	**Risks/Threat Mitigation/Equity Issues**
Servicing vehicle crashes into spacecraft intended for repair or to be repositioned to different orbit, or into other space objects, thereby creating new space debris	Accurate robotic telecommands and precision thruster systems; LEO operations and mating is much easier than for GEO orbit operations	Benefits of on-orbit servicing may be less than the economic and business risks of these operations; relative risks and benefits of LEO versus GEO	Precise contract provisions to allow on-orbit servicing and to immunize against liability for any damage would be necessary
On-orbit service vehicle might be used to disable another spacecraft or place it in a dangerous or hazardous orbit, either intentionally or inadvertently	Unless spacecraft are specifically designed for on-orbit servicing and mating, the risks of damage during capture and servicing are much higher	Benefits of on-orbit servicing may be less than the economic and business risks of these operations; relative risks and benefits of LEO versus GEO If intent was proven, economic penalties would be large; if there had been no prior agreement, penalties would still be severe	Might be prudent to only provide services to one's own spacecraft and for spacecraft designed for servicing; the risks of servicing are high Insurance coverage would likely not available until considerable experience gained
On-orbit service vehicle is actually used to disable or impair the functioning of a satellite used for national defense or military purposes	There would not be any specific technical challenge to disable a military satellite unless it had defensive mechanisms; beamed energy systems could disable a spacecraft without need of mating	Disabling a military satellite would be considered an act of war and would have severe economic and political consequences	Use of ground-based equipment to impair military systems would likely carry less risks, but the risk of military response, in space or on the ground, are presumably high
Servicing vehicle attempts repair, refuelling, retrofitting or orbital repositioning, and it fails or partially fails in its mission	Multiple points of failure, especially for on-orbit GEO servicing and orbital repositioning; electric propulsion perhaps more reliable	Without a contract allowing for immunity against liability for on-orbit operations, business risks are high; liability Convention could still apply	Risk minimization for LEO easier to achieve than for GEO; a servicing and refuelling vehicle in GEO has many risks to consider; multinational GEO servicing vehicle might reduce risk
Servicing vehicle seeks to refurbish parts from a	Many potential technical failure modes in	For similar reasons, there are also greater business risks to	Risk of such an operation are high; other functions might

defunct space object – i.e. no longer functioning spacecraft – and there is no agreement with the launching State or spacecraft operator to do so	"harvesting" activities; thus, technically, one should only work with one's own satellites and where detailed technical drawings are available	pursue "harvesting" or "de-orbit" of satellites other than one's own spacecraft	best be proven first; the concept of salvage concept under the law of the sea presumably does not apply in space
Active Orbital Debris Removal	Technical challenges much different for GEO parking orbits, MEO de-orbit, LEO above 300 km, and LEO below 300 km	Without changes to the Liability Convention provisions and "launching State" responsibilities, such salvage operations will remain very difficult	Opportunities for misunderstandings in space remain high; even if there is an explicit agreement by a State to allow the salvage of a defunct satellite, liability issues remain
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Chart 2: Possible Actions

Possible Actions Related to On-Orbit Servicing, Active Debris Removal, and Related Activities	
Type of Possible Regulatory Reform or Action	**Relevant Possible Forums**
Suggest provisions that would apply to on-orbit servicing, setting forth clear provisions to allow refuelling, servicing, repair or retrofitting, and to clearly hold party undertaking these activities "free from liability" in case of accident or misfortune; such actions would be considered legal only if explicitly agreed by the launching State or States, if applicable	- Discussions relating to International Code of Conduct for space activities - Discussions within inter-agency exchanges - Discussions within UNCOPUOS and its subcommittees - Suitable provisions for coping with orbital space debris might be included in national space laws
- Evolution of "voluntary guidelines" to build on the suggested provisions noted above - To seek broad international agreement as to how on-orbit servicing and active debris removal might be considered safe, internationally coordinated, and designed to avoid international misunderstandings	Discussions within IADC, UNCOPUOS, and consultation between UNOOSA and UNODA on new international guidelines for both on-orbit servicing and active debris removal
National space legislation setting guidelines for obtaining launching State permission and safety standards for activities in this area; such legislation could provide, for example, some mid-tier level of insurance coverage for national private entities undertaking on-orbit servicing; this legislative action might encourage the space launch industry to offer some form of insurance protection	- National legislatures and commercial space launch industry - International fora, such as SWF, IAASS or space law institutes, could help develop draft model legislation
Create channels of communications and coordination concerning activities in this area	UNOOSA (in cooperation with UNODA) and commercial mechanisms, such as Space Data Association; there could be mechanisms to share information regarding measures that might be taken in these areas
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Chapter 15:
Small Satellites and Large Commercial Satellite Constellations

This chapter address the phenomenon of the growth and deployment of CubeSat and various types of small satellites into Earth orbit. Various types of small satellites are now being deployed largely in low-Earth orbit. One of the most important trends has been the development and deployment of

low-cost small satellites for commercial purposes in large-scale satellite constellations, particularly for satellite communications and remote sensing. This chapter explores the extent to which commercial small satellite constellations might represent a "disruptive technology" that will affect the long-term future of satellite manufacturers and service. Furthermore, the potential implications of frequency interference, orbital congestion, and orbital debris, among other factors are examined. Chart 1 provides some analysis of current issues and concerns, while Chart 2 addresses possible new approaches and solutions related to improved global space governance.

Chart 1: Key Issues

Key Issues Related to Small Satellites and Large-Scale Small Satellite Constellations			
Issues and Challenges	**Technical Challenges (Natural and Man-made)**	**Economic, Business, Demographic, Health, and Other Challenges**	**Risks/Threat Mitigation/Equity Issues**
Lack of globally agreed definition of small satellites in categories of size, orbit, use, and de-orbit capabilities; the purpose would be to distinguish very low orbit student projects, which would naturally meet the 25-year de-orbit rule, from commercial systems, which need end of life active debris removal	Small satellites may have limited or no de-orbit or manoeuvrability capabilities	Commercial vehicles can be expected to meet more conditions for responsible operation, non-interference, and de-orbit responsibilities	The congested LEO orbits with small satellites possessing limited manoeuvrability capability carry higher risk of collision and, thus, create major concerns with regard to the creation of new orbital debris
Lack of different zones for different types of small satellites	It might be useful to create protected zones between small satellites with manoeuvrability and de-orbit capabilities from those that do not have such capabilities	Commercial satellites in different zones could be expected to operate differently and follow different de-orbit manoeuvres	Once deployed, the large-scale LEO constellations tend to exclude new competitive systems; is first come, first served a fair principle here?
Increase of orbital debris, especially in LEO, and the risk of the Kessler Syndrome becoming a reality	There are today some 22,000 major debris elements being tracked in LEO; the S-Band Radar Space Fence will allow tracking of some 250,000 space objects that are capable of damaging satellites and space vehicles; even meteorites are a problem as more space objects are launched	If a runaway debris event does occur, the economic consequences could be enormous and even safe access to space jeopardized; investment in active debris removal of the most dangerous non-controlled objects in orbit would potentially save billions of dollars in the future	Only a few States are responsible for today's space debris, although it puts at hazard all current and aspiring spacefaring nations

It is sometimes wrongly thought that small satellites, which are only a "trivial part" of a launch operation or are released from a space station, do not have to be formally registered or represent a liability for the "launching nation"; many small satellites are still not formally registered as required by the Registration Convention	There are no particular technical challenges here	Registration is time-consuming and exposes launching nations to potentially sizeable risk that does not require proving of "fault"	Small satellites without active or passive de-orbit capabilities pose a greater risk of creating space debris; deploying small satellite experiments on a space station and de-orbiting them, or flying a number of small satellite experiments on a multi-unit system, which could be actively de-orbited, would minimize risk and allow more States to "access" space in a safe manner
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Chart 2: Possible Solutions

Possible Actions Related to Small Satellites and Large-Scale Small Satellite Constellations	
Proposed Action	**Entities to Take Proposed Action**
Specific definition of the classes of small satellites and their orbital deployment locations to avoid interference and potential collision; this effort would be particularly focused on distinguishing student projects in very low orbits, which will meet 25-year de-orbit rule, from larger commercial systems in higher orbits requiring active de-orbit capability to meet or exceed the 25-year rule	ITU, UNCOPUOS, LTSOSA, and IADC
Efforts to undertake improved space traffic management in LEO and prioritize efforts to provide for active de-orbit of large defunct objects in LEO	ICAO, UNCOPUOS, and recommendations from a specialized Working Group of UNCOPUOS charged with space traffic management issues (this Working Group should be formed as soon as possible, be given specific due date for report with recommendations, and work with IADC)
Development of new guidelines with regard to commercial satellite constellations in non-GEO orbits; this would cover pre-launch due diligence and international coordination with respect to the launch, orbital location, priority of access, de-orbit capabilities, frequency allocation, registration, and liability provisions concerning large-scale commercial networks; these guidelines would also cover the issue of "regulation shopping" by companies seeking to deploy Mega-LEO systems so as to exploit "flexible regulations" of States not adhering to space debris guidelines	ITU Secretariat, ITU Radio Regulations Board, UNCOPUOS, LTSOSA, and two subcommittees of UNCOPUOS, plus Space Data Association (SDA) and IADC
Improved Space Situational Awareness in LEO and the Protozone to avoid collisions of space objects and vehicles or objects operating in Earth orbit and the Protozone/stratosphere	UNOOSA as mandated by UNCOPUOS under LTSOSA and UNISPACE+50 efforts (cooperation with UN Office for Disarmament Affairs (UNODA) on military issues), SDA, UNCOPUOS, and operators of major space situational awareness networks
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Chapter 16:
Space Mining and Use of Space Natural Resources

The formation of four new space companies with the stated goal of undertaking space resource recovery and the provisions of a new US law that indicate that companies could "own" natural resources that they obtained from space-based activities have raised attention with regard to the subject now known as "space mining". This has raised issues about the interpretations of the Outer Space Treaty and the Moon Agreement: how should the global space governance provisions related to efforts to reclaim natural resources from outer space – be it from the Moon, asteroids, or any other source – be interpreted? This discussion will also serve to focus on the meaning of the "common heritage of mankind" principle, when it is used with regard to outer space. This clarification of space governance provisions will also necessarily address whether the extraction of resources is the same as claiming sovereignty to celestial bodies – and indeed perhaps clarify what exactly is meant by a celestial body.

Chart 1: Key Issues

Key Elements and Issues Related to Space Mining and Use of Space Natural Resources			
Issues and Challenges	**Technical Challenges (Natural and Man-made)**	**Economic, Business, Demographic, Health, and Other Challenges**	**Risks/Threat Mitigation/Equity Issues**
How to extract, transport, and process outer space resources	Determining the safest, most efficient, and most effective method of outer space transport and resource extraction for different locations and different types of celestial bodies	High-cost technical development, past environmental and public health disasters and orbital debris, and establishing intellectual property rights to these technologies	Lack of sufficient capital to develop needed technology, safety of systems, and potential of catastrophic failures
Ability to develop other key space technologies, such as remote broadband communications, remote power sources, and telerobotic capabilities	Development of reliable, remotely located automated space capabilities	Capital investment to support such developments; establishing intellectual property rights to these technologies	Intellectual property rights protection sufficient to produce revenue streams to finance space mining; Earth-based use of these technologies in fair and equitable manner
Confusion about the interpretation of international space law treaties and need to respond to requirement to provide "for the benefit and in the interests of all countries" as well as environmental concerns	Designing systems that are safe, reliable, cost-effective, and do not cause environmental dangers or create debris	Enormous costs associated with building space mining infrastructure that is safe and environmentally sound; lack of public funds as well as lack of confidence by potential private investors	Hazardous waste from toxic chemicals plus space debris, space junk, and radioactive wastes, plus the possibility of disruption to the ecological balance of Earth and/or the Moon
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Chart 2: Possible Solutions

Proposed International Actions Related to Space Mining and Use of Space Natural Resources	
Proposed Action	**Entities to Take Proposed Action**
International discussions involving all interested States, professional space	UNCOPUOS, IISL, International

organizations, universities, directly interested companies, and various other institutions, in order to create a new global public dialogue to characterize with some precision the conditions for legally engaging in space resource exploitation activities and the benefits from such activities, and to identify mechanisms for global cooperation	Academy of Astronautics (IAA), Hague Space Resource Governance Working Group in cooperation with major space agencies and representatives of interested States with relevant technical and legal knowledge as advisors
Creation of a blue ribbon study commission to consider new international agreements or regulatory mechanisms to transcend the conflicting interests of those seeking to engage in space mining (requiring the development of new technology and great expense) and those seeking to share the benefits of space under the terms of the relevant international agreements, with the aim to establish an international regime based on the principle of "equitable sharing by all States Parties in the benefits derived from those resources", taking into consideration the technological, operational, and financial costs of space mining enterprises	UNCOPUOS, its Legal Subcommittee, IISL, International Law Association (ILA), IAA
Explore if a new confidence-building or non-binding agreement might be developed as a new protocol related to space mining that addresses environmental, public health, and property rights concerns, and create a new international regime for carrying out a process for sharing in the benefits of outer space; this process would seek to develop specific language to cover ambiguous terms and provisions that have created differences of opinion between the space entrepreneur community and the international space law community, and within the latter as well	UNCOPUOS, IISL, ILA
Identification and formal adoption of "model national space law" to provide legal guidance with regard to space mining (Such model law could address processes related to the use of natural resources from outer space in terms of space safety, environmental impacts and protections, as well as means or ways to meet actual or implied commitments to globally share the benefits of outer space; this could also be addressed in the proposed "Code of Conduct" for outer space)	UNCOPUOS, UN General Assembly, IISL, ILA, and national or regional legislative bodies
Creation of an international study process involving all interested States to see if an international taxing or benefit sharing process among nations could be agreed (Such an arrangement would need to consider the issue of major investment costs being recouped)	International study team convened as a part of the "blue ribbon committee" as noted above

Chapter 17:
Cosmic Hazards and Planetary Defence

There has been a great deal of recent scientific knowledge and measurement data obtained with regard to cosmic hazards. This has been collected from satellites monitoring solar storms and the Earth's magnetosphere, as well as satellites monitoring nuclear explosions, which also allows accurate measurement of asteroid impacts. These space-based measurements now provide much more accurate information about cosmic hazards that threaten the world's biosphere. The cumulative result of these measurements is that asteroids strikes are four times more common than previously thought. Again, the threats from solar flares and coronal mass ejections are much greater than was widely believed, and that shifts in the Earth's magnetosphere will serve to lessen the protective shielding provided by the Van Allen belts than in the past. Chart 1 provides information about these issues and concerns about cosmic hazards and the need for improved planetary defence. Chart 2 provides information about possible improvements to space governance protections and ameliorative actions.

Chart 1: Key Issues

Key Issues and Challenges Related to Cosmic Hazards and Planetary Defence			
Issues and Challenges	**Technical Challenges (Natural and Man-made)**	**Economic, Business, Demographic, Health, and Other Challenges**	**Risks/Threat Mitigation/Equity Issues**
Potentially Hazardous Asteroids and Comets	Weakening of Earth's magnetosphere	High cost of tracking and detection systems (space- and ground-based)	(i) Extreme potential destruction of urban infrastructure and massive loss of life; (ii) Asteroid defence systems and technologies can be viewed as space weapons; (iii) Unsuccessful defensive actions could expose a State to liabilities; (iv) Current international agreements to defend against cosmic hazards are generally inadequate; (v) No current agreement permits the use of UN peacekeeping forces or international resources to recover from a major asteroid strike; (vi) There are no massive insurance funds (i.e. trillions of dollars) that could be deployed to respond to a major asteroid strike
Solar flares, solar energetic particles, and coronal mass ejections from the Sun	Weakening effectiveness of Earth's magnetosphere, seasonal ozone holes in polar regions	Increased incidence of skin cancer, genetic mutations; high cost of space systems to study solar phenomena; much higher cost to develop protective systems against extreme solar weather	(i) No known means to forestall or accurately forecast extreme solar weather events or project impact of changes to Earth's magnetosphere; (ii) Techniques to forestall extreme solar events and climate change would be expensive and no globally agreed systems to finance or implement is in place; (iii) Planetary defence may require time critical response; (iv) No current agreement allows the use of UN peacekeeping forces or international resources to recover from a major solar flare event; (v) No massive insurance funds (i.e. trillions of dollars) is in place that could be deployed to respond to major solar flare event
Changes in Earth's vulnerability to these Cosmic Hazards	Earth magnetosphere could ultimately decrease to 15% of the current deflective strength of Van Allen Belt against solar storms	Spread of urban development; population growth and exposure of vital infrastructure (i.e. satellites, electric grid, electronics, and computer chips)	(i) If Earth's magnetic poles shift, its deflective strength might be greatly reduced and perhaps for hundreds of years during shift; (ii) Modern economies vulnerable to natural electromagnetic pulse (particularly satellites and electric grid) increasing every year
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Chart 2: Possible Actions

Proposed International Actions Related to Cosmic Hazards and Planetary Defence	
Proposed Action	**Entities to Take Proposed Action**
Space agencies should all explicitly adopt planetary defence as a prime strategic goal	All space agencies and national legislatures
Set up inter-agency committee of space agencies to	Inter-Agency Space Debris Coordination Committee (IADC)

address all forms of cosmic hazards including orbital space debris	should move to create a similar committee on all space hazards and planetary defence or expand the terms of reference for IADC
Space Mission Planning Advisory Group (SMPAG) and International Asteroid Warning Network (IAWN) to develop stronger procedures	SMPAG, IAWN, UNCOPUOS, and its Subcommittees
Develop new elements of an International Code of Conduct or amend language of the PPWT	- Discussion within UNCOPUOS and within CD, UNDC, UN General Assembly First and Fourth Committees; - UNOOSA and UNODA in coordination
The two improved asteroid detection infrared telescopes (Sentinel and NEOCam) should be built and launched as soon as possible	B612 Foundation and US Government/NASA
Coordinated national and international research program on cosmic hazards and planetary defence (involving potentially hazardous asteroid and comet detection, extreme solar weather, study of changes to Earth's protective systems, and new natural and human-devised protective strategies and systems against cosmic hazards)	- All national governments through legislative and budgetary action; - All relevant research institutes and laboratories around the world; - UN General Assembly and UNCOPUOS, SMPAG, IAWN, IAU, COSPAR, and professional bodies, such as International Association for the Advancement of Space Safety, IAA, and International Space University
After various studies and assessments regarding threats from cosmic hazards have been undertaken and coordinated, and after further capabilities have been developed to cope with both NEOs and extreme solar storms, UNISPACE+50 anniversary should consider, among other items, how to mitigate the risks associated with cosmic hazards – NEOs, orbital space debris, solar storms, and the weakening of Earth's magnetosphere	UNISPACE+50 Conference might consider new arrangements, goals and objects, and risk minimization and mitigation against solar hazards that might follow the precedent of UNCOPUOS Action Team 14 model, which addressed NEO hazards, now taken over by the established SMPAG and IAWN mechanisms (At its 2016 General Session, UNCOPUOS recommended an "International framework for space weather services" for adoption by UN General Assembly as one of the seven thematic priorities to be pursued through UNISPACE+50 process)
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Chapter 18:
Space Environmental Issues

The range of environmental issues in the field of space are very wide spread. This ranges from cosmic considerations, such as how to protect other planets from human virus, to much more immediate issues, such as atmospheric and stratospheric pollution if there is a significant increase in space plane flights and especially hypersonic transportation involving craft that flies at high volumes through the Protozone. Space plane flights in the Protozone may be a serious air pollution concern, but remote sensing satellites might be employed as a key way to monitor and enforce carbon based pollution to the fragile upper atmosphere of our planet. Chart 1 provides a summary of key issues and concerns related to space environment. Chart 2 provides actions that might be taken to improve global space governance in this vital area.

Chart 1: Key Issues

Key Issues Related to Space Environment			
Issues and Challenges	**Technical Challenges (Natural and Man-made)**	**Economic, Business, Demographic, Health, and Other Challenges**	**Risks/Threat Mitigation/Equity Issues**

Rocket and thruster fuels that pollute the atmosphere, or Earth, on re-entry to Earth	Some fuels, such as solid fuels, that emit particulates or gases that affect the ozone layer, or noxious fuels, such as hypergolic fuels, have key environmental concerns	There are always economic and safety trade-offs between types of rocket fuels and the environmental impacts of these fuels	Some fuels present safety and environmental dangers; migration to less polluting and dangerous fuels can reduce risk and can be achieved without great financial penalty
Increasing amount of orbital debris	Reliable means of removing defunct satellites or debris elements, such as upper stage rockets from orbit	Cost-effective, reliable, and precise operation of systems to reduce space debris from orbit is difficult and currently quite expensive	The Liability Convention does not create incentives to remove debris; debris avoidance manoeuvres themselves include risks of miscalculation; the dual-use nature of such technologies is also problematic
Introduction of invasive biological agents from space back into the Earth's biosphere	There is evidence that biological and bacteria agents that can survive in space are more virulent than Earth-based biota; decontamination of people that go into space is difficult	Absolute protection against off-*world* agents can be expensive and time consuming	The risks of a virulent bacteria lethal to all humanity is small, but the possible consequences are so severe that all reasonable precautions must be taken
Introducing invasive biological agents into planets or moons—especially where alien life forms exist or might have existed	The decontamination of space probes and isolation of life forms carried on spacecraft is difficult, must be universally enforced, and can be expensive	The search for life on other planets includes the potential health hazard of infecting humanity, but also of our probes releasing biota infecting other planets or moons	The greatest risk of this type is to do irreparable harm to an off-*world* environment where life exists
The increased level of commercial entities that are sometimes multi-national and involve transfer of ownership makes environmental enforcement via the Launching State difficult to establish and enforce	There is a challenge to keep private space entities informed of various types of environmental regulations and aware of how space operations might disturb scientific evidence	Commercial operations might be more efficient and able to produce results in space faster and more efficiently, but also could create longer term environmental problems	Risks include biological contamination, loss of scientific evidence about the formation of the Solar System, and creation of large liability claims against the launching State
The over population of Earth orbits, especially by so-called Mega-LEO networks, represents problems of equitable access to Earth orbit and elevated risk of new debris formation	The challenge is to maintain effective control of large constellations to avoid RF interference, collisions within the constellation or with other space objects and effective and safe de-orbit at end of life	There is a need for health, environmental and manoeuvrability controls without being unduly restrictive of space commerce	The risk is the achievement of the Kessler Syndrome (runway space debris) if controls are not developed with enforcement powers

The key ethical issue of space migration and colonization is essentially environmental, and if humans cannot create a sustainable Earth, should it feel empowered to engage in space migration/colonization before it has shown Earth sustainability	The challenge of environmental sustainability of Earth and Earth orbit involves overcoming pollution, resource depletion, overpopulation, clean energy, and more	Although the cost of a sustainable world economy and environment is considered to be high, a society without these capabilities cannot survive	Risk of colonization is that life on another planet cannot be sustained and another *world* will have been polluted
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Chart 2: Possible Actions

Possible International Actions Related to Space Environment	
Proposed Action	**Entities to Take Proposed Action**
Development of national environmental standards for rocket fuels, recommending international standards for rocket fuels and their use, and publishing statistics on environmental impacts of their use	National environmental agencies in coordination with national space agencies, UNCOPUOS, Inter-Agency Committees, Commercial Space Flight Federation, IAASS
Development of national programs and standards for orbital debris reduction by such means as enforcement of the end of life removal provisions, International Guidelines for active debris removal, and guidelines for manoeuvring to avoid in-orbit collisions	National Legislatures in cooperation with National Space Agencies and National Science Agencies; Inter-Agency Space Debris Coordination Committee, UNCOPUOS, COSPAR, International Academy of Astronautics (IAA), IAASS
International code of conduct for extra-terrestrial investigation and space missions that builds on the relevant provisions of the Outer Space Treaty, the Moon Agreement, and the Liability Convention	UNCOPUOS, National Space Agencies, COSPAR, IAA
Strict requirements on commercial space entities to enforce environmental protection and clear understanding of responsibilities of the Launching State	National Legislatures in cooperation with National Space Agencies and National Science Agencies plus new space companies
For the longer term, a Law of Space Environmental Protection that is in many ways equivalent to the Law of the Seas Treaty	United Nations General Assembly with assistance from relevant specialized agencies (ITU, ICAO, UNEP, World Health Organization plus UNCOPUOS, UNOOSA, and UNODA)
Some form of operating and deployment limits on the number, spacing, and types of satellites that can be deployed in Earth orbit; this would extend ITU regulatory processes to include Mega-LEO systems size and characteristics, de-orbit provisions, and penalties for noncompliance	UNCOPUOS, National administrations, ITU, COSPAR, IAA, IAASS, and space applications and launch industries
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Chapter 19:
Space Migration and Colonization

At the 2014 Manfred Lachs Conference that adopted the Montreal Declaration, there was discussion about how broad should the called for study of global space governance be. Some thought it might be better not to have an interdisciplinary study, but focus on international space law alone. Others thought that there should be a tight focus on issues of most immediate concern

rather than addressing short, medium and longer term issues. Ultimately the study participants agreed to be bold, at the risk of being overly visionary. The final study has involved scientists, engineers, space business people, and others beyond the space law community. It also has looked at longer term issues, such as consideration of the implications to global space governance that will come with efforts to create longer term space colonies and even the possibility of human's migrating to off-*world* locations. This effort is clearly more philosophical and speculative than other chapters that have a much shorter term and immediate practical implication. Nevertheless, it is thought useful to speculate on the implications that might come from efforts, such as to create a longer term colony or permanent facility on the Moon or elsewhere in outer space. There are wide differences of opinion on such issues as whether it is appropriate, legal or even moral to contemplate such actions as possibly to undertake to "terraform" Mars to make it a livable ecosystem for humans and other forms of life as we know it here on Earth. This chapter addresses some of the key issues and concerns that arise from such future actions. Chart 1 provides a listing of key issues and concerns, while Chart 2 provides thoughts on possible future actions related to global space governance in this arena of space activity, which might become of practical consideration within the two decade time horizon of this study.

Table 1: Key Issues

Key Issues Related to Space Migration and Colonization			
Issues and Challenges	**Technical Challenges (Natural and Man-made)**	**Economic, Business, Demographic, Ethical, Health, and Other Challenges**	**Risks/Threat Mitigation/Equity Issues**
Generating and applying laws	Agreeing on the rules and regulations for outer space settlement	Ensuring adapted laws promote the interests of all entities, human and extra-terrestrial	The agreed upon international laws may change at any time
International interest	Coalescing interest among various and often opposing States	Discovering the economic incentive for an international effort	If one State decides to leave/abandon the project, does it jeopardize the entire goal?
Generating interest in domestic markets for private enterprise participation	Developing economic incentives to encourage private involvement	Determining how to benefit private enterprise, but maintain "benefits for all"	Private entities begin viewing settlements only as money making enterprises and ignore scientific/evolutionary importance
Becoming multi-planetary and, as a result, perhaps contaminating Earth	Leaving Earth and establishing a settlement in outer space	Human survival in outer space in a precarious environment, but this involves potential risks to Earth	There is no insurance or financial mechanism that can effectively be used to cope with such type of risks
Dealing with potential Extra-terrestrial Life forms	Agree in advance on rules and behaviour	Consider ethical aspects in advance and as integral part of the mission planning (e.g., planetary protection)	Risk of interplanetary contamination and risk for settlers
Choosing settlers	Determining the basis upon which settlers are chosen	Determining who gets to settle outer space and how they will be representative of the species	Selecting the wrong type of settlers may jeopardize the mission or long-term sustainability of settlement
Sustainability of settlement once established	Ensuring independence from resupply missions/in situ resource acquisition	Entering into terminable contracts for supplies and ensuring redundancy if in-site acquisition fails	If initial contracts for resupply prove uneconomical, risk of private suppliers leaving resupplies unfulfilled
Lack of a breathable atmosphere or	Finding technologies that would allow	Considering whether terraforming of Mars by such means is ethical	Who would operate and control such systems and on what

farmable soil on known off-*world* locations	creating atmosphere on other solar system bodies or viable hydroponic systems	and viable in terms of health and safety	economic or governance basis?
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Table 2: Possible Actions

Proposed International Actions Related to Space Migration and Colonization	
Proposed Action	**Entities to Take Proposed Action**
Creating laws or conventions related to space settlement	An international organization that considers the interests of all States (possibly UNCOPUOS through Working Group, and possibly UNESCO through its Space Commission, taking into account their respective roles and mandates)
Reducing or removing import/export controls for settlement technology	States (e.g., US regarding ITARs) participating in settlement ought to remove barriers for cooperative technology development
Creating joint international ventures pertinent to space exploration and potential space migration (public and private)	International group or consortium (including governments and private entities) to develop technologies
Scientific research on the habitability of celestial bodies and the exploration of feasibility of creating a "sun shield" in space for Mars so as to create a "viable" Martian atmosphere	International body capable of amassing knowledge on particular celestial bodies, such as International Academy of Astronautics (IAA), COSPAR, IAU, IAASS, and ISU
Scientific research on the life support systems necessary to sustain life	International group or groups tasked with establishing technology that will make inhospitable worlds hospitable to settlers, such as IAA, COSPAR, IAU, IAASS, and ISU
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Chapter 20:
The Role of Space in Long-Term Economic Development on Earth

This chapter relates back to previous chapters, such as those related to space mining and resource utilization, cosmic hazards and planetary defence, space migration and colonization, solar power satellites, space transportation systems, and space traffic management. A fundamental question is to what extent the future growth and survival of humanity will possibly depend on future space commerce and activity. There is a wide range of thought and opinion on this subject. Such key issues for the future touch on such subjects as climate change, planetary defence against cosmic hazards, sustainability of access to vital resources and energy, and the nature of world's population in terms of its ultimate size, degree of urbanization, and dependence on various resources and infrastructure. This chapter seeks to examine key issues related to its long-term economic development and the role that space systems play in this regard. Chart 1 provides a listing of key issues and concerns. Chart 2 provides a review of possible actions related to global space governance.

Chart 1: Key Issues

Key Elements and Issues Related to the Long-Term Economic Development on Earth			
Issues and Challenges	**Technical Challenges (Natural and Man-made)**	**Economic, Business, Demographic, Health,**	**Risks/Threat Mitigation/Equity Issues**

		and Other Challenges	
The difficulty of increasing the active and direct involvement of developing States	Accessibility to space technology and space-related training as well as economic empowerment	Developing nations do not see space activities as a priority given urgent needs related to health, food, housing, security, and resource management	Most developing States are not well equipped to utilize space systems for economic development
Improving and allowing wide access to and benefit from space programs from developed to developing States	Increasing access to raw and processed/analysed satellite data and empowering developing States to be able to analyse it for their own benefit	Sensitivity of data, its pricing, and inefficient technology sharing programs	Lack of space agencies or technology transfer agencies in affected developing States
Increasing role of private actors	Revisiting and revising existing laws to be more inclusive and speak directly on the issues concerned with the role of private actors in outer space	Lack of clarity as to the meaning of "common heritage" and no practical methods for sharing resources of outer space	Different perspectives and priorities among spacefaring States, enterprises, and developing States
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Chart 2: Possible Actions

Proposed International Actions Related to the Long-Term Economic Development on Earth	
Proposed Action	**Entities to Take Proposed Action**
Resolutions and regulations aimed at increasing access to space and its benefits in the true sense of "benefit of all", including new or expanded space related training, education, and communications programs	UN General Assembly, UNOOSA, LTSOSA, International Telecommunication Union (ITU)
Actions aimed at distributing the knowledge and benefits of space resources	UN General Assembly, UNOOSA, LTSOSA
Actions aimed at increasing the sharing of space technology and economic assets between spacefaring nations and developing economies	UNOOSA, LTSOSA, ITU, new space-related economic consortia concerned with key space services
Actions aimed at the inclusion of private actors in the exploration and exploitation of space and celestial bodies	UN General Assembly, UNOOSA, LTSOSA, ITU, new space-related economic consortia concerned with key space services
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Chapter 21:
Extending the Benefits and Uses of Outer Space to All Humankind

The United Nations Sustainable Development Goals are quite challenging to achieve and space information technology systems will be key for advancing these various efforts. New space systems designed to bring Internet access to developing regions of the world may be particularly critical in this regard. Education, health-related training, and capacity-building can make tremendous progress in the world over the next two decades, and this chapter sets for how progress might be achieved and the challenges that must be overcome. Chart 1 provides a review of key issues and concerns. Chart 2 provides a listing of possible actions to improve global space governance in this area.

Chart 1: Key Issues

Key Issues Related to Extending Outer Space Benefits to All Humankind			
Issues and Challenges	**Technical Challenges (Natural and Man-made)**	**Economic, Business, Demographic, Health, and Other Challenges**	**Risks/Threat Mitigation/Equity Issues**
Difference of perspective (from the economic, political, and legal viewpoint) between early adopters of space technology and those that have yet to derive major benefit from outer space (i.e. developing States)	Exploitation of space requires a great deal of research, development, and investment in costly infrastructure and labs	"Global South" and "Global North" have different development priorities and different opportunities to derive benefits from space	There is an equity and balance issue regarding the use of outer space between early adopters "first come, first served" and those that have yet to develop space technologies and applications
Need to strengthen support for and implementing mechanisms for national and global governance of outer space	Lack of technical, legal and policy knowledge, training, and education related to the governance of outer space	Competing economic and business interests that would undermine a strong program in support of the effective governance of outer space	Lack of support for the Outer Space Treaty and the principles of shared resources of the global commons can lead to break in global consensus about effective future uses of outer space
Radio frequency allocation and use	Technology can make the use of frequency more efficient, although current users have greater opportunity to use radio frequency and orbital positions; the highest frequencies are the most expensive and difficult to use	Although the use of radio frequency in satellites for health, education, food, and economic development is key, the Global South does not have the technology or resources to effectively use satellites to the full potential and costs can be high	ITU processes seek to reserve frequencies and orbital locations, but only to some extent, for more effective use in the future
New uses of the stratosphere or the Protozone	The barriers to the use of the stratosphere (i.e. the Protozone) are not as high as for uses of outer space from developing States; some of these technologies may be optimally suited to smaller developing States	The regulation of the use of the stratosphere may require new technology and significant expenditures	Some uses of the stratosphere could be for military or defense-related purposes; some uses, such as hypersonic rocket planes, could also create air pollution risks to the stratosphere
Use of small satellites and the problem of increasing orbital debris	Many small satellites, such as CubeSats, do not have control systems for de-orbiting and can add to orbital congestion	Small satellites represent a way for developing States to participate in outer space, although controls are necessary to reduce orbital congestion; large-scale constellations of small satellites by developed States are now a greater concern	Passive de-orbiting systems or the consolidation of small satellite experiments could reduce risks; developed States deploying large constellations may reduce opportunities for Global South States to use outer space in the future, but could offer new opportunities in near-term
Space mining	Technology for space mining now concentrated in Global North	Investment capital to support space mining also concentrated in developed States	Risks of using space to replenish Earth's scarce resources delay creating a sustainable world

High investment cost and much technological development are required to achieve the benefits of space	Technology for space systems requires labs, many trained researchers, test facilities, and safety standards, which are generally not available in many developing States	Economic return on many space-based systems take many years to realize; many of the services require sophisticated customers, which are lacking in many developing States	Many space ventures are economically and technically risky and many have gone bankrupt
Space traffic control and management	The increased use of the Protozone and Earth orbital space, as well as space transport and space tourism, will likely lead to a need for space traffic management	The cost of such a system at the national and international level will be expensive and will require new international arrangements	The risks of not creating a global system for space and the Protozone are increasing all the time, and this is essential and needed for all nations to realize the opportunity of new space initiatives
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Table 2: Possible Actions

Possible Actions Related to Extending Outer Space Benefits to All Humankind	
Proposed Action	**Entities to take Proposed Action**
Develop new and open opportunities to use space communication systems to offer greater education and health care services to developing States	UNCOPUOS, UN General Assembly, UNESCO, World Health Organization, large international satellite communications systems
Initiate a new set of international discussions about sharing the benefits of space among all nations, in the context of sustainability of space that creates a new "balance" of cooperation among current and prospective users of outer space, and possible new mechanisms to allow sharing	UNCOPUOS, its Subcommittees and its Working Group on Long-Term Sustainability of Outer Space Activities (LTSOSA), UNOOSA, COSPAR
Support for the universal adoption and reasonable interpretation of the Outer Space Treaty	UNCOPUOS, UNOOSA, UN General Assembly, COSPAR, International Astronautical Congress, and IAA
Clarify the meaning, rules, and control procedures for the safe use of and free passage through the Protozone	UN General Assembly, UNCOPUOS, International Civil Aviation Organization (ICAO), ITU, and national air traffic control agencies
Adopt new mechanisms concerning the launch, registration, and de-orbit requirements of small satellites, including the 25-year de-orbit rule and the status and standing of large-scale constellations of small satellites	UNCOPUOS, Inter-Agency Space Debris Coordination Committee (IADC), and Space Data Association
Clarify the definition of celestial bodies and whether this might be determined by size or mass or other criteria (this effort could be useful to establishing terms and conditions, whereby space mining operations might remove materials from the Moon or asteroids, and the interpretation of the *res communis* principle)	UN General Assembly, UNCOPUOS, Space Mission Planning Advisory Group (SMPAG)
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Chapter 22:
Capacity-Building in Global Space Governance

The 17 goals for sustainable development set for 2030 as established by the United Nations are a useful guide to key ways that space systems can be applied to assist all humankind. It turns out that the goals for environment, social services, economic development, and sustainability are interrelated to each other and are almost universally aided by current and projected space systems

and could be aided by improved space governance. Space systems are vital to education and training, health care, tele-services, environmental improvement, economic development, and more. Global Space Governance systems, which aid in the more effective use of existing and emerging space systems, can assist in the more effective uses of space for all humankind and extend these benefits more widely and more equitably. Chart 1 summarizes some of the related issues and concerns with regard to these matters. Chart 2 indicates possible actions related to global space governance to help extend these benefits globally.

Chart 1: Key Issues

Key Elements and Issues Related to Capacity-Building in Global Space Governance			
Issues and Challenges	**Technical Challenges (Natural and Man-made)**	**Economic, Business, Demographic, Health, and Other Challenges**	**Risks/Threat Mitigation/Equity Issues**
The space industry is growing rapidly	There are few existing laws to regulate public and private space ventures, and those that do exist are unclear or are not detailed enough for current space issues	Private corporations need clear regulations; such regulations will likely define property rights, seek to prevent continued space pollution, and provide exploitation of resources, while also taking reasonable efforts to preserve the "global commons" of outer space	Without capacity-building, States will not be equipped to equitably share in benefits derived from space and space activities
The questions about the benefits of globalization or universalism in today's contentious world	Without the means to share space technology and intellectual property worldwide, the evolution of needed space systems will be slowed	Institutions of higher education are not sufficiently teaching students to address these issues	Without an adequate understanding of the issues we are faced with, we will be unable to be proactive in addressing them in decades to come
Current policymakers and lawmakers lack a full understanding of our dependence on space and future issues of concern, including the need for the sharing of international space technology and systems	Space applications and technologies are largely oriented to the social, economic, and business needs of developed economies and not those of developing States	No financial incentives or governmental support for training of new people in space technology, business applications, and governance for space in developing States	Beyond higher education, there is a lack of capacity-building for current professionals, policymakers, lawmakers, professionals, and/or executive training
There is not the same access to resources, knowledge, and space-related training in all States	Space technology development and related training is not geared to the special needs of developing States	Developing nations may not be able to prioritize education in space; institutions in developed States may not be able to fund needed new space studies to funders or budget administration	Without inclusive education, particularly through resource sharing and online education, the same few affluent States will dominate the politics of governance
Current higher education tends to be compartmentalized (aerospace scientists do not engage with political scientists or lawyers, and vice versa)	Needed policies related to intellectual property, education, and training incentives are not being developed	High schools and universities do not prioritize space studies in their budgets; faculties and schools do not engage with each other, neither within an institution, nor across institutions	Lack of interdisciplinary understanding of the issues means that solutions will only ever be partial
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Chart 2: Possible Actions

Proposed Actions Related to Capacity-Building in Global Space Governance	
Proposed Action	**Entities to Take Proposed Action**
Global clearinghouse and development centre related to current and future leaders in space governance and new space development	Higher education institutions with programs in aerospace and space policy and law, UNCOPUOS, UNOOSA through UNISPACE+50 thematic priority on capacity-building for the twenty-first century, Regional Centres for Space Science and Technology Education affiliated to UN
New investment in scholarships, student innovation, and experiences, including competitions focused on space development for developing States	Governments, higher education institutions, think tanks, UN (in particular UNOOSA in cooperation with Member States governments and institutions), and appropriate global foundations like Secure World Foundation (SWF)
Strategic public awareness campaign on a global scale with a focus on political leaders in developing States as to the need for capacity-building in space related activities for emerging economies	Governments, higher education institutions, think tanks, UN (in particular UNOOSA in cooperation with Member State governments and institutions), and related public and private entities and NGOs like SWF
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Chapter 23:
Conclusions, Consolidated Findings, and General Recommendations

The Montreal Declaration was adopted on May 31, 2014 as provided in the Appendix below. This unanimously adopted resolution reflected a rare consensus on the need to improve global space governance and to include an interdisciplinary collection of space legal experts, space scientists and engineers, business entrepreneurs, and regulators in assessing current issues and concerns related to global space systems development, operation, management, financing, and regulation. Even more importantly, it led to a globally staffed study that sought to identify problems that might be ameliorated by improved global space governance. The plan is for this study process to provide viable input to the UNISPACE+50 anniversary in 2018 on enhanced global space governance. The scope of pending space systems development, operation, planning, and regulation is much too broad for this study to have addressed all issues and identified all possible improvements in the field of global space governance.

Nevertheless, the breadth and depth of this two-year-long study process and the diversity of the people, who have participated, is such that it is hoped that the resulting "Global Space Governance: Key Proposed Actions" can serve a useful purpose in highlighting current concerns and issues. Even more so, it is hoped that the various suggested actions, which might help to improve global space governance going forward, will help to illuminate discussion of this subject around the world in the months to come. It is the sincere wish of the authors and editors that this study can contribute to setting the agenda and in defining improvements in global space governance that can be considered within the UNCOPUOS and other international forums that discuss and help to define global space governance for the coming future.

It is difficult to summarize all of the key issues and possible improvements in global space governance addressed in this book. Nevertheless, there seems to be at least seven key themes and

questions that tie all of the topics addressed in the *Global Space Governance: An International Study*. These are listed below:

1. How do we achieve a fair, equitable, and practical balance between space activities involving national governmental activities on one hand and private commercial space ventures on the other? And, how is that balance achieved and administered under an international regulatory authority and via enforcement mechanisms?
2. How do we go about clarifying the concept of a "Global Commons" when applied to outer space?
3. What principles and rules of international law can be logically and practically extended from Earthbound activities to the realm of outer space?
4. Do we need separate regulatory processes, practices, and enforcement procedures with regard to military operations, civil governmental activities, and private commercial space activities?
5. What about significant new technological trends and legal issues they give rise to in terms of regulating outer space activities?
6. Do International Specialized Agencies of the United Nations as well as International Intergovernmental Organizations around the world need enhanced authorities to cope with the new era of space commercialization and expanded off-world industries and commerce?
7. Will military and strategic considerations involving the primary space powers become the determining factor in developing international regulatory processes for outer space activities?

Conclusion and the Way Forward

These are but a few of the challenging questions to be considered in relation to designing an appropriate model of governance for future space activities that will continue to be explored in coming decades. This book and its enumeration of issues and concerns as well as its tables that set forth recommended actions, and potentially helpful actions, we hope, will be seen as a positive step forward in this process.

Appendix
Montreal Declaration – Adopted on May 31, 2014

The 2nd Manfred Lachs International Conference on Global Space Governance, held at McGill University, in Montreal, Canada, on 29-31 May 2014:

Having brought together over 120 experts from 22 countries (space-faring and non-space faring nations) involved in various aspects of space activity and regulation;

Having served as an objective venue for the conduct of international and interdisciplinary deliberations on different aspects and perspectives of global space governance;

Recognizing that the current global space governance system that was created during the 1960s and 1970s has not been comprehensively examined by the international community since its establishment;

Recognizing that the concept of global governance is comprehensive and includes a wide range of codes of conduct, confidence building measures, safety concepts, international institutions, international treaties and other agreements, regulations, procedures and standards;

Noting that numerous developments have occurred in the world in general, and the space sector in particular, with serious implications for current and future space activities and for the sustainable use of space for peaceful purposes for the benefit of all humankind (i.e. the global public interest in outer space);

Believing that the time has come to assess the efficacy of the current regime of global space governance and to propose an appropriate global space governance system that addresses current and emerging concerns;

HEREBY resolves by consensus to:

- call upon civil society, academics, governments, the private sector and other stakeholders to consider establishing a Working Group to prepare for and convene an international conference to deliberate and agree upon recommendations to governments and relevant international organizations aimed at the establishment of a global governance regime for peaceful and sustainable space exploration, use and exploitation for the benefit of all humankind;

- ensure that the proposed international conference is held as soon as possible with global participation by all key stakeholders (i.e., state and non-state actors) including: international intergovernmental organizations; relevant regional organizations; non-governmental organizations; appropriate state ministries (departments) and space agencies; academic institutions; appropriate commercial enterprises; and concerned individuals;

- call upon the McGill University Institute of Air and Space Law to take the lead in initiating, completing and broadly distributing through all forms of media, an international interdisciplinary study that examines drivers of space regulations and standards prior to, and in support of, the proposed international conference, targeting a global audience;

- ensure that the above-mentioned study examines, inter alia:

(i) changing global economic, political and social conditions and space infrastructure dependence;
(ii) identification and assessment of all known space threats;
(iii) space opportunities and the need for sustainable and peaceful use, exploration and exploitation of space for all humankind;
(iv) safety, technical and operational gaps to be filled; and
(v) appropriate space governance standards, regulations, arrangement, agreements and institutions relevant to current and emerging issues of space activities.
