SPACE SUSTAINABILITY GOVERNANCE AND THE SPACE DEBRIS CASE: A STUDY OF EPISTEMIC COMMUNITIES' INFLUENCES OVER INTERNATIONAL POLICY COORDINATION

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Abstract

The onset of the space age in the 1950s opened the way to a formidable growth in space activities. From the 1980s, more nations and commercial entities started to join, and many developments occurred in the space sector. The past decade has seen a significant transformation of the traditional space system with an even larger increase of space users both governmental and private, pursuing security and commercial interests. This evolution has generated increased threats to the sustainability of the space environment and its use as it became more crowded and contested. A fast-growing trend has been observed with growing mega constellations and counterspace capabilities developments generating new uncertainties and affecting all space stakeholders and citizen on Earth. This rapidly changing environment calls for policy evaluation to ensure its sustainability.

Considered one of the major threats to space sustainability, this study focusses on space debris. As a debris policy evaluation, it provides a historical look at debris governance since the 1970s. Using an innovative international relations' framework drawing upon Peter Haas' seminal work on epistemic communities, and Thomas Weiss and Ramesh Thakur's work on global governance, the thesis assesses global governance progress and epistemic communities' involvement in debris governance as indicators of space sustainability progress. This progress is evaluated according to knowledge, normative, policy, institutional and compliance gaps forming the basis of a global governance regime. Several epistemic communities' involvements are explored, especially the Debris Mitigation and Long-Term Sustainability groups, with some involvements from the Arms Control group. The framework considers the dynamics of these communities' involvements and shared ideas as knowledge in shaping the debris global governance rules and system.

The research findings confirm the pluri-epistemic involvement of the three proposed groups and their crucial role as enablers of the emergence and consolidation of global space debris governance. It clarifies epistemic communities' dynamics and provides more detailed assessment of the global governance progress achieved. Specifically, the study highlights the essential role played by the Debris Mitigation group as catalyzer of the emergence and evolution of a debris regime based upon international and national debris mitigation instruments. The study also reflects on how this Debris Mitigation group benefitted from the earlier Arms Control groups' influence on basic space governance rules, and how in turn the Debris Mitigation group enabled the emergence of the Long-Term Sustainability group further consolidating the regime with additional debris-related instruments. The study explores epistemic influences over debris governance from the emerging phase in the 1970s and consolidating phases until present days as phases of evolution in debris governance. The "emerging" phase analyses early debris instruments and the "consolidating" phase explores comprehensive debris instruments and additional supporting initiatives as well as the growing role of private entities in the governance process especially under the NGO-level. The thesis also confirms that cooperation was possible even when national security interests are at stake and that the increase of the number of actors provided an opportunity for debris global governance progress. This empirical study offers robust elements for the constructivist approach to global governance analysis.

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ACRONYMS

ABM	Anti-Ballistic Missile
ASAT	Anti-Satellite
ASI	*Agenzia Spaziale Italiana*, the Italian Space Agency
BNSC	British National Space Center, now the United Kingdom Space Agency (UKSA)
CNES	*Centre National d'Études Spatiales*
CCSDS	Consultative Committee for Space Data Systems
CD	Conference on Disarmament
CNES	*Centre National d'Études Spatiales*
CONFERS	Consortium for Execution of Rendezvous and Servicing Operations
COSPAR	Committee on Space Research
CSAGI	*Comité Spécial de l'Année Geophysique Internationale*
DLR	*Deutsches Zentrum für Luft und Raumfahrt e.V* (DLR), the German Space Agency
DOD	Department of Defense
EEAS	European External Action Service of the European Union
EC	European Commission
ECOC	European Code of Conduct for Space Debris Mitigation
ECSS	European Coordination on Space Standardisation Initiative
EDMS	European Debris Mitigation Standard
ENMOD	Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques
EOL	End-Of-life
ESA	European Space Agency
ESOC	European Space Operations Center of ESA
EU	European Union
GEO	Geostationary Earth Orbit
GGE	Group of Governmental Experts
IAA	International Academy of Astronautics
IAC	International Astronautical Congress of the IAF
IADC	Inter-Agency Space Debris Coordination Committee
IAF	International Astronautical Federation
IAASS	International Association for the Advancement of Space Safety
ICOC	International Code of Conduct
IGY	International Geophysical Year
ILA	International Law Association
ISAS	Institute of Space and Astronautical Science of Japan, merged under JAXA
IISL	International Institute of Space Law
ISTS	International Symposium on Space Technology and Science
ISO	International Organization for Standardization
ITU	International Telecommunication Union
JAXA	Japan Aerospace Exploration Agency
JSASS	Japan Society for Aeronautical and Space Sciences

LEO	Low Earth Orbit
LTS	Long-Term Sustainability of Space
NAL	National Aerospace Laboratory of Japan, space institution merged under JAXA
NASA	National Aeronautics and Space Administration
NASDA	National Space Development Agency of Japan, merged under JAXA
NATO	North Atlantic Treaty Organization
NGO	Non-Governmental Organization
NORAD	North American Air Defense Command
OOS	On-Orbit Services
OST	Outer Space Treaty
PAROS	Prevention of an Arms Race in Outer Space
PMD	Post-Mission Disposal
PTBT	Partial Test Ban Treaty or Treaty on Banning Nuclear Weapons Tests in the Atmosphere, in Outer Space and Under Water, also known as Limited Test Ban Treaty (LTBT)
RKA	Russian Space Agency, predecessor to ROSCOSMOS
ROSCOSMOS	Russian Federal Space Agency, also State Corporation for Space activities
RPO	Rendezvous and Proximity Operations
SALT	Strategic Arms Limitation Talks
SDA	Space Data Association
SSA	Space Situational Awareness
SSC	Space Safety Coalition
SSR	Space Sustainability Rating
STSC	Scientific and Technical Subcommittee of the UNCOPUOS
SWF	Secure World Foundation
UCS	Union of Concerned Scientists
UNCOPUOS	United Nations Committee on the Peaceful Uses of Outer Space
UNGA	United Nations General Assembly
UNIDIR	United Nations Institute for Disarmament Research
UNISPACE	United Nations Conference on the Exploration and Peaceful Uses of Outer Space

Table of Contents

1. INTRODUCTION

1.1 Background

Recent years are showing signs of disruption in the space system with rapid changes in the number of stakeholders. Several types of newcomers are joining the space community. On the one hand, the number of space-faring nations is growing; on the other hand, the number of commercial actors is expanding. These developments brought about by the increased use of space technology in support of strategic activities, by the *New Space* phenomenon involving new types of companies with new business models, and by some "outsiders" are changing the dynamics of the space economy. They are exerting pressure on the space environment threatening the sustainability of space activities with increasing space debris proliferation.[1] Some challenges concern space security with an increasingly contested use of space observed in the developments and testing of counter-space capabilities.[2] New satellite operators deploy mega constellations of small satellites greatly increasing orbital traffic and with sometimes non-maneuverable simpler design. Also, sometimes actors have different understandings of the rules of behavior in space operations, thus also adding to the risks of on-orbit collisions and debris proliferation, making existing and future space operations more difficult.

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[1] On the challenges brought by the *New Space* commercial actors disrupting the "traditional" space economy see Alessandra Vernile, "The Rise of Private Actors in the Space Sector", ESPI Reports, *Springer Briefs in Applied Sciences and Technology* (Vienna: European Space Policy Institute and Springer, 2018), doi:10.1007/978-3-319-73802-4.

[2] Brian, Weeden and Victoria Samson, "Global Counterspace Capabilities: An Open-Source Assessment" *Secure World Foundation*, April 2020, https://swfound.org/media/206955/swf_global_counterspace_april2020.pdf (accessed March 31, 2020).

These changes in the space domain create new uncertainties and call for further policy analysis of current space governance mechanisms to ensure a sustained, safe and secure use of and access to outer space, as well as to support of sustainable activities on Earth. There is an increasing global awareness that the sustainability of the planet and meeting the Sustainable Development Goals (SDGs) defined under the United Nations requires space assets,[3] and will need increased protection against space debris and the ensuring of space sustainability.[4]

There are 17 SDGs, one of which is international peace. As reiterated by Michael Sheehan and other IR scholars, space has been linked to international politics and defense politics since the beginning of the space age.[5] Satellites were used as support to strategic military information support since the early days of the space age, for reconnaissance information gathering for instance. What has been changing especially since the 2010s and over the past few years who saw the resuming of space "weaponization" concerns is not that space is becoming "militarized", rather, that it is being used for an increasing number of military support functions by an increasing number of countries other than the small club of space powers from the early space age. Space activities have increasingly been used as support for additional military support functions other than intelligence, such as for example

[3] Simonetta Di Pippo, "The contribution of space for a more sustainable earth: leveraging space to achieve the sustainable development goals". *Global Sustainability* 2 no.3(2019), 1–3; and Agnieszka Lukaszczyk, "Want to Achieve the Sustainable Development Goals? Invest in Big Data and AI", *The EU Parliament Magazine Opinion Plus* (June 29, 2019) https://www.theparliamentmagazine.eu/articles/partner_article/planet/want-achieve-sustainable-development-goals-invest-big-data-and-ai (accessed June 3, 2020).
[4] At the World Economic Forum level: "The 2020 SpaceNews Awards winners," *SpaceNews Editor*, (December 14, 2020), https://spacenews.com/the-2020-spacenews-awards-for-excellence-and-innovation-winners/ (accessed February 27, 2021).
[5] Michael, Sheehan, *The International Politics of Space* (London/New York: Routledge, 2007), 2 ; Bowen Bleddyn, *War in Space: Strategy, Spacepower, Geopolitics* (Edinburgh: Edinburgh University Press, 2020).

in support of terrestrial military operations especially for navigation and guidance. While space technologies have been central for ensuring international strategic stability since the early space age,[6] starting from the first Gulf War, the military support uses have dramatically increased by a growing number of states, besides the growth of space applications uses for many other benefits of society including many sustainable development goals. Therefore, the disruption of space assets through space debris collision especially the treaty verification satellites known as National Technical Means (NTMs) protected since the 1960s and 1970s, or the satellites providing command and control used for nuclear war prevention, could trigger a security dilemma or potentially an all-out nuclear war,[7] making space debris a notably pressing issue in contemporary international politics. The potential security dilemma resulting from each state's attempt to increase its own security results in higher overall insecurity, due to the perception of hostile behaviors by the other states.[8]

Over the past years, besides the increased space assets vulnerability due to their growing strategic uses by nations, space activities have also increasingly enabled economic development and supported many other activities on Earth. The commercial sector investments have increased astronomically especially this past decade making debris interference and risks of loss of service of expensive space assets a very pressing issue. These uncertainties for commercial operations besides national security purposes further fuel the demand for upgrading space governance, towards more detailed rules adapted to the new

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[6] Thomas Graham, *Common Sense on Weapons of Mass Destruction* (Seattle; London: University of Washington Press, 2004), 103.
[7] As UK Ambassador Aiden Liddle reminded at the Conference on Disarmament in a space security webinar by the Secure World Foundation on December 8th, 2020.
[8] Sheehan, The International Politics of Space, 8.

context. The commercial space activities' evolution is another source of demand for debris policy analysis.[9] Compagnies such as satellite operators and associations representing their interests such as industry associations get more involved in space sustainability initiatives and in the space governance and debris governance process, further calling for global governance analysis, especially for looking into the variety of non-state actors and their roles in the process.

Ensuring the continuation of space activities understood as space sustainability therefore represents an important global issue as it is affecting all stakeholders of the planet. Adequate policies and governance mechanisms are needed and require international and if possible global cooperation to tackle the main sources of changes and uncertainties in the space environment, namely the increasing counter space capabilities and mega-constellations developments. The threat of counter-space capabilities developments such as anti-satellite weapons developments and testing have been recognized by space security and space debris experts as significant sources for debris-proliferation and misinterpretation of intent, and likely to cause international instability and even space wars.[10] Also the increasing security

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[9] On the types of commercial space actors, various categories of "space industry stakeholders" are defined by the Space Safety Coalition as follows: associations and foundations, consulting and analytical services, providers of flight safety, space situational or space traffic management data, launch providers, manufacturers of spacecrafts or parts, governmental operators, commercial operators, orbital service providers for RPO and OOS operations, disposal service providers, insurers, system, and tools suppliers. *Space Safety Coalition Best Practices* Agreement, p 4, https://spacesafety.org/best-practices/, (accessed February 28, 2021).

[10] Brian, Weeden. "Through a glass, darkly: Chinese, American, and Russian anti-satellite testing in space," *The Space Review*, March 17, 2014, http://www.thespacereview.com/article/2473/1 (accessed June 16, 2020). GGE report 2018-2019 1st Session of the Group of Governmental Experts on the Prevention of an Arms Race in Outer Space, Geneva (August 6, 2018), Trends and Developments in Space Security, CSIS Counterspace studies 2018,2019, 2020, SWF Counterspace Samson and Weeden 2018-2019 and 2020 reports. Harrison, T., et al. (2019). "Space Threat Assessment", *CSIS*, https://aerospace.csis.org/wp-content/uploads/2019/04/SpaceThreatAssessment2019-compressed.pdf#page=40 (accessed November 20,2020).

tensions over the last decade have led to the resuming of anti-satellite weapons tests (ASAT) and more recently even to the emergence of space "force" concepts and military re-organizations to keep up with national defense demands and for some even to prepare for possible space warfighting. Major space-faring nations, the United States, France, and Japan[11] have recently updated their military forces organizations to prepare for what the North Atlantic Treaty Organization (NATO) recognized as the next warfighting domain.[12] The United Kingdom also recently announced its own space command as part of recent upgrades in its strategic policies in response to these changes in the global security environment. As explained by Ambassador Liddle to the CD, the increasing vulnerabilities of space assets amid a recognized rise in the lack of trust between major, medium, and emerging space powers at the international level motivated the UK proposal for a UN resolution towards building more TCBMs.[13]

The threats of mega-constellations of satellites and associated decupled risks of collisions in Earth orbits including in the protected regions of LEO where most of these constellations

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Brian Weeden and Victoria Samson, "Global Counterspace Capabilities: An Open-Source Assessment", Secure World Foundation (SWF) (April 2019) https://swfound.org/media/206406/swf_global_counterspace_april2019_web.pdf (accessed April 20, 2020).

[11] US space force 2019, French space force 2019 and Japan 2019; Xavier Pasco, "A new French Space Command, *Observer Research Foundation Monitors' Space Alert series*, Volume VII, Issue 4, September 2019, https://www.orfonline.org/research/space-alert-volume-vii-issue-4-56195/ (accessed January 31, 2020); Yamagushi, M., "Japan reveals plan for space defense unit", Defense News, January 21st, 2020. https://www.defensenews.com/space/2020/01/21/japan-reveals-plan-for-space-defense-unit/ (accessed January 30, 2020). It is important to distinguish the choices of rhetoric between the US Trump administration and others. The US space force seeks dominance, while in other nations they are responses to the worsening of the security conditions and more of a preparation for defending themselves sin case of a space war and not a will to dominate the space domain.

[12] London Declaration Issued by the Heads of State and Government, meeting of the North Atlantic Council, London (December 3-4, 2019), Press Release issued on 04 Dec. 2019. https://www.nato.int/cps/en/natohq/official_texts_171584.htm (accessed, December 9, 2020).

[13] Reducing space threats through norms, rules, and principles of responsible behaviours, https://www.un.org/ga/search/view_doc.asp?symbol=A%2FC.1%2F75%2FL.45%2FRev.1, (accessed December 9, 2020.)

are launched or planned to be launched is also increasingly recognized by experts as representing a similar risk if not an even greater risk for debris proliferation than anti-satellite weapons tests.[14]

Both trends of increasing security and safety pressures threatening space sustainability with potential large debris proliferation risks call for an assessment of space debris governance. As reminded by Kazuto Suzuki, these risks affect all space stakeholders and everyone on Earth.[15] Whether regarding military, civilian or commercial users, and also for developed or developing nations, everyone on Earth can be affected from disturbances of space assets. The responsible use of space and the key debris issue within it is a truly a "global" issue area. Therefore, there is a need to address space debris policy evaluation as a global governance issue.

This study understands the concept of space sustainability as defined by the working group on the long-term space sustainability of outer space activities chaired by Peter Martinez at the United Nations, known as the LTSWG.[16] The group formed under the Committee on the Peaceful Uses of Outer Space (COPUOS) presents long-term 'space sustainability' as:

> "the ability to maintain the conduct of space activities indefinitely into the future in a manner that realizes the objectives of equitable access to the benefits of the exploration and use of outer space for peaceful purposes, in order to meet the needs

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[14] Confirmed by several interviews, including Walter Flury and Holger Krag at IAC Bremen 2018, and Jana Robinson in 2020.

[15] Kazuto, Suzuki. "The role of international organisations for the fair and responsible use of space". *Studies in Space Policy* in Rathgeber, Wolfgang, Schrögl, Kai-Uwe, Williamson, Ray A. (Eds.). *The Fair and Responsible Use of Space: An International Perspective* (Vienna: Springer, 2010).

[16] Long-Term Sustainability Working Group (LTSWG) is also sometimes called LTSSA "Long Term Sustainability of Space Activities" in its early years.

of the present generations while preserving the outer space environment for future generations."[17]

The space domain has been encountering various types of threats since the early days of spaceflight, yet over the past decade threats to space sustainability have dramatically increased resulting in a much more congested and contested outer space and calling for improved space governance mechanisms.[18]

The largest and most urgent threat to the sustainable use of the space environment has been identified as space debris, sometimes referred to as 'orbital' debris, while the other threats are space weather, near-earth objects, and radio frequencies interferences. Figure 1-1 presents the magnitude of the orbital debris population and its increasing size over the years.

Space debris is defined as all man-made objects, including fragments and elements thereof, in Earth orbit or re-entering the atmosphere, that are non-functional.[19] The objects can be non-operational spacecrafts, derelict launch vehicle stages also called rocket stages or upper stages, fragmentation and mission-related debris, from sizes ranging from diameters of a few millimeters to a few meters. Mission-related debris are considered those resulting

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[17] A/AC.105/2018/CRP.20, Peter Martinez, "Conference room paper by the Chair of the Working Group on the Long-Term Sustainability of Outer Space Activities", 27 June 2018, 2.

[18] Todd Harrison, Kaitlyn Johnson, and Thomas G. Roberts (2018). "Space Threat Assessment 2018", Centre for Strategic and International Studies (CSIS). https://aerospace.csis.org/wpcontent/uploads/2018/04/Harrison_SpaceThreatAssessment_FULL_WEB.pdf (accessed September 19th, 2018); Space Threat Assessment 2019, https://aerospace.csis.org/wp-content/uploads/2019/04/SpaceThreatAssessment2019-compressed.pdf#page=40, and https://www.csis.org/analysis/space-threat-assessment-2020 (accessed April 30, 2020).
Brian Weeden and Victoria Samson, (2018, April). "Global Counterspace Capabilities: An Open-Source Assessment". Secure World Foundation (SWF), available at https://swfound.org/media/206118/swf_global_counterspace_april2018.pdf (accessed September 19th, 2018).

[19] Definition of the Inter-Agency Space Debris Coordination Committee in its guidelines the "IADC Space Debris Mitigation Guidelines" first adopted in 2002, https://www.iadc-home.org/documents_public/view/id/82#u (accessed November 10, 2020).

from the launch phase or satellite deployment processes, such as sensors, engine covers, straps, springs, or even during extra-vehicular activities such as screws among other pieces.

Fragmentation debris are those resulting from explosions or collisions occurring in outer space due to solar activity overheating left-over fuel in tanks, or intentional destructive activity such as anti-satellite tests with kinetic vehicles (missiles launched from the ground and hitting and destroying objects in orbit), or accidental collisions between satellites. Satellite sizes can range from a few kilograms to several metric tons.

Collisions or explosions generate hundreds of large debris and thousands of smaller pieces whose velocity of a few kilometers per second induce significant damage. Current space debris estimates as at 2012 range from 13 000 debris larger than 10 cm in diameter, 300 000 debris of diameters between 1 and 10 centimeters and millions of orbital debris smaller than 1 millimeter which can still cause serious damage. Table 1-1 illustrates various space debris categories. Also, the lifetime of orbital debris varies greatly according to the altitudes where they occurred. They can be short-lived debris, with possibilities to be dragged down back to the Earth's atmosphere usually when created near 200km, or they can be long-lived debris when occurring higher, lasting decades or centuries as shown in Table 1-2.

The space debris stakeholders and policy system include many actors at various levels, the major ones being space-faring states and the commercial entities falling under their jurisdictions, international governmental and non-governmental organizations, and the public. As the space debris issue literary affects everyone both in Outer Space and on Earth, there is a number of stakeholders. Firstly, due to space physics, everyone who operates space assets in orbit can be suffering from debris harm, as well as those who benefit from the operations back on Earth can be affected directly or indirectly from the loss of service, as well as by re-entry of orbital debris potentially causing physical damages on the ground. Consequently, as a global issue, the debris system involves a whole range of actors in its policy process, which is the focus of this research.

Figure 1-4 gives an overview of the space governance system affecting debris policy.[20] The space debris policy or governance system is composed of nations, international governmental organizations under the United Nations, international non-governmental organizations involving civil society and commercial entities, and individual experts involved as transnational actors in this global governance system. At the international governmental level, the debris policy system is composed of the general space governing bodies under the United Nations system shaping space treaties, resolutions, recommendations, and guidelines such as in COPUOS and ITU. Another intergovernmental body, the Inter-Agency Space Debris Mitigation Coordination Committee (IADC) issues guidelines. The International Organization for Standardization (ISO) is also part of the debris governing structure, with its main space debris standard and deriving family of sub-standards, and as a non-governmental organization. Various other non-governmental organizations are also composing the space debris governance system. These include federations, institutes, associations of professionals, industry associations, or mixed membership associations involving industry, government, civil society sometimes together. These new types of organizations are involved in debris governance with initiatives producing additional

[20] Figure 1-4 is sourced from the "IAA Position Paper on Space Debris Mitigation, Implementing Zero Debris Creation Zones", (October 2005/ ESA SP-1301), 11.

instruments, often shaped as best practices agreements, sometimes especially for industrial operations, sometimes as policy statements. Such examples include, among others, the International Association for the Advancement of Space Safety (IAASS), the Space Data Association (SDA), the Space Safety Coalition (SSC), the Consortium for Execution of Rendezvous and Servicing Operations (CONFERS), the Space Sustainability Rating (SSR) mixed consortium of academia, government and commercial initiative under the World Economic Forum, the International Law Association (ILA), and the Outer Space Institute (OSI).[21] National policies are also shaped involving space agencies and standardization bodies as observed in Figure 1-4.

This dissertation's analysis of the space debris policy process encompasses a larger understanding of debris mitigation efforts and includes both the mitigation and early remediation aspects. "Mitigation" is defined by the IADC as "all efforts to reduce the generation of space debris through measures associated with the design, manufacture, operation, and disposal phases of a space mission." While "remediation" or "space debris environment remediation" consists of efforts to manage the existing space debris population through active space debris removal (ADR) with emphasis on densely populated orbital regions", which are currently the Low Earth Orbit (LEO) and Geostationary Earth Orbit (GEO) regions.

As of November 2020, the largest accidental debris-generating orbital "fragmentation" was the *Cosmos* 2251/*Iridium* 33 collision in 2009 in LEO creating thousands of long-lived

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[21] Other examples include the Stimson Model Code, or the ASAT-Ban Treaty proposed by the Union of Concerned Scientists (UCS) also covering space debris aspects.

debris pieces as illustrated in Table 1-3. The longer the debris pieces stay in a crowded orbit, the longer the threat of orbital collision remains with other debris pieces, with defunct satellites also counting as large debris, or with operational satellites. The mega-constellations of hundreds and even thousands of satellites being developed and launched right now mostly also in LEO are significantly decupling these collisions risks in protected orbits. There are two Earth orbits identified as ‘protected orbits’ by the Inter-Agency Space Debris Coordination Committee’s (IADC) guidelines, which have in turn been adopted by the United Nations and cover about 90 % of spacecraft operations. The first region is the Low Earth Orbit (LEO) protected region, extending from the lowest maintainable orbital altitude up to a height of 2,000 km above the surface of the Earth, in red in Figure 1-5. The second region is the Geosynchronous Orbit also known as Geostationary Earth Orbit or Geosynchronous Equatorial Orbit (GEO) is another protected region located at an altitude of 35,786 km including a volume of plus minus 200 km, and inclination lower than 15 degrees in blue in the Figure 1-5.

The starting assumptions in this doctoral study on space debris governance are that global governance would help improve the situation and reduce debris threats overall strengthening space sustainability. Yet no global authority exists to govern the debris issue per se with verification mechanisms and powers and funding to monitor and manage violations. Still elements of a debris regime have emerged on a voluntary basis, and governance progress did occur to some extend and resembles a global governance model, helping to ensure space sustainability. While there is no agreed definition of global governance yet, there are several understandings, some stressing the need for and merits of a world government, others looking at governance mechanisms to govern global issues such as international regimes. The conceptualization of global governance in this study considers the emergence of governing mechanisms in the absence of a dedicated institution, “governing a global issue without a devoted global governing body”. Indeed, the governing mechanisms in place for tackling the global debris issue are characterized by their mostly voluntary nature and the absence of a global authority equipped with the mandate and resources to direct and implement an international response to the debris problem. Some elements of a debris regime have emerged in the form of basic elements of space law, guidelines, codes of conduct, best practices agreements, yet a binding regime is still work in progress.

The study focusses on international governance and cooperative mechanisms and the role of epistemically constructed ideas and their carriers as “epistemic” or “knowledge expert” group dynamics, exploring a constructivist outlook in international relations studies. Unlike the realist and liberal strands focusing on states as main actors of the international system and on state interests to explain international relations, constructivism considers the role of ideas and individuals and their collective influence in socially constructing the governing system shaping states’ identities, preferences, interests ultimately influencing cooperative behaviors and international policy responses to global issues.

1.2 Objective, Research questions and significance

The objective of this research is threefold. Primarily, this study aims to provide a comprehensive view of space debris policy emergence and developments as a pressing global issue affecting all space and non-space stakeholders back on Earth. Secondly, this study explores the influence of key actors in the debris governance process such as the epistemic communities of "knowledge experts". Thirdly, this research proposes to evaluate the contribution of debris governance to ensure the long-term sustainability of outer space.

In order to reach its objective, the thesis aims to answer the following research questions:

Q.1 Which community or communities have been involved in debris governance?

Q.2 Where and how did epistemic influences occur in debris governance?

Q.3 Was international policy coordination possible despite the national security component of the space debris issue?

Q.4 Did the increasing number of space stakeholders allow the emergence of cooperation and progress in debris governance?

The research is qualitative, and its framework is assessing progress in debris governance. It explores the space debris governance as a form of "global governance", by evaluating its progress using five global governance gaps. The progress is understood as steps achieved in filling these global governance gaps enabling a global debris regime emergence and consolidation. The framework uses an innovative combination of these governance gaps and of epistemic communities' contributions to fill these gaps. The study explores epistemic communities' involvement as enablers of these governance steps and forces catalyzing debris governance progress, as further explained in chapter 2.

The significance of this thesis is to provide an empirical account of specifically non-state actors as epistemic "knowledge experts" in debris governance, to highlight changes in space governance and debris governance towards more "global" governance and greater involvement especially of the commercial sector, and to measure levels of progress towards space sustainability in an innovative way. This study brings a complementary approach to space governance and international space cooperation overwhelmingly concerned with state and intergovernmental state-centric approaches, especially in the debris issue which has a strong national security dimension.

2. LITERATURE REVIEW AND ANALYTICAL FRAMEWORK

2.1 Literature review

This section presents interesting space literature mostly found touching upon the epistemic model in the study of space cooperation, with a few examples applying the epistemic concept in other cases than debris, while one recent study examined epistemic influences in the space debris case.

Some interesting space literature was found addressing the limits of achieving international cooperation and global space governance to ensure space sustainability due to conflicting national interests and gain calculations, providing a good basis for analyzing debris governance mechanism.[22] Yet it is not focusing on the actors of that governance or the epistemic experts.

Within the scarce space policy literature addressing space debris governance and mentioning the epistemic model, an environmental space law study by Lotta Viikari

[22] Eligar Sadeh. "Obstacles to International Space Governance", In: Schrögl Kai-Uwe, Hays Peter, Robinson Jana, Denis Moura and Christina Giannopapa (eds) *Handbook of Space Security* (New York: Springer, 2015). Nancy Gallagher, "International cooperation and space governance strategy", In: Sadeh E (ed) *Space strategy in the 21st century: theory and policy* (Routledge, New York, 2013).

acknowledges the important role of epistemic communities as facilitators of environmental issues' cooperation within international organizations, such as epistemic groups facilitating coordination around the debris issue at the United Nations Committee for the Peaceful Uses of Outer Space (COPUOS), providing a basis for further research.[23]

Another work by Moltz supports the case for the existence and influence of epistemic groups in arms control efforts affecting outer space and the debris issue around a case of Anti-Satellite testing (ASAT) in the 1980s.[24] Mutschler offers a detailed analysis of an arms control epistemic influence around the emergence of the Anti-Ballistic Missile Treaty (ABM Treaty), also acknowledging the existence of a preliminary epistemic influence also providing a basis for further research.[25] Mutschler's work mostly uses a game theory approach.

Some additional space literature addressing debris governance and cooperative efforts has been found on bottom-up approaches. Even though these works do not apply nor mention the epistemic model, these bottom-up concepts are closely related to and thus support the hypothesis of epistemic influence in debris governance efforts.[26] Other reflections on the IADC model as well as some historical analyses of debris mitigation initiatives provide

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[23] Lotta, Viikari, "Time is of the Essence: Making Space Law More Effective". *Space Policy* 21 (February 2005): 1-5; *The Environmental Element in Space Law: Assessing the Present and Charting the Future*. Studies in Space Law, Vol. 3 (Martinus Nijhoff Publishers, Leiden/Boston, 2008).

[24] James Clay Moltz, *The Politics of Space Security: Strategic Restraint and the Pursuit of National Interests* (Stanford, CA: Stanford University Press, 2019 third edition); Kessler, "A Partial History of Orbital Debris: A Personal View," (1998), 10-11.

[25] Max M. Mutschler, Arms Control in Space: Exploring Conditions for Preventive Arms Control (Basingstoke; Palgrave Macmillan, 2013).

[26] Gérard Brachet, "Long Term Sustainability of Outer Space Activities in United Nations Institute for Disarmament Research (UNIDIR)", Security in Space: The Next Generation Conference Report 31 March -1 April 2008; Darren S. McKnight, "Track two diplomacy: An international framework for controlling orbital debris," *Space Policy* 7, 1 (February 1991): 13–22.

additional evidence of transnational knowledge experts influences and another basis for applying the proposed epistemic framework.[27]

Additionally, some space literature on the epistemic model and its merit for space cooperation has been found covering other cases than orbital debris especially space science cooperation examples with the Halley Comet in the 1980s and space cooperation for civilian scientific projects such as early European space cooperation. Firstly, Sadeh, Lester, and Sadeh, present epistemic communities influences and policy outcomes as catalyzers for international cooperation, with an example of epistemic communities influences for cooperation in areas not related to national security aspects such as scientific data exchanges for an astronautical event.[28] Sadeh, Lester and Sadeh remind that in the case of the Inter-Agency Consultative Group (IACG) shaped in the 1980s, epistemic influences enabled transnational coordination of space science efforts and data exchange around the Halley comet.[29] Their case offers a basis to study the influence of an epistemic community comprising scientists and sharing the ideas of developing space activities for peaceful uses

[27] Joan Johnson-Freese, "Taking Out the Space Trash; a Model for Space Cooperation" (02 May 2014). https://breakingdefense.com/2014/05/taking-out-the-space-trash-a-model-for-space-cooperation/ (accessed September 19, 2018); Donald Kessler, "A Partial History of Orbital Debris: A Personal View," Paper presented at the *Hypervelocity Shielding Workshop*, Institute for Advanced Technology, Galveston, Texas, March 8-11, (1998): 81-89; Davide S. F. Portree, and Joseph P. Loftus, "Orbital Debris: A Chronology," NASA/TP-1999-208856, NASA, Washington, D.C., (January 1999); Nicholas L. Johnson, "Cleaning up space", *Harvard International Review*, 30 March 2012. http://hir.harvard.edu/article/?a=2922 (accessed September 29, 2018); Nicholas L. Johnson, "The Historical Effectiveness of Space Debris Mitigation Measures." Space Debris and Space Traffic Management Symposium, *56th International Astronautical Congress* (IAC), Fukuoka, Japan (October 17-21, 2005): 273-282; Fernand, Alby, "30 Years of Space Debris Mitigation Guidelines in Europe," *7th Conference of the International Association for the Advancement of Space Safety (IAASS)*, "Space Safety is No Accident," Friedrichshafen, Germany, (20-22, October 2014): 3-12.

[28] Sadeh, Lester and Sadeh, "Modelling International Cooperation for Space Exploration," 221.

[29] Joan, Johnson-Freese and The Inter-Agency Consultative Group, "A Model for Multinational Space Cooperation," *Space Policy* 5, no. 4 (1989): 288-300; Eligar, Sadeh, J. P., Lester, and W.Z. Sadeh, "Modelling International Cooperation for Space Exploration," *Space Policy*, 12(3) (1996): 207-223.

and scientific progress as an influential group in Europe generating space governance progress. Their finding that an epistemic group enabled the formation of the *European Space Research Organisation* (ESRO) as one of the two organizations leading to the European Space Agency (ESA) by the mid-1970s serves as supporting literature for this thesis for investigating the evolution of epistemic influences over space governance, and later on debris governance. Their results are also acknowledged by Sheehan who notes that an epistemic community of scientists existed in the early space age and helped shaping the European space effort,[30] which is also confirmed by Remuss besides by Sadeh, Lester, and Sadeh.[31] This emerging literature about epistemic influences over space governance in Europe and regarding also international space science cooperation is complementary to Kazuto Suzuki's "policy logic" approach, which gives important insights into the key policy rationales driving change across several decades and into which experts were involved in space governance progresses.[32] Of particular interest about Suzuki's policy logics for this thesis is the "logic of science." Presented as one of the drivers for governance progress in the form of emerging space institutions in Europe and Japan in the late 1950s, besides other influences such as logics of autonomy,[33] the logic of science offers interesting avenue of thoughts. It could give insights for exploring epistemic influences over this early 1950s period in space governance highlighting some key individuals involved and see if they represented epistemic groups, if

[30] Sheehan, The International Politics of Space, 73.
[31] Nina-Louisa, Remuss. Theorising Institutional Change: The Impact of the European Integration Process on the Development of Space Activities in Europe, Springer Theses, (Cham: Springer Nature Switzerland AG, 2018) https://doi.org/10.1007/978-3-319-95978-8, (accessed February 3, 2021), 151, 157 and 171; Sadeh, Lester and Sadeh, "Modelling International Cooperation for Space Exploration," 213, 214, and 221.
[32] Kazuto, Suzuki, Policy Logics and Institutions of European Space Collaboration (Aldershot: Ashgate, 2003).
[33] Suzuki, *Policy Logics and Institutions of European Space Collaboration*, and Kazuto Suzuki, "Administrative Reforms and Policy Logics of Japanese Space Policy," *Space Policy* 22(1), (2005), 13.

some epistemic groups existed and promoted ideas and norm and facilitated policy outcomes. As conceptualized by Peter Haas, epistemic communities all share a policy goal aiming at the greater good of humankind, distinguishing them from interest groups.[34] A peaceful uses group (PU) group could be analyzed as another proposed "space" epistemic communities sharing the ideas of conducting space activities peacefully to ensure continued scientific research for the benefit of mankind. The individuals carrying the logic of science could be part of this proposed PU group and be analyzed as epistemic members influential over generating space governance progress such as basic laws and institutions building the contours for space governance in a research covering these early decades.

The elements of early epistemic works in space literature also serve as basis for elaborating the framework and exploring debris governance and influences with other tentative groups, such as tentative groups such as debris mitigation, long-term sustainability and arms control groups.

Additional space cooperation literature was found other than covering debris issues, mentioning the need for more constructivist studies. Sheehan encourages to augment realism and liberalism approaches typically used in space literature.[35] Another article by Robert Pfaltzgraff presents a constructivist view of the epistemic model as complementary to realist and liberal views.[36] Lastly, David Tan further points towards the epistemic model for analyzing space sustainability, while not applying the concept. Tan also acknowledges

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[34] Peter M. Haas, "Introduction: Epistemic Communities and International Policy Coordination," *International Organization* 46, no. 1 (1992), 19-20.
[35] Sheehan, The International Politics of Space, 16-17.
[36] Robert L. Pfaltzgraff, Jr, "International Relations Theory and Spacepower" in the American National Defense University's *Collection of Essays Toward a Theory of Spacepower*, edited by Charles D. Lutes, Vincent A. Manzo, Lisa M. Yambrick and M. Elaine Bunn (2011): 40-41.

epistemic communities' influences referring to Peter Haas' seminal work and its merit to analyze the shaping of a new international regime to protect outer space.[37] Tan bases his argument on the legal concept of the "province of all mankind" as an indicator for analyzing space sustainability, therefore representing yet another call for investigating the epistemic framework in a key sustainability topic such as the space debris case.

As regards literature applying the epistemic model to the analysis of the debris case, Machon et al. identify the existence of epistemic communities influences for the emergence of specifically one debris instrument, the UN COPUOS Debris Mitigation Guidelines.[38] Machon et al. explore epistemic communities influences from the late 1970s until 2007 and across four main fora: IAF, IISL, COSPAR, IADC. This study provides a more comprehensive view of debris governance efforts, looking at expanded timeframes and additional debris relevant instruments before and after the UN COPUOS Space debris Mitigation Guidelines. Also, the understanding of these four main fora as epistemic communities could benefit from further specifications. For instance, this study provides a clearer picture of which specific working groups were involved under these platforms and how they helped in shaping the COPUOS instrument as well as many other tools in order to further highlight epistemic influences over debris policy. Also, this study looks at these four organizations as supporting institutions conducive to epistemic influences. It explores epistemic group dynamics occurring across various platforms and how they have been

[37] David, Tan, 'Towards a New Regime for the Protection of Outer Space as the "Province of All Mankind,"' 25 *Yale Journal of International Law* (2000): 185-191.
[38] Miloslav Machoň, Jana, Kohoutová, Jana, Burešová, Jana, and Jaroslava Bobková, "Epistemic Communities and their Influence in International Politics: Updating of the Concept," *Janus.net*, Vol. 9, no. 2, (November 2018-April 2019):1-15.

facilitating debris governance progress, how much progress these epistemic influences helped to bring about in the form of debris instruments and institutions.

This literature review highlighted the demand for constructivist approaches in space policy literature, the existence of foundations for studying epistemic actors' roles in debris cooperation and evaluating its global governance nature. This research seeks to increase the scarce space literature on epistemic models and global governance. The framework proposes to explore epistemic and global governance indicators to evaluate international cooperation emergence in the debris case and to measure governance and sustainability progress as explained below.

2.2 Proposed Analytical framework and Methodology

2.2.1 Analytical Framework

The research investigates the emergence of international policy coordination around the debris issue to assess governance progress in space sustainability efforts. The debris case, an issue-area involving national security interests and affecting global stakeholders, is seen as a key component of space sustainability efforts. In particular, this doctoral research on debris policy evaluation focuses on the actors involved in the emergence of space debris governance and its consolidation towards greater space sustainability, especially on the role of transnational actors known as epistemic communities or "knowledge" experts in the process.

In order to better understand how epistemic communities played a role in the emergence and evolution of debris governance, this research framework evaluates debris policy and its system. It looks into space and debris governance instruments, basic provisions, and institutions seeking clues about which type of influence occurred from which epistemic community.

The analysis explores epistemic communities' involvement either directly impacting the shaping of instruments and as norm promoters diffusing ideas across fora and inducing "learning" among the policy-shapers, impacting policy and institutions more indirectly. With the learning process, epistemic communities persuade the decision-makers of these rules, influencing their preferences and leading them to incorporate these ideas into the final policy outcomes. The presence of shared ideas of specific epistemic groups highlighted within debris instruments and basic space governance provisions or within the mandate of institutions of space governance are therefore taken as indicators of the relevant epistemic group influence.

The framework is designed to highlight the influence of specific epistemic communities over the institutionalization of debris mitigation ideas into governance rules and supporting fora, as well as to evaluate the level of progress in debris governance as a global governance regime summarized as a set of basic provisions, partial and comprehensive instruments in Table 6-1.

This debris study explores, which epistemic communities of experts sharing which ideas were involved in debris governance emergence and evolution. For instance, the research investigates how epistemic actors are involved in shaping the contours of "knowledge" around space and debris governance issues, the emergence and consolidation of norms, the socialization process, the diffusion and learning across multiple fora, the institutionalization of this knowledge or "shared ideas and policy solutions" into cooperative outcomes and the creation of a socially constructed system of global governance contributing to greater space sustainability.

This dissertation's work centers around the following hypothesis and research questions.

Hypothesis: *Epistemic influences enabled the emergence of international cooperation around the debris issue generating governance progress towards increased space sustainability.*

Research Question 1: *Which epistemic community or communities have been involved?*

Research Question 2: *Where and how did epistemic influences impact debris governance?*

Research Question 3: *Was international policy coordination possible despite the national security component of the space debris issue*

Research Question 4: *Did the increase in the number of space actors allow debris governance and space sustainability progress?*

The methodology proposed uses an innovative framework based on elements of the constructivist strand of international relations studies. It combines two theoretical conceptualizations, namely epistemic communities [39] and global governance. [40] This dissertation framework proposes to present which epistemic groups, where and how these epistemic influences occurred in the global governance process by dividing outcomes into five levels of global governance gaps. This combination seeks to evaluate debris policy emergence as a global governance regime with additional indicators for a deeper and more

[39] Peter M. Haas, "Introduction: Epistemic Communities and International Policy Coordination," *International Organization* 46, no. 1 (1992): 1-35.
[40] Thomas G. Weiss and Ramesh Thakur, *Global Governance and the UN: An Unfinished Journey*, United Nations Intellectual History Project Series, Bloomington: Indiana University Press, (2010). https://muse.jhu.edu (accessed September 17, 2018).

comprehensive governance analysis also drawing from Adler and Bernstein's views.[41] Indeed, the research focusses on the analysis of the global governance process and of the key actors shaping its rules and institutions whether formal or informal ones.

The specific epistemic 'knowledge' experts, their various sets of shared ideas or "knowledge", their involvement in diffusing ideas and norms, in shaping instruments across various space governance fora, or sometimes in creating new fora or expanding organizations' mandates is explored since the 1950s. Epistemic communities are part of an array of other transnational actors, which also influence global governance, such as advocacy networks and communities of practice as seen in the literature review.[42] These other transnational actors are beyond the scope of this thesis work. This research focusses on whether some epistemic communities acted as influencers of cooperation and international policy coordination in the space debris case, generating also global governance progress in space and debris governance.

Peter Haas' original conceptualization defines epistemic communities as groups of knowledge experts with recognized expertise in an issue-area, who share ideas, norms, causal beliefs and the specific common political goal of working towards improving humanity's living conditions, understandable more generally as working for the benefit of humanity, and

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[41] Emanuel Adler and Steven Bernstein, "Knowledge in power: the epistemic construction of global governance", 294-318, In Barnett and Duvall, *Power in Global Governance*, Cambridge University Press, 2005.
[42] Haas, "Introduction: Epistemic Communities and International Policy Coordination," 31; M. K. D. Cross, "Rethinking epistemic communities twenty years later," (2013); Sabatier, P.A., Jenkins-Smith, H.C., *Policy Change and Learning: An Advocacy Coalition Approach*. Westview Press, Boulder, CO.; Sabatier, P.A., "An advocacy coalition framework of policy change and the role of policy-oriented learning therein," *Policy Sciences* 21 (2):129–168.

which also entails some knowledge and membership validation criteria.[43] This validation mechanism feature of epistemic actors in Haas's conceptualization concerns the authority of the members as peers on the issue discussed giving the epistemic groups an authoritative status in the given topic deriving from their professional *modus operandi* also called "professionalization" by other scholars.[44] The membership selection as well as the knowledge built are verified. Recognized experts in a given field building knowledge around an issue by developing a consensual view deemed a "worldview" on a specific problem, taking into consideration earlier research, current knowledge and consensually and collectively constructed policy solutions. This worldview or knowledge constructed by these authoritative experts is then promoted and diffused by epistemic communities influencing the policy process by helping decision makers shape their preferences in issues where high technological complexity and uncertainties make it difficult. Epistemic experts can help by bringing innovative policy solutions to deal with these uncertainties or by encouraging change in preexisting policy preferences which prevent progress in the issue. Epistemic influences can help decision-makers understand and shape their preferences on topics with high uncertainties or enable change in their preexisting preferences in order to facilitate progress in dealing with these uncertainties and the emergence of new policy solutions. Such experts can also directly shape policy solutions when they become "infiltrated" in the

[43] Haas, "Introduction: Epistemic Communities and International Policy Coordination," 3; Mai'a. K. Davis, Cross. "Rethinking epistemic communities twenty years later." *Review of International Studies* 39.1 (2013): 137-160. The four features of Haas's original epistemic communities' conceptualization are known as: (1) shared set of normative and principled beliefs, (2) causal beliefs, (3) shared notions of validity, and (4) common policy enterprise.
[44] Mai'a. K. Davis Cross, "Rethinking epistemic communities twenty years later," *Review of International Studies* 39.1 (2013): 137-160.

decision-making loop by holding a governmental position or in working groups whose outcomes will serve as a policy instrument adopted by higher governmental levels.

This research framework has been designed to evaluate space sustainability and highlights its ideational foundations and key actors by looking into the involvement of specific epistemic communities and their relative sets of shared ideas and norms as enablers of progress. Debris governance is taken as one major component of the space sustainability efforts. The study looks deeper into the transnational epistemic actors' role in the debris policy-making process, considering levels of global governance progress achieved and at which shared-ideas groups helped shape debris governance as global governance and as support for further space sustainability progress. Knowledge and knowledge-experts' involvements in ideas formation, diffusion and institutionalization are explored. Specifically, this research investigates whether epistemic communities were involved in the emergence and evolution of debris governance. These groups are presented according to the main epistemic features inspired by Haas' conceptualization such as shared ideas, causal beliefs, validation mechanisms and a common policy enterprise "for the benefit of mankind." These groups serve to analyze ideational influences over progress in space governance affecting the debris issue and in the emergence of debris-dedicated instruments or of basic elements of space governance affecting debris. Ideas and their carriers are investigated as enablers of international cooperation in issue-areas where national security interests typically prevent cooperation, such as the space debris issue-area. The research looks at which ideas and communities shared and promoted ideas and were involved in enabling debris governance emergence and space sustainability progress as global governance. How the epistemic communities influenced the policy framing and agreements towards debris instruments is analyzed by looking into which fora these ideas circulated and were promoted, and what kind of governance progress and institutionalization attained.

In order to evaluate space debris policy, this research framework uses a global governance approach looking into actors shaping rules and institutions of the space governance system and of the debris governance system developing subsequently under it. The study explores how epistemic communities play a role in the emergence and evolution of space and debris governance instruments, basic provisions, and institutions seeking clues about which type of influence occurred from which epistemic groups. The analysis explores various involvements in shaping the instruments, either as members of policy coordination working groups designing instruments or as norm promoters, diffusing ideas across fora and inducing "learning" among the policy-shapers of these space governance or debris governance outcomes.

The presence of shared ideas belonging to specific epistemic groups within debris instruments and basic space governance provisions or within the mandate of institutions of space governance is taken as an indicator of epistemic influences. Their various involvements are investigated in the shaping of these policy instruments, in the shaping of institutions supporting governance, in the framing of knowledge, ideas, norms and in their diffusion across fora and into instruments and provisions.

The research framework proposes to explore the involvement of multiple groups especially epistemic communities of debris mitigation and long-term sustainability for the analysis of debris policy evolution and its global governance nature and progress, and with the assumption of the existence of an earlier group of Arms Control having influenced the shaping of early space governance rules. The epistemic communities used in the study's framework are the following ones:

- The Arms Control group (AC)
- The Debris Mitigation group (DEB)
- The Long-Term sustainability group (LTS)

These epistemic groups have been chosen for evaluating the emergence of cooperation around the space debris issue and progress in space sustainability and their role as actors in shaping space and debris policy and overall social structures as a global governance system. They have been selected as bearing some of Haas and Adler's literature indicators as well as some of other works on epistemic community features.[45] Namely, whether regular meetings formal and informal occurred, whether experts knew each other professionally and sometimes privately, if there was a peer validation for membership selection accepting only members with recognized expertise in the topic and gathering them as a community, and whether their shared policy enterprise relates to improvements and benefit for humankind.[46]

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[45]Sadeh, Lester, and Sadeh, "Modeling international cooperation for space exploration", 215-216; Mai'a. K. Davis, Cross, "Rethinking Epistemic Communities Twenty Years Later," *Review of International Studies 39, 1* (2013): 137-160. The four features of Haas's original epistemic communities' conceptualization are known as: (1) shared set of normative and principled beliefs, (2) causal beliefs, (3) shared notions of validity, and (4) common policy enterprise. Bekenova, Kristina. "The Epistemic Communities as a Key to International Cooperation" *Journal Of Humanities And Social Science* (IOSR) Volume 19, Issue 8, Ver. I (Aug. 2014), PP 68-75; Machoň, Miloslav, Kohoutová, J; Burešová, J and Bobková, "Epistemic communities and their influence in international politics: updating of the concept". *Janus.net e-journal of International Relations* 9, no.2 November 2018-April 2019.

[46] Haas, "Introduction: Epistemic Communities and International Policy Coordination."

The study analyzes whether, where, and how these multiple epistemic communities have been influencing debris policy emergence and evolution as global governance thanks to international policy coordination and as a major progress towards greater space sustainability.

These epistemic influences can result in policy outcomes generated directly by the epistemic community members or indirectly by way of shared-ideas or "epistemic knowledge" diffusion, leading to the emergence of norms, and to their consolidation by becoming institutionalized over time also making their way into some provisions of space governance and debris policy outcomes.

The Arms Control (AC) group

This epistemic community of Arms Control is considered as an external group emerging outside of the space community in the mid-1950s, which shares firstly ideas of restraint for nuclear and missiles developments such as limiting testing, developments and use of nuclear weapons and of weapons of mass destruction, and to avoid interferences with satellites used as National Technical Means for treaties verification for instance, and with time adapting its set of ideas to technological developments and gradually include the ideas of limiting anti-satellite weapons testing. This study framework assumes that this epistemic community has been firstly involved in diffusing and codifying some of its shared restraint ideas in the basic treaties and conventions shaping the early space governance system. This group relates to Adler's nuclear arms control epistemic community expanding from the United States outwards to include international scientists including Soviet experts from the mid-1950s.[47] It has been recognized also by Barletta in the literature as having helped in the emergence of the PTBT treaty and further ASAT limitation ideas.[48] This study proposes to explore their continued involvement around the debris governance progress, especially from the 1970s and 1980s onward.

The Debris Mitigation (DEB) group

This epistemic community is another space epistemic group, and shares ideas of mitigating the space debris problem such as the existing debris or creation of future ones, for space operations and also as potential issues upon re-entry on the Earth surface. It has been identified as an epistemic community recently by Machon et al., while several references have been made pointing to the DEB group existence in earlier space literature such as by Moltz. Machon et al. offer a first assessment of its influence for generating one debris instrument at the UNCOPUOS level,[49] while Moltz mentioned the existence of a debris epistemic group a bit earlier recognizing its influence for generating arms control policy outcomes.[50] The research proposes a wider investigation of its involvement in shaping additional debris governance outcomes and of the epistemic group dynamics with other epistemic communities, and its influence in overall global governance and space sustainability progress.

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[47] Emanuel Adler, "The Emergence of Cooperation: National Epistemic Communities and the International Evolution of the Idea of Nuclear Arms Control", *International Organization* 46, no. 1 (Winter, 1992): 126 and 130.

[48] Michael Barletta, "Pernicious Ideas in World Politics: 'Peaceful Nuclear Explosives,'" APSA Annual Meeting, San Francisco, CA, 30 August - 2 September 2001.

[49] Machoň et al., "Epistemic Communities and their Influence in International Politics: Updating of the Concept", 1-15.

[50] Moltz, *The Politics of Space Security: Strategic Restraint and the Pursuit of National Interest*s.

The Long-Term Sustainability (LTS) group

This epistemic community is also a space epistemic group, besides the DEB group, and shares ideas such as ensuring the sustained use of the outer space environment for current and future exploration and exploitation. It is posited as an epistemic community, consisting in an innovation of this research framework. It has emerged more recently, namely over the past decade since the turn of the 2010s. The thesis proposes to investigate its involvement in relation with debris governance and space sustainability progress.

Global Governance Gaps

Governance progress is evaluated according to five levels of progress labelled as "global governance gaps". These five indicators, the knowledge, normative, policy, institutional and compliance gaps enable to map out the progress achieved in terms of global governance thanks to qualitative indications, as explained below.

As mentioned before, there is currently no agreed definition of global governance.[51] This study's proposed framework focusses on epistemic ideational groups as drivers of policy change in the governance of global issues, understood as issues affecting all stakeholders of the international system and necessitating a global response, such as the space debris case. This research's framework uses Weiss and Thakur's initial global governance framework to further analyze ideational influences of epistemic communities in the debris case. Weiss and Thakur use five global governance gaps as units of analysis for governance progress defined

[51] Thomas G. Weiss and R. Wilkinson, "Rethinking global governance? Complexity, authority, power, change," *International Studies Quarterly*, 58(1), (2014): 207-215.

as knowledge gap, normative gap, policy gap, institutional gap, compliance gap. knowledge gap, normative gap, policy gap, institutional gap, compliance gap.[52]

Knowledge gap

The knowledge gap as a global governance gap indicator corresponds to the level of knowledge achieved for shaping the contours of the global issue studied, such as “the nature of the problem, its gravity, its magnitude, and best agreed solutions”, developed collectively.

Normative gap

The normative gap as a global governance gap indicator corresponds to the level of “shared standards or patterns of behavior that should be followed by a given value system” to address an issue, here the space debris problem.

Policy gap

The policy gap as a global governance gap indicator reflects “a set of governing principles, goals and their implementation plans” as a policy response to the issue, here of space debris.

Institutional gap

The institutional gap looks at institutions newly created or whose mandates have been expanded and acting as “homes” conducive to epistemic influences over governance here debris governance or space governance efforts affecting debris.

Compliance gap

[52] Thomas G. Weiss and Ramesh Thakur, Global Governance and the UN: An Unfinished Journey, (2010).

The compliance gap gives an account of the efforts to implement better compliance with the agreed policy responses encouraged or achieved thanks to epistemic group involvements and in the absence of a fully equipped governing authority for the issue, here debris.

The proposed framework of this debris study combines these five global governance gaps indicators with the epistemic groups presented above. Steps of progress for each global governance gaps are explained in detail under each of the debris governance examples analyzed in the study, under each of the decades covered. The “where”, “when”, and “how” epistemic communities have contributed to debris governance progress are explained in the core text of the study under the governance gaps filled and under special sections devoted to the influences of ideas and epistemic groups giving further information.

As regards the debris regime formation, the global nature of the governance as well as the level of progress achieved are explained according to the type of forum and the type of participants shaping governance outcomes among as state or non-state or mixed initiative in debris governance.

The number of gaps filled out of the five gaps of framework model gives an assessment of the level of global governance progress achieved. The framework understands the governance process as a progression from the stage of ideas becoming norm, becoming promoted and then codified into policy instruments, and sometimes leading to institutional and compliance progresses. The increasing gaps show the evolution of debris policy from its emergence as a set of shared ideas, towards becoming shared norms, to then becoming codified as policy instruments, involving sometimes dedicated institutions or expanding existing institutions’ mandates, and enabling also progress in compliance efforts with these achieved instruments. The evolution across the gaps thus illustrates the debris regime consolidation, and nature of the regime as a global governance regime aggregating progress under the five gaps. The proposed framework of this study combines elements of epistemic communities and global governance theoretical concepts to evaluate space debris policy, expanding the scopes and indicators used in the epistemic and governance debates.

Firstly, in terms of innovations from the initial epistemic model of Haas,[53] the study considers wider scopes of epistemic influence in terms of numbers of epistemic groups and of numbers of initiatives where epistemic influence can be observed. Specifically, the proposed framework investigates the influence of more than one set of ideas shaped by one epistemic group generating debris-relevant initiatives and outcomes expanding the scope of epistemic analysis. There is literature considering the existence of more than one epistemic group to impact the policy process such as the existence of competing epistemic influences,[54] yet this debris case study focusses on their complementary nature rather than their competitive one.

Secondly, the proposed framework looks deeper than Weiss and Thakur's model[55] highlighting the importance of knowledge expertise or shared ideas in international policy coordination by investigating governance gaps in the global issue of space debris. Namely, five gaps offer a more refined evaluation tool for measuring space sustainability via the level of global governance progress attained per each of these five gaps of knowledge, normative,

[53] Haas. "Introduction: Epistemic Communities and International Policy Coordination."
[54]Barletta, "Pernicious Ideas in World Politics: 'Peaceful Nuclear Explosives'"; Higuchi, Toshihiro. "Epistemic frictions: radioactive fallout, health risk assessments, and the Eisenhower administration's nuclear-test ban policy", 1954–1958, *International Relations of the Asia-Pacific* 18, no.1, 1 (January 2018): 99–124.
[55] Thomas G. Weiss and Ramesh Thakur, Global Governance and the UN: An Unfinished Journey.

policy, institutional and compliance gaps. The combination of epistemic model indicators and governance gaps thus enriches both the epistemic and global governance original frameworks. By looking at which epistemically constructed ideas influenced each of the global governance gaps of Weiss and Thakur, the analysis looks both at the contribution of epistemic knowledge experts to shaping debris governance towards the emergence of debris-relevant initiatives and at how much governance progress has been achieved qualitatively. The research presents an overview of the major international-level and national-level progress steps achieved and do not represent an exhaustive list of all the governance progress steps. For instance, a few more meetings preceding the reaching of agreements could count as policy progress step by being a gap filling effort helping towards progress on the debris issue, additional papers and reports could be added as contributing steps filling the knowledge gap about the debris problem, more discussions about debris in additional fora could also be added for the normative progress. This dissertation focusses on the most important examples illustrating governance gap progresses and bearing the mark of epistemic influences.

Thirdly, the new framework proposes an additional indicator for policy evaluation of the debris policy evolution namely the division into “phases” of governance progress. Two phases of debris governance are analyzed and compare the evolution since the 1970s, from an emerging to a consolidating phase. The phases highlight the main steps in the shaping and influence of epistemic groups - gathered around their constructed and shared ideas over the debris issue - and their respective involvements in the diffusion process across debris governance fora. The emerging phase is presented in chapter 4 and the consolidation phase in chapter 5. This counts as an innovation to the global governance and epistemic frameworks with this proposal to extend the analysis to some decades before the end of the Cold War. Indeed, in most of the global governance literature is limited to post-Cold War efforts. This research however also includes global governance examples before the 1990s, namely in the 1970s and 1980s.

Also, besides its increased time scope, the study considers the influence of more than one epistemic community over debris governance efforts. It looks into the involvement of several epistemic groups and their overall epistemically constructed ideas over the debris policy process from the 1970s until the 2010s. In particular, the framework proposes to consider some epistemic communities not yet analyzed in the space community, namely the Long - Term Sustainability (LTS) group, and expands the emerging literature on the Debris Mitigation (DEB) and Arms Control (AC) groups. A first epistemic work investigating the existence of an epistemic debris mitigation group and its influence over shaping one debris instrument, the UNCOPUOS Space Debris Mitigation Guidelines, appears in the literature as good starting point. This study however much further expands the analysis of the influences of this DEB group over generating additional debris instruments, and as an enabler for space sustainability progress and of a global governance regime. This study also highlights the direct influences process, and considers indirect influences, as well as interactions between several epistemic groups. It places this DEB group at the heart of an evolutive process of multi-epistemic interactions, where “group dynamics” or epistemic groups interactions are impacting the policy process.

2.2.2 Research methodology

This research on space debris governance used a combination of data collected from primary and secondary sources at national and international levels.

Extensive analysis of secondary sources was conducted at first, gathering international relations literature and space policy literature. Many other secondary sources materials were also used, stemming from space policy and space law academic literature, space policy and law practitioners' outputs. These include but are not limited to space agencies and conferences reports, articles, presentations, specialized space newspapers both press and online publications, space agencies' reports, especially NASA, ESA and JAXA, recent reports and older archived material of the United Nations from several bodies especially the COPUOS and ITU, as well a non-governmental organizations publications and additional various national and intergovernmental reports. Examples of non-governmental entities reports include but are not limited to the International Academy of Astronautics (IAA) position papers and study group reports, the International Astronautical Federation (IAF) and its annual congresses International Astronautical Congress publications), the Committee on Space research (COSPAR), the European Space Policy Institute (ESPI), the Japan Space Fondation (JSF), the Secure World Foundation (SWF), the Union of Concerned Scientists (UCS), Reach Critical Will (RCW), the United Nations Institute for Disarmament Research (UNIDIR), and the Space Security Index report of Project Ploughshares.

In order to further analyze debris policy and confirm the findings, this study used primary data from research interviews conducted in person with experts while in Tokyo or abroad at international conferences, workshops, webinars and over the phone/online, as indicated in

Appendix A.2. The choice of interviewees was based on their authoritative knowledge about space and debris governance. The interviews were meant to confirm avenues explored in the research, such as the existence of epistemic communities' involvements, identifying some key individuals, understanding the governance process after the collection of data from secondary sources. Some debris specialists have even been present since the beginning of debris mitigation ideas and some have been leaders of some initiatives and continue to be involved with debris, space security, space safety and space traffic and situational awareness, arms control and space sustainability issues enabling to get additional details regarding debris governance over many decades. A table of research interviews is available in Appendix A.2.

As for examples of debris conferences attended to collect primary data were several annual conferences on space sustainability organized in Japan such as the Tokyo *International Symposium for the Sustainable Use of Space for Development* (IS3DU) in 2013, and subsequent conferences in 2014 and 2015, several of the IAF's annual *International Astronautical Congress* (IAC) were attended in 2015 in Israel, in 2018 in Germany and in 2019 in Washington D.C. in the United States, and sessions at the UNCOPUOS in Vienna were also attended as an observer.

3. SPACE DEBRIS GOVERNANCE SYSTEM

The first decades of the space age starting from the 1950s enabled the emergence of a space governance system of rules and governing bodies still in place today and composed of numerous international and national organizations. Stimulated by the nuclear and missile arms race and the International Geophysical Year with *Sputnik* and other successful orbital launches, discussions about the need for space policy entered the United Nations and non-governmental organizations platforms' agendas and led to the shaping of the space governance system upon which debris governance and space sustainability progress built themselves. This chapter introduces the major platforms, actors and legal foundations of the space debris governance system and its regime.

As a global governance system, debris governance is shaped by state and non-state actors, upon basic elements and policy instruments and across various fora as illustrated in Table 6-1 and Figure 1-4. Four main platforms of discussions have been identified as enablers for shaping the governance of outer space activities with relevant policies, recommendations and guidelines since the birth of the space age and forming the basis for debris governance. These are the United Nations' level, the multi-lateral level outside of the U.N., the international non-governmental level, the national level, and epistemic communities acting across all these levels.

3.1 United Nations level of governance

The first international level of space debris governance is found under the United Nations. Specifically, the Committee on the Peaceful Uses of Outer Space and the International Telecommunication Union serve as space debris governance platforms. Space affairs started to be discussed under disarmament issues from the launch of Sputnik in 1957 prior to the creation of the Committee on the Peaceful Uses of Outer Space (COPUOS) in 1958. Soon after, the COPUOS forum helped shape the foundation of space governance facilitating the emergence of the major space treaties, conventions, and agreements. Since the early space age, the International Telecommunication Union also joined as governing actor platform with a mandate to cover space policy-relevant discussions such as supervising the management of the radio-frequency spectrum used for satellites, avoiding interferences of signal and of physical interferences including defunct or retired satellites in the geostationary orbital region slots. The Conference on Disarmament emerging in the late 1970s as another U.N. forum also contributes to space policy debates, especially for arms control topics. Yet its impact as space governing body producing space governance treaties and for the debris issue remains limited to discussions and proposals, and normative support, compared with policy contributions of COPUOS and ITU to shaping the rules of the space debris system with agreed treaties, conventions, and radio regulations. The main debris governance fora under the UN system are therefore COPUOS and ITU and presented below.

3.1.1 COPUOS

Created as an *ad hoc* committee in 1958 with UN General Assembly Resolution 1348 (XIII), the Committee on the Peaceful Uses of Outer Space (COPUOS) became the main global space governance body under the United Nations as an intergovernmental forum composed of member states and non-state actors. Initially, COPUOS was created with 18 states in 1958, then 24 states by the following year when it became permanent, and currently has evolved as the largest committee under the United Nations system with 95 member states and 42 observing member organizations such as intergovernmental organizations, industry associations, academic and research institutes, think tanks, and other NGOs.[56] Resolution 1472 (XIV) made it a permanent committee in 1959,[57] and extended its scope beyond nuclear arms control, marking the beginning of a much wider space governance mandate than the discussions of partial or general disarmament and nuclear restraint, as noted by Aoki.[58]

Since 1958, COPUOS has remained the main highest political international space governance forum operating by consensus and coordinating discussions and working groups involving many stakeholders and platforms across the space community, as a global governance body. Established by the early 1960s, two subcommittees have been tackling many space governance issues. The COPUOS subcommittee of Science and Technology (STSC) has been discussing the debris issue since the early 1990s, and the Legal Subcommittee (LSC) since the 2010s. Delegates from member states, and delegates from non-state observing members interact under this forum and contribute to shaping debris and sustainability governing instruments.[59]

The UN COPUOS as an international platform with member states and NGO as observers also exchanges with the other levels such as national and NGO levels, and the IADC advisory body level. COPUOS acts as a supporting institution to enable space and

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[56] "Committee on the Peaceful Uses of Outer Space: Membership Evolution", https://www.unoosa.org/oosa/en/ourwork/copuos/members/evolution.html and https://www.unoosa.org/oosa/en/ourwork/copuos/members/copuos-observers.html (accessed July 28, 2021).

[57] UN Res. 1348 (XIII) was adopted on 13 December 1958 and UN Res.1472 (XIV) on 12 December 1959.

[58] Setsuko Aoki, "Law and military uses of outer space," In Ram S. Jakhu and Paul S. Dempsey (ed.) *Routledge Handbook of Space Law* (1st ed.) (Taylor and Francis, 2016) https://doi.org/10.4324/9781315750965): 198-199.

[59] Fora such as COSPAR, IAA, IISL, ILA, IAASS, ISO and many others contribute to COPUOS as observing non-state actors to shaping global debris governance and sustainability progress under this platform. For the list of observers, https://www.unoosa.org/oosa/en/ourwork/copuos/members/copuos-observers.html (accessed July 28, 2021).

debris governance to be a consensually developed global governance, especially when considering how COPUOS calls on NGOs such as IAA and COSPAR to conduct debris studies, and on national member states to improve their adoption or implementation of COPUOS guidelines based on IADC guidelines.

The UN-level forum of COPUOS started to deal with some space debris issues progressively with studies conducted by the UNOOSA secretariat in the late 1970s, and a Background report prepared by COSPAR for UNISPACE II in the early 1980s as mentioned in chapter 4. During the 1980s, the UN COPUOS progressively recognized space debris as an issue of concern in 1983, 1987 and 1988 fueled thanks to increasing NGO-contributions of fora such as the IAF/COSPAR debris study ordered by COPUOS STSC in 1987, and various other contributions conducted under space agencies levels with national delegations reporting their progress to the COPUOS annual sessions.[60]

Space debris became an agenda item of COPUOS in 1994, and generated one of the main debris mitigation instruments, the UN COPUOS Space Debris Mitigation Guidelines adopted in December 2007, as well as another more comprehensive space sustainability tool, the UN COPUOS Long-Term Sustainability (LTS) Guidelines in 2019, both major debris governance and sustainability policy tools reported in Table 6-1 and explained in chapters 4 and 5.

In terms of space governance rules prior to debris governance and space sustainability instruments, COPUOS as a supporting space governance platform enabled to shape the main

[60] In 1983, COPUOS recognized space debris as a serious hazard, then in 1988, the UN General Assembly recognized space debris as serious potential hazard. See also Perek, "Space debris at the United Nations."

space treaties and conventions, which comprise the essence of the international legal space regime, namely the 1967 Outer Space Treaty, the 1968 Rescue Agreement, the 1972 Liability Convention, the 1975 Registration Convention, and the 1984 Moon Agreement.[61]

While the first UN resolution mentioning space was issued under the first committee under the UNGA and resulted from years of disarmament talks, the next resolutions led to the creation of COPUOS and the widening of the scope of outer space policy discussions and the emergence of the international space regime based upon these five main space treaties and additional resolutions and conventions.

The first space resolutions from the late 1950s and early 1960s represent the basic principles of space governance setting the ideational foundations for the rules and institutions of the space system under which debris governance will emerge. This space governance system is based upon ideas of using space for peaceful uses, other arms control ideas as other forms of restraints such as restricting the use, development and testing of some weapons in space, restraint ideas from harmful interferences with the space activities of others, ensuring the benefit of all nations and humanity thanks to the freedom of overfly and of scientific research and the non-appropriation principle, transparency with notification and registration of space objects launched, liability for space objects. This non-exhaustive list of principles and ideas represent a basis upon which debris governance and sustainability efforts will develop in the ensuing decades. The first UN Resolution 1148(XII) adopted 14 November 1957 just after

[61] United Nations Office of Outer Space Affair, *International Space Law: United Nations Instruments* (United Nations Printing Office: Vienna, 2017), https://www.unoosa.org/res/oosadoc/data/documents/2017/stspace/stspace61rev_2_0_html/V1605998-ENGLISH.pdf (accessed July 28,2021).

the launch of *Sputnik* provides that "the launch of objects through outer space shall be exclusively for peaceful and scientific purposes."[62] As noted by Setsuko Aoki, this first resolution emerged following years of disarmament discussions occurring on the bi-lateral U.S./U.S.S.R. disarmament platform and aimed at limiting the launch of nuclear-tipped missiles, while from 1958 with the second resolution to mention space as U.N. Resolution 1884 (XVIII) space discussions under the UN took a wider scope, marking a departure from issues of the UNGA first committee on disarmament affairs towards creating a separate committee,[63] which was shaped under the fourth committee, and tackled many peaceful uses aspects of space activities, and elaborated many principles of space governance and the main space governance treaties currently in force.

The General Assembly "Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space" adopted by UNGA Resolution 1962 (XVIII) in December 1963 and the Resolution 1884 (XVIII) adopted unanimously by the United Nations General Assembly on 17 October 1963 significantly expanded the space policy debate under COPUOS by shaping the basis for all the main space governance principles which will land in the Outer Space Treaty[64] and form the basis of international space law with elements of relevance for space debris.

The Outer Space Treaty (OST) formally the "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other

[62] UN Doc. A/RES/1148(XII) (14 Nov. 1957), 13 para 1(f).
[63] Setsuko Aoki, "Law and military uses of outer space," In Ram Jakhu and Paul S. Dempsey (Eds.), *Routledge Handbook of Space Law* (1st ed.), 2016. https://doi.org/10.4324/9781315750962017 (accessed 25 June 2021), 197-198.
[64] Doyle, *Origins of International Space Law and of the International Institute of Space Law of the International Astronautical Federation*; Jakhu, "The Legal Regime of the Geostationary Orbit."

Celestial Bodies"[65] is the first and foundational treaty governing outer space and still in place today. At the time of its negotiation and signature during the Cold War, the space environment was a new frontier just being discovered, and knowledge about it was limited including regarding the orbital debris issue. Yet, the treaty founders when shaping the borders of space governance in this *Magna Carta* of international space later included basic provisions relevant applicable for the debris issue as will be explained

Some provisions of the Outer Space Treaty serve as a foundation to some international debris governance instruments referring to them and also at the national level with some national regulations covering debris referring to OST for basic legal foundations.[66]

The main articles of the Outer Space Treaty referred to in debris governance legal debates are also built upon earlier treaties and resolutions such as the Antarctica Treaty of 1959, PTBT of 1963 and UN resolutions 1962 and 1884 both also adopted in 1963,[67] and are mostly Article IX for the avoidance of harmful interferences and protection of the outer space environment and Article IV for restraint in testing or placing weapons in orbit and causing explosions and long-lived debris, as explained by Stubbe,[68] Jasentuliyana,[69] Portree,[70] and Baker.[71]

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[65] The Outer Space Treaty, https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/outerspacetreaty.html, (accessed March 24, 2021).

[66] See Australia, under the United Nations Compendium of space debris mitigation standards adopted by States and international Organizations," https://www.unoosa.org/res/oosadoc/data/documents/2019/aac_105c_22019crp/aac_105c_22019crp_14_0_html/AC105_C2_2019_CRP14E.pdf (accessed March 10, 2021).

[67] Gijsbertha (Bess) C.M., Reijnen, *The United Nations Space Treaties Analysed* (Gif-sur-Yvette Cedex, France: Editions Frontières, 1992), 60.

[68] Peter, Stubbe, *State accountability for space debris*, 247- 249.

[69] Nandasiri, Jasentuliyana, *International Space Law and the United Nations* (The Hague, Boston: Kluwer Law International, 1999): 322-323.

[70] Portree and Loftus, "Orbital Debris: A Chronology,"15.

[71] Howard Baker, *Space Debris: Legal and Policy implications*, 89 and 102.

Article IV of OST mentions that: “States Parties to the Treaty undertake not to place in orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner.”[72] This article represents a basic provision for debris mitigation efforts especially for debris nonproliferation, encouraging restraint in conducting large debris-creating events such as nuclear testing in outer space, or the use of weapons of mass destruction in space, thus considered a basic element of space governance affecting debris governance.

Article IX of OST builds upon provisions of the Antarctica Treaty of 1959, found in the Declaration of principles and in PTBT and specifies that “[…] States Parties to the Treaty shall pursue studies of outer space, including the Moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose. If a State Party to the Treaty has reason to believe that an activity or experiment planned by it or its nationals in outer space, including the Moon and other celestial bodies, would cause potentially harmful interference with activities of other States Parties in the peaceful exploration and use of outer space, including the Moon and other celestial bodies, it shall undertake appropriate international consultations before proceeding with any such activity or

[72] United Nations Treaties and Principles on Outer Space, United Nations, New York, 2002, https://www.unoosa.org/pdf/publications/STSPACE11E.pdf (accessed July 15, 2020), 4.

experiment[…] may request consultation concerning the activity or experiment."[73] This article focusses principles of avoidance of harmful interferences with the space activities of other states, which includes harm caused by space debris to their assets in space but also causing harm back on Earth such as for instance contamination or damage caused by the re-entry of objects on their path or on the ground. Article IX therefore also represents a basic element of space law for the debris regime shown in Table 6-1.

Additional governing tools of the space regime developed under the UN and with elements affecting debris are the Principles Relevant to the Use of Nuclear Power Sources in Outer Space (NPS Principles) of 1992, and several ITU WARC Radio Regulations and Conventions including the recommendation of ITU-R.S.1003 on protection of GEO and 1994 Constitution of the International Telecommunications Union.

Furthermore, besides the UN-level tools, additional arms control level treaties serve as governing mechanisms such as the Partial Test Ban Treaty (PTBT) of 1963, the Intermediate-Range Nuclear Forces Treaty (INF) of 1987, the Strategic Arms Reduction Treaty (START) of 1994 and the Treaty on Strategic Offensive Reductions (SORT) of 2003.

This body of space governance tools codified a set of basic principles upon which debris and sustainability efforts built themselves, such as ensuring the safety and rescue of astronauts and spacecrafts, preventing harmful interferences with space activities and the space environment, arms control, states being liable for damage caused by space objects, the practice of notifying and registering with the UN space activities and objects launched.

[73] United Nations Treaties and Principles on Outer Space, United Nations, New York, 2002, https://www.unoosa.org/pdf/publications/STSPACE11E.pdf , (accessed July 15, 2020), 6.

Some of these foundational space governance rules and provisions represent a basis for debris governance, and are referred to in some of the main debris and sustainability instruments such as the Guidelines for the Long-term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space (COPUOS LTS Guidelines of 2019),[74] the space agencies-level developed European Code of Conduct for Space Debris Mitigation (ECoC),[75] and other initiatives supporting debris and sustainability efforts such as the EU-led International Code of Conduct initiative (ICoC),[76] and the NGO-led Stimson Model Code of Conduct for Responsible Behavior in Outer Space.[77] The main treaties and resolutions established since the 1950s and who serve as basis for later debris and sustainability instruments are reported in Table 6-1 as basic elements of space governance, and complete the debris and sustainability regime.

3.1.2 ITU

The International Telecommunication Union (ITU) created in 1865 with the name International Telegraph Union took its current name in 1932 and was included as a special agency under the United Nations system by 1947.[78] It coordinates telecommunications and

[74] The "Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space," and the "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies" are mentioned in the "Guidelines for the Long-term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space," A/74/20, Annex II, 51.

[75] European Code of Conduct for Space Debris Mitigation, Issue 1.0, 28 June 2004, 1.

[76] European Union International Code of Conduct EU ICoC Draft 2014, http://www.eeas.europa.eu/archives/docs/nonproliferationanddisarmament/pdf/space_code_conduct_draft_vers_31-march-2014_en.pdf (accessed April 29, 2020), 4-5.

[77] "Model Code of Conduct for Space-Faring Nations," Stimson Centre, October 24, 2007, https://www.stimson.org/2010/model-code-conduct-space-faring-nations/ (accessed May 12, 2020).

[78] Overview of ITU's History, https://www.itu.int/en/history/Pages/DiscoverITUsHistory.aspx; http://search.itu.int/history/HistoryDigitalCollectionDocLibrary/12.28.71.en.pdf (accessed August 6, 2020.)

information communication technology activities, issues regulations and recommendations and meets regularly to keep up with technology changes. ITU is one of the oldest bodies involved with space governance, and also later on with debris governance, and has one of the largest memberships as a specialized agency of the United Nations with 193 Member States and more than 900 sector members mostly as observers such as companies, universities, and international and regional organizations.[79] As a space governance platform, ITU has a unique structure involving sector members such as commercial actors and other organizations as non-voting observers participating in working group discussions, and a recognized track record as both a regulator and governance enabler as noted by Jakhu and Pelton.[80]

With the Convention of Geneva in 1959, ITU received its first space mandate, following a new demand emerging from the International Geophysical Year and its launch of *Sputnik* resulting interference. Indeed, the question of radio signals interferences became a new policy issue necessitating decision-making such as finding a suitable international authority. The signals transmitted by the Soviet Union's first satellite *Sputnik* had caused some trouble such as radio-frequency interferences to at least three countries, calling for the regulation of space signals.[81] Discussions at the newly created *ad hoc* UN COPUOS recognized that a suitable body already experienced with radio signal regulations and with an almost universal membership existed within the UN system, which could carry out this new task of managing

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[79] ITU Membership, https://www.itu.int/en/myitu/Membership/ITU-Members/Member-States (accessed July 29, 2021). Besides member states, the other sector members comprise organizations and companies.

[80] Ram Jakhu and Joseph Pelton, *Global Space Governance: An International Study* (Cham: Springer International Publishing, 1st edition, 2017): 34-35.

[81] Nandasiri, Jasentuliyana. "Regulatory Functions of I.T.U. in the Field of Space Telecommunications", Vol.34 Issue 1, Journal of Air Law and Commerce, (1968): 65-66. The three nations were England, the Netherlands, and the United States.

space communication signals, namely the International Telecommunication Union.[82] Thus by 1959, ITU was given its first space mandate limited to managing outer space radio frequencies for space research,[83] laying the foundations for the organization to play an important future governance role also concerning the geostationary orbit affecting debris governance.[84]

Following the first mandate of ITU including space research in its 1959 resolution, in 1963 the mandate of ITU was expanded from space research to include space communication during an Extraordinary Administrative Radio Conference (EARC).[85] As noted by Ram Jakhu in 1983,[86] this EARC conference marked the beginning of an extended space mandate for the ITU and recognized the principles of equity of access to space communication frequencies to all members.

One of the organization's goals is to ensure that there are no harmful radio interferences, and its scope further expanded to cover interferences deriving from physical sources such as space debris by the late 1980s and early 1990s as will be explained in the next decades. The WARC 1985 especially enabled progress towards expanding the ITU agenda discussions and

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[82] Ram Jakhu, Jean-Louis Magdelénat and Harold Rousselle, "The ITU Regulatory Framework for Satellite Communications: An Analysis of Space Warc 1985." *International Journal*, 42, no. 2 The Politics of International Telecommunications (Spring, 1987): 277; Jakhu, "The Legal Regime of the Geostationary Orbit," 203; Jasentuliyana," Regulatory Functions of I.T.U. in the Field of Space Telecommunications," 63.

[83] Geneva Radio Regulations of 1959.

[84] Recently there have been suggestions that ITU's mandate should also cover the LEO orbit as more communication activities are expanding beyond the only GEO region. Kiran Krishnan, Nair. *Small Satellites and Sustainable Development – Solutions in International Space Law*. (Cham: Springer, 2019), 72.

[85] Jakhu, "The Legal Regime of the Geostationary Orbit", 228 -229. Final, Acts of the Extraordinary Radio Conference to Frequency Bands for Space Radiocommunications Purposes Geneva, 1963; ITU, Annex 3 Revision of Article 5 of the Radio Regulations – The Table of Frequency a11ocation.

[86] Jakhu, "The Legal Regime of the Geostationary Orbit", 228 -229. Final, Acts of the Extraordinary Radio Conference to Frequency Bands for Space Radiocommunications Purposes Geneva, 1963; ITU, Annex 3 Revision of Article 5 of the Radio Regulations - The Table of Frequency allocation.

to start a study on physical interferences from space debris in GEO and will lead to the first partial debris instrument under the ITU in 1993 with the ITU-R.S.1003 Recommendation shown in Table 6-1 and explained under the 1990s section.

The ITU partial debris instrument such as the 1993 ITU-R.S.1003 recommendation shaped under the UN level is considered one of the main international debris instruments[87] and a reference instrument and mentioned at the national levels of many countries' debris provisions under the UN Compendium of Space Debris Mitigation Standards adopted by States and International Organizations,[88] as explained in chapter 4 and chapter 5. ITU is one of the first UN bodies to have generated legislation concerning space governance with radio regulations and conventions before the first space treaties emerged,[89] as will be the case for debris governance when it will issue a partial instrument before the COPUOS Debris Mitigation Guidelines.[90] ITU acts as a supporting institution of the debris governance system, conducive of epistemic communities influences as well as policy innovation. Indeed, since the emergence of space governance foundations as a new area of activities of telecommunications filled with uncertainties and then keeping up to date with technological developments and new issues to be solved, the ITU forum is an additional "home" or laboratory for space governance then debris governance besides COPUOS allowing for innovations and governance progress, in a similar way to Adler's "home" institutions also

[87] Stubbe, *State accountability for space debris*.
[88] UN "Compendium of space debris mitigation standards adopted by States and international Organizations," https://www.unoosa.org/res/oosadoc/data/documents/2019/aac_105c_22019crp/aac_105c_22019crp_14_0_html/AC105_C2_2019_CRP14E.pdf (accessed March 10, 2021).
[89] Jasentuliyana, "Regulatory Functions of I.T.U. in the Field of Space Telecommunications," 63.
[90] ITU will start taking decisions affecting the orbital debris issue in the ensuing decades, especially leading to the first partial debris mitigation instrument the ITU-R.S.1003 Recommendation and within articles of its convention and radio regulations.

supporting ideas epistemic communities to reinforce themselves and diffuse beyond the borders of such homes.[91]

ITU-R-S. 1003 was the first international space debris tools, and as a partial instrument it covers the geostationary orbit and promotes the rule of re-orbiting satellites at the end of their operational life (EOL) to clear and preserve the protected and busy GEO region. This instrument as a basic rule of the debris governance system was also developed in-line with some of the foundational principles found in the Outer Space Treaty, especially the prevention of physical harmful interferences which could disturb international peace of article IV of OST, as well as the non-appropriation principle found in article II, and the benefit of all nations irrespective of their economic development found in article I. Since its first space mandate, ITU regulations and conventions involved the other foundational principle found in the other UN-level space governance treaties and resolutions, such as avoiding preserving peaceful uses of space, as explained by Jasentuliyana in 1968.[92] Jasentuliyana notes that ITU's objective of managing the frequencies efficiently and rationally to avoid interferences was motivated by the dangers harmful radio interferences represent for international peace: "[…] parties to the international telecommunication agreements have intended to create not an international licensing authority for the mandatory distribution of the frequency spectrum, but an international coordinating center to facilitate the avoidance of mutual interference. The problem of frequency control in space research

[91] Adler's work on arms control communities is taken here for the supporting nature of some institutions facilitating epistemic shaping and consolidation of ideas into norms and towards policy outcomes. Adler, "The Emergence of Cooperation: National Epistemic Communities and the International Evolution of the Idea of Nuclear Arms Control", 126.

[92] Jasentuliyana, "Regulatory Functions of I.T.U. in the Field of Space Telecommunications", 77.

consists, therefore, not so much in preventing space and earth-space radio communications from interfering with each other's transmissions, but rather in clearing certain portions of the radio spectrum so as to protect these communications from interference that might lead not merely to the failure of these experiments, but also serious danger to property, life and international peace owing to some malfunctioning in the control of the space vehicle."[93]

3.2 Multilateral levels outside of the United Nations

3.2.1 Arms control negotiations platforms

Over the seven decades of the space age, several multi-lateral fora have also played a role in shaping the space governance system and its rules. The bi-lateral U.S.-Soviet forum has been producing numerous arms control treaties consolidating the space regime by reinforcing space treaties with additional arms control provisions. For instance, the most impactful arms control treaties for space governance were The Treaty on Banning Nuclear Weapons Tests in the Atmosphere, in Outer Space and Under Water or Partial Test Ban Treaty (PTBT Treaty) - also known as the Limited Testing Ban Treaty - as a multi-lateral agreement signed between the United States, the Soviet Union and the United Kingdom in 1963 PTBT Treaty,[94] and the 1972 Anti-Ballistic Missile Treaty (ABM Treaty), a bi-lateral arms control agreement between the United States and the Soviet Union (ABM Treaty) during the SALT 1 round of talks.[95] They were completed by a series of additional bi-lateral treaties and multi-lateral

[93] Jasentuliyana, "Regulatory Functions of I.T.U. in the Field of Space Telecommunications", 77.
[94] PTBT Treaty Text, https://20092017.state.gov/t/avc/trty/199116.htm#treaty; https://www.armscontrol.org/treaties/limited-test-ban-treaty (accessed May 13, 2020).
[95] ABM Treaty, US Department of Defense, Strategic Deterrence and Capabilities Information, https://www.acq.osd.mil/tc/abm/ABMtoc.htm (accessed July 14, 2020).

following the ABM treaty such as the INF Treaty, the CFE, START, SORT and New START treaties.[96]

PTBT and ABM treaties both included restraint provisions supporting the main Outer Space Treaty principles of peaceful uses and restraint in space weaponization. The PTBT enabled restraint in nuclear testing in outer space, while the ABM treaty enabled to reinforce restraint in space fragmentations and resulting debris proliferation with the ABM inherited provision protecting space assets as National Technical Means (NTMs).[97] These arms control treaties have been important for the space governance system as additional normative support to responsible behavior and restraint. They supplement the general space regime and represent basic and preliminary elements for debris mitigation efforts to build upon, especially when considering intentional debris creation under the Anti-Satellite Weapons (ASAT) testing aspects. These arms control treaties as additional instruments of space governance are beyond the scope of this study, limited to the formation and evolution of the debris regime from the 1970s onward, as they played only a minor normative support role in the making of debris instruments. Some debris instruments occasionally refer to these treaties besides other basic space treaties and agreements illustrated in Table 6-1 as foundations.

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[96] United States Department of State, Bureau of Arms Control, Verification and Compliance, Treaties (ABM, INF, START I, CFE, SORT/Moscow, New START. https://2009-2017.state.gov/t/avc/trty/102360.htm, (accessed May 14, 2020). The CFE Treaty was multi-later and involved many European nations.

[97] "ABM Treaty, Article XII:

1. For the purpose of providing assurance or compliance with the provisions of this Treaty, each Party shall use national technical means of verification at its disposal in a manner consistent with generally recognized principles of international law.

2. Each Party undertakes not to interfere with the national technical means of verification of the other Party operating in accordance with paragraph 1 of this Article."

On the ABM Treaty, see https://www.armscontrol.org/treaties/anti-ballistic-missile-treaty and https://2009-2017.state.gov/t/avc/trty/101888.htm, (accessed May 13, 2020).

3.2.2 International space agencies' levels

The Inter-Agency Space Debris Coordination Committee (IADC) was created in 1993 by four main space agencies and institutions of the United States, Europe, Russia and Japan as NASA, ESA, RKA and the Japanese institutions NASDA, NAL, ISAS.[98]

The committee membership currently comprises 13 space agencies.[99] This IADC space agencies level of governance is the central actor for international debris policy coordination, as shown in Figure 1-4 and explored in this study.

The IADC's aim is to exchange and investigate developments around space debris mitigation and remediation efforts, and to keep up with the latest space debris risks. This platform acts as a supporting home conducive to epistemic influences, enabling the development of debris knowledge, norms, mitigation recommendations, statements, and guidelines consensually among the space agencies' delegates meeting regularly in working groups and annually in a larger assembly.

This international level of space agencies has been playing an important role in space debris governance especially from the 1980s and 1990s onward. Since the early 1990s, IADC worked towards shaping debris mitigation guidelines issued in 2002, revised in 2020, and serving as the reference international debris mitigation instrument. The IADC forum was

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[98] IADC Terms of Reference, https://www.iadc-home.org/what_iadc (accessed July 28, 2021). In the beginning, the Japanese participation was registered as "Japan" and comprised these three bodies before the JAXA merger in 2003.

[99] ASI (Agenzia Spaziale Italiana), CNES (Centre National d'Etudes Spatiales), CNSA (China National Space Administration), CSA (Canadian Space Agency), DLR (German Aerospace Center), ESA (European Space Agency), ISRO (Indian Space Research Organisation), JAXA (Japan Aerospace Exploration Agency), KARI (Korea Aerospace Research Institute), NASA (National Aeronautics and Space Administration), ROSCOSMOS (Russian Federal State Agency), SSAU (State Space Agency of Ukraine), UKSA (United Kingdom Space Agency).

built upon emerging bi-lateral efforts since the 1980s. Prior to the IADC creation, this level of debris governance was already active with exchanges regarding space debris mitigation best practices and operational procedures especially between the founding members of IADC such as NASA, ESA, RKA and Japanese institutions, especially NASDA, as explained in chapter 4.

Figure 1-4 indicates the debris governance mechanism illustrated with arrows exchanging between the IADC and national space agencies levels and the other levels of the United Nations, and of standardization organizations and initiatives such as the ISO and ECSS. The IADC guidelines have been the reference instrument upon which governance tools were shaped in other levels linked by arrows, in-line with the central IADC guidelines, especially the UN COPUOS Debris Mitigation Guidelines, the ECCS standard EDMS and the ECoC and the ISO Debris Standard 24113, as detailed in chapter 5.

The IADC as governance platform represents the space agencies' delegates as one of the stakeholders of the debris system. The committee acts as a supporting home for some epistemic communities to exchange, build or update knowledge, in addition to the other three levels of space governance presented here who also act as supporting institutions and where these experts also meet with additional epistemic members outside of the circle of space agencies' experts.[100]

[100] Experts from academia, private research laboratories, commercial satellite operators, civilian strategists and analysts at think tanks, officers of other governmental agencies such as departments of defense besides space agencies experts also represent significant contributors and members of epistemic groups.

3.2.3 European Union

The European Union entered the debris governance system as a governing platform when it proposed its International Code of Conduct Initiative (ICoC) in 2008. As an emerging space diplomacy actor, the EU European External Action Service in particular made contributions to debris governance with its rounds of consultations and its efforts to develop an international draft code of conduct for responsible behavior in space operations also covering debris mitigation aspects and intentional aspects. This inter-governmental platform serves as an additional level of discussion across delegations of many countries and complementing debris mitigation efforts occurring under the other debris governance platforms.

3.3 NGO-level of governance

This non-governmental level includes various types of non-state organizations, as platforms for knowledge exchange and learning, for policy innovations and best practices shaping and for standards development. These NGO-level organizations facilitate the development of additional and sometimes complementary instruments to the reference debris mitigation instruments shaped under governmental and intergovernmental fora such as the UNCOPUOS guidelines, the IADC guidelines, the ITU recommendations, and additional national space debris mitigation standards and legislations, all of which are mentioned under the UN COPUOS Compendium of Space Debris Mitigation Standards adopted by States and International Organizations.[101] Many of these non-state actors of debris governance are also

[101] United Nations, "Compendium of Space Debris Mitigation Standards adopted by States and International Organizations,"

observers of the COPUOS forum, presenting their debris governance initiatives and achievements during the COPUOS sessions.

The first category of non-governmental debris governance platforms comprises networking organizations combining multiple professions, think tanks, private and academic research institutes and foundations, and associations of professionals, which enable discussions, exchanges, learning and policy innovations around space debris mitigation issues. In these platforms, experts usually act in their individual capacity and not as representing the views of a particular company or governmental entity. The main ones active in debris governance are mostly the IAF, IAA and IISL, ILA, COSPAR, and additionally SWF, UNIDIR, UCS, Stimson Fondation, IAASS, ESPI, IASL McGill, IASL Cologne, OSI.

The International Astronautical Federation (IAF)[102] is a non-governmental organization created in 1951 as a network of national astronautical associations and rocket societies joining as a discussion platform for international cooperation and exchange of knowledge around peaceful space exploration. Currently, the IAF's annual congress is one of the oldest and major platforms for the whole space community to meet regularly, exchange, conclude or announce important policy decisions affecting space activities and also debris activities.[103]

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https://www.unoosa.org/res/oosadoc/data/documents/2019/aac_105c_22019crp/aac_105c_22019crp_14_0_html/AC105_C2_2019_CRP14E.pdf (accessed March 10, 2021).

[102] The IAF Constitution, https://www.iafastro.org/about/governance/iaf-constitution-and-bylaws.html, (accessed March 17, 2021).

[103] From the *Sputnik* launch's announcement in IAC Barcelona in 1957, to the presentation of space policies and strategies by heads of space agencies generally holding foreign affairs mandates such as signing international cooperative agreements, to progress on other important partnerships like the revised IADC Terms of Reference with new members to the debris coordination committee, IACs have affected space policy and public policy since the 1950s.

The IAF and its annual congress known as the "International Astronautical Congress" (IAC) offer a significant supporting role as governance enabler, together with its sub-bodies of the IISL and IAA. During space debris sessions under the IAC, IAA and IISL roundtables and IISL Symposia, debris governance ideas get consolidated and progress reports are presented. The major debris governance instruments produced under the IAF-related bodies under either ad hoc or permanent committees are the various debris or sustainability studies prepared by working groups.

Created in the early 1960s, the International Academy of Astronautics (IAA) starts to act as a supporting forum for debris governance from the 1980s especially, and with studies discussions and policy innovations under study groups and still to present day representing an important platform conducive to epistemic ideas and norm shaping and acting as a home for many epistemic groups including the DEB group and LTS groups in the phases analyzes in this research. As contributions of the IAA to debris governance, The IAA debris studies are for instance considered by experts as reference debris knowledge contributions. The first one was conducted between the IAF and COSPAR in 1988, then IAA produced studies in 1993 and in the 2000s up to present day. The IISL symposia have enabled lots of discussions around the debris legal and policy issues, and some experts consider it as no less than the "most important international forum for discussions and lectures on space law.[104]

While the International Law Association (ILA) was created in 1873, the creation of the ILA Space Committee in 1958 transformed the ILA platform in another early supporting institution conducive to epistemic influences and helping to shape early space governance

[104] Jasentuliyana, Space Law Development and Scope, 223.

principles as basic provisions for debris governance under resolutions, treaties, and conventions of COPUOS or ITU firstly, and later also for shaping debris-specific recommendations from the 1980s, leading to the development of an instrument for space debris mitigation in 1994 known as the ILA Draft International Instrument on the Protection of the Environment from Damage Caused by Space Debris[105] also considered an important reference point for legal debris aspects discussed under COPUOS LSC.

The Committee for Space Research (COSPAR)[106] was also one of the early space governance platforms created in 1958 as part of the International Council of Scientific Unions (ICSU) following the International Geophysical Year's successful experience of international scientific exchanges. COSPAR's mandate is to advise the UN and other organizations as required on matters concerning scientific research especially issues impacting scientific space research. COSPAR members are national and international scientific institutions.[107]

COSPAR started covering debris discussions and acting as a debris governance facilitating NGO-level platform from the 1980s. Among the debris milestones produced were the Background report prepared for UNISPACE II in 1981, the organization of an international debris workshop in 1984, a study co-produced with IAF in 1988, and it continues to be a platform of exchange conducive to learning, promotion and normative and policy efforts

[105] ILA Draft International Instrument on the Protection of the Environment from Damage Caused by Space Debris (1994).
[106] "About COSPAR," https://cosparhq.cnes.fr/about/ (accessed August 4, 2021).
[107] "COSPAR Charter," https://cosparhq.cnes.fr/about/charter/ accessed August 4, 2021).

thanks to continued publications and international symposia besides issuing policies for other areas such as planetary protection.

Other debris governance platforms have also been contributing to developing additional debris mitigation instruments. One example is the International Association for the Advancement of Space Safety (IAASS)[108] recognized by space experts as also an important governance body,[109] and which works in collaboration with academia and space agency experts amongst others. Created in 2004, IAASS' work on space safety and sustainability covered debris issues under working group from 2006 following the IAA Cosmic Study on STM issued in 2005. The IAASS WG developed space traffic management policy innovations and under the ensuing report known as "An ICAO for Space?" This initiative led to a book and a Manifesto signed in Rome 2008 summarizing the main findings identified in the study on ICAO for space.[110] This Manifesto completes the other debris governance tools forming the debris regime found in Table 6-1.

The Stimson Foundation and its Model Code in the early 2000s, following the Union of Concerned Scientists ASAT ban proposal in the 1980s and continued support and UNIDIR space security conference debates, and the Outer Space Institute's debris declaration all provide additional debris governance exchange and policy coordination platforms, and extra debris governing tools covering aspects of intentional debris creation under the space security

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[108] International Association for the Advancement of Space Safety, https://iaass.space-safety.org/ (accessed August 4, 2021).
[109] Jakhu, Ram S. and Joseph N. Pelton, (Eds.) *Global Space Governance: An International Study*, 43.
[110] Interview with Tommaso Sgobba, 2020.

and ASATs testing debates,[111] and completing the space debris regime instruments shaped at the other governmental fora levels.

The Secure World Foundation is a private non-governmental research organization founded in 2004 in Colorado, United States with a mandate to "create a secure, sustainable and peaceful use of outer space by working with governments, industry, international organizations, and civil society to develop and promote ideas and actions."[112] SWF publishes many reports and studies covering space debris governance and space sustainability and acts as a regular networking platform organizing workshops and seminar in collaboration with other fora such as UNIDIR -which is an NGO research institute and not a UN agency, and reports to UNCOPUOS as an observing member during the annual sessions. Since the early 2000s, SWF has been another active contributor to the debris governance system, often acting in collaboration with several other NGO platforms.

Founded in 2018 as a new Canadian NGO actor, the Outer Space Institute (OSI) is hosted by the University of British Columbia in Vancouver.[113] As a network platform for exchanges between experts, OSI is also involved in debris and sustainability multidisciplinary research, which supports the existing consensus expressed by the main international debris mitigation instruments and proposes policy innovations to further strengthen these mechanisms. Based in Canada at the University of British Columbia, the Outer Space Institute's mandate specializes in interdisciplinary research including space debris mitigation and space

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[111] OSI Salt Spring Recommendations on Space Debris, Section II. 1. Recommends "The avoidance of anti-satellite (ASAT) weapon tests, especially those that generate debris, and the negotiation of an international treaty prohibiting such tests," 1.
[112] Secure World Foundation, https://swfound.org/about-us/who-we-are/(accessed August 4, 2021).
[113] Outer Space Institute, http://www.outerspaceinstitute.ca/people.html (accessed August 4, 2021).

sustainability issues. Following conferences organized around these topics over the past few years, OSI is also slowly emerging as yet another non-governmental platform in the space debris governance system contributing with policy coordination and policy declarations to the debris governance debate and conducive to epistemic interactions. Its fellows involve experts in space debris from all over the world. It is also organizing interdisciplinary expert workshops shaping policy innovations and even issuing its own set of recommendations, such as during the international workshop on 'Space Debris and National Security' organized in January 2020 in Salt Spring Canada which led to the "Salt Spring Recommendations on Space Debris."[114]

The second category of non-state actors' platforms involved in the debris governance system encompasses associations of space industrial players and mixed organizations combining industry delegates, academia and government individuals gathered in consortia providing additional international policy coordination platforms. These NGOs also propose initiatives or sometimes consensually develop best practices agreements in support of debris governance and space sustainability efforts. This debris governance platform category is one of the newest emerging especially in the last decade. It involves largely commercial actors of the space industry in their own debris instruments shaping initiatives with a lesser role from space agencies experts and other governmental delegates, and with a greater emphasis on learning from their practical experience gained during their daily operations and associated best practices needs, such as in their satellite operations for instance. Examples

[114] "Salt Spring Recommendations on Space Debris," http://www.outerspaceinstitute.ca/docs/SaltSpringRecommendations.pdf (accessed August 4, 2021).

comprise the Space Data Association (SDA), the Space Safety Coalition (SSC), the Consortium for Execution of Rendezvous and Servicing Operations (CONFERS), and also the Space Sustainability Rating (SSR) initiative involves commercial delegates and their operational experiences for this instrument shaping.

The Space Data Association (SDA) was created in 2009 based in great Britain on the Isle of Man (British Isles) as a commercial sector initiative led by the largest satellite operators Inmarsat, Intelsat and SES, and Eutelsat joining by 2011.[115] Its mandate is to "provide reliable and efficient data-sharing critical to the safety and integrity of the space environment and the RF spectrum," contributing to collision warning and avoidance physical and radiofrequency interferences for satellite operators. It tackles operations of debris mitigation with its Data Exchange Center

SDA initiated best practices behaviors among commercial actors as early support to debris mitigation and space sustainability efforts. The SDA platform was aimed as a complementary effort to governmental regulatory initiatives in response to the latest needs in the space activities such as better space traffic management resulting from the drastic development of commercial space activities and creating a much more congested near-Earth environment and urgent regulatory demands. [116] This privately non-for-profit association provided some form of behavioral rules more quickly than formal governmental rules, even if informal.

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[115] Stewart Sanders, "Space Data Association," Secure World Foundation Presentation, Brussels October 2012, https://swfound.org/media/94538/sanders_rpo_brussels_oct2012.pdf (accessed August 5, 2021).

[116] Jonty Kasku-Jackson, "Space and Defense," https://inss.ndu.edu/Portals/97/Space_and_Defense_7_1.pdf?ver=2018-09-06-135102-190 (accessed Feb 11 2020). Space & Defense, *Journal of the United States Air Force Academy*, Eisenhower Center for Space and Defense Studies, Vol 7, issue 1 (Winter 2014), 26-38.

The SDA initiative belongs to the debris governance system as a platform which developed informal rules and practices as an industry-led innovative shaping of standards, even without the existence of mandatory rules or a formal international authority to govern traffic in outer space. SDA set a kind precedent serving as of role model for developing best practices for space operation even under an informal system of sharing space situational awareness data as a Space Data Center (SDC).[117] It is a voluntary, informal, self-regulating initiative facilitating the process of satellite tracking and collisions warning, to improve space operations safety, debris mitigation and overall space sustainability efforts.

Starting with satellite operations as private sector members,[118] the SDA membership widely expanded during the 2010s to include many more operators now with 28 participants including some governmental entities.[119] SDA provides a forum of exchanges consolidating experiences and compliance with best practices thanks to notification and operational data exchange for increased space safety and preventing space debris. Its Data Exchange Platform is run by a sustainability and space debris expert member of epistemic groups,[120] and the association has earned recognition of its peers as a space safety governing platform.[121] SDA

[117] SDA's Space Data Center, space-data.org/sda/space-data-center-3/(accessed August 5, 2021).

[118] Early members of SDA in October 2012 are Eutelsat, Inmarsat, Intelsat, SES, Paradigm, AMOS-Spacecom, Arabsat, Avanti, Echostar, GE, GeoEye, Optus, StarOne, SS/L, Telesat, NASA, NOAA. https://swfound.org/media/94538/sanders_rpo_brussels_oct2012.pdf (accessed August 5, 2021).

[119] SDA Membership, https://www.space-data.org/sda/participants/ (accessed August 5, 2021), including also U.S. DOD since 2012 https://www.businesswire.com/news/home/20140808005645/en/Space-Data-Association-SDA-and-U.S.-Department-of-Defense-Sign-Space-Situational-Awareness-Agreement (accessed August 5, 2021).

[120] Pascal Wauthier, "The Rising Problem of Space Debris," https://www.space-data.org/sda/blog/the-rising-problem-of-space-debris//(accessed August 5, 2021).

[121] "Space Data Association Recognized by World Space Risk Forum and Society of Satellite Professionals International," *PRNewswire*, Mar 14, 2012, https://www.prnewswire.com/news-releases/space-data-association-recognized-by-world-space-risk-forum-and-society-of-satellite-professionals-international-142601416.html (accessed August 5, 2021).

thus represents another platform in the space debris governance system who initiated commercial operational best practices agreements, conducive to epistemic influences and who will inspire ensuing NGO-level standardization efforts as explained chapter 5.

The Space Safety Coalition (SSC) emerged in 2019 as a non-governmental entity and as a group of private actors completing the other debris governance initiatives from governmental platforms. SSC members include traditional space industry companies and emerging commercial operators of space assets known as *New Space*,[122] space operations insurance companies, and also civil society associations, research institutes and foundations.[123] The Coalition acts as another platform for debris governance where policy coordination occurred and led to already one additional instrument such as SSC Best practices for the sustainability of space operations.[124] Its mixed membership of the non-state actors delegates also provide an additional supporting forum in the sense of Adler's "home" where debris policy coordination and policy innovations can be nested as another governing platform within the global debris governance system.

The Consortium for Execution of Rendezvous and Servicing Operations (CONFERS) [125] is also a recent mixed industry-governmental-academia platform of the debris governance

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[122] Some of the traditional satellite operators include Inmarsat, Intelsat and SES, who also initiated the Space Data Association initiative a decade earlier. Examples of new operators include Planet, OneWeb and SpaceX to name only a few.
[123] Space Safety Coalition Endorsees: https://spacesafety.org/endorsees/ (accessed February 26, 2021).
[124] Space Safety Coalition, "Best practices for the sustainability of space operations," 16 September 2019. https://spacesafety.org/wp-content/uploads/2019/09/Endorsement-of-Best-Practices-for-Sustainability_v20.pdf (accessed February 26, 2020).
[125] Consortium for Execution of Rendezvous and Servicing Operations, https://www.satelliteconfers.org/ (accessed August 5, 2021).

system. Created in 2018 to develop international satellite servicing standards,[126] CONFERS already gained recognition by experts as a valuable standardization fora besides ISO.[127] Its membership includes international commercial stakeholders of the satellite servicing community.[128] Examples are the leading debris removal and on-orbit servicing company Astroscale, mega constellation operators such as OneWeb, traditional satellite manufacturers and operators such as Airbus, Thales Alenia Space, Lockheed Martin and Maxar, as well as insurers such as AXA, forming quite an innovative mix of participants shaping debris-related best practices tools. The Consortium already produced consensually developed space sustainability instruments also covering some debris aspects and known as CONFERS Guiding Principles of 2018,[129] CONFERS Recommended Design and Operational Practices of 2019,[130] and CONFERS On-Orbit Servicing (OOS) Mission Phases of 2019,[131]which complement the current governmentally developed regime debris governance system. Initiated by the U.S. government, the CONFERS policy coordination process involves state and non-state actors such as delegates of the commercial space sector interacting under

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[126] Brian Weeden, "Update on the Consortium for Execution of Rendezvous and Servicing Operations, (CONFERS)," Japan Space Forum SSA Symposium, Tokyo, Japan February 27-28, 2020, https://swfound.org/media/206949/bw_confers_jsf_feb2020.pdf (Accessed April 10th, 2020).
[127] Paul B. Larsen, "Minimum International Norms For Managing Space Traffic, Space Debris, and Near-Earth Object Impacts", 83 J. Air L. & Com. 739 (2018), https://scholar.smu.edu/jalc/vol83/iss4/3 (accessed June 2, 2020), 781.
[128] Brian Weeden, "Update on the Consortium for Execution of Rendezvous and Servicing Operations, (CONFERS)," Japan Space Forum SSA Symposium, Tokyo, Japan February 27-28, 2020, https://swfound.org/media/206949/bw_confers_jsf_feb2020.pdf (Accessed April 10th, 2020), 4.
[129] "Guiding Principles for Commercial Rendezvous and Proximity Operations (RPO) and On-Orbit Servicing (OOS)," https://www.satelliteconfers.org/wp-content/uploads/2018/11/CONFERS-Guiding-Principles_7Nov18.pdf (accessed August 5, 2021).
[130] "CONFERS Recommended Design and Operational Practices," Consortium for Execution of Rendezvous and Servicing Operations, https://www.satelliteconfers.org/wp-content/uploads/2019/10/CONFERS_Operating_Practices.pdf (accessed August 5, 2021).
[131] "CONFERS On-Orbit Servicing (OOS) Mission Phases," Consortium for Execution of Rendezvous and Servicing Operations, 1 October 2019, https://www.satelliteconfers.org/wp-content/uploads/2019/10/OOS_Mission_Phases.pdf (accessed August 5, 2021).

working groups coordinated by the Secure World Foundation, and governmental entities which can participate but not become actual members, and academic research institutes and non-profit organizations are also eligible as full members.[132] The CONFERS platform collaborates with ISO on some standard developments, progress steps are presented at UNCOPUOS sessions and other international conferences and platforms of ESA or the Japan Space Forum, reflecting the pluri-level interactions of the debris governance system.

The Space Sustainability Rating (SSR) is also a recent mixed membership initiative launched in 2019 by the World Economic Forum's Global Future Council on Space Technologies at the NGO-level.[133] Its members combine experts from academia, space agencies, research laboratories firstly coordinated under the Massachusetts Institute of Technology MIT Media Lab's Space Enabled research group during a conceptualization phase, and now by the Swiss Federal Institute of Technology Lausanne (EPFL) Space Center "eSpace" as the entity chosen to lead and operate the SSR, and the rating system is scheduled to bed launched in 2022.[134] Space debris experts are interacting in this platform such as experts from the Debris Office of the European Space Agency, debris and safety experts at the University of Texas at Austin, and in cooperation also with Bryce Tech and the WEF

[132] Brian Weeden, "Update on the Consortium for Execution of Rendezvous and Servicing Operations, (CONFERS)," 11.

[133] MIT Media Lab, "Creating a Space Sustainability Rating," June 12, 2019, https://www.media.mit.edu/posts/creating-a-space-sustainability-rating/ (accessed January 28, 2020).

[134] World Economic Forum, "Space Sustainability Rating," https://www.weforum.org/projects/space-sustainability-rating (accessed August 5, 2021).

Forum.[135] Some commercial actors are involved in SSR under the Forum as partners or supporters of the rating system.[136]

As in other sectors such as the construction sector or the finance sector, ratings are meant to reward best practices behavior. The aim of SSR is tailored as a policy innovation, to tackle the sustainability threats in orbit including of debris proliferation thanks to "encouraging responsible behaviour in space through increasing transparency of actors' debris mitigation efforts." The SSR as another tool of debris governance would enable to address or strengthen about seven of the COPUOS LTS guidelines as reported by Rathnasabapathya et al.[137] Around this SSR initiative, the WEF platform also enables the exchange between debris and sustainability experts acting across state and non-state actors, as yet another supporting platform conducive of epistemic exchanges for strengthening the debris governance regime.

The SSR initiative places the World Economic Forum's Global Future Council on Space Technologies as a new platform of the debris and governance system and overall space sustainability efforts, shaping space debris initiatives together with other traditional actors such as space agencies with ESA as a governmental actors, academia with the MIT lab and industry with some satellite operators also involved. WEF is an emerging forum where now

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[135] Minoo Rathnasabapathya, Danielle Wood, Moriba Jah, Diane Howard, Carissa Christensen, Aschley Schiller, Francesca Letizia, Holger Krag, Stijn Lemmens, Nikolai Khlystov, Maksim Soshkin, "Space Sustainability Rating: Towards An Assessment Tool To Assuring The Long-Term Sustainability Of The Space Environment," Paper IAC-19-A6.8.9, *70th International Astronautical Congress* (IAC), Washington D.C., United States, 21-25 October 2019 (Paris: International Astronautical Federation (IAF), 2019), 1.

[136] Among the commercial space industrial actors involved in SSR as partners are Airbus Defence and Space, Boeing, Bryce Space and Technology, Lockheed Martin, Planet Labs, Voyager Space Holdings. Other companies who support the initiative and intend to join once SSR will be ready and openly available are Airbus, Astroscale, AXA XL, elseco, Lockheed Martin, Planet, SpaceX and Voyager Space Holdings. https://www.weforum.org/our-impact/world-s-first-space-sustainability-rating-launched/ (accessed August 5, 2021).

[137] Rathnasabapathya, et al., "Space Sustainability Rating: Towards An Assessment Tool To Assuring The Long-Term Sustainability Of The Space Environment," 9-10.

policy innovations are being designed around the debris issues in support of increased space sustainability, thus as an active governance forum for debris governance.

The third category of non-state debris governing platforms is composed of mainly standardization platforms, such as the European Coordination on Space Standardisation initiative (ECSS) and the International Organization for Standardization (ISO). Their memberships are mixed as well as the second category, yet they involve largely governmental delegates in working groups with some private companies' delegates. The slight difference between the earlier two international levels of space agencies under these NGOs is that governing instruments are shaped also in consultations with private space sector delegates.

The International Organization for Standardization (ISO) is a non-governmental entity created in 1947, which started to deal with space safety issues by the late 1990s and more systematically and coordinated space debris standardization efforts from the 2000s. The work is conducted under Technical Committee 20's two subcommittees 13 and 14 (TC20/SC13 and TC20/SC14) by technical working groups led by space agencies debris experts, and also involving private industry as participants. The work of SC 13 is mostly conducted under the Consultative Committee for Space Data Systems (CCSDS) as a multi-national organization created in 1982 by major space agencies. CCSDS membership includes eleven agencies and about thirty observers. Its navigation working group (NavWG) is the one developing the standards under CCSDS, which are then adopted under SC 13 as ISO standards.

The International Organization for Standardization (ISO) is network of national standardization authorities composed of 165 countries,[138] and with a combination of governmental and non-governmental members namely the private industrial sector involved as "full "or "body" members, and as "corresponding" or "observing" members. The industrial members take part into the technical committees shaping the ISO standards.[139] Once a standard is approved, ISO members promote and adopt international ISO standards nationally afterwards, and the adoption of ISO standards is also reported in the UN Compendium of Space Debris Mitigation Standards,[140] maintained by UNOOSA, the secretariat for COPUOS.

The main ISO-level space debris mitigation standard is known as ISO 24113:2019 "Space systems - Space debris mitigation requirements."[141] Issued in 2010 and revised in 2011 and 2019, considered a reference instrument of the debris regime. About ten more other sub standards are also being developed under ISO, as explained later.

The European Coordination on Space Standardisation initiative (ECSS) was created in 1994 by an ESA resolution (ESA/C/CXIII/Res.1) following a request made in 1988 by the European industry association – *Eurospace* - to the Director Generals of ESA and of CNES to develop and harmonize standards for the whole European space sector.[142]

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[138] https://www.iso.org/members.html (accessed March 15, 2021).
[139] https://www.iso.org/get-involved.html (accessed March 15, 2021).
[140] United Nations, "Compendium of Space Debris Mitigation Standards adopted by States and International Organizations,"https://www.unoosa.org/res/oosadoc/data/documents/2019/aac_105c_22019crp/aac_105c_22019crp_14_0_html/AC105_C2_2019_CRP14E.pdf (accessed March 10, 2021).
[141] ISO 24113, https://www.iso.org/obp/ui/#iso:std:iso:24113:ed-3:v1:en (accessed August 4, 2021).
[142] El Gammal, "ECSS - European Cooperation for Space Standardization," 1.

ECSS is a collaborative platform between national space agencies in Europe, ESA, and European space industry members, with some international governmental organizations as observers. The members are the five national space agencies who participated since 1987 to the Space Debris Working Group (SDWG) namely Agenzia Spaziale Italiana (ASI), UK Space Agency, Centre National d'Etudes Spatiales (CNES), Deutsches Zentrum für Luft- und Raumfahrt (DLR) and the European Space Agency (ESA), plus also the Netherlands Space Office (NSO) and the Norwegian Space Centre, Eurospace, and as associated member the Canadian Space Agency (CSA) and as observers, the governmental bodies of the European Union (EU), the European Defense Agency (EDA), the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), and the European Committee for Standardization (CEN) and the European Committee for Electrotechnical Standardization (CENELEC), which are two other official European standardization bodies for product safety and quality.[143] ECSS is thus a mixed platform, involving both governmental experts and members of commercial space entities of the European space industry as well.

ECSS's main secretariat is provided by the European Space Agency's European Space Research and Technology Centre (ESTEC) in Noordwijk, the Netherlands. ECSS is headed by a steering board setting policy and seconded by a technical panel, and the working groups are the ones developing draft standards. The ECSS is both an international and regional debris governance platform, which shaped the European Space Debris Mitigation Standard (EDMS)

[143] European Cooperation for Space Standardization, "Members" https://ecss.nl/organization/members/ (accessed August 4, 2021).

issued in the early 2000s and prepared for the European Code of Conduct (ECoC) which is not a standard.

EDMS succeeded the earlier ESA-level-only developed standards known as the ESA "Procedures, Specifications and Standards" (PSS) documents. EDMS shaped in conjunction between delegates from ESA, national space agencies and the European space industry experts served as the main standard in Europe before the ISO main debris standard 24113 was ready by the 2010s. ECSS has developed a total of 139 standards covering space sustainability as well as management, engineering, and product assurance. The space debris standard fitting under the space sustainability category is ECSS-U-AS-10C Rev.1 – Adoption Notice of ISO 24113: Space systems – Space debris mitigation requirements (3 December 2019).[144] ECSS interacts with other standardization organizations such as ISO, CEN, contributing to developing standards, and in turn adopting their standards in the ECSS system.

All of the categories of NGO level platforms interact across the national and the international levels, providing a pluri-level platform shaping consensual and global debris governance tools. Epistemic experts contribute to the debris governance system with taking part in debris and sustainability policy coordination, promoting their shared ideas, proposing policy innovations as policy papers, recommendations, or best practices agreements across several of these NGO fora, and in addition to involvement in the other governmental platforms introduced in sections 3.1and 3.2. and at the national level in section 3.4. The

[144] European Cooperation for Space Standardization, "Active Standards" https://ecss.nl/standards/active-standards/ (accessed August 4, 2021).

following chapters 4 and 5 illustrate the involvement of epistemic communities in the overall debris governance system.

3.4 National level of governance: Space agencies

The last of the four main governance fora consisting of the debris governance system are the national governmental bodies in charge of space debris affairs, especially space agencies or alternatively as research centers.

These platforms also act as governance bodies shaping debris policy advice actively involved in the latest research developments and typically bringing experience and helping to increase awareness about current trends and policy needs in space governance issues. In this analysis of debris policy, the role of these national space agencies as governance actors will become more observable from the 1970s and 1980s onwards. Many national space agencies and bodies act at the foreign policy level, concluding international cooperative agreements at the bi-lateral and multilateral levels besides other international space governance platforms.

In terms of space debris rules, the national space agencies have contributed on the one hand with national space agency standards, and on the other hand with international space debris mitigation guidelines under the Inter-Agency Space Debris Coordination Committee (IADC) as a transnational governmental body. This study looks into the national space agency standards rules of the IADC founding agencies, namely NASA, ESA,[145] Japan and

[145] The European Space Agency (ESA) is an international level combining the efforts of several national space agencies. Under the IADC, the ESA contributions derive mostly from experts of CNES, DLR, ASI and BNSC cooperating under an ESA working group since the late 1980s.

RKA,[146] as national-level contributions to debris governance besides the IADC-level guidelines and other efforts.

3.5 Transnational epistemic communities

As explained in chapter 2, the study explores the role of epistemic communities of "socially constructed knowledge experts" as actors of the space governance system, in particular of space debris and sustainability governance efforts.

These epistemic experts gathered around their sharing of ideas about a policy problem and its potential solutions, updating their knowledge and shaping policy innovations consensually, evolve mostly as transnational groups. In some cases, such epistemic communities can build themselves firstly at national levels. However, they typically mature into transnational groups after a few years of promoting and diffusing ideas in international fora growing the borders of their memberships.[147]

These epistemic communities are approached in this study as groups involved in the shaping and updating of debris policymaking across the four main governance platforms described above of the intergovernmental UN-level, intergovernmental outside the UN-level,

[146] The founding space agencies of the IADC in 1993 are NASA, ESA, NASDA and ROSCOSMOS/RKA. Over the years, national space agencies names have evolved in Russia and in Germany, and later also in Japan and the United Kingdom. During the late 1990s, the Russian space agency created in 92 as RKA became the Russian Aviation and Space Agency ROSAVIAKOSMOS in 1999, before becoming the Russian Federal Space Agency (ROSCOSMOS) in the 2000s, and Japan was registered as Japan before the creation of JAXA in 2003.

[147] It was the case for Adler's arms control epistemic groups, shaping themselves nationally first in the mi-1950s, and becoming influential and gaining membership across borders from the early 1960s after a few Pugwash conferences had taken place and several studies such as Doty and Daedalus gained ideational support. For more information see Adler, "The Emergence of Cooperation: National Epistemic Communities and the International Evolution of the Idea of Nuclear Arms Control" ; and Kristina Bekenova, "The Epistemic Communities as a Key to International Cooperation" *Journal Of Humanities And Social Science* 19, no.8, I (Aug. 2014): 68-75.

international non-governmental NGO-level and national level. The epistemic groups are therefore analyzed as a pluri-level type of actor, influencing the debris policy process in several organizations, operating therefore as a distinct type of governance actor impacting all of the four main levels. Epistemic groups are transnational and trans-level, as they guide the policy process under various international and sometimes national discussion platforms. These experts' groups highlight even more the global nature of the policy process analyzed in this debris study, as enabling global governance, shaped with the participation of states and non-state actors at various levels and under multiple fora. The five global governance gaps framework explained in chapter 2 provides a more detailed image of this debris policy process as a global governance process, illustrated by gaps filled and labelled "progress steps" observed at these various levels across the space governance system.

4. EMERGING PHASE OF DEBRIS GOVERNANCE

This "Emerging" phase introduces the analysis of debris governance in the 1970s and 1980s with the appearance of the first national and international space debris instruments. The study explores governance gaps filled such as knowledge, normative, policy, and compliance steps.

This phase builds upon earlier space governance outcomes achieved in the 1950s and 1960s such as space and arms control treaties, which shaped the foundational principles, rules and institutions of the space debris governance system as presented in chapter 3. These space governance tools contain provisions serving as basic elements for a debris regime and as preliminary progress prior to the emergence of debris-dedicated governance and are illustrated in Table 6-1. During the previous decades, organizations, regular conferences fora and treaties such as the IAF, the UN COPUOS, the Outer Space Treaty and the Partial Test Ban Treaty unintentionally impacted the debris issue in a preliminary way by building and consolidating normative support to ideas such as restraint on space weaponization, avoiding harmful interferences, increasing responsible behavior in space operations.

This emerging chapter marks a first crucial turning point in the history of debris governance with the beginning of actual "debris-specific" outcomes within the space governance system and catalysed especially thanks to an emerging epistemic community of Debris Mitigation (DEB), and with some observed influences of the Arms Control group (AC).

This period also accounts for continued general space governance progress with basic elements relevant to the debris issue as well as dedicated debris outcomes noted in Table 6-1, paving the way towards the emergence of a space debris regime and space sustainability progress.

These outcomes of governance progress take various forms, such as agreements, new institutions or special committees and have been facilitated by epistemic communities influences under various fora, as enablers of governance progress as further explained in this chapter.

4.1 Emerging steps in the 1970s

4.1.1 UN-level Emerging Progress in the 1970s

UNOOSA Reports and "United Nations of the Decade" Conference

In the late 1970s, the study found traces of pioneering debris mitigation ideas diffusing across the UN-level and the involvement of a pioneer debris expert and early shaper of emerging debris epistemic community. Namely, some debris studies were prepared by the secretariat supporting the work of UN COPUOS, the UN Office for Outer Space Affairs (UNOOSA),[148] and debris ideas discussed at a UN co-sponsored conference *The 13th Conference on the United Nations of the Decade.*[149]

Knowledge and Normative

The diffusion of debris mitigation ideas at the United Nations level in the late 1970s represents early knowledge and normative progress steps for debris governance. Namely, a few reports were presented to COPUOS between 1977 and 1979 with two of them stemming from the Secretariat,[150] and one debris mitigation recommendation was issued at the *13th Conference on the United Nations of the Decade,* namely recommending minimizing orbital debris production by removing inactive satellites for the GEO orbit, as noted by Perek in 1978.[151] This was an early normative progress step supporting the emerging debris mitigation

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148 United Nations Office for Outer Space Affairs (UNOOSA), https://www.unoosa.org/documents/pdf/aboutus/UNOOSA_About_Us.pdf (accessed June 27, 2021).

149 "Cooperation or Confrontation in Outer Space." *Thirteenth Conference on the United Nations of the Decade*, held in Iowa City, Iowa, USA, (July 9–15, 1978), sponsored by The Stanley Foundation. Perek, "Space debris at the United Nations,"125.

150 A/AC.105/203 of 29 August 1977. Physical Nature and Technical Attributes of the Geostationary Orbit; A/AC.105/261 of 7 December 1979. Mutual Relations of Space Missions, Information paper, UN OOSA Secretariat.

151 Perek, "Space debris at the United Nations," 125.

ideas such the de-orbiting of satellites. The early epistemic influence of a DEB member is found especially via Lubos Perek himself, who was actively promoting debris mitigation ideas in international conferences papers in 1977 at IAC, as well as the United Nations, in his capacity as the Director of the Secretariat from 1975 to 1980 at a time when the community of interest around space debris was nascent.

The Czech Professor's efforts to shape and promote debris mitigation began especially in the late 1970s and represent pioneering awareness raising efforts at the international level, in this example under the United Nations besides the other international conference forum of the IAF annual congress. Perek was one of the first debris experts to diffuse key debris mitigation ideas which will form the basis for the future debris instruments in the next decades across scientific and political fora. Lubos Perek was one of the first to discuss concerns of orbital debris in GEO and to promote debris mitigation ideas in GEO and the need to deorbit inactive satellites at the end of life in his 1977 IAC paper, [152] and ideas of rules of the road and space traffic management in his 1979 IAC paper.[153] And in the same period, working across multiple fora,[154] Perek was the first to bring debris mitigation ideas to the highest international political level such as the United Nations, as being instrumental

[152] Lubos Perek, "Physics, Uses and Regulation of the Geostationary Orbit, or, ex facto sequitur lex", IAF Paper SL-77-44), presented at the 28th *International Astronautical Federation Congress*, Prague, Czechoslovakia. September 25-October 1, 1977. Portree and Loftus, "Orbital Debris: A Chronology,"29.

[153] Portree and Loftus note his quotation: "the spirit of the Rule of Good Seamanship could be a basis for future space traffic regulation," Portree and Loftus, 24. Perek, "Outer Space Activities versus Outer Space," in Proceedings of the 22nd Colloquium on the Law of Outer Space, IAC 1979 held in Munich, Germany, (published by AIAA, 1980): 283-286.

[154] Perek was also involved as member of the International Academy Astronautics (IAA), the International Astronomical Union (IAU) and the International Council of Scientific Unions (ICSU) around the 1970s period, with experience in executive roles: International Astronomical Union (General Secretary 1967-1970), International Council of Scientific Unions (Vice President 1968-1970).

in preparing debris studies by the secretariat.[155] Perek represents one of the early founders of the DEB group as an epistemic group actively shaping debris knowledge, exchanging and communicating with other pioneers of debris research at NASA and in international conferences, helping to shape a "community of interest" around orbital debris. Perek was an early promoter of ideas circulating only in a few international conferences and in NASA studies and reports, especially of the 1978 study of Kessler and Cour-Palais which became a reference work and an earlier NASA report by David Brooks, Dale Bess and Joe Alvarez working in another NASA centre at Langley and whose orbital debris work also enabled important national debris research progress as well.[156] As governance gap filling efforts for debris governance, this promotion efforts represent normative and knowledge efforts facilitating the emergence of debris governance already in the 1970s and will be followed by many more examples of Perek's direct contributions to debris governance progress throughout the thesis

4.1.2 Progress observed at national levels in the 1970s

This section gives an overview of some early governance gaps filled during the 1970s planting the seeds towards the emergence of debris governance efforts across several nations and internationally. This section's examples involve national debris experts as pioneers of debris mitigation ideas and of an emerging epistemic community (DEB) by the end of the decade. A few studies were conducted in the United States in the 1960s as part of the

[155] Portree and Loftus, "Orbital Debris: A Chronology," 24.
[156] Kessler, "A Partial History of Orbital Debris: A Personal View," 4-6.

preparation for the manned exploration mission Apollo, however as they reveled low risks, debris research stalled for a while.[157] In the 1970s, small clusters of pioneering debris research started to emerge across a few other spacefaring nations besides the United States, namely in Japan, and with some interest rising for debris concerns by experts in France and in Czechoslovakia. These pioneer experts helped build the foundations of an international space debris mitigation epistemic group (DEB) by the late 1970s, early 1980s by raising awareness nationally and internationally about the debris problem. Internationally, the examples are covered in the other sections, such as by introducing ideas and promoting them also at international conferences and the United Nations, namely at ITU and UNOOSA levels. In terms of national outcomes for emerging debris governance efforts in the 1970s, the research found that these experts filled also several national governance gaps for debris governance. These are knowledge and normative gaps in several nations and even a small institutional gap progress was found in the US with a dedicated debris program and laying foundations for later multi-lateral coordination between space agencies over the next decades, as explained below.

United States national progress 1970s

Following preliminary knowledge gathered by debris studies and *Ablestar*'s break-up, further debris studies continued yet largely underfunded or with budget interruptions in the

[157] Kessler, "A Partial History of Orbital Debris: A Personal View," 2-3. By 1970, Debris knowledge was that bumping shields were sufficient to protect against very small debris suspected to be the major threat. For Skylab, its design was from the 1960s. Studies on meteoroids for spaceflight missions resumed by the mid-1970s combined with other methods and allowed for debris knowledge breakthroughs in the US. The lower threat and bumping shield findings are also mentioned on the Soviet side in preparation of their manned space program in the 1960s and in the 1990s for the station MIR.

1970s. However, further domestic debris research continued by the first half of the 1970s at Langley and Johnson Space Center, combining the earlier meteoroid hazard assessments models and leading to breakthrough in debris research, especially revealing a much higher threat of orbital debris to operations than previously.[158] These methodological innovations calculated much higher risks and when external events created additional uncertainties for space operations safety. Resuming of Anti-satellite testing by the Soviet Union, and the international energy crisis also raised the interest of NASA management to look into the issue of orbital debris threats such as for assessing potential damage to space systems in orbit. The 1970s oil and energy crisis led NASA to investigate large orbital solar power stations and their impact on the space environment and associated risks of orbital debris. Kessler explored the impact of power stations and of potential debris on the space environment.[159] Another crisis was the *Cosmos* 954 satellite crash in 1978 over Canada with radioactive material on-board suspected to have been hit by a piece of orbital debris. Also, during the SALT II arms control discussions, the issue of orbital debris was mentioned, and this further increased interest nationally about the orbital debris issue, supporting the pioneering debris experts' national promotion efforts.[160]

Thanks to the persistence of debris pioneers such as Kessler at NASA to keep studying debris in the 1970s despite budget and priority setbacks, knowledge progress perdured and led to the foundations towards systematic debris research from 1978-1979 when the emerging DEB group members of Kessler, Potter and Loftus helped create the first consistent NASA

[158] Kessler, "A Partial History of Orbital Debris: A Personal View," 1-6.
[159] Kessler, "A Partial History of Orbital Debris: A Personal View," 5-6.
[160] Kessler, "A Partial History of Orbital Debris: A Personal View," 5-6.

debris program,[161] which will consolidate as a debris office. The knowledge progress at NASA led to institutional progress for debris governance with the beginning of the NASA Orbital Debris Office program at JSC in Houston, becoming the new “home” for debris knowledge to grow, taking on a leading promoting role nationally and internationally in the next decade. Details regarding the specific types of debris governance progress enabled by national debris epistemic experts in the US in this 1970s section, such as breakthrough knowledge, emerging normative, and institutional progress steps are explained below.

Knowledge

In the 1970s, early national debris expertise and ideas shaping and promotion by pioneering epistemic experts identified in the US led to knowledge progress for emerging debris governance. Donald Kessler’s work on debris started in the late 1960s yet it would soon be interrupted several times with budget cuts due to a lack of knowledge about the issue and resulting low interest and funding supports within NASA in the 1970s. It took a combination of international crisis, such as an energy crisis, a resuming space security crisis fueling arms control talks such as SALT II, and an environmental crisis on the ground caused by the re-entry of a space object namely *Cosmos 954* and additional theoretical developments for debris research to regain higher interest at NASA and increasing support by the late 1970s.[162]

[161] Kessler, “A Partial History of Orbital Debris: A Personal View,” 6.
[162] Kessler, “A Partial History of Orbital Debris: A Personal View,” 6.

Kessler's conceptualization of a "cascading syndrome" by which a chain reaction of orbital debris collisions could seriously affect space operations and cause some orbits to become unusable even by smaller debris caught national and international attention. It was published as the Kessler-Cour Palais Study of 1978,[163] marking a turning point in terms of national debris expertise at NASA JSC and international debris theoretical knowledge. This paper stimulated more interest by internationally for debris research by experts such as Lubos Perek chair at UNOOSA during that period. This study became an international reference study in debris research still cited nowadays. The work of another NASA team under David Brooks at Langley contributed to early debris awareness nationally and internationally by presenting at the 25th IAC in Amsterdam in 1974 and under an ensuing NASA report in 1976 orbital collision about risks with small debris and meteoroids, also forging the basis for debris mitigation ideas to become circulated also at the UNOSSA level by Perek[164] and towards shaping an epistemic group.

Normative

The research also found normative progress at national US level achieved thanks to epistemic influences of debris experts. Indeed, the above national knowledge progress achieved with additional studies in the second part of the 1970s under several NASA departments uncovering a more accurate understanding of the hazard of orbital debris for space operations by pioneering DEB epistemic experts such as Kessler, in turn also facilitated

[163] Donald J., Kessler and Burton G. Cour-Palais. "Collision frequency of artificial satellites: The creation of a debris belt," *Journal of Geophysical Research*, Vol. 83 No. A6 (1978): 2637–2646.
[164] Portree and Loftus, "Orbital Debris: A Chronology," 28.

normative progress nationally for debris governance. The Kessler study and pioneering debris team benefitting also from external international developments such as concerns over Soviet anti-satellite activities and related congressional hearings and re-entry concerns of Skylab in 1979 and of the nuclear-powered satellite *Cosmos* 954 in 1978[165] helped convince the higher hierarchy of the need for studying the debris issue thoroughly and no longer just as ad-hoc studies, facilitating the normalization of the ideas that orbital debris need to be mitigated to ensure safe operations. US national debris experts thus forged a path for debris mitigation ideas towards normative progress promoting their greater acceptance nationally, as well as also stimulating interest also internationally in support of other debris experts promoting debris mitigation ideas as studies presented in international conferences such as the *International Symposium for Space Technology and Science* (ISTS) or the *International Astronautical Congresses*.[166] Indeed, the Kessler paper stimulated the debris interest at the UNOOSA secretariat level where findings were presented by Lubos Perek,[167] who as

[165] For weeks, the unknown location of the Skylab orbital laboratory re-entry created a global scare in 1979 following the radioactive fallout over Canadian remote territories after the crash of Cosmos 954 in 1978 both events contributing the raising awareness about the re-entry dangers of orbital objects and also stimulating the overall discussion about dangers of space debris in orbit as well. See Alby "30 Years of Space Debris Mitigation Guidelines in Europe," 2 and Kessler, "A Partial History of Orbital Debris: A Personal View," 6. The *Salyut* 5 re-entry in 1977 also raised concerns, as even if it was controlled, the station was very large, adding to the raising awareness about space debris dangers on Earth. ESA "Re-entry" workshops will follow in the 1980s.

[166] Makoto Nagatomo, Hiroki Matsuo and Kuninori Uesugi, "Some Consideration on Utilization Control of the Near-Earth Space in Future," *Proc. 9th ISTS*, Tokyo 1971, 257-263. Makoto, Nagatomo, Matsuo, Hiroki and Kuninori Uesugi, "Safety Design of Space Station against Collision Hazards with Artificial Orbiting Bodies," in: Proceedings of the *5th International Space Rescue Symposium*, XXIII IAF Congress, Vienna, 8–15 October 1972; David Brooks, Gary Gibson and Bess Dale: "Predicting the Probability that earth-Orbiting Spacecrafts Will Collide With Objects in Space," *XXV International Astronautical Congress*, Seventh Annual Space Rescue and Safety Symposium, paper no. A74-34, Amsterdam, 30 September 1974 (another NASA team); Lubos Perek, "Physics, Uses, and Regulation of the Geostationary Orbit, or, ex facto sequitur lex," IAF Paper SL-77-44, presented at the *28th International Astronautical Federation Congress*, Prague, Czechoslovakia, September 25-October 1, 1977.

[167] Kessler, "A Partial History of Orbital Debris: A Personal View," 6.

chairman initiated some studies by the late 70s,[168] promoting normative support for debris mitigation ideas at higher international political level. The impact of the US national epistemic knowledge published in the Kessler study in 1978, and of the normalization of debris research at NASA under a permanent debris program at JSC by 1979 seen below represent important progress for debris governance nationally and internationally. These national steps catalyzed the emergence of and transitions from debris mitigation ideas towards a growing norm gradually opening the way for policy outcomes codifying debris mitigation ideas in the next decades.

Institutional

As mentioned above, several debris studies in the 1970s were conducted across NASA offices while often dealing with budget cuts. However, thanks to the promotion of debris mitigation ideas by experts including Donald Kessler, Andrew E. Potter and Joseph P. Loftus, at higher level within their national space agency, a permanent debris research program was secured at the Johnson Space Center in Houston (JSC) by 1979.[169]

After years of struggles to keep debris research ongoing, this step represents a significant progress as filling the first institutional gap in debris governance emerging in the late 1970s. The securing of a more regular and persistent debris program under JSC is an important step for US debris efforts towards consolidating a national epistemic group supporting debris

[168] United Nations 1979, "Mutual Relations of Space Missions" Information Paper Prepared by Secretariat, 7. 12. 1979, s. 1-6; A/AC.105/261 of 7 December 1979, "Mutual Relations of Space Missions," Information paper prepared by the Secretariat / A/AC.105/203 of 29 August 1977, "Physical Nature and Technical Attributes of the Geostationary Orbit," Study prepared by the Secretariat." See Perek, 2002, 124-125.
[169] Kessler, "A Partial History of Orbital Debris: A Personal View," 6-7.

mitigation ideas, and promoting it nationally at higher political level, and internationally as it will lead to the later inter-agency coordination group initiative supported at the US national space policy level. JSC's debris program will greatly enable debris governance progress nationally and internationally as will be explained in the next sections. Thus, these US debris experts started shaping a more systematic debris mitigation effort building epistemic foundations nationally and supporting the foundation also for an international epistemic group (DEB) in the ensuing decades. This US national step therefore represents an important institutional progress step in terms of debris governance as a devoted unit to debris research acting as a "home" for epistemic ideas to grow nationally and also for soon spearheading international initiatives and further building debris governance efforts. This new orbital debris program under JSC facilitated debris mitigation knowledge building acting as a new home supporting institution enabling innovative and controversial ideas to emerge and be promoted also to higher political levels similarly to the supporting or home institution concept used in Adler's study on arms control epistemic influences reminded across this research.[170] This was the case for the orbital debris issue ideas at the time when this national program started. Indeed, Kessler reminds that their shared ideas about the debris issue were facing skepticism nationally by the top-management within their space agency as well as internationally also among other agencies. Especially, ideas about debris representing a threat to spaceflight operations were not accepted yet by the end of the 1970s.[171] Thus, the creation of this first consistent debris program at NASA JSC by early debris epistemic

[170] Adler, "The Emergence of Cooperation: National Epistemic Communities and the International Evolution of the Idea of Nuclear Arms Control," 126 and 130.
[171] Kessler, "A Partial History of Orbital Debris: A Personal View," 7.

members such as Kessler and Loftus after years of ongoing cuts counts as an important governance progress for space debris governance. It affected both the knowledge and normative progress nationally and internationally from the 1970s onward and acted as a foundation leading towards the emergence of regular space agencies and international conferences discussions and enabler of growing the emerging (DEB) group as an international space debris epistemic community. Nationally, the group consolidated the debris issue as an important agenda item within NASA and helped promoting it higher, towards becoming part of the national space policy within the following decades as will be explained in the next chapters.

The epistemic group and related ideas involved in this early debris mitigation national progress steps in the 1970s is mostly the debris mitigation group (DEB). Indeed, the pioneering debris knowledge, normative and institutional steps with a more permanent debris program are attributed to the work of an emerging "space" epistemic group, the "space debris mitigation epistemic group" shortened as DEB in this thesis and presented in Table 6-3. The national DEB pioneering members found involved in the governance progresses of this section are especially Donald Kessler and Joseph Loftus. They were the early national epistemic members who helped increase debris mitigation knowledge and to secure debris research under their space agency as the first debris governance enabling this national turning point in awareness and funding support at higher level under NASA.[172] Kessler was among

[172] During the 1970s, the national debris group was emerging from knowledge gathered across various entities before the debris program emerged under NASA JSC. Among other national debris experts helping to grow debris knowledge across various were John Gabbard at NORAD, Val Chobotov at Aerospace, and Andrew

the early promoters of debris mitigation ideas also internationally via conference presentations and journal publications, besides a few other national debris experts at Langley, in other agencies at NORAD or in the private sector.[173] Andrew Potter was department head of the NASA Environmental Impact office in the mid-1970s, and Joseph Loftus was assistant to the Director of his department and organized many briefings with VIPs during the second part of the 1970s,[174] which helped promote the emerging epistemic DEB ideas higher within the NASA management and also across agencies. This will continue in the early 1980s, Loftus and Kessler to diffuse DEB ideas to General Abrahamson at some NASA briefing, the soon to become head of the Strategic Defense Initiative under the Department of Defense.[175] As found often throughout this research, a combination of epistemic experts helped achieve space debris governance progresses nationally in this US example and also across several international level fora examples thanks to holding executive positions or being close to decision-makers, besides presenting and publishing internationally. Joseph Loftus is recognized by his peers as a pioneer debris mitigation influencer. Upon his passing in the 2000s, the IAASS organization honored him as the "father of the NASA debris office" with a space sustainability awards to the next generations of debris influencers.[176]

Potter, Burt Cour-Palais, Joe Alvarez, Robert Reynolds, John F. Stanley, David Brooks under other NASA departments. More details about the people involved in which decades are explained in Kessler, "A Partial History of Orbital Debris: A Personal View," with several mentions also under Portree and Loftus "Orbital Debris: A Chronology."

[173] David Brooks and a team at NASA Langley published in 1974 at IAC. Loftus in the 1970s is mostly a strong support for securing nationally debris research interest. Loftus will also soon reach out internationally regarding rocket upper stages passivation ideas diffusing knowledge outside of the US by 1981 especially to the Japanese team operating their launcher using a similar technology to Delta II.

[174] Kessler, "A Partial History of Orbital Debris: A Personal View," 5.

[175] Kessler, "A Partial History of Orbital Debris: A Personal View," 9.

[176] International Association for the Advancement of Space Safety (IAASS) "Joseph P. Loftus Space Sustainability Award," http://iaass.space-safety.org/awards/11th-hour-sustainability/ (accessed June 14, 2021).

Japan early debris studies 1970s

This study found some early cluster of expertise in Japan contributing to raising debris mitigation awareness efforts throughout the 1970s at international conference levels and also in the US national level. In particular, the research noted early debris governance efforts especially for knowledge and normative gaps by national experts at the Institute of Space and Astronautical Science (ISAS) mostly as a few internationally published papers. Whilst there were only a few debris studies and reports, the ideas contained were pioneering and innovative ideas for debris governance as explained below. These steps are therefore deemed significant as they reflect early Japanese debris expertise contributions to emerging debris governance efforts at a time when very few experts conducted debris research under national institutions such as in the United States and Europe as mentioned in the other examples.

Knowledge

Before the creation of the current Japanese Space Exploration Agency (JAXA) in 2003, Japanese space activities were divided under three main organizations, namely under the Institute of Space and Astronautical Science (ISAS), the National Research Laboratory (NAL) and the National Space Development Agency of Japan (NASDA) all created in the 1960s.

The Nagatomo team at ISAS was one of the first debris work helping to fill some knowledge gaps useful as basis for understanding and approaching debris governance to develop by the next decades. These national experts of Japan pioneered in filling debris knowledge gaps nationally, as well as internationally by diffusing debris mitigation ideas internationally via their pioneering debris publications and presentations at conferences such as the IAC and in 1971 and 1972 and 1977.[177]

The pioneering national debris knowledge in the early 1970s was shaped mainly under the Institute of Space and Astronautical Science (ISAS) at the University of Tokyo under a team led by Professor Nagatomo. One of this pioneering debris team member, Uesugi, will continue to be involved in the emerging DEB community in the following decades and keep publishing debris studies. Nagatomo and Uesugi's efforts as early contributors to DEB ideas and epistemic community members acted as enablers in support of debris knowledge progress nationally, and also internationally by presenting at international conferences such as the ISTS in 1971, the IAC in 1972, and in continued publications. While they did not yet achieve policy outcomes yet in the 1970s, they enabled the diffusion of debris mitigation ideas from their research findings as knowledge gap for the emerging debris governance efforts appearing in the 1970s. The 1971 paper was one of the primary studies mentioning about the dangers of orbital debris collisions with satellites[178] and proposing a space traffic management system,[179] and also in 1972 for dangers for manned space stations. With some innovative policy ideas contained in these papers, the national debris experts also contributed

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[177] Makoto Nagatomo, Matsuo Hiroki and Kuninori Uesugi, "Some Consideration on Utilization Control of the Near-Earth Space in Future," Proceedings of the *9th International Symposium on Space Technology and Science (ISTS),* Tokyo 1971: 257-263; Makoto Nagatomo, Matsuo Hiroki and Kuninori Uesugi, "Safety Design of Space Station against Collision Hazards with Artificial Orbiting Bodies," Proceedings of the *5th International Space Rescue Symposium*, *XXIII IAF Congress (IAC*), Vienna, 8–15 October 1972; Kuninori Uesugi, "Optimum Low-Thrust Multiple Rendezvous," ISAS Report 551, Institute of Space and Aeronautical Science, University of Tokyo, Japan (November 1977).

[178] Susumu Toda, "Activities on Space Debris in Japan," Proceedings of the Second European Conference on Space Debris, ESOC, 17-19 March 1997, Darmstadt, Germany, (ESA SP-393): 25-29.

[179] Portree and Loftus, "Orbital Debris: A chronology."

to open up a normative journey for debris mitigation efforts, especially orbital debris removal, which goes a long way as a debris mitigation idea where a Japanese firm became leader for ADR operations. These early papers and debris work of Nagatomo's team illustrate that ISAS acted as a home for innovative ideas to shape themselves and from which to diffuse wider at the international level via conferences already, similarly to the home institution concept developed by Adler and mentioned across this thesis.[180]

These national efforts will be completed by other pioneering studies first in the 1970s in the United States such as Brooks and Kessler-Cour-Palais, facilitating the circulation of debris mitigation ideas and supporting the emergence of an epistemic community sharing these ideas and identified as (DEB) by the end of the decade, as illustrated in Table 6-3.

In Europe, national outcomes of debris governance progress were found as mostly knowledge and normative contributions enabled by pioneers of the DEB group of debris-mitigation which was not formed yet as an epistemic group and emerging thanks to circulation of a few pioneering papers diffusing debris knowledge at international fora. Debris related expertise and ideas started to develop, especially also with Czech expert Lubos Perek as explored in other sections. In the case of France, it has been found that experts were promoting debris mitigation ideas such as re-orbiting the GEO satellites since the mid-1970s at the international level, while nationally this idea would also grow to become a norm of operations by the early 1980s for the Franco-German Symphonie satellites, contributing to the emergence of a DEB epistemic transnational group and to promoting its ideas. The

[180] Adler, "The Emergence of Cooperation: National Epistemic Communities and the International Evolution of the Idea of Nuclear Arms Control," 126 and 130.

research found traces of normative steps by French CNES delegates as early promoters of GEO de-orbiting/boosting idea at the international level in the 1970s with delegates sent to ITU.[181]

Pioneers of debris mitigation ideas were especially found with Lubos Perek circulating emerging DEB ideas also transnationally with papers at international conferences or under the United Nations' secretariat already in the late 1970s. Among the pioneering ideas circulated from the late 1970s were the existence of orbital debris in GEO and proposals for GEO re-orbiting of inactive satellites and of dangers of orbital debris in LEO space operations from smaller debris, such as in the Kessler study.

National experts from several nations are especially found to lead to the emergence of debris mitigation ideas and governance steps such as the creation of a debris office in the US under NASA, and to some pioneering debris operational best practices ideas diffusion laying the foundations in the 1970s towards becoming a transnational a voice in the following decades. Indeed, this research considers that pioneering national experts in the United States and other nations such as in Japan, France, and the Czech Republic also rapidly enabled the transition from national clusters of expertise to merge and allow for the emergence of a DEB epistemic transnational group, which in turn will further impact additional debris governance steps nationally and internationally in the ensuing decades.[182]

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[181] Jean-Louis, Marcé, "How France Handles Space Debris," 115 and 116.

[182] The debris governance gaps filled in the 1970s by these pioneering experts are especially first elements of the knowledge and normative gaps, and for the US an institutional progress with the creation of the dedicated debris office.

The ideas presented by national debris expert Lubos Perek especially in his IAC paper of 1977 belong to the early debris mitigation ideas as an emerging epistemic group, and which he helped building by the end of the 1970s. As a pioneering idea, Lubos Perek was one of the first to mention about the existence of an orbital debris problem in the geostationary orbit (GEO).[183]

4.2 Emerging steps in the 1980s

4.2.1 United Nations progress 1980s

UNISPACE II

The research found debris governance progress as knowledge, normative and policy levels at the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE) II held in 1982.[184] This conference was part of a series of global conferences, labelled UNISPACE Conferences, held every few decades in view of enhancing international cooperation to promote peaceful uses of space and specially to broaden space science and technology for the benefit of all mankind and nations, and to adapt space governance to the technological and commercial developments of space activities. The focus in 1982 was to enable developing nations to benefit more of space applications. The UNISPACE Conferences are high-level political conferences, which also grow the interest

[183] Portree and Loftus, "Orbital Debris: A chronology," 24. Lubos Perek. "Physics Uses, and Regulation of the Geostationary Orbit, or, ex facto sequitur lex," (IAF Paper SL-77-44), presented at the *28th International Astronautical Federation Congress*, Prague, Czechoslovakia. September 25-October 1, 1977.; Perek, "Outer Space Activities versus Outer Space," in Proceedings of *the 22nd Colloquium on the Law of Outer Space* of the International Institute of Space Law of the IAF, Munich, West Germany, held September 16-22, 1979.
[184] UNISPACE II was held in Vienna from 9-21 August 1982. UNISPACE Conferences, https://www.unoosa.org/oosa/en/aboutus/history/unispace.html (accessed July 22, 2021).

for and importance of space under the UN and which attract the highest political representatives of member states. For instance, opening remarks to the UNISPACE II conference of 1982 were made by U.S. President Ronald Reagan, Soviet Premier Brezhnev, and Indira Gandhi.[185]

After a first promotion of space debris mitigation at the UN level with studies in 1977 to 1979 circulated by Lubos Perek in his time as chief of the UNOOSA as seen above, a continued diffusion of debris mitigation ideas is found also under UNCOPUOS in a 1981 Background report prepared for the UNISPACE II conference of 1982.[186] This step represents another normative progress step for debris governance in the 1980s as the Background Paper was prepared by COSPAR[187] involving 56 scientists from 13 countries,[188] including DEB epistemic members and covering the debris issue more comprehensively than earlier studies presented internationally. This COPSAR background report was prepared in parallel to another larger debris study initiative, such as the NGO-Level of the AIAA 1981 study, also involving DEB experts and contributing to raise knowledge and normative support for DEB ideas, as explained under the 1980s national U.S. section.

External events also influenced debris mitigation efforts progress and the impact of the emerging DEB group over debris governance outcomes in the1980s by raising awareness

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[185] United States Congress, House of Representatives, Committee on Science and Technology, Subcommittee on Space Science and Applications, *UNISPACE '82: Report and Hearing Before the Subcommittee on Space Science and Applications of the Committee on Science and Technology*, Ninety-seventh Congress, Second Session, July 14, 1982, (U.S. Government Printing Office, January 1983).

[186] 1982 Background Paper on the Impact of Space Activities on the Earth and Space Environment (A/CONF.101/BP/4), ensuing book form publication (*The World in Space*).

[187] Perek, "Space Debris at the United Nations," 125.

[188] Lubos Perek, "Space debris and the world community," *Space Policy* 7(1) (February 1991): 9–12, doi:10.1016/0265-9646(91)90041-f, 9.

and attention by higher political levels, especially the 1978 crash of *Cosmos 954* over Canada and the 1979 *Skylab* uncontrolled re-entry. All the above-mentioned reports led to increasing the normative progress of the emerging debris norm and governance efforts, was facilitated by DEB epistemic experts directly involved such as Perek and others.

The debris knowledge progress is found from the data gathered in the Background report facilitated by the DEB group and shared in discussions at the conference. In turn, normative progress followed with increased DEB awareness at COPUOS acknowledging the debris issue in 1983 and fueling demand for more debris studies in the later 1980s after the first efforts of COPUOS concentrated on nuclear-powered satellite issues and re-entering space debris. Lastly, the ITU recommendation represents a normative consolidation for debris governance and diffuses DEB ideas and encourages normative support at ITU, entrusting also with a supporting institutional role, by the encouragement to study the debris issues.
Also, the UNISPACE II report recommended to ITU to make the satellite re-orbiting in GEO at the end of the operational life mandatory for ITU members with a radio regulation,[189] showing the diffusion of DEB ideas under the UN in the early 1980s. This recommendation further expresses a policy progress for debris governance as it aims at shaping a partial space debris mitigation regime, given that radio regulations of the ITU are binding rules for all ITU members.[190]

[189] UNISPACE II Report, Vienna, 9-21 August 1982 (A/CONF.101/10 and Corr.1and 2), 70.
[190] "The Radio Regulations are part of the Administrative Regulations complementing the provisions of the ITU Convention, which govern the use of telecommunications and are binding on all Members, https://www.itu.int/net/ITU-R/terrestrial/faq/index.html#g005 (accessed April 20, 2020).

4.2.2 Bi-lateral and multi-lateral progresses outside of the UN

This section presents some debris governance steps achieved in the 1980s at the multi-lateral level outside of the United Nations. The research uncovered especially additional normative, policy and compliance progress at the multilateral level. Namely, the emergence of bi-lateral space agencies workshops involving NASA and NASDA, and ESA and NASA helped shaping early steps for debris mitigation coordination. Also regionally at the ESA multi-lateral level, the creation of an ESA Space Debris Working Group (SDWG) and Space Debris Advisory Group (SDAG) and a first ESA Council Resolution mentioning debris also consolidated the emerging debris governance. The epistemic group influence found is mainly an increasing influence of the emerging Debris Mitigation group (DEB) over the space agencies-levels developments, as explained in the examples below.

Space Agencies bi-lateral and multi-lateral progresses 1980s

This section presents bi-lateral and multi-lateral debris governance progress steps bearing epistemic involvement found in the 1980s at space agency levels. Especially three bi-lateral space agency meetings held between the American space agency and its Japanese, European and Soviet counterparts, and multi-lateral developments within ESA.

The research also found governance gaps filled for debris governance at the multi-lateral space agency level within ESA especially with the emergence of a regular space debris working group (SDWG) created in 1986 upon the Director General's request,[191] leading to the 1988 ESA Debris report and the ESA Council first policy covering orbital debris.

[191] Heiner Klinkrad, "ESA Concepts for Space Debris Mitigation and Risk Reduction," in John A. Simpson, *Preserving the Near-earth Environment*, 109.

These outcomes represent various knowledge, normative, policy and institutional progress steps. They result from the involvement of the emerging Debris Mitigation (DEB) group active across multiple fora, and also from external factors as explained below.

Bi-lateral NASA/NASDA Exchanges and Meeting

In 1985, following some debris knowledge and normative progress occurring first within the United States around the Delta II launcher and its break-up problems, debris mitigation knowledge about the passivation of upper stages was diffused to Japan by some NASA experts.[192] Initiated by Joseph Loftus, a debris expert who helped shape the newly formed NASA debris office at JSC in 1979, and with other U.S. members of the emerging DEB group such as Donald Kessler, the first bi-lateral NASA/SADA discussion in 1985 led directly to knowledge diffusion and normative and compliance progress in Japan at NASDA whose launcher was based on a similar design to Delta II. NASDA adopted the debris mitigation knowledge of upper stage passivation by venting residual fuel to avoid explosions as a norm from 1985 and has complied with that norm since.[193]

Later in the decade, after the adoption of the 1989 U.S. National Space Policy, a NASA delegation visited Japan in May 1989. This represents another step at the space agencies-level of emerging policy coordination around the debris issue, preparing the basis for the later formation of the IADC as an international coordination body in the 1990s. The visit to Japan involved Joseph Loftus and Andrew Potter of NASA debris office at JSC,[194] as early

[192] Portree and Loftus, “Orbital Debris: A Chronology,” 37.
[193] Kessler, “A Partial History of Orbital Debris: A Personal View,” 7; Alby “30 Years of Space Debris Mitigation Guidelines in Europe.”
[194] Portree, “Orbital Debris: A Chronology,”62.

members and shapers of the DEB epistemic group, facilitating its emergence since the mid-1970s, and especially developing its membership via tutorial series nationally and the organization of inter-agency and then international meetings from the early 1980s following budget consolidation for their debris program based at the NASA Johnson Space Center (JSC) in Houston.

These two bi-lateral debris exchanging steps between NASA and Japanese experts communicating first and then meeting physically especially between NASA and NASDA highlight how the emerging DEB group was involved in policy coordination initiatives from the 1980s, leading towards the IADC creation, and future emergence of its reference international debris mitigation instrument as explained in the next sections.

Bi-lateral NASA/ESA Meeting

Another example of bi-lateral space agency debris governance progress in the 1980s has been found in the NASA/ESA meeting organized in 1987 following the European Launcher Ariane's break up in 1986. It marks also direct influence of the DEB epistemic group, emerging at the time. The governance gaps filled for debris governance are namely knowledge, normative and compliance gaps.

The NASA/ESA meeting of 1987 took place following the Ariane upper stage break up during the launch of SPOT 1 satellite by the European Space Agency in November of 1986. At that time, the ESA Director was visiting NASA JSC in Houston. Thanks to the advanced U.S. tracking capabilities, the Americans quickly noticed the breakup event and informed the visiting ESA official, who then transmitted new debris mitigation knowledge about passivation procedures used on the Delta rocket to the CNES launcher design experts. DEB early members were especially involved directly in this information sharing such as Nicholas Johnson, Donald Kessler, and Joseph Loftus, with Loftus initiating a workshop in the following months.[195]

This led to first NASA/ESA debris workshop was held in May 1987 at JSC, which began a trend of regular meetings between the two space agencies, as well as a systematic debris mitigation effort within Europe.[196] This bi-lateral space agencies meeting thus reflects additional normative progress on the DEB emerging norm of upper stages passivation and compliance progress at the ESA level, besides similar normative and compliance progress steps achieved at NASA and NASDA during the 1980s. This 1987 NASA/ESA bi-lateral debris meeting also marked a significant turning point for international debris policy coordination as well as a basis towards the creation of the IADC and its later reference debris instrument.

Bilateral NASA/ Soviet Union Meeting

Another example of debris governance progress in the 1980s was found at the bi-lateral space agencies level and involved epistemic members, especially of the Debris Mitigation (DEB) group. Specifically, the meeting between NASA and its Soviet agency counterpart in December 1989 led to knowledge and normative progress around the debris issue and represents an early debris policy coordination in addition to the other examples of Japanese

[195] Kessler, ,"A Partial History of Orbital Debris: A Personal View," 12.
[196] Alby,"30 Years of Space Debris Mitigation Guidelines in Europe," 1-3 ; Johnson, "Cleaning up space," 67-68.

and European meetings presented above. Regarding this knowledge step, both sides learned from each other, and some exchange of debris knowledge occurred on several aspects besides upper stage passivation, such as orbital impact evidence from the Soviet manned missions found on their space stations.[197] This debris-relevant data was in turn helping to consolidate debris knowledge and normative progress in the 1980s led by the emerging debris epistemic group observed to shape and diffuse "debris epistemic knowledge" across several fora in the United States, the Soviet Union, Europe and Japan.

The members of the DEB emerging group in the U.S. delegation were Kessler, Loftus and Potter accompanied by Daniel Jacobs of headquarters and they met with the Ministry of General Machine Building Central Research Institute (TsNIIMash), Glavcosmos, NPO Energia and the Foreign and Defense ministries representatives. This first U.S./U.S.S.R. bi-lateral space debris meeting led to the formation of a U.S.-Soviet "Orbital Debris Working Group", which also started to regularize joint debris meetings and prepared for international space debris coordination towards the IADC, following what was accomplished in May of 1989 with the Japanese, and in May of 1987 with ESA.

ESA Multi-Lateral Debris Meetings in the 1980s

In Europe, the space debris expertise policy coordination efforts developed in parallel to NASA/ESA meetings also after the Ariane break up event of 1986 and especially a dedicated working group was established in 1987 namely the ESA Space Debris Working Group

[197] Portree, "Orbital Debris: A Chronology,"63.

Report, Space Debris (SDWG). The working group prepared a debris study in 1988,[198] followed by an ESA Resolution mentioning debris,[199] representing policy progress steps for debris governance in the 1980s at the multi-lateral space agency level, gathering the efforts of four nations' space agencies of France, Germany, Italy, the United Kingdom and of the European Space Agency.[200] The progress leading up to the creation of the ESA space debris working group leading to the 1988 report and followed by the 1989 ESA Council resolution discussed in other sections reflect combined epistemic influences from especially the DEB group in Europe. The DEB influences were also facilitated by external events, such as re-entry events of 1978 and 1979 *Cosmos* 954 and *Skylab*, and orbital break up events such as learning from the *Ariane* break up 1986, and the necessity to prepare for the manned program, in which Europeans were interested in at the time considering to develop the *Hermes* shuttle program and join the planned space station.[201] The emergence of this systematic European-level debris work is a combination of influences from the DEB group besides these external events.

At the ESA level in the 1980s, the influence of DEB ideas and of its members to generate debris governance progress is especially found in the formation of the space debris working group in 1986 involving the same experts who will exchange within a few months later with the NASA JSC team in the bi-lateral meeting in 1987. The ESA debris study of 1987 echoes

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[198] ESA Space Debris Working Group, *Space Debris, The Report of the ESA Space Debris Working Group* - ESA SP-1109 (ESA Publication Division: Noordwijk, 1988).
[199] ESA Council Resolution 1989, "ESA Activities for Space Debris," ESA/C(89)24, rev. 1.
[200] The five space agencies are CNES, DLR ASI, BNSC and ESA.
[201] The *Hermes* space shuttle benefitted from the Mitterrand presidency's interest in manned missions and will later be cancelled, yet it enabled political and financial support to prepare for manned programs and helped as external event to encourage debris studies as well, to prepare for safety aspects. Manned missions are a common supporting external driver event for stimulating debris research as seen also in the U.S. examples.

similar ideas with the Interagency debris and both reports increased the DEB knowledge. The ESA report as well as the IG report resulted from the direct involvement of an emerging epistemic community of experts sharing an interest in shaping and promoting a debris mitigation norm. The DEB emerging group became more influential internationally and in Europe too especially after the trigger event of the Ariane break-up in 1986. The ESA Resolution of 1989 is the first to include space debris mitigation ideas following the Debris Working Group Report of 1988.[202] As a debris governance policy step it codified the DEB ideas and consolidated the emerging DEB norm progress reached from the ESA report and IG reports. It also created a network as a supporting "home" for European experts to work on their debris mitigation ideas as an international and regional policy coordination platform, opening the way to shaping European debris instruments, prior to the IADC forum. The ESOC center will assume the equivalent role of the NASA JSC office for nurturing DEB ideas in-house and for gathering DEB members by hosting international conferences.[203] As a specific role, ESOC will also be in charge of implementing the ESA policy.[204] This makes the progress made in the 1980s within the European Space Agency on debris awareness since first concerns for debris in the GEO in the 1970s[205] and first working groups in 1985 and in 1986 with the starting of an ESA Space Debris Working Group (SDWG) combining five

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[202] ESA Space Debris Working Group, *Space Debris, The Report of the ESA Space Debris Working Group* ESA SP-1109.
[203] The ESOC space debris conference starting in the early 1990s has been gathering many members of the DEB community over the years and until present.
[204] Heiner Klinkrad, "ESA Concepts for Space Debris Mitigation and Risk Reduction", 109 in Simpson, *Preserving the Near-earth Environment*, 108-113.
[205] Walter, Flury, "Activities on Space Debris in Europe," *Proceedings of the 3rd European Conference on Space Debris*, ESOC, Darmstadt, Germany, 19 - 21 March 2001 (ESA SP-473, August 2001), 1.

national space agencies' efforts as an institutional debris governance step and is further explained in the ECoC section.[206]

Early members of these debris working groups include for instance Fernand Alby and Walter Flury amongst others. Flury was the chair of this first ESA-led group in the late 1980s[207] and increasingly advocated for space debris to become an international policy issue also together with other members of the emerging DEB group across other fora such as the IAA in the 1990s onward.[208]

The members of this emerging group helped raise the awareness about the need for debris mitigation and get the DEB idea to a higher political level at the ESA Council of Ministers level which is the highest ESA level. This first policy debris governance step under ESA was enabled by the work of a first dedicated debris experts group meeting regularly from 1987 as the Space Debris Mitigation Working Group (SDWG).[209] This group gathered experts from five agencies working collaboratively namely the Italian space agency (ASI), the British National Space Centre (BNSC), the French Space agency (CNES), German Space Agency (DLR) and experts from the European Space Agency (ESA). The experts of this working group were part of the emerging DEB epistemic community from the 1980s, examples include Portelli, Crowther, Alby, Bonnal, and Klinkrad as observable also in Table 6-3. They

[206] Alby, "30 Years of Space Debris Mitigation Guidelines in Europe," 1, 3, 4. The five space agencies are ASI, BNSC, CNES, DLR and ESA.
[207] Kessler, "A Partial History of Orbital Debris," 12. Personal interviews conducted during IAC Debris sessions with other European experts also confirmed the important role played by Flury as a driver for debris efforts under ESA in the early years, helping to promote interest for more debris research ideas to higher management.
[208] Darren McKnight and Walter Flury, "Space debris: An international policy issue," *Advances in Space Research* 13, No 8 (August 1993) : 299-309; Darren McKnight, Walter Flury and Hartmut Sax (eds), "IAA Position Paper on Orbital Debris," *Acta Astronautica* 31 (Oct. 1993): 167-191.
[209] Alby, "30 Years of Space Debris Mitigation Guidelines in Europe," 1, 3, 4.

promoted debris mitigation ideas within ESA and also outside of the working group in other international platforms via conference presentations and journal articles and book publications, and presentations under the UNCOPUOS Sessions

The ESA Space Debris Working Group Report, Space Debris [210] and the ESA Resolution[211] both represent policy progress steps for debris governance in the 1980s at multi-lateral space agency level. These debris-related outcomes emerging as a policy governance progress in debris governance achieved with the direct influence of experts of the emerging DEB epistemic community.

The Space Debris report marks a first policy progress for debris governance in Europe as it embodied the first public political statement made by a multi-lateral space agency on space debris in 1988.[212] The Resolution consolidated this policy progress at the higher level of the Agency. It allowed debris mitigation ideas and norm to reach the highest political body of the Agency, namely the ESA Council.[213] This marked the beginning of a growing support for debris illustrated by ensuing political support with even a greater sense of urgency and priority found in ensuing ESA Resolutions supporting Debris, securing debris research funding, laying out the action plan and illustrating the commitment of the Council level to

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[210] ESA SDWG, *Space Debris, The Report of the ESA Space Debris Working Group* – ESA SP-1109.
[211] ESA Council Resolution 1989, "ESA Activities for Space Debris," ESA/C(89)24, rev. 1.
[212] Howard Baker, "The ESA and US reports on space debris: Platform for future policy initiatives," *Space Policy* 6 no. 4 (November 1990), 332.
[213] The ESA Convention made the Council and the Director General the top bodies of the Agency(articles X and XII of ESA Convention, p 25, see ESA Convention, https://esamultimedia.esa.int/multimedia/publications/SP-1337/SP-1337_EN.pdf).The Council meets at ministerial level gathering ministers of Member States joining every two to three years. In 1989, the number of ESA member states was about 13, see http://www.esa.int/About_Us/Law_at_ESA/ESA_Convention; ESA organs, http://www.esa.int/About_Us/Law_at_ESA/ESA_s_organs_and_functioning (accessed June 11, 2021).

support debris mitigation efforts such as in the ESA Resolution of 2000,[214] and later on also in the 2010s as seen in the next chapters.

4.2.3 Progress observed at national levels in the 1980s

Following some pioneering debris mitigation ideas development and DEB ideas circulation progress observed thanks to emerging national debris expertise and transnational diffusion with papers and reports in the 1970s,[215] this section on the 1980s gives an overview of additional steps observed as national debris outcomes, and deriving from direct involvement of epistemic groups of especially the emerging Debris Mitigation group (DEB) and from ongoing influences of the external Arms Control group (AC).

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[214] Walter Flury, "Activities on Space Debris in Europe," *Proceedings of the 3rd European Conference on Space Debris*, ESOC, Darmstadt, Germany, 19 - 21 March 2001 (ESA SP-473, August 2001), 1; Marietta Benkö and Kai-Uwe Schrögl, "The 1999 UNCOPUOS 'Technical Report on Space Debris' and the New Work Plan on Space Debris (2002-2005): Perspectives and Legal Consequence," *Proceedings of the 3rd European Conference on Space Debris*, ESOC, Darmstadt, Germany, 19 - 21 March 2001 (ESA SP-473, August 2001), 2. "Resolution for a European Policy on Protection of the Space Environment from Debris," adopted on 20 December 2000 as ESA's Council in December 2000 (ESA/C(2000)93).

[215] Several debris papers were presented at international levels such as at IAC and ISTS Conferences and within the UN secretariat UNOOSA. Makoto Nagatomo, Matsuo Hiroki and Kuninori Uesugi, "Some Consideration on Utilization Control of the Near-Earth Space in Future," Proceedings of the *9th International Symposium on Space Technology and Science* (ISTS), Tokyo 1971: 257-263; Makoto Nagatomo, Matsuo Hiroki and Kuninori Uesugi, "Safety Design of Space Station against Collision Hazards with Artificial Orbiting Bodies," Proceedings of the *5th International Space Rescue Symposium*, XXIII IAF Congress (IAC), Vienna, 8–15 October 1972; Brooks, David R., Gibson, Gary G. and Bess, T. Dale: "Predicting the Probability that earth-Orbiting Spacecrafts Will Collide With Objects in Space," XXV International Astronautical Congress, *Seventh Annual Space Rescue and Safety Symposium*, paper no. A74-34, Amsterdam, 30 September 1974; Kuninori Uesugi, "Optimum Low-Thrust Multiple Rendezvous," ISAS Report 551, Institute of Space and Aeronautical Science, University of Tokyo, Japan (November 1977); Lubos Perek, "Physics, Uses, and Regulation of the Geostationary Orbit, or, ex facto sequitur lex" IAF Paper SL-77-44, *28th International Astronautical Federation Congress*, Prague, Czechoslovakia. September 25-October 1, 1977; A/AC.105/203 of 29 August 1977, Physical Nature and Technical Attributes of the Geostationary Orbit; A/AC.105/261 of 7 December 1979, Mutual Relations of Space Missions, Information paper, UNOOSA Secretariat; and Lubos Perek, "Outer Space Activities versus Outer Space," in Proceedings of *22nd Colloquium on the Law of Outer Space of the IISL*, Munich, West Germany, 1979 (AIAA, 1980).

The study found that the 1980s represents a crucial decade for debris governance progress both internationally and nationally. At the national level, knowledge, normative, policy and compliance steps in debris governance were found to involve epistemic community members, mostly the DEB group, and also with some contributions of the AC group. These national debris governance outcomes occurred especially in the United States, Soviet Union, France and Germany, Japan, and to some extend China and India as explained below. The influences of the Arms Control (AC) group already active over space governance since the 1960s are observed in the 1980s especially nationally in the United States and Soviet Union as explained in this section.[216]

Knowledge and Normative

In the United States, some early debris research in the 1960s and 1970s, especially under NASA and DOD groups, led to the creation of a permanent debris program at the Johnson Space Center (JSC) in Houston by 1979 as mentioned in Kessler. From the 1980s an expansion and diffusion of debris knowledge and interest was observed across many federal agencies of the U. S. government and spacecraft operators. These steps correspond to knowledge and normative progress for U.S. national debris governance.

Among the most pertinent contributions found are a series of national debris mitigation tutorials held in the early 1980s by early members of the debris epistemic community, namely

[216] Emmanuel Adler's work analyses the influence of the arms control epistemic community over facilitating the emergence of the PTBT treaty in 1963, and later ABM treaty in 1972, considered as basic elements of the space governance regime and with some provisions of restraint affecting the debris issue. This AC group will generate additional space governance progress outcomes in the 1980s in the U.S. and U.S.S.R. as explained in this section.

by the JSC debris team with Burt Cour-Palais, Donald Kessler, and Joseph Loftus.[217] The governmental offices briefed included the State Department, the Department of Transportation, the USAF Space Division, NORAD, other NASA centers, and the Strategic Defense Command. This contributed as knowledge and normative diffusion nationally, paving the way for more national debris policy outcomes to keep emerge in the 1990s, [218] and 2000s.[219] Joseph Loftus as a chair of the Space Transportation Technical Committee and Kessler as another DEB member were involved in the preparation of an American Institute of Astronautics and Astronautics (AIAA) 's first Position Paper on Orbital Debris in 1981 as the first debris study, encouraged especially by observations of Delta II launcher explosions.[220] It was aiming at raising awareness of debris as being a national policy issue, together with other experts sharing debris mitigation interest.[221] In 1981, the AIAA served as a supporting institution conducive to epistemic influence and enabling the shaping of ideas similar to Adler's "home" institutions,[222] besides the newly created NASA debris program still small, developing and promoting the idea of debris mitigation at a time when the idea wasn't really accepted yet neither by other foreign space agencies nor nationally, facilitating the emergence of the DEB group and of its influence.

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[217] Kessler,"A Partial History of Orbital Debris: A Personal View," 10.
[218] Akira Kato, "Comparison of National Space Debris Mitigation Standards," *Advances in Space Research* 28, no. 9 (2001), 1448.
[219] Weeden, IAC-16.A6.8.3 The Evolution of U.S. National Policy for Addressing the Threat of Space Debris
[220] Joseph Loftus was involved in AIAA as chair, other debris experts over time will also assume executive roles as chairs such as Dick Kline. On the normative influence of this first 1981 AIAA paper to raise debris awareness across national agencies, see Joseph P. Loftus, Jr. , NASA Johnson Space Center Oral History Project, Edited Oral History Transcript, Interviewed by Summer Chick Bergen, Houston, Texas – 8 November 2000 https://historycollection.jsc.nasa.gov/JSCHistoryPortal/history/oral_histories/LoftusJP/LoftusJP_11-8-00.htm (accessed June 27, 2021). Kessler, "A Partial History of Orbital Debris: A Personal View," 7.
[221] Kessler, "A Partial History of Orbital Debris: A Personal View," 7.
[222] Adler, "The Emergence of Cooperation."

Additionally, a national workshop organized in Johnson Space Center (JSC) in 1982 served as catalyzer for the debris mitigation group to become a transnational epistemic group, sharing a set of ideas and values about the debris issue and mitigation solutions. The workshop gathering about 100 participants included foreign and national experts of various professional backgrounds from scientists and engineers to lawyers and representing about forty organizations.[223] It involved space agency experts of the European Space Agency, NASA (JPL), commercial entities such as Lockheed and Comsat, research institutions such as the German Max Plank Institute, the National Academy of Sciences, as well as the defense sector with U.S. DoD and NORAD amongst others. As noted in Loftus, the workshop crystalized a "community of interest around orbital debris."[224] The 1982 JSC Orbital Debris Workshop therefore contributed to shaping a transnational epistemic community around debris mitigation interests and ideas (DEB). Elements of a national DEB epistemic group were emerging in the United States across specific NASA and DOD units in the late 1970s as observable in Kessler and Portree and Loftus' publications,[225] however the DEB group grew with increasing its membership nationally, internationally, and further developing a community of interests from the early to mid-1980s. This period marks a turning point whereby debris mitigation ideas promoted internationally by a few pioneers via individual papers and by early operational behaviors such as de-orbiting moves of the 1970s become gradually shared by an epistemic community emerging as the Debris Mitigation group

[223] Portree and Loftus, "Orbital Debris: A Chronology," 39.
[224] Portree and Loftus, "Orbital Debris: A Chronology," 39.
[225] Kessler, "A Partial History of Orbital Debris: A Personal View"; Portree and Loftus, "Orbital Debris: A Chronology."

(DEB). This represents national knowledge and normative progress for debris governance in the U.S. and also internationally, as this workshop gathering 100 participants invited also foreign participants and encouraged further debris efforts. International debris knowledge and normative progress steps start to emerge with ensuing dedicated debris conferences such as the COSPAR meeting in 1984 and the IAU meeting in Marseilles, France the same year, enabling the same community to meet again and further construct its knowledge about the debris issue. These two international meetings in turn then also helped also raise national awareness in the U.S., together with events such as the 1984 announcement of the manned space station program *Space Station Freedom* - before it became the International Space Station,[226] and ASAT testing lessons especially from the 1985 Solwind (P78) test.[227]

Other national knowledge and normative steps in the 1980s were involving direct participation of DEB group members, especially of the JSC center like Kessler and Potter interacting with DOD members in several DOD orbital debris groups such as the USAF SAB studies in 1983 and 1987.[228]

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[226] Kessler, "A Partial History of Orbital Debris: A Personal View," 10. The first manned space programs stimulated the earlier debris research efforts as observed under NASA, in the Soviet Union, and even for the first study in Japan emerging for concerns of safety of manned missions. In the U.S. in the 1950s and 1960s first NASA debris research Mercury and Apollo. In Europe, the manned mission programs planned in the 1980s also stimulated debris research besides the Ariane launcher break-up event.

[227] Kessler, "A Partial History of Orbital Debris: A Personal View," 12; Brian C. Weeden, "The Evolution of U.S. National Policy for Addressing the Threat of Space Debris" Paper IAC-16-A6.8.3, 67th International Astronautical Congress (IAC), Guadalajara, Mexico, 26-30 September 2016, (Paris: International Astronautical Federation, 2017), 2; Moltz, *Crowded Orbits*, 153.

[228] Report of the U.S. Air Force Scientific Advisory Board (USAF SAB) Ad Hoc Committee on Potential Threat to U.S. Satellites Posed by Space Debris, December 1983; Report on Orbital Debris, U.S. Air Force Scientific Advisory Board," Current and Potential Technology to Protect Air Force Space Missions from Current and Future Debris," December 1987.

Lastly, as a major knowledge and normative contribution is found in the 1989 Interagency report (Space),[229] which is a landmark report for debris national knowledge progress and normative progress as a consensual knowledge gathered across federal agencies. As Kessler noted, it contained all the ideas that the orbital debris community had been putting forward for years.[230] Also, the Interagency (Space)1989 report represents a normative steppingstone for debris governance as it contains a mandate for the U.S. national experts to lead international cooperative efforts around the space debris issue, on the basis of the consensual knowledge achieved within this U.S. level Interagency report.

Policy

Several national policy gap filling efforts in debris governance were uncovered in the United States during the 1980s. These U.S. national debris policy steps were observed especially in 1983 and 1987 at the DOD level with the USAF SAB reports, in 1986 and 1987 at the U.S. Congress level with national bans and cancellations on ASAT testing programs, and in 1988 and 1989 at the White House level, with the first Presidential Directive and National Space Policies mentioning space debris under the Reagan and George H. W. Bush administrations. These policy steps were achieved thanks to influences from essentially the DEB epistemic group, and also from the arms control AC group whose influence over shaping some elements of space governance as an external group endured since the late 1950s

[229] United States National Security Council, Interagency Group (Space), *Report on Orbital Debris*, (Washington, D.C.: National Security Council, February 1989).
[230] Portree and Loftus, "Orbital Debris: A Chronology," 60.

early 1960s in the arms control discussion platform and was observed as still active in the U.S. and U.S.S.R. in the 1980s.

The national influence of the arms control group as an external group to the space community and emerging in the late 1950s has been noted in Adler and in Evangelista, both highlighting the AC group's involvement in reaching earlier arms control agreements in the 1960s with the PTBT and in the 1970s with the ABM treaties, and noting a continued influence in the 1980s around Reagan Administrations' Strategic Defense Initiative (SDI) known as "Star wars" initiative, and Soviet proposals of a bi-lateral U.S.-Soviet space weapons ban treaty.[231] The particular policy outcome steps facilitated by the AC group in that period and counting as basic elements of space governance affecting the debris issue are several limited national ASAT-testing bans and budgetary cuts appearing in Congress successively in 1985, in 1986, and in 1987 supported also at the White House level.[232] These limited bans steps consolidated the emerging debris mitigation ideas and norm in the 1980s both nationally and on the Soviet side, encouraging restraint as explained further in the Soviet national progress section. Aoki[233] and Moltz[234] also acknowledge the influence of arms

[231] Adler, "The Emergence of Cooperation," 140 and Matthew Evangelista, *Unarmed Forces: The Transnational Movement to End the Cold War*, 237–238, see more details in the Soviet Union 1980s national progress section.

[232] Laura Grego, "A History of ASAT Programs," Union of Concerned Scientists, January 2012, https://www.ucsusa.org/sites/default/files/2019-09/a-history-of-ASAT-programs_lo-res.pdf (accessed June 15, 2021), 5; Brian Weeden, "Through A Glass, Darkly, Chinese, American, and Russian Anti-Satellite Testing in Space," Secure World Foundations, available in *The Space Review*, March 17, 2014, http://www.thespacereview.com/article/2473/1 (accessed June 16, 2020), 25.

[233] Setsuko Aoki, "Japanese Perspectives on Space Security," In John M. Logsdon and James Clay Moltz (Ed.) "Collective Security in Space: Asian Perspectives." Washington D.C.: Space Policy Institute, (January 2008), 50.

[234] Moltz, *Crowded Orbits*, 153.

controls promoters in diffusing awareness about of the dangers of disturbing the U.S.-Soviet balance with ASAT testing and of triggering a space arms race.

Another epistemic group influence was observed nationally in the U.S. in the 1980s besides the AC group's impact over ASAT-testing bans, namely the DEB group influence as a space epistemic community. Indeed, the involvement of the DEB members were observed in the SAB report of 1983 to which one of the early DEB members, Donald Kessler, participated. [235] The SAB report was encouraging negotiations with the Soviets on limiting ASAT testing, echoing ideas circulating in the Soviet Union such as the proposal for an Anti-satellite Weapons Ban Treaty, and in the NGO fora in the United States in 1983 such as the UCS ASAT Weapons Ban Treaty proposal which contained a limited ban provision calling for limiting the testing against of physical targets or destructive testing, creating large amounts of and long-lived space debris. These national policy steps such as the SAB reports and influence of DEB members as support to the AC group discussing in the bi-lateral arms control platform and under the UCS NGO level was further encouraged by growing debris knowledge gained from physical evidence of orbital debris damage on manned missions such as on STS-7 in 1983, and an impact on the *Salyut-7* mission,[236] and later by further ASAT testing lessons learned in 1985.

The first national space policy to include debris is found in the 1988 Presidential Directive of 1988,[237] which specifies that: "[…] all space sectors will seek to minimize the creation of

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[235] Kessler, "A Partial History of Orbital Debris: A Personal View,"10. Kessler, Potter and Dick Kline were involved. Kline was also part of the first AIAA study on debris as chair in 1981.

[236] Portree and Loftus, "Orbital Debris: A Chronology," 42. The two Cosmonauts had to make an emergency evacuation taking refuge in the Soyuz spacecraft.

[237] Kessler,"A Partial History of Orbital Debris: A Personal View".

space debris. Design and operations of space tests, experiments and systems will strive to minimize or reduce accumulation of space debris consistent with mission requirements and cost effectiveness." The Directive further calls for establishing a working group for its implementation*:* "[…]an IG (Space) working group will provide recommendations on the implementation of the Space Debris Policy contained in the Policy section of this directive."[238]

Overall, the other 1987 national ASAT DOD guidelines, ASAT limited bans and the first national debris space policies of the 1988 Presidential Directive and 1989 National Space Policy illustrate the culmination of years of awareness efforts on the part of DEB members active across several national agencies, especially active under NASA and DOD experts and reaching out to other international for a, besides some ongoing efforts observed for the AC group.

These national steps supporting the emergence of debris mitigation norms and codification into policy outcomes mark a national policy progress for debris governance in the United States and, as will be shown in the next decades, a foundation for space debris governance progress setting some basic principles found later in space agency debris mitigation instruments, such as the NASA 1995 standard, and the later IADC debris mitigation guidelines largely based upon it.

The late 1980s period marks a turning point for debris policy progress as also recognized by Baker, and Obermann and Williamson, who see the 1988 and 1989 as crucial for national

[238] Logsdon (ed.), *Exploring the Unknown*, 610.

debris efforts in the United States.[239] As explained in Portree and Loftus,[240] Alby[241] and reminded by Obermann and Williamson,[242] the year 1988 marked a turning point after which the debris issue achieved national political attention as a national policy item. As Kessler mentioned, it started a "post presidential directive phase" towards gaining wider international political attention.[243]

In terms of ideas, the above paragraphs already established that especially observable from the IG report, a comprehensive debris mitigation approach emerged and contained arms control ideas such as limiting the testing of ASATs causing debris proliferation, besides the other ideas entailed under the increasingly comprehensive space debris mitigation operational and design practices as emerging DEB norms. And as regard the epistemic members involved on the national level, Kessler's personal view paper and Portree and Loftus's chronology provide a detailed account of the key experts which contributed to what they see as a generating a national consensus on the orbital debris issue." Kessler's work though best describes especially on the last page the large extend of the list of individuals

[239] Howard Baker, "The ESA and US reports on space debris: Platform for future policy initiatives"; Richard M. Obermann and Ray W. Williamson, "New Challenges in International Orbital Debris Policy," IISL 4.94-845, Paper presented at the International Institute of Space Law Symposium, *45th International Astronautical Congress* (IAC), Jerusalem, Israel, 9–14 October 1994.
[240] Portree and Loftus. "*Orbital Debris: A Chronology*," 55 and 60.
[241] Alby, "30 Years of Space Debris Mitigation Guidelines in Europe," 2.
[242] Kessler, "A Partial History of Orbital Debris: A Personal View" ; Richard M. Obermann and Ray W. Williamson, "New Challenges in International Orbital Debris Policy," IISL 4.94-845, Paper presented at the International Institute of Space Law Symposium, *45th International Astronautical Congress* (IAC), Jerusalem, Israel, 9–14 October 1994, 292.
[243] Kessler,"A Partial History of Orbital Debris: A Personal View," 1 and 13.

who soon joined the early JSC group and DOD-related experts[244] and which is too long to mention in this thesis.[245]

Another policy outcome for national debris governance in the 1980s is found in the U.S. Commercial Space Launch Act in 1984,[246] which besides the Space Station Freedom was also among the priorities of the Reagan Administration.[247] The Act entrusted the Department of Transportation (DOT) to license U.S. launches according to proper safety requirements which cover broadly orbital debris issues. This governance step was facilitated by the awareness campaigns conducted by members of the DEB community such as Joseph Loftus, Burt Cour-Palais and Donald Kessler who diffused their shared debris mitigation knowledge in the early 1980s via tutorials of other governmental agencies including the DOT.[248] This national basic debris provision increasing safety with licensing requirements marks another policy innovation besides the first national debris space policy in a major space power. Indeed, as noted by Bonnal, the issuing of the licensing act was followed by the emergence of numerous licensing regulations covering debris in other nations.[249] The UK issued its first commercial launching act soon after in 1986, and a series of acts followed in the 1990s covering debris as well.[250] The U.S. Commercial Launching Act of 1984 enabled thanks to

[244] These experts include contractors working for NASA and for the DOD, such as Nicholas Johnson who was a consultant with Teledyne and not yet a member of the NASA JSC Orbital debris office.
[245] Kessler, "A Partial History of Orbital Debris: A Personal View," 13.
[246] Commercial Space Launch Act, October 1984, https://www.govtrack.us/congress/bills/98/hr3942/text, (accessed June 29,2021).
[247] Logsdon, *Exploring the Unknown*, "The Evolution of U.S. Space Policy and Plans," 390.
[248] Kessler, "A Partial History of Orbital Debris: A Personal View," 10.
[249] Christophe, Bonnal, "A Brief historical overview of space debris mitigation rules," Paper presented at *Clean Space Industrial Days,* ESTEC (23-27 May 2016), 14.
[250] The "UK Outer Space Act" followed in 1986, the "South Africa Space Affairs Act" in 1993, Argentina's "National Registry of objects launched into outer space" in 1995, Russia's "Decree and statute on licensing space operations" in 1996, Australia's " Space Activities Act "in 1998 and more in the 2000s and 2010s.

the influence of DEB experts therefore supported the emerging national as well as international debris mitigation norms and debris governance progresses in the 1980s.

Compliance

The ASAT testing restraint observed after 1986 expresses national compliance progress for debris governance, facilitated by national epistemic influences and lessons from ASAT testing in the 1980s especially in 1985,[251] and encouraging also the continued compliance with destructive ASAT-testing moratorium on the Soviet Union side.

As seen before, after the debris lessons learned from the Solwind ASAT test in 1985 thanks to involvement of DEB members Donald Kessler, Andrew Potter and John Stanley, the following test of Delta-180 conducted under General Abrahamson who had been consulting with the NASA debris experts since the late 1970s[252] was the first to comply with the safer requirements to minimize long-lived debris creation as a direct influence of the DEB group. Namely, the Delta-180 test was conducted according to the DEB group suggested requirements at lower altitude and deemed more responsible as testified by DEB expert Nicholas Johnson before Congress in 1988.[253] As the last ASAT test before the series of U.S. Congressional testing bans, it consolidated the emerging DEB norm of non-destructive or less destructive and more responsible ASATs and led to a long-lasting moratorium observed by the U.S. since 86 and Soviet Union since 1983, interrupted only by the Chinese test in

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[251] Setsuko Aoki, "Japanese Perspectives on Space Security," in John M. Logsdon and James Clay Moltz (Ed.) "Collective Security in Space: Asian Perspectives", Space Policy Institute, (January 2008), 50.
[252] Kessler, "A Partial History of Orbital Debris: A Personal View."
[253] "Orbital Space Debris," *Hearing Before the Subcommittee on Space Science and Applications,* Committee on Science, Space and Technology, U.S. House of Representatives, July 13, 1988, and Portree and Loftus, "Orbital Debris: A Chronology," 56.

2007. The compliance started in 1986 will perdure until present day as the USA-193 ASAT test in 2008[254] was also conducted according to lower altitude requirements, inheriting from these 1980s efforts.

As national debris efforts progress steps in the 1980s' Soviet Union, the research found knowledge, normative and compliance efforts in debris governance also involving epistemic community members, especially the Arms Control (AC) group already active earlier over space governance and with a renewed influence, and in time also the emerging Debris Mitigation (DEB) group. Their epistemic influences are highlighted in bi-lateral space agencies meetings and arms control initiatives, as explained below.

Knowledge and normative

Exchanges between Soviet and American space debris scientists occurred during the late 1980s. For exchanges about space debris research, bi-lateral workshops started especially from 1989,[255] involving members of the DEB epistemic group. This was facilitated thanks to the U.S. Presidential Directive of 1988 calling for an interagency working group to study the debris issue and led to U.S. Interagency (IG) Report on space debris, mandating the U.S. and involving the NASA debris office to develop international space debris cooperation.[256] In December 1989, the American delegation visiting Moscow included some key experts of the emerging DEB group such as Donald Kessler and Joseph Loftus mentioned in Table 6-3 as

[254] Weeden, "Through a Glass, Darkly: Chinese, American and Russian Anti-Satellite Testing in Space," SWF Issue Brief, SSA Sharing Program, http://swfound.org/media/167224/through_a_glass_darkly_march2014.pdf, 29-30.
[255] Kessler, "A Partial History of Orbital Debris: A Personal View".
[256] Portree and Loftus, "Orbital Debris: A chronology," 60. That recommendation of U.S. leading international debris cooperation efforts was already in the DOD SAB 1987 report (Portree and Loftus, "Orbital Debris: A Chronology,"54).

well as Andrew Potter., besides NASA headquarters people.[257] These interactions prepared the basis for the establishment of the Inter Agency Space Debris Coordination Committee (IADC) within only a few years thanks to the direct involvement of the early American members of the DEB epistemic group and of some Soviet counterparts.[258]

A bi-lateral orbital debris working group was formed during this 1989 visit involving space agency delegates from NASA, and on the Soviet side, the Central Research Institute for the Ministry of General Machine Building, *TsNIIMash*, RPO *Energia*, the Ministries of Defense and Foreign Affairs, and *Glavcosmos*, as the civilian space agency dealing with international cooperation created under the Ministry of General Machine Building in 1985.[259] This bi-lateral meeting facilitated knowledge and normative progress for debris governance in the late 1980s.

An additional norm was emerging in the Soviet Union in the 1980s observed in another platform, namely the arms control level of discussions. Indeed, the norm of refraining from conducting destructive antisatellite weapons tests (ASATs) found already on the Soviet since 1983 with its unilateral moratorium declaration. This arms control restraint norm was completed by the growing influence of the debris mitigation norm, which had diffused also at the highest state political levels as observed in a statement delivered in 1988 by the Soviet Foreign Minister calling on reducing orbital debris pollution.[260] National normative progress

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[257] Portree and Loftus, “Orbital Debris: A chronology,” 63.
[258] The base of this epistemic community experts of the DEB group will consolidate further and grow its membership in the 1990s , when additional debris members will also participate in workshops held in Russia from the 1990s. In a 2012 paper by Seidelmann, himself exchanging with Soviet and Russian scientists for decades, additional members of the DEB group are found to attend several space tracking workshops, such as Nicholas Johnson, Steve Knowles.
[259] Portree and Loftus, “Orbital Debris: A chronology,” 63.
[260] Portree and Loftus, “Orbital Debris: A chronology,” 58.

on debris mitigation norms during the 1980s were observed in both superpowers by the end of the decade. As noted in Adler in 1992, the heritage of the U.S. arms control epistemic community influence to diffuse its ideas at the highest political levels in the Soviet Union since the 1960s, leading to the first achievements of PTBT, and then ABM in 1972 as part of the SALT talks, had left a legacy and endured in the l980s on the Soviet side. This influence was observed even before Gorbachev came to power.[261] As noted in Portree and Loftus,[262] Edvard Shevardnadze, as the Soviet Foreign Minister, had declared in May 1988 that space pollution needed to be prevented, and that the State Department considered the orbital debris issue as an inherently international issue, as "orbital debris does not observe national boundaries, […] we are all in this together. Sooner or later, we need to consult with others." Adding to the AC group influences which led to the moratorium in 1983, this statement indicated the emerging influence of the transnational DEB group on the Soviet side, with the diffusion of ideas of debris mitigation. This political statement came at a time when the DEB group gained strength also in the U.S. and Europe with two crucial reports in preparation, and under COPUOS which had made several statements recognizing the debris issue as an item to consider especially since UNISPACE II, report, and with a debris study called for by COPUOS and conducted under COPSAR/IAA, and the emergence of regular NASA/ESA debris working groups emerging since 1987.

Evangelista further elaborates on this AC group legacy in the 1980s period, and on a continued influence of arms control ideas of the AC epistemic group even before Gorbachev

[261] Adler, "The Emergence of Cooperation," 140.
[262] Portree and Loftus, "Orbital Debris: A chronology," 58.

came to power, and, as mentioned in Adler too, promoting some of the same arguments used already in the 1960s to convey knowledge about dangers of space weapons and the need for some restraint.[263] Evangelista mentions how especially two Soviet scientists went to Washington D.C. in the Spring of 1983 and discussed with the U.S. National Academy of Sciences and the shapers of the same year's Treaty proposal by the Union of Concerned Scientists' for an ASAT weapons ban treaty,[264] and brought these ideas back to the defense minister and how it influenced to decision for the Soviet unilateral moratorium on the testing of ASAT declared later that year by Andropov along with a proposal for a space weapons ban treaty, which was later abandoned.[265] This highlights the involvement of the AC group in the emergence and growth of the norm of ASAT testing restraint on both superpower sides

[263] Evangelista, Unarmed Forces: The Transnational Movement to End the Cold War, 237–238.

[264] Evangelista, *Unarmed Forces*: *The Transnational Movement to End the Cold War,* 237–238. The UCS ASAT-ban Treaty proposal was shaped by UCS scientists in cooperation with other U.S. arms controllers as noted in the hearing report (United States. Congress. House. Committee on Foreign Affairs. Subcommittee on International Security and Scientific Affairs. "Arms Control in Outer Space: Hearings Before the Subcommittee on International Security and Scientific Affairs of the Committee on Foreign Affairs, House of Representatives, Ninety-eighth Congress, November 10, 1983, April 10, May 2, and July 26, 1984, Volume 4," U.S. Government Printing Office, (Jan. 1984), 248; "A Draft Treaty Limiting Anti-Satellite (ASAT) Weapons," http://www.nuclearfiles.org/menu/key-issues/space-weapons/history/drafttreaty1983.html# (accessed June 16, 2021).

[265] Evangelista, *Unarmed Forces*: *The Transnational Movement to End the Cold War*, 237–238. The influential Soviet scientists for the moratorium outcome were Evgenii Velikhov and Roald Sagdeev, as part of a larger group of scientists sharing arms control ideas, promoting them in publications and directly to top leaders as close advisers, and which had grown and persisted in the U.S. and the Soviet Union since the 1960s and regularly exchanged with counter parts in the National Academy of Sciences in the U.S. See more details on the legacy since the 1960s and the exchanges between counter parts explained in Adler "The Emergence of Cooperation" also in Richard L. Garwin, "Sagdeev in Arms Control", paper presented at the University of Maryland Symposium "Sagdeev at 80: Plasma, Space and International Security" February 7, 2013, https://fas.org/rlg/Sagdeev%20in%20(Arms)%20Control.pdf (accessed June 16, 2021). Garwin as one of the drafters of the 1983 UCS ASAT Ban Treaty proposal was part of many U.S. advisory entities, close to politicians, and part of home institutions nesting the arms control epistemic community since the 1960s, as such as the PSAC under the Kennedy administration covered in Alder. Garwin also published widely promoting AC ideas, was awarded numerous prices, exemplifies "epistemic knowledge experts". "The Garwin Archive," Federation of American Scientists, https://fas.org/rlg/ (accessed June 16, 2021). Velikhov and Sagdeev were his Soviet/Russian counterparts with similar advisory functions, proximity to political leaders, nested in supporting institutions conducive to their AC epistemic group such as the Soviet Academy of Sciences.

in the 1980s, which will lead to 30 years of restraint from destructive ASAT and counts as a second normative progress consolidating debris mitigation norms.

The study thus found that during this period of the 1980s, the debris governance epistemic group dynamics combines two groups, the efforts of the enduring and growing Arms Control (AC) epistemic group involving Scientists on both superpower sides, and the complementary efforts of the space debris experts of the emerging DEB epistemic group efforts on the space agencies' platform.

Compliance

The research also found some data regarding early compliance progress steps with the emerging debris mitigation efforts of the 1980s in the Soviet Union. As noted in the European Debris report of 1988, the Interagency (Space) IG report of 1989[266] and noted by Baker,[267] the Soviet Union also belonged to the group of pioneering space-faring nations and organizations adopting de-orbiting practices in geostationary orbit in the 1980s, expressing the diffusion of the emerging norms of GEO de-orbiting as a DEB shared norm circulating in international fora such as ITU and leading to a compliance step in the Soviet Union too. This first compliance step came before the Soviets had a formal GEO deorbiting requirement policy.[268]

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[266] U.S. 1989 Interagency Group (Space) *Report on Orbital Debris,* 39.

[267] European Space Agency SDWG, *Space Debris, The Report of the ESA Space Debris Working Group*, 33-34; Howard Baker, "The ESA and US reports on space debris: Platform for future policy initiatives," *Space Policy* 6 no. 4 (November 1990), 333.

[268] U.S. 1989 Interagency Group (Space) *Report on Orbital Debris,* 39. Besides the United States after 1981, the other early compliers with the DEB GEO deorbit norm emerging in the late 1970s and strengthening in the 1980s were some ESA members involving France/Germany with *Symphonie*, Italy, Japan, India's ISRO, the European Telecommunications Satellite Organization (EUTELSAT), the International Telecommunication

Additionally, by declaring a unilateral moratorium on testing of anti-satellite weapons in 1983 and by observing it throughout the decade and for 30 years, the Soviet Union also started to comply with and promote compliance efforts with the emerging DEB norm and efforts, besides GEO deorbiting emerging efforts. This moratorium marks the beginning of a lasting trend of compliance, corresponding for this research of debris governance progress to filling the compliance gap on the intentional and security aspects of debris mitigation. This step of the Soviets on the testing moratorium came in a period when bi-lateral negotiations were attempted on a space weapons ban treaty a between the U.S. and Soviet Union which did not succeed as a full treaty ban but led to some restraints achievements such as US domestic congressional bans and budgetary cuts on ASAT testing programs,[269] especially from 1986 after some increased debris awareness and learning resulted from an 1985 ASAT test involving debris experts.[270] This compliance step initiated nationally on the Soviet side and diffusing on both Soviet and U.S. sides consolidated debris mitigation efforts as it lasted for about 30 years, was observed by both superpowers and other spacefaring nations from 1987 until 2008.[271] This ASAT testing moratorium step therefore represents another

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Satellite Organization (INTELSAT), the International Maritime Satellite Organization (INMARSAT), US-based Comsat, Canada-based Telesat.

[269] U.S. National Academy of Sciences. *Nuclear Arms Control: Background and Issues*. Washington, DC: The National Academies Press, 1985, https://doi.org/10.17226/11(accessed June 15, 2021), 159-186. The bi-lateral negotiations for a treaty led to diffusion of arms control ideas nationally in the U.S. too especially under Congress, at NGO level such as the UCS treaty proposal of 1983 also presented at Congress and among NATO allies, see especially 169-172.

[270] Kessler "A Partial History of Orbital Debris: A Personal View," 11-12; Moltz, *Crowded Orbits: Conflict and Cooperation in Space*, 153.

[271] Laura Grego, "A History of ASAT Programs," Union of Concerned Scientists, January 2012, https://www.ucsusa.org/sites/default/files/2019-09/a-history-of-ASAT-programs_lo-res.pdf (accessed June 15, 2021).

important compliance progress for debris mitigation efforts in terms of the long duration and observance by the largest space powers.

Aside from the two superpowers major debris governance national outcomes in the 1980s, some other national debris governance steps were found as relating to epistemic influences, especially from the emerging DEB group. The examples are found in the United Kingdom, France-Germany, Japan, China and India. For instance, one national licensing progress was found together with compliance steps with emerging debris mitigation operation procedures and the creation of national debris working groups as normative progress steps.

In the United Kingdom, national debris progress found as a policy step is the UK Space Act of 1986.[272] Its licensing requirements cover space operations safety and cover space debris issues. This regulatory step follows a similar debris mitigation normative progress trend observed with the U.S. Commercial Space Launch Act in 1984, as earlier, facilitated by the influence of DEB members.

The sharing of DEB ideas by experts in the UK is also observable under the ITU forum around the same time when the UK delegation were the ones calling for a debris study to be started by CCIR to prepare GEO deorbiting recommendations at ITU.[273] This illustrates the sharing of DEB ideas by British national experts, and diffusing of ideas across fora, here consolidating normative debris progress on GEO boosting carried by the British delegates internationally under ITU. This contribution of the UK delegation to ITU's normative

[272] Claudio Portelli, Fernand Alby, Richard Crowther, and Uwe Wirt, "Space Debris Mitigation in France, Germany, Italy and United Kingdom," *Advances in Space Research* 45 No.8 (2010): 1036-1038.
[273] Ram S. Jakhu, J. L. Magdelénat and H. Rousselle. "The ITU Regulatory Framework for Satellite Communications: An Analysis of Space Warc 1985." *International Journal*, 42, no. 2 The Politics of International Telecommunications (Spring, 1987): 276-288.

progress will open the way towards a CCIR first debris study in 1985, as foundations towards the ITU recommendation ITU-R.S.1003 which will emerge in the next decade. It also complements in the 1980 some earlier observed normative contributions of other delegations such as the promotion of GEO re-orbiting ideas at ITU conducted by French CNES delegates since the early 1970s.[274]

A last important national debris governance outcome in the 1980s is observed in the UK with the joining of the British National Space Council (BNSC) in the first European space debris working group (SDWG) created in 1986.[275] This first space debris working group under ESA, with CNES, ASI, and DLR debris experts led to first ESA Report on Space Debris of 1988 (ESA-SP 1009) and the ESA Council Resolution[276] outcomes in 1989. With these collaborative efforts, the UK contributed to shaping debris governance regional instruments, towards a European debris mitigation standard (EDMS) and the European Code of Conduct for debris mitigation (ECoC).[277]

As regards France and Germany, national debris efforts were found in the 1980s especially as knowledge, normative and compliance efforts for GEO re-orbiting practices with the Franco-German Symphonie satellites launched in the mid-1970s, and with upper stage passivation ideas deriving from the 1986 learning thanks to information diffused from NASA DEB members.

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[274] Jean-Louis, Marcé, "How France Handles Space Debris," 115 and 116.
[275] Walter Flury, "European Activities on Space Debris," *Proceedings of the First European Conference on Space Debris*, ESOC, Darmstadt, Germany, 5-7 April 1993 (ESA SD-1), 1.
[276] "Resolution on the Agency's Policy vis-à-vis the Space Debris Issue" (ESA/C(89)24, 1989.
[277] The ECoC developed at regional level under ESA is a distinct initiative from the International Code of Conduct (ICoC) launched by the European Commission as international diplomatic level as explained in the ECoC section in the 2000s.

Re-orbited in 1983 and 1984 at about 50km above their positions, Symphonie A and B operational behaviors were arguably not sufficient in terms of altitude as pointed by Alby,[278] yet they illustrated the sharing of emerging DEB ideas in France and Germany at the time, marking a normative progress by the 1980s, and supporting international efforts promoting the GEO boosting norm under ITU and via conference papers. As explained by Marcé at an international debris conference, emerging ideas of GEO re-orbiting were promoted by CNES delegates across fora, including CCIR/ITU, since the launch of *Symphonie* satellites. Regarding the GEO de-orbiting issues, Marcé reminds of CNES' ongoing promotion of GEO de-orbiting practices ideas since the launch of the first GEO satellites in the 1970s thus also in the 1980s,[279] representing a normative consolidation progress of French experts supporting the emergence of this DEB norm and as part of the emerging DEB itself. The GEO-deorbit norm was emerging among commercial operators in the United States (INTELSAT, Comsat), Canada (TELESAT), the United Kingdom (INMARSAT) and France (Eutelsat),[280] and CNES also further consolidated it with two early compliance steps in 1983 and 1984 by de-orbiting the Franco-German *Symphonie* satellites in higher orbits.

As reminded in by Marcé,[281] debris knowledge in France increased further in the 1980s thanks to national experts' exchanges across various fora. Indeed, besides learning from operational experiences, CNES debris experts started to join debris working groups emerging in the 1980s,[282] exchanging with other space agencies and as delegates in international fora

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[278] Alby, "30 Years of Space Debris Mitigation Guidelines in Europe," 3.
[279] Jean-Louis, Marcé, "How France Handles Space Debris," 115, 116.
[280] U.S. 1989 Interagency (Space) *Report on Space Debris*, 43.
[281] Marcé, "How France Handles Space Debris," 115, 116.
[282] Space Debris Working Group under ESA (SDAG) formed in 1987.

where debris mitigation ideas started to diffuse especially under UN COPUOS discussions since the late 1970s and UNISPACE II in 1982, under ITU/CCIR preparing GEO deorbit recommendations from 1984 for WARC 1985 and 1988, under IAF with a debris study group emerging in the 1980s. As reminded by Marcé, CNES sent delegates to COPUOS, ITU, a space debris working group under the International Astronautics Academy (IAA), and to other space agencies such as the ESA space debris advisory group, NASA, and additional space agencies, thus greatly facilitating debris knowledge exchanges.[283]

By 1987, another French national normative progress was observed for another emerging DEB norm, namely the "upper stage passivation" again involving DEB members. Indeed, upon observations of the Ariane break-up in November 1986, Nicholas Johnson, Donald Kessler and Joseph Loftus as early members of the DEB epistemic group took action and the visiting ESA Director General and CNES debris expert Remi Hergott, in charge of the Ariane design were informed.[284] The "upper stage passivation" was growing as a norm in the United States from 1981, expanding to Japan from 1985 also thanks to the same DEB group knowledge sharing.[285] The knowledge about the upper stage fragmentation risks and the operational best practice to mitigate this high debris generating type of incident was learned mostly following the Ariane launcher's upper stage break-up in 1986 and was diffused from the NASA experts pioneer members of the DEB group to CNES experts and ensuing regular bi-lateral meetings were held between NASA and ESA from 1987 onwards building more

[283] Marcé, "How France Handles Space Debris," 115, 116.
[284] Kessler, "A Partial History of Orbital Debris: A Personal View," 12; Portree, "Orbital Debris: A Chronology."
[285] Portree and Loftus, "Orbital Debris: A Chronology."

DEB shared knowledge about the debris issue in France as part of ESA. Also, a Space Debris Advisory Group (SDAG) was formed in 1986 involving CNES, DLR, ASI and ESA to advise ESA on debris matters, besides the systematic debris research program conducted by the working group (SDWG),[286] whose efforts will facilitate the shaping also of the CNES space debris standard in the next decade.

This upper stage passivation knowledge gap filling efforts for national space debris mitigation activities involved especially DEB members on both sides such as Kessler and Loftus, Flury and Rex, and as French expert the national epistemic communities involved in the ESA Space debris working group (SDWG) were especially Fernand Alby and Christophe Bonnal.[287] They were among the national pioneers of this DEB group in France and continue promoting these ideas also beyond the space agencies' discussions such as by publishing and presenting at the UNCOPUOS and international workshops and conferences.

The creation of the ESA space debris working group in 1986 which French agency delegates joined also represents a national debris outcome for France, as it supported national-level normative progress, and prepared towards the development of a standard. Counting as a national debris policy progress at the CNES level, a space agency standard was issued by 1999, and later on a space law emerged with the 2008 Space Act. CNES played an important role in this European debris working group and coordination effort since the *Ariane* break-up event of 1986, as the establishment of the CNES standard led to the proposal of

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[286] Flury, "European Activities on Space Debris," Proceedings of the First European Conference on Space Debris, ESOC, Darmstadt, Germany, 5-7 April 1993 (ESA SD-1), 27; and Klinkrad, H., Alby, F., Alwes, D., Portelli, C., and Tremayne-Smith, R. "Space Debris Activities in Europe". *Proceedings of the 4th European Conference on Space Debris* (ESA SP-587). 18-20 April 2005, ESA/ESOC, Darmstadt, Germany, 1.
[287] Interview notes and email correspondence with CNES experts.

elaborate the ensuing European ESA-level debris mitigation instruments on the basis of the CNES standard, namely the European Debris Mitigation Standard (EDMS) issued in 2000 followed by the ensuing European Code of Conduct (ECoC) in 2004.[288]

As regards Germany, debris national progress steps were observed as a compliance progress with the Franco-German *Symphonie* Satellites re-orbiting maneuver as early as 1983 and 1984. In terms of policy progress, national debris outcomes emerged later alongside the ECoC in the 2000s. Yet, German debris experts have been part of the ESA debris coordination efforts since the beginning of the systematic working groups in 1986 helping to build debris normative progress. Professor Rex of Braunschweig University was involved as early coordinator of both the ESA working group and advisory body respectively SDWG and the SDAG,[289] and with Heiner Klinkrad they could contribute to shaping, growing and promoting DEB group ideas under these ESA groups and across various national and international fora.

As national debris progresses for Japan in the 1980s, several steps were found in the 1980s. Especially, in the area of launcher passivation, Japanese experts learned from the NASA DEB early group members by the mid-1980s. Also, debris studies continued to be carried out in the 1980s, while the turn of the decade marked increased efforts with the shaping of the Japan Society for Aeronautical and Space Sciences (JSASS) working group in 1990, starting a systematic national debris coordination effort and bigger involvement of the DEB group in

[288] Alby, "30 Years of Space Debris Mitigation Guidelines in Europe," 3.
[289] Heiner Klinkrad, "ESA Concepts for Space Debris Mitigation and Risk Reduction," 109.

Japan, both as contributing to international knowledge and as learning nationally from the group, as explained later.

In the previous decade, national contributions of Japanese debris experts were found as pioneering debris mitigation ideas presented as conference papers and as contributing knowledge and normative support to an emerging debris epistemic community (DEB) by the late 1970s. In the 1980s, progress in human spaceflight and space stations stimulated further interest in debris hazard across spacefaring nations, which also included Japan and two types of debris governance outcomes were found relating to epistemic influences in Japan. Firstly, there was an ongoing knowledge contribution from national debris experts to enrich the debris mitigation ideas and support normative efforts internationally. Secondly, there was knowledge progress in Japan thanks to direct influence of the DEB epistemic group growing in the United States. These national debris governance progress steps relating mostly to the emerging DEB group are explained below.

After being among the first ones to promote pioneering debris mitigation ideas of orbital collisions avoidance, managing the outer space traffic[290] and even sweeping orbital debris by 1977,[291] the team of Japanese debris experts at the University of Tokyo's Institute of Space and Astronautical Science (ISAS) continued to support the ideas of the emerging DEB epistemic group with continued studies published and presented at the international

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[290] Makoto, Nagatomo, Hiroki Matsuo and Kuninori Uesugi, "Safety Design of Space Station against Collision Hazards with Artificial Orbiting Bodies," In *Proceedings of the 5th International Space Rescue Symposium*, XXIII IAF Congress (IAC), Vienna, 8–15 October 1972; Makoto, Nagatomo, Hiroki Matsuo, and Kuninori Uesugi, "Some Consideration on Utilization Control of the Near-Earth Space in Future," *Proceedings of the 9th International Symposium on Space Technology and Science (ISTS)*, Tokyo 1971: 257-263.

[291] Kuninori Uesugi, "Collisions in space: a retrospective overview of ISAS studies," *Adv. Space R*. 11,no. 12 pp. (12)19--(12)27,1991, p 12(19). Kuninori Uesugi, "Optimum Low-Thrust Multiple Rendezvous," ISAS Report 551, Institute of Space and Aeronautical Science, University of Tokyo, Tokyo, Japan (November 1977).

conference ISTS on the same debris mitigation concepts.[292] These studies were further stimulated by longer-duration spaceflight programs such as manned space stations, which continued in the 1980s in the U.S. and Europe. National Japanese knowledge contributions to the international debris mitigation debates were found again,[293] completing the body of debris mitigation knowledge made by DEB group experts also in the United States and Europe. These studies represent ongoing support towards debris governance efforts as continued knowledge and normative gap filling efforts.

A second normative progress outcome is found in Japan in the support for the emerging norm of “upper stage passivation” following the NASA DEB members’ visit in 1985, and which had become a national norm nationally in the U.S since 1981.[294] After 1985, the compliance with this debris mitigation practice extended this norm also to Japan, consolidating further as a debris norm when it soon also became observed by CNES/ESA from 1987, and even more nations after that in the 1990s.

The study also identified a national compliance progress in Japan in the 1980s, filling a debris governance compliance gap, besides the above-mentioned Japanese expertise contribution to the internationally emerging debris mitigation knowledge and norm. Indeed, by the mid-1980s, national debris knowledge progress also occurred in Japan specifically regarding upper stage passivation. This early compliance progress in terms of debris

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[292] Keiichi Sato and Makoto, Nagatomo, Collision Probability in Space and the Debris Environment in Future, in: Proc. *14th International Symposium on Space Technology and Science (ISTS)*, Tokyo 1984; Masahisa Yanagisawa, Keiichi Sato, Akira, Yamori and Nobuki Kawashima, “Development of Railgun Accelerator at ISAS,” *IEEE Transactions on Magnetics* 25, no. 1 (1989).
[293] Makoto Nagatomo and Keiichi Sato, “Earth Satellite Collision Probability in Space Station Era,” *Acta Astronautica* 13, no 6–7 (1986): 333-338, https://doi.org/10.1016/0094-5765(86)90088-3.
[294] Kessler, “A Partial History of Orbital Debris: A Personal View,” 7.

governance chronology was catalyzed by the direct influence of a DEB epistemic group member. Namely, as an early member of emerging DEB group and locomotive of the newly created NASA Orbital Debris program, Joseph Loftus contacted and visited the Japanese entity dealing with launchers in 1985, the National Space Development Agency of Japan (NASDA), and following this diffusion of a DEB idea shared in the U.S. by 1981, all ensuing Japanese launchers were passivated.[295] This compliance practice of venting fuel left in launchers' upper stages to prevent orbital explosions is known as the "upper stage passivation" and its observance represents an important step for debris mitigation efforts since upper stages explosions were found to represent a large source of orbital debris creation.

Besides the passivation step, another compliance step was observed in Japan in the 1980s also under NASDA, namely Japan's compliance with emerging re-orbiting satellites practices in GEO, with ongoing research and several GEO satellites re-orbited at the end of their operational lives already from the mid-1980s.[296] These steps put Japan in the leading small group of nations and organizations following this debris mitigation practice, as mentioned in the first comprehensive ESA Space Debris report of 1988, in the 1989 U.S. Interagency (Space) IG group and noted in Baker.[297] This compliance step found in Japan illustrates the diffusion progress of the GEO re-orbiting ideas circulating and being promoted

[295]Alby, "30 Years of Space Debris Mitigation Guidelines in Europe," 2; Portree and Loftus, "Orbital Debris: A chronology," 37; Kessler, "A Partial History of Orbital Debris: A Personal View," 7. Tetsuo Yasaka, "Space Debris Related Activities: Japanese Case," Presentation at the IAF Workshop, held during the UN/COPUOS Sessions, Vienna, 11 February 2013, https://www.unoosa.org/pdf/pres/stsc2013/2013iaf-03E.pdf (accessed June 16, 2021), 2.

[296] Susumu Toda and Tetsuo Yasaka, "Space Debris Studies in Japan," (8)294, Kibe, Takano and Toda, "Current Space Debris Related Activities in Japan," *Advances in Space Research*, 16 no. 11 (1995) : (11)176.

[297] ESA Space Debris Space Debris, *The Report of the ESA Space Debris Working Group* ESA SP-1109 (November 1988), 33-34; Howard Baker, "The ESA and US reports on space debris: Platform for future policy initiatives," *Space Policy* 6 no. 4 (November 1990), 333.

internationally under especially the ITU, and also under UNISPACE II at the UN level in 1982 and at international conferences, involving the DEB group and reaching also Japan participating in these platforms in the 1980s.[298]

Already from the 1980s, some diffusion of the shared ideas of the emerging transnational DEB group circulating internationally, especially under ITU and also in studies presented at COPUOS and IACs were found in China. Some early debris governance steps are found to emerge, for instance filling some knowledge about the debris issue from 1986 and 1989 onward and some normative step with early compliance with the emerging norm of GEO deorbiting uncovered in the 1980's ITU discussions especially from WARC 1985 in preparation for ITU-R 1003.

Knowledge and normative gap filling efforts are found in China with the beginning of debris data collections from 1986, and the establishment of a national debris study team efforts involving many domestic agencies in 1989 as well as some early interest in debris legal aspects and increasing international exchanges by inviting delegations in China and visiting international debris fora involving a growing transnational DEB epistemic community.

Indeed, at a similar period when other spacefaring and launching nations began systematic debris research groups, China established its debris team "Team for Study of Space Debris

[298] Space agencies send expert delegates to ITU and COPUOS. Japanese debris experts also regularly interact at international conferences platforms especially under COSPAR and IAF in the 1980s including meetings and studies of IAA and IISL occurring during IACs, before additional fora will enable regular exchanges in the 1990s (IADC creation in 1993, beginning of ESA space debris conferences organized by ESOC in Darmstadt, Germany, amongst others).

Issue" in 1989,[299] interacted with international debris experts from NASA from 1989 and space law experts from ILA International Law Association.[300]

After some space debris observations with optical and radar satellites national capabilities from the 1970s and 1980s, from 1986 several efforts emerged across various institutions in China to collect debris-relevant data including legal aspects, leading to the formation of a space debris study team in 1989 composed of multiple national institutions such as the Chinese Academy of Space Technology, the China Academy of Launch-vehicle Technology, the Shanghai Space Agency and the Zijinshan Observatory.[301]

The ideas found in the Chinese debris efforts in the late 1980s express shared ideas of the emerging Debris Mitigation group (DEB). Specifically, awareness is found for the ideas of GEO deorbiting at the end of operational lives of satellites, which was circulating under ITU in the 1980s discussing and preparing for a recommendation to protect GEO from space debris by deorbiting.[302] The presence of these DEB group ideas and increasing ensuing efforts towards shaping up a national debris effort in China denote the involvement of the transnational DEB epistemic group already in the 1980s. Accounts of meetings with NASA

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[299] The U.S. issued several debris reports in the 1980s, yet the 1989 Interagency Group (Space) *Report on Orbital Debris* is deemed the most impactful one. ESA published its first debris working group report in 1988. Japan gathered its first interagency debris working group under Japan Society for Aeronautical and Space Sciences (JSASS) the following year, and as a co-founder of IADC soon after. The Soviet Union began bi-lateral meetings with NASA in 1989 and joined as host and cofounding member of IADC as Russian Space Agency within a few years by 1993. Chinese debris experts meet with NASA experts in 1991, join Centennial symposium focusing on debris in 1992, and are invited to join IADC in 1995.

[300] Qi, Yong Liang, "Facing Seriously the Issue of Protection of the Outer Space Environment," 118- 120, In Simpson, Preserving the Near-earth. 1994

[301] Qi, Yong Liang, "Facing Seriously the Issue of Protection of the Outer Space Environment," In Simpson, *Preserving the Near-earth*. 1994, 118-120.

[302] IG report 1989, 40; Ram J. Jakhu , Proceedings of the 34th Colloquium of Space law of the IISL, Montreal, Canada, 1-5 October 1991, 212. ITU/CCIR discussions and WARC 85 and 1988 reports.

debris experts,[303] UN experts and legal experts of international law associations in the United States in 1989 and of joining other international conferences indicate ideas promotions of the DEB group with Chinese specialists, which also enabled to growing the membership of this DEB group with Chinese debris experts, thus supporting debris governance progress with knowledge and normative gap filling efforts from the 1980s.

The study also found national debris governance progress in Indian in the 1980s. Indeed, India was among the first nations to have codified partially the GEO boosting DEB norm with the adoption of a national space agency policy under the Indian Space Research organization (ISRO). This policy was requiring future satellite designs to enable re-orbiting in GEO at the end of (operational) life in the 1980s.[304] The Indian Space Research Organization worked on its first geostationary satellite APPEL with a CNES team,[305] who was already supporting this DEB emerging norm, and promoting it under ITU. The diffusion of these GEO debris mitigation ideas of the DEB group to India in the 1980s therefore illustrates also national normative debris governance progress besides the two space superpowers of the U.S. and Soviet Union, and also the United Kingdom, France, Germany, Japan and China.

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[303] Kessler,"A Partial History of Orbital Debris: A Personal View,"; Qi Yong Liang, "Facing Seriously the Issue of Protection of the Outer Space Environment," 118-120; the debris knowledge diffusion such as upper stage passivation's will especially lead to modifications in the 1991 NASA visit to China, see Portree and Loftus, "Orbital Debris: A Chronology," 74; and United States, Office of Science and Technology Policy, Interagency *Report on Orbital Debris*, (Washington, DC, November 1995), 44.
[304] United States National Security Council, Interagency Group (Space) *Report on Orbital Debris*, (Washington, D.C.: National Security Council, February 1989), 39.
[305] Angathevar Baskaran, "Competence Building in complex systems in the developing countries: the case of satellite building in India", *Discussion paper Series, Middlesex University Business School*, no. 94, December 2000, "ISRO APPLE", https://www.vssc.gov.in/VSSC/index.php/apple, (accessed June 29, 2021).

5. CONSOLIDATING PHASE OF DEBRIS GOVERNANCE

This chapter covers the last phase in the chronology of sustainability and debris governance progress. This "Consolidating" phase highlights the debris governance steps achieved in the 1990s, 2000s and 2010s and represents the continuation of debris efforts built incrementally over many decades, following a pre-phase when basic elements of space governance were shaped in the 1950s and 1960s, and the emerging phase when debris-specific governance outcomes started to appear in the 1970s and 1980s.

The consolidating phase marks another turning point in the history of debris governance with the further codification of debris mitigation ideas into comprehensive or "universal" instruments, shaping a debris regime and enhancing space sustainability.

The research found that during this last phase covering the 1990s onward, the same discussion platforms have continued to play a significant role as supporting "homes" facilitating the epistemic process and generating progress as observed during the emerging phase in chapter 4. These platforms are the international non-governmental fora, the United Nations System fora, the multi-lateral fora outside of the UN system and the national level fora. The study uncovered some changes within the NGO level, namely the emergence of associations and consortia involving industry and sometimes as mixed public-private memberships and producing best practices initiatives especially from the 2000s and 2010s.[306] This section presents how all these above-mentioned fora levels acted as catalyzers of epistemic communities influences and towards debris governance progress, helping to

[306] Examples are IAASS, SDA, SSC, CONFERS and SSR and their respective initiatives.

consolidate debris and space sustainability efforts, even in the absence of a binding debris regime.

Two major epistemic groups were found to impact debris governance progress over this consolidating period from the 1990s until present, in particular the continued and increasing involvement of the Debris Mitigation epistemic group (DEB) and the formation of a new group promoting the ideas of Long-Term Sustainability of space activities (LTS). Continued influence of the earlier group of Arms Control (AC) observed in the earlier decade was also noted in this consolidating phase as an indirect one. These epistemic group dynamics impacting debris governance, facilitating the emergence of the LTS group, and their respective involvement levels are explained in this chapter.

5.1 Consolidating steps in the 1990s

This section presents the steps achieved in debris governance consolidating a growing body of additional basic provisions in space governance and of debris mitigation instruments during the 1990s decade illustrated in Table 6-1.

Similarly to the earlier decade of the 1980s, the influence of several epistemic groups has been identified and across multiple fora. International non-governmental organizations, the United Nations level, additional multi-lateral fora outside of the UN system and some national levels facilitated epistemic exchanges and involvement over debris governance progress.

The 1990s mark the appearance of the first international debris policy coordination initiatives and additional knowledge, normative, policy, institutional and compliance progress steps in space and debris governance. These governance steps and the main epistemic groups involved for the 1990s are explained further below.

5.1.1 International NGO-level initiatives 1990s

This section presents debris governance progress at the international non-governmental level in the 1990s, especially the International Academy of Astronautics' first Position Paper on Space Debris in 1993 and the debris instrument initiative emerging under the International Law Association in 1994.

International Academy of Astronautics (IAA) Position Paper 1993

The International Academy of Astronautics' Position Paper on Space Debris from 1993[307] represents contributions to several debris governance gaps, such as knowledge, normative, policy and institutional. The IAA is found to be a source of policy innovation for debris policy, a consolidating institutional platform facilitating debris policy innovation, and a catalyzer for epistemic community involvement. As a sub-entity of the International Astronautical Federation (IAF), the IAA also meets regularly with now in the 1990s a special working group devoted to debris facilitating further debris mitigation ideas shaping, enabling debris experts to exchange and shape debris knowledge and policy solutions, consolidating the DEB epistemic community's basis and membership and catalyzing debris efforts.

Knowledge and Normative

[307] IAA position paper 1993 on space debris International Academy of Astronautics Committee on Safety, Rescue, and Quality. 1992. Position Paper on Orbital Debris. August 27. Paris: International Academy of Astronautics.

This first IAA debris report of 1993 represents normative progress as consolidating the 1980s reports which were incremental to the shaping of the DEB community contours, gathering around a socially constructed and consensual debris knowledge as explained especially in the U.S. 1980s section of this research. The IAA position paper builds on earlier achieved debris mitigation outcomes such as knowledge and normative steps achieved from pioneering studies in the 1970s conceptualizing the debris threat to space operations and in the 1980s elaborating also on potential solutions as promoted by early epistemic members of the DEB group. The normative progress for DEB emerged especially from the 1980s across several other fora such as during IAC and COSPAR major debris findings from paper presentations an emerging debris workshop discussions such as the JSW 1982 workshop, the 1984 COSPAR and IAU international conferences, and also at bi-lateral 1980s space agencies-level meetings,[308] and under 1980s IAF congress meetings such as symposia and roundtables of IISL.[309] now further consolidating under the IADC,[310] the ILA,[311] and across the UN fora since UNISPACE II[312] such as the COPUOS and ITU.

[308] NASA-NASDA bi-lateral meeting 1989, NASA-ESA bi-lateral meeting 1987, NASA-Soviet meeting 1989.
[309] Nicholas L. Johnson, "Hazards of the Artificial Space Debris Environment," In *Proceedings of the 32nd Coll. on the Law of Outer Space,* (American Institute for Aeronautics and Astronautics, 1989): 482–489. 1990; Debris epistemic members joined IISL/IAA roundtables and discussed debris issues since the 1980s see Scarlet Wagner, "30 IAA/IISL Scientific-Legal Roundtable at International Astronautical Congresses," 2016, available at https://iislweb.org/30-years-of-iaa-iisl-scientific-legal-round-tables/ (accessed June 26, 2021).
[310] Working group for COPUOS and 1999 Technical Debris Report of the COPUOS WG.
[311] ILA Buenos Aires Instrument.
[312] UNISPACE II preparatory background report of 1981, UNISPACE II report recommendations that ITU should take action on debris in GEO, growing awareness of the debris issue in COPUOS, and UNGA in the 1980s.

The IAA Debris Position Paper has also been circulated across other IAF bodies being reviewed under IISL and other IAA committees,[313] giving it an even stronger epistemic and peer-validated value and encouraging further normative progress of debris mitigation ideas.

Policy

As a policy progress compared with the earlier U.S. IG Interagency (Space) report and 1988 Space Debris ESA reports is the inclusion in the IAA Position paper of space traffic management ideas supported by a code of conduct on space debris to be adopted under the ITU or COPUOS forum under the United Nations. Ideas of traffic rules obedience, seamanship and space traffic management were brought up earlier in the 1970s by pioneering papers such by the Lubos Perek.[314] Their inclusion into a paper being developed consensually by the consolidating DEB group of space debris experts who prepared this first IAA debris study represents a policy progress for space debris governance.[315]

Institutional

The 1993 IAA Position paper also fills an institutional gap in debris governance as it consolidates the IAA as a supporting home conducive for epistemic influences, from the growth of knowledge to wider promotion of ideas, especially for the DEB group which emerged especially in the 1980s. It also helps growth for consolidating debris mitigation ideas such as no deliberate break ups, and the need for a code of conduct which will be promoted in consecutive studies and reports. The 1990s marks a turning point for the IAA to

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[313] National Research Council, *Orbital Debris: A Technical Assessment,* 187-188.
[314] Portree and Loftus, “Orbital Debris: a Chronology”, 24.
[315] McKnight, Darren, and Walter Flury, “Space Debris: An International Policy Issue,” *Advances in Space Research* 13, no 8 (August 1993), (8)307.

become another debris governance conducive platform and for the DEB epistemic community to keep adapting to emerging debris-relevant issues and policy innovations over the years thanks to consecutive debris working groups and eventually a permanent debris committee, besides the other enduring supportive platforms under the UN and other NGOs.

The ideas contained in the IAA Space Debris report express the main influences of the epistemic community of DEB as the shaper the report, with inherited influences also of the AC group by way of diffusion of their ideas into debris governance tools.

DEB

Many of the IAA Position paper study group members were involved in the workshops and conferences which built the DEB group in the 1980s, and especially the U.S. Interagency IG Space Debris report of 1989, and the ESA Space debris report of 1988 both foundational reports crystalizing the debris knowledge and ideas consensually developed over the 1980s within the DEB community. As the first IAA comprehensive debris study, the 1993 IAA Debris Position paper contains all key debris mitigation concepts upon which space debris governance instruments will emerge, based on the two major ESA 1988 and IG 1989 studies which also built upon ideas circulating since the 1970s and across many fora of the IAF, IISL, COSPAR, and under the United Nations.

The position paper's *ad hoc* group was composed of several epistemic members of the DEB group such as the pioneers of the 1970s such as Donald Kessler, Lubos Perek, early promoters in the 1980s like Darren McKnight and Walter Flury as co-chairs of the IAA study, and newcomers to the debris group in the 1990s who will further promote debris mitigation ideas across several fora such as Nicholas Johnson and Heiner Klinkrad who will publish many papers, head the debris offices of their respective agencies for years, chair many debris sessions under international conferences and workshops and promote DEB ideas for decades.[316] Pamela Meredith as co-chair of AIAA Orbital Debris Committee also circulated DEB ideas across fora such as at the international centennial symposium in 1992,[317] and published on debris with other DEB group members.[318]

AC

As for the inherited influences of the AC group and presence of some ideas of the arms control group in the first IAA Position Paper on space debris in 1993, this research found traces under the recommendations section stipulating that: "The following actions are

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[316] Nicholas L. Johnson was NASA's Chief Scientist for Orbital Debris from 1996 until 2014 and deemed a strong debris mitigation advocate supporting the IADC guidelines work by peers. Johnson was granted the US Department of Defense "Joint Meritorious Civilian Service Award" for his contribution to Operation Burnt Frost. NASA MMOD Office News, " Updated: Nick Johnson, Chief Scientist of Orbital Debris, Says Goodbye to NASA, March 28, 2014 https://sma.nasa.gov/news/articles/newsitem/2014/03/28/updated-nick-johnson-chief-scientist-of-orbital-debris-says-goodbye-to-nasa; "Nicholas Johnson, Chief Scientist and Program Manager for NASA's Orbital Debris Program Office, Johnson Space Flight Center," May 01, 2009, *Tech Briefs*, https://www.techbriefs.com/component/content/article/tb/pub/features/whos-who/5143 (accessed June 14, 2021).

Heiner Klinkrad headed the ESA debris office at ESOC from 2006 until 2015, involved since 1988.

Both published books and many articles on debris and chaired many sessions at debris conferences and earned awards in recognition for their debris contributions. Klinkrad and the ESOC Debris office were awarded the "IAASS Joseph Loftus Space Sustainability Award" in 2013 as recognition by their peers for debris mitigation efforts in support of space sustainability, Merryl Azriel, "Heiner Klinkrad and ESA Space Debris Office Receive Space Sustainability Award" April 30, 2013, *Space Safety Magazine*, http://www.spacesafetymagazine.com/news/heiner-klinkrad-esa-space-debris-office-receive-joseph-loftus-space-sustainability-award/(accessed June 14, 2021).

[317] Pamela Meredith, "A Legal Regime for Orbital Debris: Elements of a Multilateral Treaty," presented at the *Preservation of Near-Earth Space for Future Generations - Centennial Symposium*, University of Chicago, June 24-26, 1992; Meredith, "Damage Caused by Orbital Debris to a Commercial Satellite: Liability Issues Raised by a Hypothetical Case Scenario," Proc. of the XXXVII Colloquium on the Law of Outer Space (1994); Meredith, "Legal Implementation of Space Debris Mitigation Measures," *American University Journal of International Law and Policy* (1991);

[318] Philip Chrystal, Darren McKnight and Pamela L. Meredith, "Space Debris: On a Collision Course for Insurers, Swiss Reinsurance Company," (2011). Meredith published on space law and policy since the 1980s.

recommended for immediate application in a first phase: (I) No deliberate breakups of spacecraft which produce debris in long-lived orbits."[319] This restraint idea of intentional debris creation will form the basis for the "intentional" provisions found in most of the ensuing debris governance instruments. These restraint ideas were emerging in the early 1980s and the efforts at limiting the testing of anti-satellite weapons at the bi-lateral U.S./Soviet arms control platform. As explained earlier, the AC group efforts had led to various limited ASAT-testing bans and moratoria, around the same time when the DEB group was also involved in the U.S. with the U.S. DOD preparing a study which covered the ASAT tests and the risks of creating long-lived orbital debris and started to recommend some level of restraint when conducting ASAT tests as well.

International Law Association Buenos Aires Debris Mitigation Instrument 1994

The international agreement known as the 1994 Draft Convention on Space Debris Mitigation[320] from the International Law Association's (ILA) represents another debris-dedicated governance progress step with contributions in several governance gaps. The ILA's space committee exists since the late 1950s and started discussing the debris issue around 1986.[321] The research found the ILA forum to be both a source and a consolidating entity for debris policy innovation, similarly to the IAA. In the ILA forum, debris mitigation ideas have

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[319] IAA, "Position paper on Orbital Debris," *Acta Astronautica* Vol. 31 (London: Pergamon Press Ltd,1993), 183.
[320] Maureen, Williams, *Safeguarding Outer Space*.
[321] "A space law and orbital debris." National Research Council, *Orbital Debris: A Technical Assessment*. (Washington, DC: The National Academies Press, 1995), doi: 10.17226/4765 (accessed February 18, 2021), 187.

also been shaped drawing upon already circulating ideas in other fora since the late 1970s and early 1980s such as the IISL and UNISPACE II. This ILA Debris proposal as an international non-governmental organization represents a policy outcome as well as knowledge and normative governance gaps progresses facilitated by epistemic influences and also by an external awareness building event. Specifically, during the uncontrolled re-entry of a Salyut 7 space station, a large piece of space debris failed to burn up in the atmosphere and caused a forest fire in Argentina in 1991.[322]

Knowledge

Firstly, this instrument helps further filling the knowledge gap regarding the highly technical debris issue and the little understanding of its legal basis. The ILA instrument helped prepare the work prior to the debris issue becoming an agenda item under the COPUOS Legal Subcommittee (LSC), complementing preliminary efforts undergone under the IISL forum in the late 1980s, such as with Nicholas Johnson's presentation of legal debris aspects as a technical expert member of the emerging debris mitigation group of DEB.[323]

Normative

Secondly, the ILA Draft Debris Instrument fills some normative gaps for debris governance by consolidating the growing consensus observed across several international fora around the necessity to tackle the debris problem, which had started to take shape during the 1980s, and here in another international non-governmental forum.

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[322] Portree and Loftus, "Orbital Debris: A Chronology," 71.
[323] Perek, "Space Debris at the United Nations," 123–136.

The DEB experts working on this instrument outcome have therefore facilitated normative progress helping emerging debris mitigation ideas including legal debris mitigation ideas towards becoming more widely accepted norms in the ILA forum, which diffused and actively promoted the legal aspects of debris mitigation for years as an additional forum hosting debris policy innovative ideas in the 1990s, as noted by Williams.[324] As one particular new norm promoted by ILA belonging to DEB ideas was specifically the integration of space debris under LSC since early 1990s.[325]

Policy

The ILA Debris Instrument represents an important policy progress step for debris governance efforts which are consolidating in the 1990s as it was one the first comprehensive debris draft instrument adopted in an international forum as a resolution.[326]

Also, the ILA debris instrument fills parts of the policy governance gap by providing policy innovation with its instrument proposal. The innovation lies in the details regarding the definition of space debris and obligation of states and international organizations to prevent damage to the Outer space environment and Earth detailed in 16 articles including the controversial definition of space debris and also the first legal text on space debris agreed to by an international body. Quite more stringent that later guidelines calling for conditional recommendations, the ILA instrument describes "the general obligation of states and international organizations to cooperate (inform, consult, and negotiate in good faith) in the prevention of damage to the space environment." It will also become a reference instrument

[324] Maureen Williams, *Safeguarding Outer Space*, 91.
[325] Maureen Williams, *Safeguarding Outer Space*, 92.
[326] U.S. National Research Council, *Orbital Debris: A Technical Assessment*, 187.

in debris legal discussions held at COPUOS after 1995. Böckstiegel as a member of the Debris group introduced the instrument at COPUOS in 1995 and promoted its adoption as an agenda item under the Legal Subcommittee (LSC) for years.[327]

As a further policy innovation and reminding of the ILA's role as supporting organization conducive to epistemic influences, this ILA instrument is the first model covering the legal aspect of space debris developing at a time when the debris issue was just entering the agenda item list of the COPUOS Scientific and Technical Subcommittee and not yet the Legal Subcommittee's agenda. Deemed as a premature issue.[328]

A last policy innovation for debris governance in the 1990s with the ILA comprehensive instrument is found in its specific application of earlier basic space governance elements such as OST article IX, Liability and Registration Conventions.[329]

Institutional

This ILA proposal marks another interesting stepping-stone for epistemic influences of the DEB group in the 1990s, whereby the ILA acted as a support or home organization facilitating the shaping of debris governance solutions, providing support enabling innovative DEB epistemic community ideas such as early propositions of legal debris aspects, reminding of Adler's work on arms control where some organizations acted as "homes" for epistemic communities supporting novel and potentially controversial ideas

[327] Maureen Williams, *Safeguarding Outer Space*, 91.
[328] Perek, "Space Debris at the United Nations," 123–136.
[329] Maureen Williams, *Safeguarding Outer Space*, 87-89.

susceptible to criticism because not widely accepted yet.[330] It is the "first legal text on space debris agreed to by an international body"[331] as it will play a role in the next decades namely thank to ILA's influence towards the shaping of a model law MSL and the debris issue will be included in its article 8.[332]

The research found that the *ILA International Instrument on the Protection of the Environment* contains DEB ideas from the emerging DEB epistemic community and inherited by diffusion towards the space community platforms of AC ideas. The ILA Instrument reflects direct epistemic communities influences of the DEB group as well as some indirect influences diffusing to space governance and debris governance from the AC group.

AC

Some concepts of arms control are found in the ILA draft instrument "Article 4: Obligations to Prevent, Inform, Consult, and Negotiate in Good Faith" indicating inheritance of AC ideas diffusion, such as obligation to inform of harmful activities which could create space debris, modification to the space environment, and to prevent damage in outer space, as a form of restraint of intentional debris creation. Phrased in a different manner in the ILA instrument, the ideas of restraint of creating new debris are still present, even if the wording "intentional" is not there. Thus, AC group influences it expressed the diffusion of restraint

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330 Adler, "The Emergence of Cooperation: National Epistemic Communities and the International Evolution of the Idea of Nuclear Arms Control," 126 and 130.
331 National Research Council, Orbital Debris: A Technical Assessment, 187.
332 Stubbe, *State accountability for space debris*, Brünner and Soucek, *Outer Space in Society, Politics and Law*.

ideas which impacted debris governance as found in the 1980s sections, and explained in more details under the national steps sections covering the United States and Soviet Union.

DEB

As observed in other decade chapters, the ILA Space Committee has been conducive to epistemic communities influences over space governance shaping in the 1960s for instance. Direct epistemic involvement was found from the DEB group members from the executive level members themselves part of an epistemic group and helping to shape a governance instrument and diffusing ideas across various other fora such as COPUOS as ILA is and across other NGO fora. Böckstiegel as chair of the ILA Space Law Committee at the time is an example of DEB expert, presenting the ILA instrument at COPUOS in 1995. He also organized awareness symposia for debris discussions sometimes together with IISL and the Cologne IASL such as in in 1988.[333] Other people sharing an interest in debris mitigation and legal aspects and joining as epistemic members meeting regularly and promoting the ideas in that period are Kai-Uwe Schrögl, and Ram S. Jakhu. Both were early promoter of DEB ideas publishing papers in the 1980s and 1990s on the debris issue. Schrögl also published under the NPS debris partial efforts after UNISPACE II promoting interest in the debris issue.[334] Finally, early DEB epistemic members were directly involved in ILA's debris work as the ILA Space Law Committee lawyers also gained scientific knowledge expertise especially

[333] Maureen Williams, *Safeguarding Outer Space*, 87-89.

[334] M. Benkö, G. Gruber, K.-U. Schrögl, "The UN Committee on the Peaceful Uses of Outer Space: Adoption of Principles Relevant to the Use of Nuclear Power Sources in Outer Space and Other Recent Developments" (ZLW, 1993), 35.; C. Q. Cristol "Nuclear Power Sources (NPSs) for Space Objects: A New Challenge for International Law," In "Proceedings of the Thirty-Sixth Colloquium on the Law of Outer Space, 1993; "Space Debris: An Item for the Future," In Marietta Benkö and Kai-Uwe Schrögl (eds.): *International Space Law in the Making. Current Issues in the UN Committee on the Peaceful Uses of Outer Space*, Gif-sur-Yvette: Editions Frontières, 1993), 233-270.

from Scientific Consultants including two DEB members, namely Lubos Perek from the Czech Republic and Dietrich Rex from Germany.[335]

5.1.2 UN progress steps in the 1990s

This section presents debris governance progress at the United Nations governmental level in the 1990s, as a new partial debris instrument emerging under the International Telecommunication Union platform and additional basic provisions emerging under the Committee on the Peaceful Uses of Outer Space forum.

1993 ITU Recommendation S.1003 and ITU Constitution

This section covers debris governance progress made at the UN forum of the International Telecommunications Union (ITU) during the 1990s and illustrative of epistemic communities' shared ideas diffusion and influences. ITU was given a space mandate since the early space age and started discussing issues relevant to debris by the mid-1980s as seen in earlier chapters. In this last "consolidating" phase of debris governance, the research found a first debris-specific governance outcome under the ITU forum as the Recommendation ITU-R.S.1003 "Environmental protection of the geostationary-satellite orbit.[336] Its contribution to fill global governance gaps of normative, policy, institutional and compliance progress and the epistemic influences found are explained below.

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[335] Karl-Heinz Böckstiegel, "Commentary paper," 207-211, In *Proceedings of the Workshop on Space Law in the Twenty-first Century*, organized by IISL and UNOOSA, UNISPACE III Technical Forum, July 1999, 207.
[336] ITU Recommendation S.1003 : Environmental protection of the geostationary-satellite orbit, https://www.itu.int/dms_pubrec/itu-r/rec/s/R-REC-S.1003-0-199304-S!!PDF-E.pdf, approved 25 April 1993, firstly revised in 2003 and superseded by second revision in 2010 by ITU-R.S.1003-2 (accessed April 7, 2020).

Normative

This ITU recommendation represents a normative progress for debris governance. It covers a partial aspect of debris mitigation ideas, such as the protection of the geostationary orbit from risks of debris creation thanks to the re-orbiting of satellites at the end of their operational lifetime. The recommendation indicates the consolidation of norm sharing of this debris mitigation norm under the ITU forum during the early 1990s, besides growing normative support at international conferences like IACs and at the UNCOPUOS discussions following UNISPACE II and under STSC towards creating a new agenda item, as well as nationally and multi-laterally at the space agencies' level among the founders of the IADC forum.[337] This ITU recommendation achieved in 1993 inherited normative progress observed since the late 1970s when some space agencies delegates already advocated for re-orbiting in GEO,[338] and by the early 1980s with specific orbit proposals above the operational zone for such re-orbiting emerged also. The awareness at the ITU forum of the need to remove inactive satellites from GEO at their end-of-life had grown further with the results of the study presented at WARC-1988 helping to make shared DEB ideas towards becoming an agreed norm. ITU-R.S.1003 consolidated an already existing basis, benefitting from and in turn contributing to the emerging working group discussions at COPUOS STSC and IADC towards the need to protect GEO as a protection zone also further helping towards this norm

[337] The founding space agencies of the IADC in 1993 are NASA, ESA, JAXA and ROSCOSMOS/RKA.
[338] Marcé, "Space Debris: How France Handles Mitigation and Adaptation", 116.
Marcé mentions how CNES delegates have advocated for re-orbiting since the beginning of the operations of Symphonie satellites in the mid-1970s, while Perek mentions about several propositions such as Roth regarding specifics of altitude for such re-orbiting in the early 1980s.

consolidation within the ITU forum by the early 1990s. Indeed, this normative step at ITU happened around a similar timeline with the normative progress made at the level of space agencies and the creation of the IADC, further consolidating the debris mitigation norm. This normative contribution involved epistemic experts especially from space agencies which send delegates to ITU, as explained in the ideas section below.

Policy

This step follows the discussions from WARC ORB-85 which, while not achieving any consensus then, did generate progress almost a decade later with the agreement on ITU-R.S.1003.[339] Indeed, the 1985 ITU Space World Administrative Radio Conference (WARC) discussions and led to a first debris study by 1988 regarding the potential physical harms caused in geostationary orbit by satellite crowding or space debris. These efforts finally led to a recommendation in the early 1990s. Specifically, the first internationally agreed debris mitigation recommendation emerged in 1993, as ITU-R.S.1003[340] focusing on the protection of the geostationary orbit for which ITU is the governing body.[341] This recommendation marks a turning point for debris governance at ITU. The ITU-R.S.1003 recommendation represents one of the first internationally agreed policy outcome achieved at the United-Nations level and directly relevant to space debris. This recommendation marks thus a

[339] Dr Liou presentation at 2nd IAA Conference on Space Situational Awareness, Washington DC, January 14-16, 2020, slide 3, available at https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20200000450.pdf (accessed March 19, 2020).

[340] ITU Recommendation S.1003: Environmental protection of the geostationary-satellite orbit, https://www.itu.int/dms_pubrec/itu-r/rec/s/R-REC-S.1003-0-199304-S!!PDF-E.pdf, approved 25 April 1993, firstly revised in 2003 and superseded by second revision in 2010 by ITU-R.S.1003-2 (accessed April 7, 2020).

[341] Perek, "Space Debris at the United Nations," 128.

turning point as a policy progress consolidating debris governance with a first partial debris-specific instrument as shown in Table 6-1. ITU-R.S.1003 is a reference debris governance instrument regarded as one of five main international voluntary recommendations observed by spacefaring nations today. Therefore, its original version and consecutive revisions in the 2000s and 2010s represent a significant policy progress for debris governance.

This outcome follows the diffusion of epistemically constructed ideas, which have been circulating in international conferences and as paper proposals outside of the ITU forum since the early 1970s, and which have been reaching the International Telecommunication Union quite early as reflected in the ITU Constitution and Conventions of 1971 and 1982 art. 33 and succeeding ones. As seen in the previous sections, the ideas of debris mitigation were discussed in the 1970s and increasingly in the 1980s across various fora such as international conferences of the IAF, under the ILA and IISL, between multi-lateral space agencies fora, in studies of the UNOOSA Secretariat of COPUOS and then under UNISPACE II, and have been diffusing to the ITU forum since the 1980s especially as explained surrounding the ITU WARC 1985 study on physical interferences from space debris, and following a demand by several states to have a mandatory removal of inactive satellites in GEO.[342] The member states of ITU with space agencies typically send delegates who contributed to these debris discussions in the early 1990s as well.[343] The section below about epistemic influences

[342] Jakhu, "The Legal Regime of the Geostationary Orbit."
[343] Jean-Louis Marcé, "Space Debris: How France Handles Mitigation and Adaptation," in John A. Simpson (ed.) *Centennial Interdisciplinary Symposium "The Preservation of Near-Earth space for future generations*," 100th anniversary of the University of Chicago, University of Chicago, June 24-26, (Cambridge University Press, 1994), 116.

provides more details about the debris epistemic community influence over helping to bring this recommendation into being.

The ITU debris mitigation instrument namely the recommendation ITU-R.S.1003 in the 1990s derives from these efforts since the 1980s towards agreeing on recommendations already made in the ITU study report of 1988 on debris physical interferences calling for clear guidelines and information on how to remove safely the satellites from GEO at the end of their operational life. This ITU recommendation consist therefore of an important policy and institutionalization progress steps, codifying some debris mitigation ideas in the early days when the first national and international debris mitigation standards and discussions towards guidelines were just also making policy and institutional, making it this an "important" recommendation for space debris mitigation efforts as recognized by Perek in 2002,[344] as well as placing the ITU among the early influential governance fora regarding debris governance. This important role of ITU as a governance body for debris mitigation in the 1990s period is not only illustrated by the agreement reached around the recommendation, but also by its role as a facilitator beyond the ITU forum, namely with the diffusion of these ideas into the scientific and technical subcommittee of COPUOS in 1995, where an ITU delegate will present a paper.[345] Moreover, ITU-R.S.1003's importance as a debris policy outcome will perdure, as will be explained in the next decades' sections.

Institutional

344 Perek, "Space Debris at the United Nations", 128.
345 Perek, "Space Debris at the United Nations", 128.

The adoption of this first debris instrument consolidates the ITU forum in its role as a supporting organization for debris governance, representing an institutional progress step for debris governance. Indeed, already in the 1970s and 1980s, debris-relevant discussions about physical interferences and GEO protection had emerged and took momentum around WARC 1985, followed by a report in 1988, making ITU an emerging debris discussion platform conducive to ideas diffusion and shaping of norms and policy innovations by experts especially delegates of space agencies. In 1993, the adoption of ITU-R.S.1003 strengthened ITU's role as a supporting governing body, shaping the debris governance rule and system and consolidating a regime during this phase. Reminding of Adler's supporting institutions acting as "homes" for pioneering ideas, protective of innovative policy solutions,[346] the ITU became a "home" for ideas of debris mitigation in GEO to consolidate further as a norm, and towards institutionalization in ITU rules and regulations.

Bearing authority for the management of the geostationary orbit, with the recommendation and constitution, ITU also becomes one of the first institutions having a partial debris governance mandate.

Compliance

The recommendation covering debris mitigation aspects and serving as one of the debris governance instruments as shown in Table 6-1 was adopted by many member states under the ITU forum. This represents a political commitment, thus encouraging the large membership to comply with this improved operational practice of re-orbiting satellites at the

[346] Adler, "The Emergence of Cooperation: National Epistemic Communities and the International Evolution of the Idea of Nuclear Arms Control," 126, 130.

end of their mission to clear the way and protect the geostationary orbit. This step of encouraging compliance with one of five internationally adopted debris mitigation instruments and deemed as reference ones under the UN Compendium of space debris mitigation standards adopted by states represents a compliance progress for debris governance.[347]

In terms of epistemic ideas found and relevant epistemic influences, the 1993 ITU-R S.1003 recommendation and its ensuing Constitution of 1994 bear the mark of direct epistemic influences, especially of the group of DEB and of indirect ones such as the AC group.

AC

The presence of arms control influences is found in the ITU Constitution recalling ITU's objective to ensure the rational use of the radio frequency spectrum to avoid harmful interferences. This AC ideas and epistemic influence is indirect by way of diffusion and inherited from the Geneva Convention period. The AC group influence in ITU-R.S.1003 is found as inherited from the 1950s influences which led to the ITU Geneva Convention of 1959 containing harmful avoidance restraint ideas of the AC group found across most space governance instruments besides the ensuing debris instruments. Similarly to the first ITU constitution of 1959 as the first ITU one with a space mandate, AC ideas of restraint are found again in the 1992 ITU Constitution under the" avoidance of harmful interferences" and

[347] United Nations, "Compendium of space debris mitigation standards adopted by States and International Organizations," https://www.unoosa.org/res/oosadoc/data/documents/2019/aac_105c_22019crp/aac_105c_22019crp_14_0_html/AC105_C2_2019_CRP14E.pdf (accessed March 10, 2021).

aim of rational use for avoiding interferences, which could disturb international peace and stability. The ITU space mandate was designed to avoid harmful interferences found in article 1, article 6, article 10, article 12, art. 42, article 45, and in the annex. Article 1 para 2 a) and b) concerning the purposes of the Union provides that:

> "2. To this end, the Union shall in particular:
>
> a) effect allocation of bands of the radio-frequency spectrum, the allotment of radio frequencies and registration of radio-frequency assignments and any associated orbital positions in the geostationary satellite orbit <u>in order to avoid harmful interference</u> between radio stations of different countries;
>
> b) <u>coordinate</u> efforts to <u>eliminate harmful interference</u> between radio stations of different countries and to improve the use made of the radiofrequency spectrum and of the geostationary-satellite orbit for radiocommunication services;"[348]

This presence components of some shared AC ideas in this ITU outcome of the 1990s shows an ongoing influence of the AC group of ideas which had been occurring over space governance basic instruments in the previous decades, and which have now diffused into debris instruments at the ITU level. This ongoing influence of AC ideas over space governance and debris governance after the 1980s is illustrated in the chronology represented in Figure 6-1.

DEB

The research found that some debris experts, part of the DEB group, diffused ideas and norms at ITU and helped with this recommendation. As space agency or national delegates

[348] Constitution and Convention of the International Telecommunication Union, 1992http://search.itu.int/history/HistoryDigitalCollectionDocLibrary/5.12.61.en.100.pdf (accessed July 30, 2020), 3.

of other national relevant bodies, delegates have been promoting debris mitigation ideas such as the GEO de-orbiting idea under ITU. Confirmed by both literature and interviews, it is often the case that the same space agency experts have been representing their nations as delegates across several international fora, carrying shared ideas with them when belonging to an epistemic group, occurring also in the debris case. Some debris experts from space agencies promoted the GEO deorbiting ideas at ITU already in the 1970s, and 1980s especially around the preparations for and following phase after WARC-1985. For instance, in France, some CNES delegates were promoting the GEO de-orbiting ideas since launching the GEO Symphonie A and B satellites in the mid-1970s, ongoingly in the 1980s and 1990s.[349]

UN NPS Principles of 1992

The outcome of the " Principles Relevant to the Use of Nuclear Power Sources in Outer Space" adopted by UNGA Resolution 47/68 (1992) or "*NPS Principles*"[350] represents another important step for the evolution of debris governance under the UNCOPUOS forum, highlighting knowledge, normative, policy and institutional governance progress.

Knowledge

[349] Marcé, "How France Handles Space Debris," 116.
[350] Principles Relevant to the Use of Nuclear Power Sources in Outer Space (NPS Principles) UN Doc. A/RES/47/68. 14 December 1992. GAOR, 47th sess., Suppl. no. 49., http://www.unoosa.org/pdf/publications/STSPACE11E.pdf (accessed June 30, 2021).

Work towards preparing the *NPS Principles* helped shape and brought knowledge about one additional orbital debris risk relating to the space operations. Among the main dangers associated with nuclear-powered satellites are the risks posed by collisions with other satellites and resulting damage or harm to space operations from nuclear explosion in space or radiation including harm to manned missions and to space assets also from resulting electro-magnetic damage to electrical components following nuclear explosions, [351] and risks of radioactive contamination of the Earth environment by debris re-entries. Specifically, these principles help protecting against risks associated with a specific class of satellites, those powered by nuclear sources such as nuclear reactors and against several risks relating to space debris mentioned above. This process started as a result of the first major NPS re-entry event in 1978 when *Cosmos* 954 polluted Canadian Northern Territories following failure and unforeseen re-entry as a result of an apparent collisions with a piece of orbital debris,[352] led to increasing overall knowledge including mitigation operations about the debris issue.

Normative

The *NPS Principles* are also a normative progress step for debris governance, since they consolidate the norm of debris mitigation ideas thanks to codifying them in an agreed

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[351] For more information regarding NPS risks, see Viikari *The Environmental Element in Space Law*; Nicholas Johnson, "A New Look at Nuclear Power Sources and Space Debris." Proceedings of the *Fourth European Conference on Space Debris*, ESA/ESOC, Darmstadt/Germany, 18–20 April (ESA SP-587. 2005): 551–555. http://www.orbitaldebris.jsc.nasa.gov/newsletter/pdfs/ODQNv9i2.pdf (accessed, March 23, 2021).

[352] Lotta Viikari, *The Environmental Element in Space Law: Assessing the Present and Charting the Future*. Studies in Space Law, Vol. 3, (Martinus Nijhoff Publishers, Leiden/Boston, 2008), 48; and Kessler, "Orbital Debris: A personal view."

international instrument thus adding to basic debris-related provisions under other space governance and arms control tools such as treaties, resolutions, conventions, declarations which have emerged up to 1992 as seen in the preliminary and emerging phases of this thesis and in Table 6-1. This normative step occurring under the UN COPUOS forum builds upon discussions and awareness raising since the early 1970s as part of the work around the Liability Convention,[353] gaining momentum from the 1978 *Cosmos* 954 incident.[354] As the membership of COPUOS kept rising with more than 50 members by the early 1990s,[355] the *NPS Principles* debris mitigation aspects such as protecting the LEO and Earth environments from nuclear-powered satellite collisions or re-entries contributed to widen the diffusion of partial debris ideas and norm and consolidated the increasing debris awareness observed at COPUOS since the 1980s, and especially from UNISPACE II when the debris mitigation norm started to gain momentum at the COPUOS forum.

Policy

The *NPS Principles* represent a direct outcome from the *Cosmos* 954 re-entry in 1978 and resulting safety discussions.[356] This international agreement reached at the UN forum,

[353] Carl Q. Christol, "Introductory Note." "https://aerospace.org/sites/default/files/policy_archives/Principles%20on%20Nuclear%20Power%20Sources%20in%20Space.pdf, "United Nations: General Assembly Resolution and Principles relevant to the Use of Nuclear Power Sources in Outer space," Introductory Note, 32 I.L.M. 917 (1993).

[354] Carl Q. Christol, "Introductory Note." https://aerospace.org/sites/default/files/policy_archives/Principles%20on%20Nuclear%20Power%20Sources%20in%20Space.pdf, "United Nations: General Assembly Resolution and Principles relevant to the Use of Nuclear Power Sources in Outer space," Introductory Note, 32 I.L.M. 917 (1993).

[355] "Committee on the Peaceful Uses of Outer Space Membership Evolution," https://www.unoosa.org/oosa/en/ourwork/copuos/members/evolution.html (accessed July 7, 2020).

[356] Kai-Uwe Schrögl, "Space and its sustainable uses", In Brünner and Soucek, *Outer Space in Society, Politics and Law,* (Vienna: ESPI, 2011), 612.

represents a policy step in terms of debris governance as it contains a provision covering collision avoidance, prevention, and post-mission disposal for objects in LEO under principle 3, para.2.[357] The level of the UN also means that even-though it is a voluntary and thus non-binding measure, it was agreed to at a high political level. The *NPS Principles* also count as a partial debris mitigation instrument, covering one aspect of debris mitigation and completes the existing body of debris-related provisions found under treaties, resolutions, conventions, declarations observed from the 1950s to the 1990s, as seen in earlier sections of the thesis and in Table 6-1. As argued by Remuss in 2011,[358] the *NPS Principles* also count as a tool to prevent an arms race in outer space by favouring some level of restraint relating to nuclear risks in orbit. In particular, besides representing safety guidelines for space operations and post-mission procedures and even covering re-entry aspects for nuclear-powered satellites, the *Principle*s also call for nuclear restraint by limiting the number of nuclear-powered satellites who remain in the LEO orbit at the end of their operational life.

Institutional

The NPS Principles under COPUOS further consolidate the role of COPUOS as a supporting institution for debris governance, and conducive to epistemic influences and ideas circulation in the 1990s. This counts as an institutional progress step for debris governance, with COPUOS incrementally increasing its role since the 1980s when first debris covering

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[357] Principles Relevant to the Use of Nuclear Power Sources in Outer Space (*NPS Principles*) UN Doc. A/RES/47/68. 14 December 1992. https://www.unoosa.org/oosa/en/ourwork/spacelaw/principles/nps-principles.html#princ0302b (accessed July 7, 2020).

[358] Nina-Louise Remuss, "Space and Security," In Brünner and Soucek, *Outer Space in Society, Politics and Law (*Vienna: Springer, European Space Policy Institute, 2011), 522.

studies were circulated and the debris mitigation ideas started to gained recognition especially following UNISPACE II, as seen in under the ITU sections.

The ideas found in the *NPS Principles*, and which are relevant to debris governance are the debris mitigation ideas from the DEB group. They express direct involvement of members of the DEB group, especially from the time of the UNISPACE II in 1982 onwards. By the early 1990s, debris experts were involved by diffusing ideas of mitigation nuclear power sources satellite collision and re-entry risks across multiple fora, such as the IISL, international conferences, shaping the debate around the *NPS Principles*. Among some members of the DEB group for that period and promoting NPS ideas and wider debris mitigation norms especially under the IISL colloquium of space law meeting annually at the IACs are Kopal,[359]Jasentuliyana,[360] and Christol,[361] publishing about debris already in the 1990s. All three have held influential chairmanships and other executive positions in the space governance system, either under IISL, COPUOS subcommittees and at IAF. For instance, Vladimir Kopal was holding the Principal Officer position of the United Nations in New York, the Secretary to the COPUOS Scientific and Technical Subcommittee and Chief

[359] Vladimir Kopal, "The Use of Nuclear Power Sources in Outer Space: A New Set of United Nations Principles?" *Journal of Space Law* 19, no.2 (1991): 105-12.
[360] Nandasiri Jasentuliyana, "An Assessment of the United Nations Principles on the Use of Nuclear Power Sources," In "Proceedings of the *Thirty-Sixth Colloquium on the Law of Outer Space*, 1993"; and Nandasiri Jasentuliyana, "Space Debris and International Law," *Journal of Space Law* 26, no: 2 (1998): 139.
[361] Carl Q. Christol, "Nuclear Power Sources (NPSs) for Space Objects: A New Challenge for International Law," In *Proceedings of the Thirty-Sixth Colloquium on the Law of Outer Space, 1993* ; Carl Q. Christol, "Scientific and Legal Aspects of Space Debris," Paper presented at the *44th Congress of the International Astronautical Federation*, Graz, Austria: October 16–22; Carl Q. Christol, *The Modern International Law of Outer Space* (New York: Pergamon Press, 1982).

of the UN Outer Space Affairs Division during the 1980s.[362] Professor Christol was a recognized academician and rewarded with a lifetime awards by IISL for his contributions to international space law.[363] Jasentuliyana is also recognized as key figure of international space law, he held several executive positions at the UN as Director of the United Nations Office for Outer Space Affairs, Executive Secretary of both UN Conferences on the Exploration and Peaceful Uses of Outer Space UNISPACE II in 1982 and UNISPACE III in 1999, both of which led to progress on the space debris issue with ensuing recommendations. Jasentuliyana was also President of the International Institute of Space Law, received IAF and IAA awards for his contribution to space law and policy in the 1980s, contributed to literature on debris and earned his own lecture series named after him under IISL.[364]

Debris Mitigation (DEB)

The DEB ideas are found under section 3 para. 2 under the post-mission disposal provision, calling for de-orbiting a nuclear-powered satellite above the LEO region at the end of its operational life.[365]

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[362] United Nations Audiovisual Library of International Law, "Biography, Professor Vladimir Kopal," https://legal.un.org/avl/pdf/ls/Kopal_bio.pdf (accessed March 16, 2021).

[363] Scott Hatton, "Carl Q. Christol (1913-2012)," 27 February 2012, *IISL News*, https://iislweb.org/carl-q-christol-1913-2012/(accessed March 16, 2021).

[364] https://www.iislweb.org/bio/Bio-jasentuliyana.pdf, (accessed March 16, 2021). Jasentuliyana became president of IISL in the 2000s.

[365] Stubbe, *State accountability for space debris*, 242; NPS Principles, Principle 3, para. 2.

5.1.3 Multi-lateral International Governmental Initiatives progress outside of the UN 1990s

This section presents debris governance progress at the multi-lateral governmental level outside of the United Nations system in the 2000s, mainly as new debris initiatives emerging under the international space agencies-level.

Inter-Agency Space Debris Coordination Committee creation 1993

The Inter-Agency Space Debris Coordination Committee (IADC) is an international advisory forum created by four space agencies in 1993.[366] Acting as an intergovernmental forum, it coordinates research, information exchanges and policy shaping regarding space debris issues, including man-made and natural debris. The research found the creation of the IADC as an outcome filling several governance gaps in debris governance, namely, knowledge, normative, policy and institutional gaps in debris governance during the 1990s period. It also directly results from the influence of the DEB epistemic community now consolidating under this committee.

Knowledge

Firstly, knowledge progress is expressed by the mandate of the new IADC organization, designed as an advisory body and devoted to further studying the debris issue and mitigation

[366] The IADC was founded by four agencies in 1993: NASA, ESA, RKA and originally the Japanese delegation was registered just under "Japan" with NASDA, NAL and ISAS conducting some debris-related research. After the 2003 merger, it became JAXA. RKA created in 1992 changed into Russian Aviation and Space Agency (ROSAVIAKOSMOS) in 1999, and then to Russian Federal Space Agency (ROSCOSMOS). Today IADC includes 13 space agencies members: ASI (Agenzia Spaziale Italiana), CNES (Centre National d'Etudes Spatiales), CNSA (China National Space Administration), CSA (Canadian Space Agency), DLR (German Aerospace Center), ESA (European Space Agency), ISRO (Indian Space Research Organisation), JAXA (Japan Aerospace Exploration Agency), KARI (Korea Aerospace Research Institute), NASA (National Aeronautics and Space Administration), ROSCOSMOS (State Space Corporation), SSAU (State Space Agency of Ukraine), and the UK Space Agency; https://www.iadc-home.org/terms_reference (accessed June 29, 2020).

options and to share information among member agencies. The founding principles of the IADC body represent a commitment to growing and enhancing debris knowledge thanks to the exchange and merging of accumulated knowledge and seeking new options, as expressed in its terms of reference. Namely, the IADC Terms of Reference (ToR) indicate that:

> "The primary purpose of the IADC is to exchange information on space debris research activities between members, to facilitate opportunities for cooperation in space debris research, to review the progress of ongoing cooperative activities and to identify debris mitigation options."[367]

Normative

Additionally, normative progress can be found in the creation of the IADC body the member space agencies shaped a permanent, systematic and cooperative effort which will further consolidate and promote debris mitigation ideas and norms, which emerged since the 1970s as seen in earlier sections among space agencies, among some commercial operators practices.[368] As stated in the TOR,[369] one of the missions of the IADC is also directly to "promote the education of the aerospace community and the general public on space debris matters" consolidating the IADC's creation as supporting debris normative progress.

Policy

Policy progress was found in the IADC creation as a step towards consolidating debris ideas by institutionalizing the policy shaping process at the international level under this new

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[367] IADC Terms of Reference, IADC-93-01 (rev. 11.5, 2018), https://www.iadc-home.org/terms_reference (accessed June 29, 2020), 7.

[368] For instance, Intelsat moved one of its satellites above the GEO orbit in 1977, Perek, "Space Debris at the United Nations."

[369] IADC Terms of Reference, IADC-93-01 (rev. 11.5), 2018, p7, https://www.iadc-home.org/terms_reference, (accessed June 29, 2020), 10.

permanent body. The creation of IADC derived from efforts started during the previous decade of the 1980s with bi-lateral and later multi-lateral space agencies workshops on debris mitigation initiated by U.S. debris members and which soon were joined also by European experts, and some Canadian and Japanese.

NASA-led bi-lateral space agency meetings started with ESA from 1987, with the Soviet Union from 1989, and then Japan by 1991. It started to become logistically heavy to organize and given the recommendations in various US national reports such as the 1989 Interagency report that the US should lead in reaching out to other space-faring nations to help debris mitigation efforts expand internationally,[370] the bi-lateral meetings became first trilateral NASA/ESA/Japan in 1991, until a proposal was made to establish a permanent coordination group by 1992. The Inter-Agency Space Debris Coordination Committee (IADC) created in 1993 between the national space agencies of the United States, Japan,[371] Europe[372] and Russia[373] represents one of the first debris-specific policy outcomes with the emergence of debris policy coordination at the international level. Moltz points to the creation of IADC as related to debris knowledge progress attributable to an epistemic community of debris

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[370] Nicholas Johnson, 2012, *Cleaning up space*, 67.

[371] Originally, the Japanese national space agency at the time of the IADC creation was known as NASDA, yet the name for IADC was registered under the country name not its agency. NASD, NAL and ISAS, three different national agencies in charge of different aspects of space activities will be merged in 2003 into JAXA, the current Japanese space agency.

[372] The IADC was created with ESA first, under which several national space agencies also contribute. Only later the main contributing space agencies (the same 4 which also worked on developing debris mitigation standards at the European level leading to the ECoC from the 80s until the 2000s in parallel to their IADC contributions) will join in turn as individual members to IADC.

[373] Russia's space agency originally registered for IADC was RKA in 1993, the Russian Aviation and Space Agency ROSAVIAKOSMOS in 1999, replaced by ROSCOSMOS as the Russian Federal Space Agency in 2004, State Space Corporation in 2015-16. A national debris mitigation standard was prepared in the 1990s and issued in 2000, see Kato, "Comparison of National Space Debris Mitigation Standards," 1447-1456.

experts, corresponding to a DEB group emerging in the US,[374] especially from the 1980s ASATs and from a will to reach out to other ASAT-capable nations such as the Soviet Union in order to mitigate debris proliferation from such intentional sources.[375] The creation of IADC with Russia as a founding member in 1993 thus also represents a policy step.

Furthermore, the IADC creation does entail another level of policy progress in the composition of its membership. Following bi-lateral efforts started between the United States and European Space agencies, the addition of Russia and Japan to the IADC advisory body in the early 1990s expands the governance shaping and contributions of the entity with the inclusion of important space-faring nations with launching capabilities. This is important because launchers' upper stages do represent an important source of debris creation. This policy progress will grow more within a few years of the creation of the IADC, as additional space-faring nations will join in 1995 and 1996 doubling the membership. Namely, China's space agency CNSA joined in 1995 followed by India's ISRO, France's CNES and the United Kingdom's BNSC in 1996,[376] enlarging participation in debris mitigation governance to a larger group of space-faring nations.

Institutional

Lastly but not the least, the creation of the IADC represents a major institutional progress step for space debris governance, as it is the first permanent committee devoted solely to investigating debris mitigation issues and shaping solutions. The emergence of the Inter-

374 Moltz, The Politics of Space Security: Strategic Restraint and the Pursuit of National Interests, 177.
375 Moltz, *Crowded Orbits*, 153.
376 Latest version of ToR IADC 2018, https://www.iadc-home.org/terms_reference (accessed June 29, 2020), 3.

Agency Space Debris Coordination Committee represents the institutionalization of debris mitigation ideas into the first dedicated "debris" governance body. Even if it only advisory body, IADC will enable to shape the first universal debris mitigation instrument upon which all other main international and comprehensive instruments will be based in the 2000s and 2010s decades as will be covered in the next sections. The IADC is a multi-lateral body functioning outside of the United Nations system, where the delegates represent their respective national space agencies, but who reports its progress at the COPUOS level like many other organizations do, as a testimonial of existing efforts and activities consolidating the peaceful uses of outer space. This institutional step in 1993 thus marks an important turn for debris governance, with the beginning of a systematic international debris governance shaping process and legitimization of IADC as the main debris governance body, whose influence will be crucial for the development of debris guidelines in the next decade.

The ideas contained in the IADC Terms of Reference (TOR) establishing document are mostly reflecting the influence of debris mitigation ideas of the consolidating DEB epistemic group.

The DEB ideas are laid out under both the purpose and the scope of the TOR[377] stating that: "The primary purpose of the IADC is to exchange information on space debris research activities between members, to facilitate opportunities for cooperation in space debris research, to review the progress of ongoing cooperative activities and to identify debris mitigation options" [378], as well as under the description of four specialized working groups'

[377] IADC TOR, https://www.iadc-home.org/terms_reference, 7.
[378] IADC Terms of Reference, IADC-93-01 (rev. 11.5, 2018), 7, https://www.iadc-home.org/terms_reference (accessed June 29, 2020).

scopes and responsibilities, namely Working Group 1 on Measurements, Working Group 2 on Environment and Data Base, Working Group 3 on Protection and Working Group 4 on Mitigation.[379]

The IADC creation is the result of about a decade of dialogue and exchanges especially between space agencies experts, and which benefitted also from knowledge from other fora diffused thanks to the DEB group as wider than just space agencies delegates, involving between experts promoting debris mitigation ideas across various national governmental agencies, private research labs, academia, DODs, NORAD, NGO platforms and at international conferences and other UN fora. The creation of the Committee in itself though reflects mostly the direct influence of debris experts from space agencies, who started to meet regularly at bi-lateral levels in the 1980s as explained in earlier sections. Such individuals involved in the early 1990s comprised Nicholas Johnson, Donald Kessler, Joseph Loftus (NASA), Fernand Alby, Christophe Bonnal, Walter Flury (CNES/ ESA Group), Walter Flury and Heiner Klinkrad (ESA), Susumu Toda (NAL), to name just a few of the space agency debris experts of the larger DEB epistemic group.

5.1.4. Progress observed at national levels in the 1990s

Following the emergence of the first national debris governance outcomes in the 1980s especially in the United States, and the U.K as presented in chapter 4, this section on the 1990s presents a consolidation of national debris progress. The DEB group and its members

[379] IADC Terms of Reference, IADC-93-01 (rev. 11.5, 2018), 7, https://www.iadc-home.org/terms_reference, (accessed June 29, 2020), 11-15.

have been found especially influential in generating national debris steps in the 1990s among mostly the founding nations of the Inter-Agency Space Debris Coordination Committee (IADC). These are namely the Unites States, Russia, Japan and France involved under ESA as founding member.[380] The governance gaps filled nationally as complementary debris governance steps to the international efforts observed in the other examples and the groups and fora involved are detailed below.

National debris governance progress steps in the U.S. in the 1990s and involving the DEB epistemic group and heritage of the AC group are numerous.[381] Among the majors U.S. debris outcomes of the 1990s are the emergence of the NASA Debris Mitigation standard in 1995. As the first comprehensive national space agency standard developed by a spacefaring nation following the steps achieved in 1988, 1989 with presidential directive, the NASA standard will serve as basis for developing the IADC guidelines, upon which other debris instruments will also be based as seen in other sections. Additional debris knowledge and normative outcomes are the revision to the IG Interagency report of 1989 with an updated issue in 1995,[382] also updating the U.S. national consensus position which was reached in the

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[380] The Chinese and Indian space agencies also joined the IADC in 1997, yet they are not founding members. While the French agency CNES joined as a national member consecutively also in 1997 separately from ESA, the experts of CNES were involved in debris research under the ESA debris working group since the 1980s, which also entailed British experts.

[381] Kato provides a list of the 1990s U.S. instruments Akira Kato, "Comparison of National Space Debris Mitigation Standards," *Advances in Space Research* 28, no. 9 (2001): 1447-1456 ; Weeden gives a comparative analysis between successive U.S. national space policies' addition to the 1989 one in Brian C. Weeden, "The Evolution of U.S. National Policy for Addressing the Threat of Space Debris" Paper IAC-16-A6.8.3, 67th International Astronautical Congress (IAC), Guadalajara, Mexico, 26-30 September 2016, (Paris: International Astronautical Federation, 2016), 2-3.

[382] The Interagency IG (Space) *Report on Orbital Debris* of 1995 is updating the landmark 1989 IG (space) report which was deemed the first national consensus on orbital debris across federal agencies.

1989 version. Two other reports emerged in the 1990 further assessing the debris issue and supporting the DEB knowledge and normative progress such as an OTA report of the U.S. Congress in 1990[383] and National Research Council report in 1995 NRC report involving a group of DEB members including European, Japanese, Russian and a Canadian expert providing additional policy coordination under the NRC,[384] such as Walter Flury and Dietrich Rex for Europe, Susumu Toda for Japan, Kessler, and Loftus for JSC. These reports are further contributing to national normative progress and impactful for international debris governance normative progress as enabling further diffusion across transnational group of the consolidating DEB epistemic community by multiplying the number of platforms of debris policy coordination in the 1990s.

During this new consolidating phase for debris governance starting in the 1990s, the study found national knowledge, normative and policy steps filling gaps in Japan, involving a larger and growing DEB epistemic community as explained below. As external events, the invitation by the U.S. to join the *Space Station Freedom* was another source of motivation stimulating debris mitigation efforts in the 1990s. A first space debris working group emerged gathering all national space stakeholders including ISAS, NAL and NASDA and private organizations under JSASS, as an interagency study like in the United States in 1988-1989. The Japan Society for Aeronautical and Space Sciences (JSASS) interagency debris group started a systematic and more structured debris mitigation efforts than the individual

[383] U.S. Congress, Office of Technology Assessment. 1990. "Orbiting Debris: A Space Environmental Problem-Background Paper" OTA-BP-ISC-72. Washington, D.C.: U.S. Government Printing Office.
[384] National Research Council, "Orbital Debris: A Technical Assessment", 1995.

studies conducted across the ISAS, NAL and NASDA in the previous decades. The JSASS effort led to a national policy step under the long-term vision of Japanese space activities as a debris mitigation provision at the space council level, and to the starting of a working group under NASDA. The NASDA standard was prepared for two years and considered NASA and ESA efforts in a spirit of harmonization with other existing practices,[385] as well as the 1995 NASA standard inspired by the IG Interagency Space report of 1989 and IADC emerging guidelines ideas,[386]expressing the DEB epistemic group influences. As a founding member of IADC in 1993, the NASDA contributed to the IADC guidelines shaping from early on and benefitted from DEB ideas from its members for shaping its own national standard, while also taking on a new role as member of the international debris policy coordination efforts under the IADC. The Japanese debris experts active during the 1990s across regular DEB fora were Toda, Yasaka and Kato amongst others.

A first national policy step achieved for debris governance in Japan concerns the joining of the three space institutions of ISAS, NAL and NASDA to IADC as founding members.

A second national policy step is found in the 1990s with the 1996 first national debris standard emerging as the NASDA space agency level.[387] This fills the gap of debris governance instruments as one of the first national debris mitigation tools to emerge here at the Japanese national level, besides the NASA space agency standard of 1995, soon followed by the CNES standard in 1999 and the Russian one in 2000. The influence of the NASA

[385] Seishiro Kibe, Takano, Toda, Akira Takano and Susumu Toda, “Current Space Debris Related Activities in Japan,” *Advances in Space Research*, 16 no. 11 (1995), (11)171.
[386] Akira Kato, “Comparison of National Space Debris Mitigation Standards,” *Advances in Space Research* 28, no. 9 (2001): 1447-1456.
[387] NASDA-STD-18, Space Debris Mitigation Standard, 1996.

standard over the other national space agency standards is analysed by Akira Kato who notes some differences on certain aspects but an overall convergence between all these first national standards.

Following two decades of studies conducted by several institutes such as ISAS, NASDA and NAL, the 1990s marked the emergence of the first comprehensive debris efforts under the Japan Society for Aeronautical and Space Sciences (JSASS) with a debris working group and ensuing and report in 1993. The JSASS study consolidated debris knowledge and normative progress towards greater awareness of the debris issue internationally and domestically. About the JSASS space debris study initiated in 1990 and whose report was issued by 1992, it emerged following the growing awareness also observed in other nations since the late 1980s such as in the U.S. and Europe and also Soviet Union for the need of international cooperation to tackle the debris issue by major space faring nations, and as a result from NASA's bi-lateral initiatives and U.S. national policies in that period, [388] with a policy-backed mandate to lead such cooperative efforts since 1989 and developing a series of national space debris standards as mentioned previously.

The JSASS study began a new phase for debris research in Japan, marking a transition from pioneering but scarce debris studies in the 1970s and 1980s towards a systematic debris research and with more coordination across the three institutions of ISAS, NAL and NASDA.[389] The start of this regular Japanese debris efforts follows other national progresses

[388] Susumu Toda and Tetsuo Yasaka, "Space Debris Studies in Japan," *Advances in Space Research*,13(8) (1993):289–298. doi:10.1016/0273-1177(93)90601-7 (accessed June 15, 2021), 1.
Both authors are members of the IAA Permanent Committee on Space Debris https://iaaspace.org/about/permanent-committees/#SA-PERMCspacedebris (accessed June 21, 2021).

[389] Toda, Susumu. "Activities on Space Debris in Japan." Proceedings of the Second European Conference on Space Debris, ESOC, 17-19 March 1997, Darmstadt, Germany, (ESA SP-393): 25-29.

observed in the United States and Europe. Indeed, since 1987 and 1988, reference debris reports such as the ESA Debris report of 1988 and the US IG group study of 1989 also marked important transitions opening towards more systematic and comprehensive domestic debris research efforts.[390] These regular and systematic national efforts in the U.S., Europe and Japan all consolidate normative progress in debris governance in the 1990s, besides the international normative support and knowledge developments achieved under the newly created IADC. National Japanese experts who organized themselves under consolidated debris with JSASS from the 1990s also contributed actively to the process of the shaping of the IADC guidelines during the 1990s, supporting normative progress and policy shaping progress in debris governance efforts which also occurred during discussions held in other for a such as under the IAA debris studies of the 1990s and which are still ongoing presently.[391] As an example of a Japanese DEB group member in the 1990s which helped circulating DEB ideas from international levels to Japan and contributing as a Japanese expert to these international levels in both directions is Susumu Toda. Presenting the JSASS Study Group report at the international Chicago Centennial Symposium devoted to space debris in 1992,[392] Toda then became the delegate to the IADC forum exchanging with that platform on a regular basis for years. Toda was involved in the shaping of debris mitigation ideas, and norms which would lead to the IADC guidelines proposals and to the Japanese standard by

[390] Alby, "30 Years of Space Debris Mitigation Guidelines in Europe"; Kessler, "A Partial History of Orbital Debris: A Personal View," Howard Baker, "The ESA and US reports on space debris: Platform for future policy initiatives," *Space Policy* 6 no. 4 (November 1990).
[391] The experts involved din debris discussions at IAC such as Susumu Toda is also member of the IAA permanent debris committee, he was also involved in the 1995 OTA report, illustrating how DEB ideas circulated with Japanese experts and were carried across multiple for a in the 1990s. https://iaaspace.org/about/permanent-committees/#SA-PERMCspacedebris
[392] Toda, In *Preserving Near-Earth*, Portree and Loftus, "Orbital Debris: A Chronology," 77.

1995, promoting DEB ideas also via papers at international space debris conferences in the early 1990s such as the European space debris conferences under ESA and at COPSAR.[393] Toda was also part of the Space Debris Committee preparing the U.S. National Research Council Debris Study of 1995,[394] which was composed of the pioneering members of the DEB group who shaped the IG 1989 crucial report such as Donald Kessler, Joseph Loftus and with also European and Canadian early DEB group members, and in IAA debris studies.

The national debris governance steps found for France in the 1990s and relating to epistemic influences are found in the emergence of the CNES space debris mitigation standard in 1999 "CNES, MPM-50-00-12, Method and Procedure, Space Debris - Safety Requirements" and in the joining as member of the IADC in 1993 under the ESA group and then as CNES in 1996.[395] They both represent normative and policy progress steps filling "national" debris governance gaps. The groups involved are mostly DEB, with some inherited influences from the AC group found especially via the diffusion of restraint ideas codified under an intentional provision within the CNES 1999 standard, as observable in Kato's comparative national standard tables.[396] In particular, Kato showed that several other national debris mitigation standards besides the CNES one, such as NASDA, EDMS, and the Russian space agency one all included a similar requirement to avoid intentional debris

[393] Susumu Toda and Tetsuo Yasaka, "Space Debris Studies in Japan," Advances in Space Research,13(8), (1993):289–298. doi:10.1016/0273-1177(93)90601-7.(accessed June 15, 2021) Toda, Susumu. "Activities on Space Debris in Japan." *Proceedings of the Second European Conference on Space Debris*, ESOC, 17-19 March 1997, Darmstadt, Germany, (ESA SP-393): 25-29.
[394] U.S. National Research Council, *Orbital Debris: A Technical Assessment*, III.
[395] "IADC Terms of Reference (TOR)" https://www.iadc-home.org/terms_reference (accessed June 18, 2021), 3.
[396] Akira Kato, "Comparison of National Space Debris Mitigation Standards," Advances in Space Research 28, no. 9 (2001), 1455.

creating events also called “break-up” events, including the NASA standard setting limits also for these intentional break-ups such as lower altitude amongst others.

It was mostly after the joining of IADC in 1996 that debris regulatory work really started in France by 1997 towards developing the CNES debris standard and led to the proposal by the CNES team to develop a regional debris instrument under ESA.[397] Knowledge exchanges were facilitated between CNES experts and the DEB group with the regular IADC meetings since 1993 under ESA efforts and it also enabled CNES experts to join in the exercise of international debris policy coordination as contributors also to the DEB ideas and shaping global debris governance with the IADC guidelines.

These outcomes mark the continued direct involvement of the DEB community, with CNES experts such as Christophe Bonnal and Fernand Alby amongst others interacting in various for a where DEB members regularly met such as ITU, IAA/COSPAR, COPUOS STSC, IACs, and the ESA/ESOC space debris conferences. The DEB involvement is traceable since the 1980s as seen earlier, with national experts promoting and sharing the GEO re-orbit norm and leading to the boosting of Symphonie satellites. In the 1990s, French experts of the DEB group already involved in the ESA debris group since 1986 following the Ariane break-up and with NASA in bi-lateral meetings join the IADC committee, IAA debris study, and the UN COPUOS debris working group contributing besides the normative platform also in the international debris policy coordination besides their involvement with ESA. As noted by Bonnal, the NASA 1995 standard “NASA Safety Standard 1740.14, Guidelines and Assessment Procedures for Limiting Orbital Debris” was a model for developing the CNES

[397] Portelli et al., “Space Debris Mitigation in France, Germany, Italy and United Kingdom,” 1038.

standard. Yet, some differences are found, for instance similarly to the NASDA and Russian standards, the CNES standard developed in the same period also contained a stronger requirement for intentional debris creation than the NASA standard. As a policy contribution to debris governance internationally, the CNES standard developed around ideas shared by the DEB group also consolidated the IADC preparatory work towards international guidelines during the 1990s. The CNES standard as a normative support supplemented the body of debris governance instruments which was emerging such as other national standards of NASA, U.S. DoD, NASDA and the first international partial instrument of ITU-R. S 1003., consolidating DEB norms and contributing to grow the emerging debris governance regime.

The study found additional debris governance progress in Russia during the 1990s. Following the Soviet national debris steps presented in the earlier section of the 1980s which involved contributions of the DEB, and AC groups around ASAT testing limits, the 1990s marked the continuation of debris policy national progress with the emergence of a debris provision found within the Russian national law. Indeed, the Russian Federation Law "On space activity", dated August 20, 1993, N 5363-1,[398] stipulates in its section I, Article 4, Paragraph 2 that "For the purpose of ensuring strategic and ecological safety in the Russian Federation, the following are forbidden: […] harmful pollution of space, leading to unfavorable environmental changes, including intentional destruction of space objects in space."[399] This steps follows DEB normative progress made since the unilateral moratorium

[398] United Nations, "Compendium of Space Debris Mitigation Standards adopted by States and International Organizations,"https://www.unoosa.org/documents/pdf/spacelaw/sd/RF.pdf (accessed June 29,2021).
[399] U.S. National Research Council, *Orbital Debris: A Technical Assessment*, 188.

on ASAT testing of 1983, which had been influenced also by the AC group, and reinforced in the 1990s by the DEB group influences consolidating after further direct exchanges and ideas diffusion and support to shaping debris instruments especially on the space agencies-level between NASA and RKA with the DEB group members at regular meetings since 1989,[400]and which led towards the IADC creation in 1993, and following beginning of international debris policy coordination towards standard developments in the 1990s, including also influence from IADC's work on the shaping of national standards involving mostly the same DEB experts as explained in the policy progress below.

Indeed, as another national policy step for debris governance, Russia's joining as a co-founder of IADC in 1993 enabled Russian experts to keep exchanging debris knowledge, which they started with the NASA delegation visit in 1989, and to also include exchanges with other space faring nations with Japanese and ESA experts at regular meetings under IADC in the 1990s,[401] and to join the international debris policy coordination efforts towards the development of the IADC guidelines over the 1990s. The national benefit represented by the Russian membership to IADC is especially found in the support to shaping its space agency debris mitigation standard during the 1990s by exchanging with experts from the DEB group and meeting at IADC, developed in parallel and inspired also by the NASA standard of 95, was used as a model as well for CNES, NASDA and EDMS debris mitigation standards as explained by Akira Kato.[402]

[400] More details are provided in the national paragraph for the United States. See especially Kessler, "A Partial History of Orbital Debris: A Personal View," and Portree and Loftus, "Orbital Debris: A Chronology."
[401] Portree and Loftus, "Orbital Debris: A Chronology."
[402] Akira Kato, "Comparison of National Space Debris Mitigation Standards," *Advances in Space Research* 28, no. 9 (2001): 1447-1456.

The debris governance progress steps found in China in the 1990s as a result of direct DEB epistemic group influences are an early compliance step for upper stage designs and the joining of the Inter-Agency Space Debris Coordination Committee (IADC) in 1995.[403] Indeed, following a meeting with NASA debris experts in 1989 in the U.S., and the visit to China of the NASA JSC experts in 1991 as part of the new U.S. space policies mandates, the Chinese started to learn also after the American and Japanese launcher experts about the upper stage passivation method to mitigate against debris proliferation, and they modified Long March rocket in order to minimize debris.[404] This step expressed the direct impact of shared ideas of the DEB group and of its members over debris progress as national knowledge and compliance steps in China. The members involved on the U.S. side were notably Kessler, Loftus, and Potter.[405]

Also, Chinese debris experts started to be more present on the international discussions platforms and joined especially the Special Debris Symposium held in Chicago in 1992 presenting about its progress to colleagues in other space agencies members or soon to become early members of the IADC, which China will join in 1995.

The adherence of the China Space Administration to IADC also represents an important national policy step, as it enables Chinese experts to participate in international debris policy coordination benefitting from its knowledge and as contributor to shaping the reference IADC guidelines.

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[403] "IADC Terms of Reference (TOR) "; https://www.iadc-home.org/terms_reference (accessed June 18, 2021), 3.
[404] Qi, Yong Ling, "Facing Seriously the Issue of Protection of the Outer Space Environment," 119; and 1995 U.S. Interagency *Report on Orbital Debris*, 44; and Portree and Loftus, "Orbital Debris: A Chronology," 74.
[405] Portree and Loftus, "Orbital Debris: A Chronology", 74.

The national debris progress found for India in the 1990s are increasing normative support expressed especially by promoting DEB ideas in international fora as well as a policy step with the joining of the Inter-Agency Space Debris Coordination Committee (IADC) in 96.[406] The normative gap filling efforts are found as further supporting the GEO re-orbiting ideas at international debris conferences, and also supporting a growing set of debris mitigation ideas now circulating widely across more international for a in the 1990s. These ideas included more debris mitigation operational ideas and principles since the 1988 ESA Space Debris Report and the US IG report of 1989, which crystalized the DEB group ideas. These served as basis for the later IADC debris instrument development work, also supported by other important debris reports for consensual knowledge building such as JSASS 1993 report, AIAA's Space debris report in 1981, IAA's first Position Paper in 1993. While India did not contribute significantly to the international debris debate before the 1990s, its supporting voice started to emerge as noted by Rao in 1992,[407] gradually leading to its IADC membership as a first important debris governance national step in 96. Indeed, India started to join international debris conferences such as the Chicago symposium where the main member agencies of IADC presented their debris policy and operational efforts and methodologies, delegates from space institutions of Europe, China, India, Japan, France, Russia, and the U.S. joined the symposium. This enabled further exchanges and knowledge gains from the international debris community stemming from space agencies DEB members

[406]"IADC Terms of Reference (TOR)," https://www.iadc-home.org/terms_reference (accessed June 18, 2021), 3.

[407] Udupi Ramachandra Rao, "Space Debris Mitigation and Adaptation," In John A. Simpson (ed.), *Centennial Interdisciplinary Symposium "The Preservation of Near-Earth space for future generations*, 100th anniversary of the University of Chicago, University of Chicago, June 24-26 1992 (Cambridge University Press, 1994): 121-124.

present under IADC, it expresses normative progress by showing the Indian experts also share the increasing set of debris mitigation ideas deriving from ongoing work on the IADC guidelines developments. Also, it involves Indian space experts of high-level facilitating epistemic influence and debris mitigation ideas promotion such as Professor Rao - chairman of the Indian Space Agency (ISRO), member of the national space commission and from 1997 to 2000 chairman of COPUOS[408] in the transnational debris policy coordination process. India in the 1990s joined the shaping of the IADC guidelines besides the four founding member agencies of NASA, NASDA, RKA and ESA - involving members of CNES, DARA[409] and BNSC already under ESA-, and also besides delegates of the Chinese National Space Administration.

5.2 Consolidating steps in the 2000s

5.2.1 International non-governmental NGO initiatives in the 2000s

This section presents debris governance progress at the international non-governmental level in the 2010s, mainly as new debris instruments and initiatives emerging under the International Organization for Standardization (ISO).

International Organization for Standardization in the 2000s

The International Organization for Standardization (ISO) is a non-governmental organization created in 1947 as a network of national standardization authorities now

[408] "Professor U. R. Rao inducted into the Satellite Hall of Fame Washington," *Vikram Sarabhai Space Centre (VSSC) News*, March 19, 2013, https://www.vssc.gov.in/VSSC/index.php/67-press-release-articles/113-prof-u-r-rao-inducted-into-the-satellite-hall-of-fame-washington (accessed July 20, 2021).
[409] *Deutsche Agentur für Raumfahrtangelegenheiten* (DARA) German Space Agency was the DLR predecessor.

composed of 165 countries.[410] Most members are full or "body" members and corresponding or "observing" members. Industry experts are involved as part of the technical committees shaping the ISO standards.[411] ISO members promote and adopt international ISO standards nationally afterwards. There are also smaller "subscribing" members. As regards the debris issue, there are two specific subcommittees under Technical Committee 20 who develop standards affecting debris mitigation efforts, namely Subcommittees 13 and 14. During the 2000s, some debris governance progress started to emerge under the ISO forum, under Technical Committee 20 and its two Subcommittees 13 and 14 (SC 13/SC14). In Subcommittee 13, the *Orbit Data Messages* Standard (ODM) developed by the *Consultative Committee for Space Data Systems* (CCSDS) under a navigation working group, emerged as an international general spaceflight safety standard with some applications for debris mitigation in approved as ISO-22644:2006 "Space data and information transfer systems - Orbit data messages." In Subcommittee 14, another working group was set up around 2003 as *the Orbital Debris Coordination Working Group* (ODCWG) to prepare an international standard this time covering debris comprehensively and working in coordination with SC/13.

This section provides more details about which governance gaps were filled thanks to these developments observed at ISO for debris governance, and which epistemic communities were involved.

ISO Subcommittee 13 : Orbit Data Management Standard

[410] https://www.iso.org/members.html (accessed March 15, 2021).
[411] https://www.iso.org/get-involved.html (accessed March 15, 2021).

The *Consultative Committee for Space Data Systems* (CCSDS) is a multi-national organization created in 1982 by some major space agencies with the task of developing international communications and data systems standards for spaceflight. CCSDS membership includes eleven space agencies and about thirty observing member institutes, and its navigation working group (NavWG) is the one developing the standards.[412] Since an agreement signed with ISO in the 1990s,[413] CCSDS is the main technical knowledge source recommending standards to ISO Technical Committee 20 Subcommittee 13 (T20/SC13).[414]

Space agencies experts started working on a standard in the 1990s and in 2004 CCSDS issued the *Orbit Data Messages* Standard (ODM) approved as ISO-22644[415] in 2006. As a general standard about exchanging information for spaceflight safety, it is useful for identifying collision risks and collision avoidance maneuvers, a requirement found in the main debris instruments issued by IADC. The ODM standard facilitates the implementation of the IADC Guidelines of 2002, especially recommendation 5.4 for the prevention of on-orbit collisions, serving therefore as a debris mitigation instrument. For this research, ODM represents progress steps for debris governance and indicates epistemic communities' involvement as explained below.

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[412] The eleven member agencies are listed in https://public.ccsds.org/participation/member_agencies.aspx (accessed March 12, 2021). The CCSDS NavWG includes regular membership representing seven of the eleven main CCSDS member Space Agencies: (CNES, France), (DLR, Germany), (ESA, European Union), (JAXA, Japan), (NASA, USA), (RFSA, Russia), (UKSA, United Kingdom).

[413] CCSDS A02.1-Y-4 , "Organization and Processes for the Consultative Committee for Space Data Systems", 2, https://public.ccsds.org/Pubs/A02x1y4c2.pdf (accessed April 17, 2020). For ISO TC20/SC13 Charter : http://isotc.iso.org/livelink/livelink/open/tc20sc13" (accessed April 17, 2020).

[414] NASA Headquarters. "CCSDS organization and management doc 2014: *Organization and Processes for the* Consultative Committee for Space Data Systems (CCSDS A02.1-Y-4)". 2014.

[415] ISO-22644:2006 "Space data and information transfer systems-Orbit data messages."

Normative

As a general standard for spaceflight safety which is still important for debris aspects, ODM especially consolidates the debris mitigation norm on the collision avoidance aspects. In this research, this highlights the role of the new standard acting as normative progress with consolidation of DEB and LTS norm, thanks to better spaceflight safety with information exchange on orbital data. The members of the CCDSD working group developing ODM have presented results at international conferences further promoting this standard as a partial debris mitigation norm beyond ISO for instance at *SpaceOps* and *International Symposium on Space Flight Dynamics, and at* the *AIAA International Communications Satellite Systems Conference and Exhibit especially since the ODM standard progress,* especially from 2004.[416]

Policy

The issuing of the ODM represents a first partial instrument codifying debris mitigation ideas under the ISO forum covering especially collision avoidance issue. As an industrial standard, ODM is further consolidating debris policy progress achieved during the 2000s under IADC, UN COPUOS and ITU which are more recommendations by codifying it as an ISO standard. Indeed, the ODM standard issued by SC/13 in 2004 and approved under ISO in 2006 as ISO-22644:2006 is one of the first of a series of industrial standards affecting debris mitigation. This complements the other debris instruments such as the IADC guidelines and ITU-R-S.1003 recommendation which are less binding, thus representing a policy progress for debris governance. Indeed, ODM is considered by debris specialists as a

[416] Oltrogge and Berry, "The Evolution of the CCSDS Orbit Data Messages," 1.

general standard also affecting debris for the collision avoidance aspects. ODM specifically contributes to the implementation of the IADC Guideline 5.4 Prevention of On-Orbit Collisions and complements the body of debris instruments with an industrial standard thus consolidating the policy progress achieved earlier with the IADC guidelines.

The research found one issue related to the policy progress for debris governance regarding the ODM standard. Specifically, the presence of a "trigger event" was observed as an influential factor stimulating the ODM first revision and demand for epistemic knowledge and policy adaptation. Similar influences of trigger events such as orbital collisions creating large and many long-lived debris or re-entry events have been detected several times in this research acting as stimuli for debris governance progress, especially as growing demand for epistemic expertise or by increasing the impact of epistemic ideas in the shaping or updating of instruments. As noted here for ODM by Berry and Finkelman, the accidental collision of the *Cosmos* 2251 and *Iridium* 33 satellites early 2009 acted as a stimulus for the ODM revision, which led to the issuing of ODM version 2 in November of 2009.[417]

This ODM example also illustrates another policy progress of debris governance such as the evolutionary progress or upgrade to a revised standard. Indeed, in the same decade, the ODM instrument recommended in 2004 by CCSDS and issued in 2006 under ISO as ODMv1 has already been revised in ODMv2 in 2009,[418] further consolidating debris governance by

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[417] Berry and Finkelman, David S. Berry and David Finkelman, "The CCSDS Orbit Data Messages – Blue Book Version 2: Status, Applications, Issues," Paper AIAA 2010-2282, *SpaceOps 2010 Conference*, 25 - 30 April 2010, Huntsville, Alabama, 2010, 2.

[418] *Orbit Data Messages*, CCSDS 502.0-B-2, Blue Book, Issue 2, November 2009, http://public.ccsds.org/publications/archive/502x0b2c1.pdf (accessed March 12, 2021).

remaining accurate to tackling the debris issue and changes in the space environment.[419] This finding about the evolutionary and adaptative nature of their work involving epistemic experts of the DEB group is found across several of the debris instruments over the consolidation period. The shared knowledge or "worldview" on the problem keeps being updated, sometimes on a regular schedule such as planned for every 5 years like under ISO,[420] or in response to a new identified crisis in the space system calling for changes in the requirements.[421] This process results in multiple iterations of the same instrument in response to new knowledge and problems appearing. This finding for debris governance and its instruments differs with the five main space governance treaties and following conventions under COPUOS which remaining unchanged even if discussions to modify them sometimes lead to new initiatives and drafts. Examples of such adaptative process by iteration and revisions to the instrument has been observed in the 2000s for the IADC revised guidelines in 2007 and revised ITU-R.S1003 recommendation in 2002, and numerous ITU Radio Regulations and new issued conventions over decades containing basic principles of relevance to this research as seen earlier.

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[419] ODM will be revised again in 2012 as mentioned in Berry and Oltrogge, "The Evolution of the CCSDS Orbit Data Messages," and Berry and Finkelman, "The CCSDS Orbit Data Messages – Blue Book Version 2: Status, Applications, Issues," and in the ISO next decade section of this thesis. The revised version of ISO is 26900:2012. https://iso.org/standard/42722.html ,(accessed May 21, 2020).

[420] Youssef El Gammal, "ECSS - European Cooperation for Space Standardization," *Space Programs and Technologies Conference*, doi:10.2514/6.1996-4305, AIAA Paper 96-4305, AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 24-26, 1996; El Gammal regarding the ECSS European standardization organization notes a similar planned revision schedule and iterative process under its space agencies and industry delegates mixed working group process.

[421] In the 2000s, trigger evens such as the Chinese ASAT and the 2009 *Cosmos* 2251/*Iridium* 33 collision generated large and long-lived debris populations calling for revision for these instruments. El Gammal regarding the ECSS European standardization organization notes a similar planned revision schedule and iterative process under its space agencies and industry delegates mixed working group process.

Institutional

With its work on ODM starting under CCSDS in the 1990s and validated under ISO subcommittee SC/13 by 2006 represents a small institutional progress for debris governance by initiating debris-relevant discussions under the International Organization for Standardization (ISO). The general standard work on ODM while only partially affecting the debris issue and not shaping a comprehensive debris instrument still contributed to bring ISO along in the debris system as a new supporting institution for the emergence of debris governance instruments, as a catalyzer of epistemic ideas circulation and shaping of requirements besides the IADC, COPUOS and ITU. The CCSDS and SC/13 count as an additional "home" in the space debris system conducive to epistemic influences and facilitating the process of further codification of debris mitigation ideas into standards and consolidating the debris governance regime with additional instruments. Indeed, the CCSDS forum enables experts to meet frequently under the working group meeting twice a year, over monthly teleconferences further diffusing knowledge by presenting their results at international conferences. Some of its experts are also debris specialists as mentioned in the idea section below. Also, CCSDS delegates also interact with subcommittee SC 14 experts, which entails even more members of the DEB epistemic community.

Compliance

The ODM standard is regarded by experts as widely successful due its diffusion into the major space agencies' national operational requirements as noted by Oltrogge and Berry.[422] This incorporation helps encouraging compliance with debris governing instruments.

[422] David S. Berry and Daniel L. Oltrogge, 2018, "The Evolution of the CCSDS Orbit Data Messages," Paper presented at the *2018 SpaceOps Conference,* 28 May - 1 June 2018, Marseille, France, published by the

Also, as an international industrial standard, ODM carries more weight than the IADC Guidelines across the commercial sector, therefore ODM helps consolidate compliance with IADC guidelines especially for the collision avoidance provision: “5.4 Prevention of On-Orbit Collisions.”

As a finding observed for several other debris instruments of this research, the ODM case illustrates how some epistemic members have been actors directly impacting debris policy-relevant outcomes such as shaping this ODM standard instruments, and then in promoting these instruments and norms and ideas contained by presenting and publishing across other debris or space governance fora. The study identified members of the DEB epistemic group sharing an interest in debris mitigation involved under ISO with the work of CCSDS, either directly under the NavWG Navigation Working Group or as contributors from the SC14 towards shaping standards such as the ODM. Namely these are David S. Berry, David Finkelman, Daniel L. Oltrogge and J. Chan, who are all members of the IAA debris working group and reported about CCSDS progress at the conferences mentioned under the normative section above from especially 2004 onwards. As is the case with other examples throughout this thesis, an epistemic member has been found as chairperson directly shaping or updating the debris-related governance instrument. For ODM, the key epistemic member of the DEB group involved in as executive positions is David Berry as the current chairperson.

ISO Subcommittee 14: Orbital Debris Coordination Working Group

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American Institute of Aeronautics and Astronautics, Inc, https://arc.aiaa.org/doi/pdf/10.2514/6.2018-2456 (accessed April 13, 2020), 2 and 7-8.

Normative

The Subcommittee 14 created a special Orbital Debris Coordination Working Group (ODCWG) for developing international space debris mitigation standards under ISO in 2003. The starting of this special debris working group represents a normative progress for debris governance under ISO in this third consolidation phase from the 1990s. Indeed, just following the IADC Debris Mitigation Guidelines adoption in 2002, and with the specific objective of shaping a comprehensive international standard for space debris in line with the IADC guidelines, the ODCWG clearly strengthens of the DEB norm, recently codified under the IADC, also gaining ground under COPUOS STSC as observed with the working group efforts towards agreeing on guidelines after releasing the Rex Technical Debris Report in 1999. This normative momentum also builds upon partial codification progress of debris instruments emerging in other fora in the 1990s such as under ITU with ITU-R.S.1003 for the protection of GEO in 1993, and under ILA with the proposed Buenos Aires legal instrument in 1994. Another example of the normative progress achieved for DEB ideas as comprehensive ideas in the early 2000s at the time of the ODCWG creation occurred in Europe with the European Debris Mitigation Standard (EDMS) of 2000 leading to the European Code of Conduct for Debris Mitigation adopted in 2004 and serving as basic reference text for the work on the ISO standard.

Another normative aspect of the ISO SC14 ODCWG lies in its coordination with the Subcommittee 13 also working on standards affecting debris from the collision avoidance aspect, especially the *Orbit Data Messages (ODM)* standard mentioned above. As the main debris working group under ISO, its experts by exchanging with the telecommunication experts under SC13 are further consolidating the norm of debris mitigation, especially from their cooperative work for the first revision of ODM the mid-2000s on the upgrading of the first version ODM standard version.[423] SC/14 will help from 2005 the SC/13 improve its second version of ODM to exchange orbital data information for increasing space safety and avoid debris creation from collisions and will continue developing a more comprehensive debris standard on its own, the ISO 24113, as explained in the 2010s section.

Policy

In a similar vein as EDMS, the ODCWG work involves industry stakeholders in the elaboration of its standard who worked together with the space agency experts, while the IADC guidelines were elaborated by space agency experts. Therefore, the initiating of the ODCWG under ISO Subcommittee 14 represents a policy innovation in terms of debris governance compared with the IADC instrument. This new initiative under ISO expanding the debris governance steps achieved under the IADC with the guidelines as the reference international instrument, and at regional level under EDMS, also consolidate debris governance becoming a more global process than the IADC and COPUOS efforts where delegates of member states and involving mostly space agencies have been the ones shaping the respective debris instruments.[424]

Institutional

[423] David S. Berry and David Finkelman, "The CCSDS Orbit Data Messages – Blue Book Version 2: Status, Applications, Issues," Paper AIAA 2010-2282, *SpaceOps 2010 Conference*, 25 - 30 April 2010, Huntsville, Alabama, 2010, 2.

[424] COPUOS has observing members involving industry such as industry associations and other mixed fora. National delegations have space agencies experts and also academia experts to advise the diplomats in their work under COPUOS. IADC has space agencies or other relevant national space institutions delegates.

During the 2000s, the ODCWG initiative under Subcommittee 14, besides the CCSDS work on the ODM standard attached to Subcommittee 13, further enabled the International Organization for Standardization (ISO) role as a supporting institution conducive to epistemic influences as catalyzers for the emergence of debris governance instruments, besides the IADC, COPUOS and ITU. ISO subcommittee 14 will grow during the 2000s as the main space debris "home" subcommittee, as yet another debris governance supporting body. This second sub-forum under ISO enables regular meetings and exchanges between epistemic experts, consolidating the existing IADC instrument and strengthening the debris regime representing an institutional gap filling effort for debris governance. This is one more contribution to fill this gap which remains a larger challenge, as there is still no existing international debris organization with the mandate, authority, and funding to act as a regime verification and managing institution, as the Inter-Agency Space Debris Committee is mostly an advisory body with limited functions and budgets.

As observed for ODM above and for several other debris instruments of this research, the ODCWG creation expresses the involvement of epistemic community members under ISO Subcommittee 14 in the efforts to shape another debris instrument, especially here the DEB group. The creation of the ODCWG working group to develop an international and comprehensive space debris instrument under ISO Subcommittee 14 illustrates how some epistemic members directly impacted debris policy-relevant outcomes under ISO. The study found that epistemic experts consolidated the DEB ideas from IADC guidelines under ISO as per the ODCWG mandate to make the wording stronger. The work of these debris experts is reported already from 2005 at international conferences on debris. Davey being the convenor of the group at the time promoted the DEB norms further by presenting and publishing across other debris or space governance fora. The members of the DEB epistemic community involved in the 2000s under ODCWG include space agencies people and consultants amongst others Emma Taylor and John Davey,[425] Heiner Klinkrad, Fernand Alby amongst many others during this decade of the 2000s.[426] As the Subcommittee 14 under which ODCWG belongs is tasked with liaising with the other debris governance fora,[427] the epistemic ideas have been easily diffused across especially the IADC, IAA, COSPAR, COPUOS and ITU fora. Davey being the convenor of the group at the time was as attending IADC sessions in order to ensure coherence of the developing ISO standard as per the objective of the ODCWG.[428] An epistemic member has again been found as the chairperson or rather here acting as "convenor" directly impacting the content of the debris governance instrument efforts under SC14 in the 2000s and in preparing what will become the general or "top" level space debris standard of ISO 24113 by 2010.

[425] John Davey and Emma A. Taylor, "Development of ISO Standards addressing mitigation of orbital debris," *Proceedings of the Fourth European Conference on Space Debris*, Darmstadt, Germany, 18-20 April 2005(ESA SP-587, August 2005).
[426] Klinkrad, H., Alby, F., Alwes, D., Portelli, C., & Tremayne-Smith, R, "Space Debris Activities in Europe," *Proceedings of the 4th European Conference on Space Debris* (ESA SP-587), 18-20 April 2005, ESA/ESOC, Darmstadt, Germany.
[427] John Davey and Emma A. Taylor, "Development of ISO Standards addressing mitigation of orbital debris," *Proceedings of the Fourth European Conference on Space Debris*, Darmstadt, Germany, 18-20 April 2005(ESA SP-587, August 2005), 5.
[428] As confirmed by interviews and access to primary sources such as internal circulation only proprietary ISO documents.

5.2.2 UN progress steps in the 2000s

This section presents debris governance progress at the United Nations governmental level in the 2000s, as new debris instruments emerging, or existing ones being revised under the International Telecommunication Union and the Committee on the Peaceful Uses of Outer Space fora.

ITU-R S.1003-1: Environmental protection of the geostationary-satellite orbit, first revision

The year 2004 marks a small progress towards the consolidation of debris mitigation efforts at the ITU forum with the first revision of ITU-R.S.1003, originally approved in 1993, and becoming ITU-R.S.1003-1.[429] This ITU recommendation revision coming about a decade after the first version is filling some knowledge, normative, policy and institutional gaps.

Knowledge

The knowledge progress is noticeable from increased details regarding the debris situation in the geostationary orbit as well as an emerging quantitative specification regarding a recommended minimal re-orbiting altitude above the protection region to ensure a better protection of the geostationary orbit.

Normative

This revised ITU recommendation is also found to reflect normative progress, as it is consolidating the norm of protection of the geostationary orbit from physical harm caused by

[429] ITU-R S.1003-1: Environmental protection of the geostationary-satellite orbit, approved January 2004, https://www.itu.int/rec/R-REC-S.1003-1-200401-S/en, (Accessed April 7th, 2020). Some sources mention the ITU constitution documents instead and the years 1994 for the first, and 2002 Radio Regulations.

debris, inherited from the previous decades' normative progresses. It is also completing a trend of normative progress observed during this period of the early 2000s marked by numerous international debris mitigation efforts in other fora. Indeed, the ITU recommendation devoted to the protection of the geostationary orbit had just been reinforced in more details by the IADC Guidelines in 2002, and similar debris mitigation ideas for the GEO were being discussed also at the UNCOPUOS, started to be addressed at the ISO level, while European efforts were also ongoing towards the shaping of a European Code for Debris Mitigation (ECoC) also including the ITU GEO protection idea.

Policy

A policy progress aspect of this first revised issue of the ITU Recommendation also derives from this quantitative specification, in particular of 200km as recommended altitude for removing satellites or launch-stages above the geostationary orbit, consolidating the recommendation thanks to being more specific, as specified in the document:

> "The ITU Radiocommunication Assembly recommends:
>
> 1 that as little debris as possible should be released into the GSO region during the placement of a satellite in orbit;
>
> 2 that every reasonable effort should be made to shorten the lifetime of debris in elliptical transfer orbits with the apogees at or near GSO altitude;
>
> 3 that before complete exhaustion of its propellant, a geostationary satellite at the end of its life should be removed from the GSO region such that under the influence of perturbing forces on its trajectory, it would subsequently remain in an orbit with a perigee <u>no less than 200 km above the geostationary altitude</u> (see Annex 1);

4 that the transfer to the graveyard orbit removal should be carried out with particular caution in order to avoid RF interference with active satellites."[430]

The first edition of ITU-R.S.1003 in 1993 left the decision for setting a minimum for the higher altitude to be further discussed,[431] therefore this second issue marks a progress step, which has been facilitated thanks to epistemic experts of the DEB group and by diffusion of ideas from other groups as explained in the ideas section.

Institutional

The research found an institutional progress step expressed by this revision of ITU-R.S.1003 during the 2000s, namely its consolidation of ITU's governance role in the debris issue, showing an upgrade to an instrument further codifying debris mitigation ideas.

Moreover, the importance of the ITU recommendation as a debris policy outcome will further increase in the ensuing decade as will be presented in the next decade section, reinforcing this research finding about the ongoing iterative and evolutionary nature of debris mitigation governance illustrated by the ITU body's involvement as one of the key governance bodies in the debris issue.

The first revised recommendation ITU-R.S.1003.1 expresses the presence of the same epistemically developed ideas than in the original version of 1993, namely DEB, some underlying AC ideas, and bears also epistemic communities' direct involvement.

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430 ITU-R.S.1003-1 : Environmental protection of the geostationary-satellite orbit, https://www.itu.int/rec/R-REC-S.1003-1-200401-S/en , 1.

431 ITU-R.S.1003 : Environmental protection of the geostationary-satellite orbit, https://www.itu.int/rec/R-REC-S.1003-0-199304-S/en, 3.

As seen in earlier ITU sections, some arms control ideas shared by the AC group already diffused into the ITU regime since the 1950s with restraint ideas under the harmful interferences provisions since the 1959 Geneva Convention, and kept diffusing into successive ITU agreements including to the first recommendation of 1993, and in the 2000s in this first revision to ITU-R.S.1003, whose major change is the specification of the re-orbiting altitude, without changes regarding the avoidance of harmful interferences aspects as enduring ideas.

The strongest influence for the Recommendation's revision is the DEB group, which has now consolidated since the 1990s and the IADC forum creation and its issuing of the IADC debris mitigation guidelines. Mejia-Kaiser noted the influence of the protected zones ideas under the IADC platform as stimulating progress also at the ITU-level platform in the 2000s around this revision,[432] confirming the involvement of the DEB experts of the IADC member agencies. As space agencies - where a lot of epistemic community experts of the debris mitigation group are found - have been sending delegates to ITU for decades, these same DEB experts have been carrying debris mitigation ideas with them since the late 1970s, throughout the 1980s and 1990s, confirming the continued influence of the DEB group within the ITU forum towards facilitating the ITU recommendation as a debris instrument and now for revising it.

[432] Martha, Mejía-Kaiser, The Geostationary Ring: Practice and Law, 246.

COPUOS Space Debris Mitigation Guidelines 2007

After several decades of studies and discussions at various fora about the issue of space debris, momentum followed the first debris technical report in 1999 at COPUOS leading to a comprehensive debris policy outcome at the United Nations level. The "Space Debris Mitigation Guidelines of the United Nations Committee for the Peaceful Uses of Outer Space" were agreed-to in 2006 and endorsed by UNGA Resolution 62/217 in December of 2007[433] and represent normative, policy, institutional and compliance progress steps for debris governance efforts in the 2000s decade, as presented below.

Normative

As reminded by experts and specified in relevant COPUOS reports, the COPUOS Debris Mitigation guidelines are based upon the IADC 2002 guidelines[434] with the exception of one idea, namely the 25-year rule for de-orbiting spacecrafts at the end of their operational lives not included in the COPUOS Guidelines.[435] The COPUOS Debris guidelines of 2007 therefore further consolidate a wide range of debris mitigation ideas and norms already codified in the IADC instrument and in other partial instruments from other fora such as the ITU and its GEO re-orbiting recommendation and numerous arms control treaties with limited protective provisions of space assets as observable in Table 6-1. This time though,

[433] A/RES/62/217. Resolution adopted by the General Assembly on 22 December 2007 [on the report of the Special Political and Decolonization Committee (Fourth Committee) (A/62/403)]; https://undocs.org/A/RES/62/217 , accessed July 10th, 2020. https://www.unoosa.org/oosa/oosadoc/data/resolutions/2007/general_assembly_62nd_session/ares62217.html

[434] As reminded in Jakhu, Ram S., Tommaso Sgobba and Paul Stephen Dempsey (Eds.), *The Need for an Integrated Regulatory Regime for Aviation and Space. ICAO for Space?* European Space Policy Institute Studies in Space Policy Series Vol. 7 (Vienna: Springer, 2011), 113; Stubbe, *State accountability for space debris*, 235.

[435] As reminded in Jakhu, Sgobba and Dempsey, The Need for an Integrated Regulatory Regime for Aviation and Space. ICAO for Space? 113.

these debris ideas having transformed into norms have been promoted among a much larger number of nations and at the higher political level forum of the UNCOPUOS and at the UN General Assembly level, thus representing a strong normative progress for debris governance efforts in the 2000s. The COPUOS Debris Guidelines thus also further improve norm consolidation achieved in other fora and in earlier decades as well. The COPUOS Guidelines' value as normative progress are even recognized as having succeeded in building a solid international norm of responsible behavior of restraint from intentional debris-generating activities in outer space for security-related aspect,[436] one of the most sensitive aspects to agree upon, as highlighted by the long history of failed attempts at creating an anti-satellite ban treaty.

Policy

Firstly, the UN COPUOS Space Debris Mitigation Guidelines adopted in 2007 represent a strong policy progress step in terms of debris governance as they further institutionalize the ideas of debris mitigation into an internationally agreed instrument building upon the earlier IADC space-agencies 'level instrument. Their adoption at a high level international political forum such as the United Nations General Assembly make the COPUOS Debris Mitigation Guidelines a further political progress step for debris mitigation efforts. The Debris Mitigation Guidelines have been adopted unanimously at the COPUOS plenary level and then at the UNGA by more than 120 states, confirming a large support.[437]

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[436] Frank Rose, "Safeguarding the Heavens", 3.
[437] A/RES/62/217.
https://www.unoosa.org/oosa/oosadoc/data/resolutions/2007/general_assembly_62nd_session/ares62217.html (accessed July 19, 2020).

Secondly, COPUOS Debris Mitigation Guidelines are deemed one of the main comprehensive instruments covering debris mitigation aspects as they tackle most of the debris mitigation aspects and have been shaped internationally.[438] As an additional comprehensive instrument, these COPUOS Debris guidelines therefore expand the body of existing basic provisions, partial and comprehensive international instruments mentioned in Table 6-1, helping towards the emergence of a space debris regime.

Thirdly, an additional policy step expressed by the COPUOS Debris Guidelines deserves attention. Among the comprehensive provisions found in the COPUOS debris instrument of 2007, the presence of the "intentional provision" is found under guideline 4 and is similar to provision 5.2.3 of the IADC Guidelines. COPUOS Debris Guidelines 4 states that:

> "Recognizing that an increased risk of collision could pose a threat to space operations, the intentional destruction of any on-orbit spacecraft and launch vehicle orbital stages or other harmful activities that generate long-lived debris should be avoided. When intentional break-ups are necessary, they should be conducted at sufficiently low altitudes to limit the orbital lifetime of resulting fragments."[439]

In addition to the normative value already recognized in the above paragraph for these COPUOS Guidelines in terms of restraints towards avoiding debris-creation[440] by codifying a security-related aspect of debris, guideline 4 represents another significant policy progress for debris governance, especially given that COPUOS typically does not deal much with arms control matters. Indeed, UN COPUOS forum reports typically barely mention arms control

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[438] Stubbe, *State accountability for space debris*, 233.
[439] Report of the Committee on the Peaceful Uses of Outer Space General Assembly Official Records Sixty-second session, Supplement No. 20 (A/62/20), Annex, 49. https://www.unoosa.org/oosa/oosadoc/data/documents/2007/a/a6220_0.html (accessed July 19, 2020).
[440] Frank Rose, "Safeguarding the Heavens," 3.

concerns and the need to prevent an arms race in outer space by recalling article IV of the Outer Space Treaty and usually defers discussions of disarmament and arms control to the other forum of the Conference on Disarmament (CD). Therefore, the COPUOS Debris guidelines consensus achieved at this high-level policy forum over a debris provision affecting arms control aspects represents a considerable policy improvement achieved for debris governance, further consolidating a similar policy step achieved in 2002 at the space agencies' level forum on this intentional aspect with the IADC Guidelines and growing the body of debris instruments containing this limited arms control "intentional" provision mentioned in Table 6-2. This guideline 4 on intentional debris creation offers a good example of the diffusion and promotion process of ideas from the technical level forum of IADC towards the higher political level of the UN COPUOS observed in the debris governance process.

Institutional

The adoption of the UN COPUOS Guidelines in 2007 also represents an institutional progress step for debris governance. Indeed, while COPUOS had been slow to accept the issue of space debris as an agenda item since the first round of papers were circulated in the late 1970s,[441] the work which finally started on debris at COPUOS in the 1990s had already brought COPUOS into the club of space debris governance actors. The COPUOS Debris guidelines in 2007 thus further consolidated the role of this UN-level forum as one of the main debris governance fora, extending participation in debris governance beyond the main

[441] Lubos Perek, "Space Debris at the United Nations".

space-faring nations and their respective agencies, as is the case under the work of the IADC forum for instance.[442] COPUOS' role as a debris governance body also complements the efforts of the second UN-level debris mitigation body, namely ITU, which had already issued debris-relevant provisions with its Recommendation ITU-R in 1993 as a partial debris instrument covering issues relating to the protection of the geostationary orbit.

Compliance

The adoption of the COPUOS Debris Mitigation Guidelines of 2007 by over one hundred and twenty states at the United Nations' General Assembly level arguably encouraged greater compliance progress than the IADC Guidelines which were agreed between 11 space agencies. China who created the largest debris cloud in its January 2007 ASAT was a signatory of the UNGA resolution endorsing these COPUOS Guidelines by the end of that same year. Following this step, China has complied with the provisions of these COPUOS Guidelines, especially guideline 4 by avoiding engaging orbital targets and creating debris in its subsequent anti-satellite weapons tests. Other nations also observed guideline 4 after 2007 behaving more responsibly in their ASAT activities by conducting them at lower orbits to reduce debris creation or by avoiding the engaging of targets which create debris altogether as illustrated in Table 1-4 reported under a CSIS/SWF study.[443] The COPUOS Debris

[442] Even though the COPUOS Debris guidelines are based upon the IADC Guidelines which were shaped by space agencies, as regards the governance process at least greater participation and involvement can be found in their endorsement by many more nations. Indeed, COPUOS Guidelines encouraged endorsement by a wider number of states including the non-space-faring states, thus allowing for more participation in the debris governance process.

[443] The United States conducted a lower orbit ASAT in 2008 known as Operation Burn Frost, China continued its tests without engaging targets in orbit, Russia also conducted non-target ASAT tests of its *Nudol* as observed this year in April 2020 while India conducted its 2019 ASAT at lower orbit to create less debris. For more information on ASAT activities, see the CSIS and SWF counterspace studies of 2018, 2019, 2020 (Weeden

Guidelines are therefore considered a compliance consolidation step for debris governance efforts with observance of "better" behavior form the 2000s onward already following the adoption in December of 2007.

The COPUOS Debris Mitigation Guidelines of 2007 reflect the presence of mostly shared debris mitigation ideas of the DEB group, some inherited arms control ideas from the AC group and a slight mention of long-term sustainability ideas of the emerging LTS group.

Debris Mitigation (DEB)

As a comprehensive debris mitigation instrument, all the provisions of the COPUOS Debris Mitigation Guidelines of 2007 express debris mitigation DEB ideas addressing aspects from the mission planning, design, manufacture and operational (launch, mission, and disposal) phases of spacecraft and launch vehicle orbital stage in the introductory paragraphs and in all of the 7 guidelines.[444]

Arms Control (AC)

Mentioned above in the policy step paragraph and similar to the IADC Guidelines' intentional debris creation provision, guidelines 4 of the COPUOS Debris Mitigation Guidelines of 2007 is the one indicating the presence of arms control AC ideas as inherited from earlier influences over space governance instruments and over debris governance especially in the 1980s, and which diffused to the main international space debris mitigation

and Samson, Weeden, Brian and Victoria Samson. "Global Counterspace Capabilities: An Open-Source Assessment". Secure World Foundation; Todd Harrison, Kaitlyn Johnson, and Thomas G. Roberts. "Space Threat Assessment", (Washington, D.C.: Centre for Strategic and International Studies CSIS, 2019).

[444] Report of the Committee on the Peaceful Uses of Outer Space General Assembly Official Records Sixty-second session, Supplement No. 20 (A/62/20), Annex,47-50. https://www.unoosa.org/oosa/oosadoc/data/documents/2007/a/a6220_0.html (accessed July 19, 2020).

instruments, as explained earlier. Indeed, COPUOS DM guideline 4 expresses the diffusion of AC restraint ideas into the COPUOS Debris Mitigation Guidelines of 2007 similarly to the IADC guidelines and as shown in Table 6-2 summarizing the body of instruments containing "intentional" or restraint provisions. It implies that some level of restraint ought to be observed when conducting intentional debris-creating activities, covering activities such as Anti-Satellite Weapons tests (ASAT). It further provides that if unavoidable, destructive activities should be conducted at lower orbits to reduce the number and longevity of orbital debris and thus hazard to other space operations.

Long Term Sustainability (LTS)

The presence of elements relating to Long Term Sustainability shared ideas LTS were found scarcely in the COPUOS Debris Mitigation Guidelines of 2007, mostly in the background section:

> "The prompt implementation of appropriate debris mitigation measures is therefore considered a prudent and necessary step towards preserving the outer space environment for future generations." [445]

The fact that the LTS is mentioned in the introductory paragraph of the COPUOS DM guidelines shows how the LTS set of ideas are emerging towards a norm, as an early step towards recognition of the importance of the long-term sustainability shared ideas in the early stages of the diffusion process of LTS ideas, which start to become shared ideas from 2007 onwards.

[445] A/62/20, Annex, 47.

The COPUOS Debris Mitigation Guidelines example thus illustrates the same influence pattern identified with IADC Guidelines, namely that the DEB group were the main epistemic influencers, and that ideational influences of the AC shared ideas inherited from the earlier decades were also found to endure under these COPUOS Debris Mitigation guidelines as an additional main international space debris governance instrument.

COPUOS Long-Term Sustainability Initiative Proposal

The Long-Term Sustainability Initiative took shape during the late 2000s and was formally presented under the UN COPUOS forum by 2009. These early steps during the 2000s represent several governance progress aspects for debris governance and entail the involvement of epistemic communities' members as explained below.

Normative

The emergence of the LTS initiative proposal including space debris in its holistic working plan represents normative progress for debris governance in the 2000s as a consolidation of earlier steps achieved with the debris norm already institutionalized in various instruments mentioned in Table 6-1. The Long-Term Sustainability proposal and ideas are an outgrowth of mainly the space debris efforts including the space traffic management and the sustainable development efforts involving epistemic community experts. Especially, Brachet reminds of the preliminary contributions shaped at the non-governmental level under working groups in NGOs such as the IAA *Cosmic Study on Space Traffic Management* of 2005-2006, the working group held under IAASS "An ICAO for

Space” and also at the IADC multi-lateral space agencies forum as basis towards LTS ideas.[446]

The LTS initiative is embedded in the success of debris efforts leading to the COPUOS Debris Mitigation Guidelines[447] and has been fueled by rising concerns about the worsening of orbital collisions risks after the Chinese ASAT test in 2007 creating the largest debris cloud in history,[448] the overall increasing congestion of the space domain, the development of much larger satellite constellations, the lack of traffic rules, and the overall risks they represent for the sustained use of and access to outer space. These increased threats to space operations gave the impetus for a more comprehensive approach to ensure the long-term sustainability of the space domain.

The concerns for preserving space activities and the space domain for future generations also played a role for LTS ideas as observable in the LTS initiative definition and as pointed out by several experts. However, despite similarities presented by Martinez between the LTS definition and the sustainable development definition in the Brundtland report of 1987, both highlighting the need to preserve a limited environmental resource for present and future generations, the LTS initiative is mostly focusing on the space environment and its economic activities based upon protecting it to sustain access and use of outer space rather than on an

[446] Gérard, Brachet, “From GEO and Spectrum Crowding to the Threat of Space Debris: Is our Present Use of Outer Space Sustainable?” in Guilhem, Penent (ed.), “Governing the Geostationary Orbit: Orbital Slots and Spectrum Use in an Era of Interference,” January 2014, *Notes de l’IFRI,* Space Policy programme, 83.
[447] Brachet, “The Origins of the “Long-term Sustainability of Outer Space Activities” Initiative at UNCOPUOS,’162.
[448] See Table 1-1, “Top Ten Satellite break-ups” from the NASA JSC Debris office (ODPO).

environmental protection angle and sustainable development angle targeting socio-economic activities and the ecological environment of the Earth.[449] Martinez defined the LTS ideas as:

> "The long-term sustainability of outer space activities is defined as the ability to maintain the conduct of space activities indefinitely into the future in a manner that realizes the objectives of equitable access to the benefits of the exploration and use of outer space for peaceful purposes, in order to meet the needs of the present generations while preserving the outer space environment for future generations."[450]

The ideas proposed in the LTS initiative are also supporting the sustainable development ideas and efforts promoting sustainable economic development on Earth such as the efforts conducted under the United Nations under the "Space for SDGs" initiative which emerged in the mid-2010s. Indeed, thanks to the benefits from space science and technology applications and uses, space activities can contribute to many of the seventeen Sustainable Development Goals. However, the LTS initiative launched almost a decade before the SDGs is a different set of ideas focused on ensuring the sustainability or continued use of the space activities themselves thanks to a safer and more secure the space environment.[451]

As reminded by Gérard Brachet in 2012,[452] Theresa Hitchens in 2008[453] and Peter Martinez in 2018,[454] a process of socialization starting after 2007 especially at the informal

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[449] Deriving from interviews with debris and space traffic issues experts, including Brachet.

[450] Martinez, "First Fruits of the Long-Term Sustainability discussions in UN COPUOS: From guideline development to guideline implementation,"2.

[451] Lotta Viikari, *The Environmental Element in Space Law: Assessing the Present and Charting the Future*. Studies in Space Law, Vol. 3, (Martinus Nijhoff Publishers, Leiden/Boston, 2008).

[452] Gérard, Brachet, 'The origins of the "Long-term Sustainability of Outer Space Activities" initiative at UN COPUOS,' *Space Policy* 3 (August 2012), 161-165.

[453] Theresa Hitchens, 2008, COPUOS wades into the next great space debate, June 26, 2008, https://thebulletin.org/2008/06/copuos-wades-into-the-next-great-space-debate/ (accessed January 8, 2020).

[454] Peter Martinez, "Development of an international compendium of guidelines for the long-term sustainability of outer space activities," *Space Policy* 43 (2018):13-17.

level led to the emergence of LTS ideas as the next COPUOS debate, reflecting normative progress in the late 2000s, also affecting debris efforts. This normative progress for debris governance grew in the next decade when LTS ideas materialized into the COPUOS LTS initiative proposal, reinforcing the space debris mitigation norm under the broader space sustainability approach of LTS guidelines which also contain debris provisions as explained later in the 2010s section. Theresa Hitchens confirms this normative turning point by 2008 towards greater international acceptance of LTS ideas, around the time when the LTS initiative was about ready to get formally presented at COPUOS:

> "the key question now bedeviling the global space community: How to ensure the long-term security of space operations in a more crowded, and more militarized, environment?" […]"space sustainability" has become a buzzword not just at COPUOS but also among a wide variety of global space stakeholders – and a coded acknowledgement of the need for new international processes to underpin that sustainability. That recognition is, in and of itself, progress."[455]

Other fora also enabled LTS ideas circulation, strengthening this normative progress thanks to being carried by epistemic community experts. For instance, besides earlier contributions made in the IAA Cosmic Study of 2006 on Space Traffic Management, the IAASS " ICAO for Space" working group effort and under the IADC, Brachet mentions the various other fora where he himself promoted the LTS initiative such as during informal

[455] Theresa Hitchens, "COPUOS wades into the next great space debate," June 26, 2008, https://thebulletin.org/2008/06/copuos-wades-into-the-next-great-space-debate/, (accessed January 8, 2020). 2008, 3.

meeting in-between COPUOS sessions, at the CD forum and at the NGO-levels IAF Congress in Glasgow in 2008 and UNIDIR,[456] illustrating his direct role as a catalyst in diffusing the LTS ideas and role as enablers of this "socializing process." Brachet further promoted LTS ideas contributing to grow the membership and influence of the emerging LTS epistemic group at additional NGO level conferences such as the IAA/ESPI/SWF "Fair and Responsible Use" conference held at EPSI in 2008 while Schrögl was president and the McGill/IASL Interdisciplinary Congress in 2009 involving Jakhu and Böckstiegel, both conferences also leading to book publications generating normative progress for LTS and DEB ideas in the 2000s.[457]

Policy

Formally introduced in 2009,[458] the LTS initiative represents a policy step for debris governance as it marks to beginning of another initiative entailing a space debris component amongst its several thematic priorities. With its aim of shaping best practices guidelines, the LTS initiative represents an additional effort at codifying space debris mitigation ideas into an additional internationally agreed instrument, enriching the existing body of instruments mentioned in Table 6-1 and helping towards consolidating a space debris regime.

Also, as COPUOS decisions are made by consensus, the long-term sustainability proposal and its approval as an agenda item also confirm that a wide support was reached

[456] Gérard Brachet, 'The origins of the "Long-Term Sustainability of Outer Space Activities" initiative at UN COPUOS,' *Space Policy* 3 (August 2012): 161-165.
[457] Wolfgang Rathgeber, Kai-Uwe Schrögl, and Ray A. Williamson (Eds.), *The Fair and Responsible Use of Space: An International Perspective* (Vienna: Springer, 2010).
[458] A/AC.105/L.274, 21 May 2009.

internationally and at a high political level among the 69 member states of 2009 about the need to act on LTS,[459] strengthening the political value of this progress step.

The LTS proposal also represents a small policy innovation in so far as it is a holistic approach to space sustainability, expanding the scope of space debris mitigation ideas and covering additional aspects affecting the orbital debris issue than those covered in the space debris mitigation instruments. For instance, the LTS proposal established four thematic areas focusing on sustainable development activities on Earth, space weather aspects and the improvement of regulatory frameworks, besides space debris and operation safety. It therefore acts a complementary approach and policy progress step for debris governances, as LTS aims to establish best practices recommendations as basis for an international comprehensive regime to ensure greater space sustainability.

Institutional

Following its entry into debris mitigation and governance discussions in the 1990s with space debris becoming an agenda item with a dedicated debris working group under STSC preparing for the COPUOS Debris Mitigation guidelines in the 2000s, the LTS guidelines initiative consolidates the role of COPUOS as space debris governance body under a wider approach to space sustainability efforts in the 2000s.

In terms of epistemic groups and respective ideas influences over the COPUOS LTS initiative in the 2000s - which started the journey towards work a dedicated working group and towards developing the LTS guidelines in the following decade-, the study found LTS

[459] United Nations Office for Outer Space Affairs (UNOOSA), Secretariat of COPUOS, "Committee on the Peaceful Uses of Outer Space: Membership Evolution," https://www.unoosa.org/oosa/en/ourwork/copuos/members/evolution.html (accessed July 27, 2020).

ideas, debris mitigation ideas DEB, and underlying AC arms control ideas, confirming that not one, but several epistemic communities helped form the ideational foundations of the LTS initiative carried by these communities' members directly, and indirectly by way of inherited ideas diffusion.

As regards epistemic influences for the emergence of the LTS initiative under the COPUOS forum, the study found that it emerged especially from the DEB epistemic group members by the late 2000s, especially under the impetus of Gérard Brachet during his term as chair of UNCOPUOS.[460] Brachet was involved in debris studies under the IAA Cosmic Study on Space Traffic Management in 2006, and as member of other debris study committees, and later of the permanent space debris committee of the IAA as a recognized peer on the topic.[461] Brachet also held a Vice President position under the IAF around the period when he helped conceptualize the LTS ideas between 2007-2008.[462] He introduced the comprehensive LTS ideas including debris ideas across several fora during his mandate as COPUOS chair, presenting under the CD, at space security conferences, at IACs, and in academia such as at a McGill University conference in 2009.[463] As noted in other examples throughout this research, Brachet's involvement as an epistemic community member

[460]"IAF Biographies, Brachet," https://www.iafastro.org/biographie/gerard-brachet.html, (accessed March 22, 2021).

[461] "IAA Permanent Committee on Space Debris," https://iaaspace.org/about/permanent-committees/#SA-PERMCspacedebris (accessed March 22, 2021).

[462] "IAF Biographies, Brachet." https://www.iafastro.org/biographie/gerard-brachet.html, (accessed March 22, 2021).

[463] 2009 Space Governance Roundtable and Space Debris Congress, McGill University, Institute of Air and Space Law (IASL), 6 May 2009, https://www.mcgill.ca/iasl/files/iasl/Space_Governance_6May09_Gerard_Brachet.pdf ; Brachet, Gérard. 'The Origins of the "Long-term Sustainability of Outer Space Activities" initiative at UN COPUOS,' *Space Policy* 3 (August 2012): 164-165.

illustrates the process of direct influence of experts in shaping new initiatives covering debris governance, and contributing to increasing space sustainability. The study also found that some influential experts usually hold executive positions in organizations identified as platforms conducive to epistemic influences, providing “homes” such as those explored by Adler[464] for developing or introducing new ideas, consolidating them, leading to policy coordination with special working groups. The socially constructed ideas are then promoted across multiple other fora, typically COPUOS, IAF and other dedicated conferences on the topic hosted also sometimes by academic platforms such as conferences and seminars co-organized by several universities. Then gradually evolving from ideas towards norms, and with help from further promotion by epistemic members become agenda-items and lead to new working groups, sometimes towards recommendations such as the GGE groups or guidelines such as COPUOS Debris Mitigation Guidelines. Here in this initiative example of the late 2000s, the LTS initiative was firstly shaped at informal meetings held during side-events occurring during the main regular meeting of IAF and COPUOS sessions and other supporting NGOs-level meetings.

Several international conferences contributed to the emergence of the LTS as an epistemic community group, whose consolidation in turn facilitated the emergence and progress of the LTSWG initiative and LTS guidelines progress in the next decade under COPUOS. Important conferences amongst others for raising awareness about LTS ideas and growing

[464] Adler, “The Emergence of Cooperation: National Epistemic Communities and the International Evolution of the Idea of Nuclear Arms Control,” 126, 130.

the epistemic support were the 2008 Fair and Responsible use meeting,[465] and the International Interdisciplinary Congress[466] organized by the University of McGill and Cologne Space Law institutes and the IAASS, involving Ram Jakhu as well. Gerard Brachet in his executive role as COPUOS chair and as an early LTS epistemic member facilitated the policy progress for the LTS initiative becoming an agenda item, as will be seen in the next decade, and leading to a proper working group under UNCOPUOS by 2009, and wider policy coordination towards approved LTS guidelines in the 2010s. Brachet, also a DEB member, facilitated the LTS initiative as one of the pioneers of the LTS epistemic group, which in the late 2000s comprised other space debris and safety experts sharing an interest in space sustainability. These included Ram Jakhu of McGill University's Institute of Air and Space Law, Tommaso Sgobba President of IAASS,[467] Ray Williamson, Executive Director of Secure World Foundation and Brian Weeden of SWF, Peter Martinez as chair of the LTSWG, David Finkelman of the Center for Space Standards and Innovation Analytical Graphics, Colorado, and Akira Kato of JAXA chair of numerous conference debris sessions and of IAA debris studies, amongst many others who will grow the LTS group membership over the next decade.

[465] Ram Jakhu and Kai-Uwe Schrögl became even more involved in promoting DEB ideas in the 2000s than in the 90s when they started to publish about the topic. Schrögl belongs to several epistemic groups and increased his participation further in debris-related initiatives and discussions in the 2000s as President of ESPI, publishing also on space sustainability, and joining in working groups in some IAA debris-covering reports such as the IAA 2006 Cosmic Study, or the IAASS "An ICAO for Space" Working group together with Ram Jakhu another debris expert and member of several groups, namely DEB and LTS. Schrögl, Brachet, Williamson and many early DEB community members including Perek participated in the 2008 conference and helped promote DEB ideas and emerging LTS ideas.

[466] International Interdisciplinary Congress on Space Debris, 7-9 May 2009, McGill University, Montreal, Canada, https://www.mcgill.ca/iasl/events/spacedebris2009 (accessed March 22, 2021).

[467]Tommaso Sgobba, http://iaass.space-safety.org/organization/2297-2/ (accessed March 22, 2021).

Some more details about the ideas contained in the Long-Term Sustainability initiative launched in the 2000s and opening the way towards work on the LTSWG towards guidelines in the following decade are presented below. Mostly, LTS and DEB and inherited AC ideas were found.

Debris Mitigation (DEB) and Long-Term Sustainability (LTS)

The influence of debris mitigation DEB ideas in relation with the LTS initiative is mostly highlighted by Brachet in 2012[468] as one of the driving ideas and as the inspiration for the process at COPUOS. Space Debris Mitigation Guidelines at COPUOS level and NGO-level proposals developed by the IAA Cosmic paper of 2006 on Space Traffic Management, or even the IAASS initiative on space traffic management also covering space debris mitigation ideas all played a significant role in the emergence of the LTS proposal by 2009 confirming the presence of space debris ideas in this initiative in the 2000s, prior to the agreements on guidelines analyzed in the next section on the 2010s decade. The LTS initiative goes further in its debris mitigation ideas under the more comprehensive LTS proposal seeking to answer the recognized need and calls for a space traffic management regime for instance,[469] with additional provisions to enhance sustainability of the outer space activities not just to mitigate the debris issue but to secure space operations and benefits on the long run.

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[468] Brachet, Gérard, 'The origins of the "Long-term Sustainability of Outer Space Activities" initiative at UN COPUOS,' *Space Policy*, 3 (August 2012): 161-165.

[469] The IAA Cosmic Study of 2006 called for an international regime for Space Traffic Management (IAA, *Cosmic Study on Space Traffic Management* (Paris: International Academy of Astronautics, 2006). The IAASS also conducted a study proposing a model drawing lessons from the ICAO model of air traffic management for space traffic management (Jakhu, Ram S., Tommaso Sgobba and Paul Stephen Dempsey (Eds.), *The Need for an Integrated Regulatory Regime for Aviation and Space: ICAO for Space?* European Space Policy Institute Studies in Space Policy Series Vol. 7 (Vienna: Springer European Space Policy Institute, 2011).

Arms Control (AC)

The comprehensive approach to the LTS guidelines proposal deriving from debris mitigation successful outcomes and from emerging ideas of space traffic management are focusing on space safety but still contain some restraint ideas inherited from earlier arms control ideas influences over space governance. With the starting of the work on guidelines arms control ideas will diffuse as an indirect AC group influence under some paragraphs of the some of the COPUOS LTS guidelines which have not been yet agreed, and called the draft guidelines, as explained later under the 2010s sections.

5.2.3 Multi-lateral governmental initiative outside of the UN 2000s

This section presents debris governance progress at the multi-lateral governmental level outside of the United Nations system in the 2000s, mainly as new debris instruments emerging under the international space agencies-level, the European space agencies-level, and the European Union level.

The Inter-Agency Space Debris Coordination Committee Guidelines 2002

Resulting from a decade-long discussion process, the 2002 IADC Guidelines were adopted in 2002 among 11 space agencies[470] and represent consolidated knowledge,

[470] IADC Terms of Reference (TOR), IADC-93-01 (rev. 11.5) latest version of 2018. https://www.iadc-home.org/terms_reference, accessed July 5th, 2020. The 11 IADC member agencies as at 2002 are: ASI (Agenzia Spaziale Italiana), CNES (Centre National d'Etudes Spatiales), CNSA (China National Space Administration), DLR (German Aerospace Center), ESA (European Space Agency), ISRO (Indian Space Research Organisation), JAXA (Japan Aerospace Exploration Agency), NASA (National Aeronautics and Space Administration), ROSCOSMOS (State Space Corporation "ROSCOSMOS"), SSAU (State Space Agency of Ukraine), UKSA (United Kingdom Space Agency).

normative, policy, institutional and compliance progress steps as well as direct epistemic community influences and indirect ones.

Knowledge

The IADC Guidelines represent a knowledge progress step in their comprehensive and aggregative approach to debris mitigation. They are not limited to one category of space assets to be protected like national technical means of treaty verification such as reconnaissance satellites (NTMs), to restraint on one type of weapon used in space such as weapons of mass destruction or nuclear weapons, or to one orbit like the Geostationary orbit protection under ITU rules, nor to one category of debris mitigation like the passivation of upper-stage rocket bodies. Consisting of a sum of all available space debris mitigation knowledge brought by the cooperation with the member space agencies in the shaping process of these IADC Guidelines, they represent a space debris knowledge progress step as an increased knowledge.

Normative

The IADC Guidelines represent a normative progress step for debris governance as they aggregate and consolidate ideas, which have been codified gradually as limited provisions under several space and arms control treaties, conventions and constitutions like the Outer Space Treaty, the PTBT, and served as support to debris mitigation ideas and earlier instruments such as the ITU recommendation and the ITU Constitution. For instance, to name just a few ideas such as restraint ones protecting some categories of space assets, or some specific orbits or partially restricting some harmful space activities such as those involving testing or use of destructive weapons in outer space such as nuclear weapons and other weapons of mass destruction. Some of these basic space governance regime instruments and the partial debris mitigation instruments emerging prior to the IADC Guidelines count as preliminary and early debris governance tools and are shown in Table 6-1.

Policy

Firstly, the IADC Guidelines agreed in 2002 represent of policy progress step in debris governance, as the guidelines institutionalize the ideas of debris mitigation DEB into a first universally agreed instrument, which will serve as the basis for ensuing debris instruments like the COPUOS Guidelines of 2007, the ISO Standard 24113, the ECoC, and which many national debris mitigation regulations will observe. The IADC Guidelines express progress shaping policy preferences and technical solutions as an international coordination mechanism, generating an international policy outcome and shaping the foundations for debris governance and the beginning of an international regime, growing the body of debris basic provisions and instruments mentioned in Table 6-1.

Secondly, the IADC Guidelines represent a policy step due to the nature of the IADC membership, which includes the major spacefaring and launching nations including the United States, Russia, the main European space agencies,[471] Japan, China and India amongst others, adding political weight to the outcome of the IADC international multi-lateral body outside of the United Nations forum.

Lastly, another policy progress of the IADC debris guidelines resides in the inclusion of a specific provision covering intentional debris creation. Indeed, this IADC space-agency

[471] The most active space agencies leading the debris effort at the European level since the 1980s are: the French CNES, German DLR, Italian ASI, British BNSC then UKSA, and the European Space Agency (ESA).

level international agreement on a national security-related provision between rival space powers reflects an important political step. The provision 5.2.3 of the IADC Guidelines recommends that the:

> "Intentional destruction of a spacecraft or orbital stage, (self-destruction, intentional collision, etc.), and other harmful activities that may significantly increase collision risks to other spacecraft and orbital stages should be avoided. For instance, intentional break-ups should be conducted at sufficiently low altitudes so that orbital fragments are short lived."[472]

This provision represents a significant policy progress in so far as it limits activities such as anti-satellite tests (ASATs) to be either avoided or conducted at lower orbits, especially given the deadlock at the United Nations Conference on Disarmament since the 1990s and the failure of ASAT ban treaty attempts since the 1970s between the United States and the Soviet Union. This IADC Guideline provision on "intentional" aspects complements earlier achieved basic steps of restraint found within the body of the space regime since the early space age and benefiting from influences of the AC group as explained in the 1980s section, as a complementary effort to the emerging DEB group efforts also observed during the early 1980s. Also the basic elements of space governance have been consolidating the norm of restraint in space weaponization and destructive behavior in outer space since the first decades of the space age under the main space treaty the Outer Space Treaty (OST) of 1967, especially article IV limiting the deployment, testing and use of weapons of mass destruction,

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[472] Inter-Agency Space Debris Coordination Committee (IADC). "IADC Space Debris Mitigation Guidelines", IADC-02-01, Revision 1, September 2007 is the earlier version available at https://orbitaldebris.jsc.nasa.gov/library/iadc_mitigation_guidelines_rev_1_sep07.pdf , (accessed July 22, 2020).

and article IX banning harmful interferences with other nations' space operations, and other arms control treaties belonging to the general space regime such as the Partial Test Ban Treaty (PTBT) of 1963 banning nuclear testing in outer space and the Anti-Ballistic Missiles Treaty of 1972 banning the harm of satellites used as National Technical Means (NTM), and also several UN resolutions since the 1950s calling for restraint by keeping space activities for exclusively peaceful uses, all listed in Table 6-1. These earlier space governance provisions affecting restraint principles which will serve as basis for ensuing debris governance and deriving from bi-lateral and multi-lateral arms control efforts and AC influences are covered under the main ensuing international debris instruments "intentional" destruction provisions as summarized in Table 6-2. This shows again that some arms control ideas affecting the debris issue diffused for decades and across multiple fora before also reaching the IADC forum of space agencies and become codified under its debris governance instrument.

Institutional

The success of the IADC Guidelines also represents an institutional progress step for debris governance in so far as it reinforces the debris regime and its governance system with a major supporting forum for debris and as an additional debris governance platform besides the UN platform. The role of the IADC forum as a debris governance body thanks to its first internationally agreed instrument is also conducive to epistemic ideas and norm consolidation. Space agency experts conduct studies and identify new challenges for upgrading knowledge about the debris issue and enabling policy innovations under the IADC as supporting institution reminding of Adler's concept.[473] However, it is more limited as a "home" than other fora such as the IAA or IISL whose membership are not restricted to governmental delegates representing their respective space agency delegates such as is the case for IADC. The guidelines illustrate IADC's role as a further debris governance consolidation forum in the 2000s. Conducive to epistemic community influence especially of the DEB group, the committee enabled the shaping a reference international and comprehensive debris mitigation instrument, which will serve as a basis for several other main instruments, establishing its legacy as the reference debris forum. The IADC in the 2000s became an important debris body in the growing space debris governance system. Many space-faring nations will later develop their debris mitigation practices and legal provisions based upon the work of the committee and its guidelines, which will be also taken as reference point to develop other debris governance and space sustainability instruments in other fora such as under UNCOPUOS, ISO, and other mixed platforms as explained in later sections.

Compliance

The 2002 IADC Guidelines also represent some level of compliance progress. Indeed, reflecting consensus between 11 space agencies at the time,[474] the guidelines represent a

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[473] Adler, "The Emergence of Cooperation: National Epistemic Communities and the International Evolution of the Idea of Nuclear Arms Control," 126, 130.

[474] IADC Terms of Reference (TOR), IADC-93-01 (rev. 11.5) latest version of 2018. https://www.iadc-home.org/terms_reference, accessed July 5th, 2020. The 11 IADC member agencies as at 20002 are: ASI (Agenzia Spaziale Italiana), CNES (Centre National d'Etudes Spatiales), CNSA (China National Space Administration), DLR (German Aerospace Center), ESA (European Space Agency), ISRO (Indian Space Research Organisation), JAXA (Japan Aerospace Exploration Agency), NASA (National Aeronautics and Space Administration), ROSCOSMOS (State Space Corporation "ROSCOSMOS"), SSAU (State Space Agency of Ukraine), UKSA (United Kingdom Space Agency).

commitment by the signatory members to comply with these agreed debris mitigation provisions.

Also, under section 4. General Guidance, the IADC Guidelines are encouraging the shaping of a “Space Debris Mitigation Plan”, which includes a compliance matrix showing which recommendations of the IADC Guidelines have been addressed under the Space Debris Mitigation Plan.[475]

The fact that the main space powers and launching states space agencies are members of IADC also reinforces the value of these IADC Guidelines as facilitating better compliance, as international instruments are often deemed more like to be observed if the main powers are adhering to them.

In terms of epistemic ideas and group influences, the IADC guidelines express a main involvement of the DEB epistemic community, directly impacting the creation of this debris mitigation instrument, as well as traces of diffusion of some arms control group AC shared ideas by diffusion, and traces of the emerging LTS group.

The IADC Guidelines express direct influences of the epistemic group of debris mitigation named DEB in this research, with many delegates to the IADC forum also contributing to debris norm promotion and policy innovation shaping under other fora such as several of the IAA debris working groups for instance. Some of the same IADC delegates are also sent to the ISO forum, to COPUOS Subcommittees, to IISL space law colloquia, COSPAR, or ILA space committee conferences. Kato mentioned that American experts proposed their national

[475] IADC Space Debris Mitigation Guidelines, General Guidance, IADC-02-01, Revision 1, September 2007, 7.

standard as a basis, and valuable inputs were also made by Japanese experts, while Alby confirms that experts of the five European Space Agency members also largely contributed to shaping the IADC guidelines,[476] illustrating the DEB group's ideas circulations across these multiple platforms.

Members of the DEB group influential in this period and involved in the guideline include space agency experts under their space agency hats and not as individuals such as in other fora conducive to epistemic process due to validation of membership selection and wider membership than just space agencies. For the guidelines, some of the major people included are Nicholas Johnson from NASA, Christophe Bonnal and Fernand Alby from CNES, Heiner Klinkrad from ESA amongst others. A legacy of arms control shared by the AC group were also found, expressing a heritage of earlier epistemic communities' influences over the basic space governance treaties, and gradually also diffusing into the debris governance as mentioned above. The emerging idea of LTS during the 2000s was also found already in the IADC Guidelines, as explained below.

Debris Mitigation (DEB)

In terms of debris mitigation ideas, details are provided under this subsection. As seen in the previous section of the creation of the Inter-Agency Space Debris Coordination Committee in the 1990s, the purpose of the IADC is "to exchange information on space debris research activities between members, to facilitate opportunities for cooperation in space

[476] Akira Kato, "Comparison of National Space Debris Mitigation Standards," *Advances in Space Research* 28, no. 9 (2001): 1447-1456 ; Alby, "30 Years of Space Debris Mitigation Guidelines in Europe," 5.

debris research, to review the progress of ongoing cooperative activities and to identify debris mitigation options."[477] The IADC Guidelines as an outcome of debris mitigation cooperative efforts therefore reflect a set of universally agreed measures covering all identified aspect of debris mitigation activities from the design and planning phase of spacecrafts and their operations, to the normal operations, to post-mission and including prevention of and management of accidental collisions, as well as covering also potential re-entry aspects for objects in lower orbits. The principles shared with the IADC Guidelines reflect input from earlier debris mitigation instruments agreed-to nationally or in international fora and are as follows:

> "1) Preventing on-orbit break-ups
>
> (2) Removing spacecraft and orbital stages that have reached the end of their mission operations from the useful densely populated orbit regions
>
> (3) Limiting the objects released during normal operations."[478]

All sections of the IADC Guidelines whether they concern definitions of "which" space debris, "which" protected orbits covered, or "which" phase of the operation is concerned relate to DEB ideas, building upon several decades of operational experiences and of debris mitigation efforts in the form of studies in international fora and of national standardization steps as seen in other sections of the thesis. As the first "comprehensive" international debris mitigation instrument, the 2002 IADC Debris Mitigation Guidelines' The IADC Guidelines include all the debris mitigation concepts which have been evolving as norms and derived

[477] IADC TOR, 2018.
[478] IADC Guidelines, IADC-02-01, Revision 1 September 2007, 4.

from crucial provisions achieved in earlier basic space governance shown in Table 6-1 and partial debris instruments shaped in other fora - such as the ITU recommendations.

Arms Control (AC)

In terms of arms control ideas, details are provided in this paragraph. Some heritage from ideas shared by the AC group especially in the 1980s around limiting ASATs testing where also found in the IADC guidelines as indicators of indirect epistemic influences by diffusion. These AC ideas act as complement as they also impact debris mitigation efforts as a support to the shared ideas of the DEB group, namely reducing the altitude of ASAT testing if they can't be avoided in order to limit orbital debris proliferation and long-lived debris.

Some ideas of arms control (AC) are found in the IADC Guidelines of the 2000s, reflecting the heritage of some Cold War initiatives. Failed attempts at negotiating an ASAT-ban Treaty in the 1970s were followed by limited test-bans and moratoria in the 1980s in the United States and Soviet Union as explained earlier in this study. As reminded by Kessler in 1998 and Moltz in 2014,[479] by the mid-1980s, there was an emerging knowledge about ASATs producing long-lived orbital debris at the United States national level, which resulted also in some US Congressional temporary ban of destructive ASATs systems. At the same period, a moratorium on the Soviet side for similar systems was observed. The US Department of Defense even issued some guidelines for conducting ASATs in the 1980s, which diffused into the first US national space policies like the Presidential Directive in 1988 and Policy by 1989 including provisions encouraging restraint of intentional destructions for

[479] Kessler, "A Partial History of Orbital Debris: A Personal View,"10-11; Moltz, *Crowded Orbits*, 153.

minimizing debris creation. These policy steps in the US diffused into the first NASA debris standard by 1995, upon which other space agencies in Japan and France soon built their own debris standards including intentional provisions,[480] and these first national standards serving as foundations towards the shaping of the IADC Guidelines.[481] The intentional provision reflecting AC ideas in the first IADC Guidelines are mostly found under section 5.2.3. Avoidance of intentional destruction and other harmful activities", stating that :

> "Intentional destruction of a spacecraft or orbital stage, (self-destruction, intentional collision, etc.), and other harmful activities that may significantly increase collision risks to other spacecraft and orbital stages should be avoided. For instance, intentional break-ups should be conducted at sufficiently low altitudes so that orbital fragments are short-lived."[482]

These low altitude for minimizing debris ideas reflect the learning already found in the mid-1980s under the US DOD SAB reports, which diffused to the 1995 NASA standard and serve as a basis among other national standards of Japan and France to shape this IADC guideline provision. As for the avoidance of harmful activities idea, this principle diffused across space fora for decades before the IADC Guidelines, already in the Outer Space Treaty of 1967 and at the ITU level in the 1980s, showing the continuity of ideas diffusion across fora over many decades and illustrating how debris governance did shape itself incrementally and thanks to the contribution of several ideas, including AC shared ideas.

[480] Akira Kato, 2001, mentions how the NASA 1995 standard inspired the Japanese NASDA 96 standard and the CNES 99 standard and how these national standards helped shape the IADC Guidelines. However, the Japanese and French version 's intentional provisions were calling for refraining from intentional destruction as stronger guidelines than the NASA 1995 standard which just called for limiting the debris creation resulting from intentional activities.

[481] Akira Kato, "Comparison of National Space Debris Mitigation Standards," *Advances in Space Research* 28, no. 9 (2001): 1447-1456; Interviews with Christophe Bonnal.

[482] IADC-02-01, 9.

Long-Term Sustainability (LTS)

The ideas of ensuring the long-term sustainability of the outer space environment and its exploration and use shared by the emerging LTS group was found in the IADC Guidelines of 2002 and in its revised version of 2007 in the introduction and under the protected orbital regions sections.

The introduction mentions that:

> "[…] the implementation of debris mitigation measures today is a prudent and necessary step towards preserving the space environment for future generations.",

while 3.3.2. stipulates that:

> "any activity that takes place in outer space should be performed while recognising the unique nature of the following regions, A and B, of outer space, to ensure their future safe and sustainable use."[483]

The LTS ideas presence in the IADC Guidelines of the 2000s illustrates the diffusion of ideas circulating across several fora in the 1980s and 1990s, especially under the United Nations and NGO fora, which also reached the IADC by the 2000s. As reminded by Gérard Brachet in 2012,[484] the work on space traffic management and the deemed success of debris mitigation efforts both inspired the LTS initiative, highlighting the importance of DEB ideas shared by the DEB group as catalyzers for progress towards the LTS ideas emergence in the 2000s.

[483] IADC Guidelines, IADC-02-01 Revision 1 September 2007, 4 and 6.
[484] Gérard, Brachet, "The origins of the "Long-term Sustainability of Outer Space Activities" initiative at UN COPUOS,' *Space Policy* 3 (August 2012): 161-165.

European Code of Conduct for Space Debris Mitigation and ESA Debris Policy 2004

The European Code of Conduct for Debris Mitigation (ECoC) [485] has been signed in 2004 and adopted by five space agencies in Europe by 2006. It is the work of years of systematic debris research and coordination under ESA. The research finds that this instrument fills many governance gaps for debris governance consolidation in the 2000s and expresses direct involvement of the DEB epistemic community in shaping it and promoting its ideas across diffusing to other instruments as explained below.

Knowledge

The research found several debris governance outcomes at the European regional level in the 2000s representing knowledge progress steps, in particular the European Debris Mitigation Standard (EDMS) in 2000, the European Code of Conduct for Debris Mitigation (ECoC) [486] in 2004 and the ESA Space Debris Mitigation for Agency Projects instruction of 2008 ESA/ADMIN/IPOL (2008).

Firstly, the EDMS debris outcome resulted from years of debris mitigation work conducted at the European level under an ESA coordinated working group since the 1980s especially following the Ariane break-up event of 1986, but also benefiting from external and earlier influences. Especially, other debris research efforts in the United States at the NASA debris office, national efforts observed in Japan, and from knowledge sharing and

[485] European Code of conduct for Space Debris Mitigation, https://www.unoosa.org/documents/pdf/spacelaw/sd/European_code_of_conduct_for_space_debris_mitigation.pdf, accessed February 25th, 2020. Another source than Krag et al. 2014 of ESA webpage mentions signed in 2006 not 2004. Tbc https://www.esa.int/Safety_Security/Space_Debris/Mitigating_space_debris_generation

[486] European Code of conduct for Space Debris Mitigation, https://www.unoosa.org/documents/pdf/spacelaw/sd/European_code_of_conduct_for_space_debris_mitigation.pdf, accessed February 25th, 2020. Another source than Krag et al. 2014 of ESA webpage mentions signed in 2006 not 2004. Tbc https://www.esa.int/Safety_Security/Space_Debris/Mitigating_space_debris_generation

policy coordination efforts occurring outside of Europe as part of the IADC group created in the 1990s also enabled debris knowledge shaping and diffusion leading to EDMS in Europe.

Secondly, the European Code of Conduct for Debris Mitigation (ECoC)[487] represents a knowledge progress step for debris governance as the result of a long and incremental learning process occurring at the ESA multi-agency level involving debris knowledge experts of the DEB epistemic group since 1987. Regular meetings and knowledge building were organized under debris working groups set up after the Ariane break-up of 1986.[488] Following decades of debris research, the ECoC outcome was designed as one of the most detailed internationally agreed debris mitigation instruments among the ones presented in Table 6-1 thanks to the inputs of debris knowledge experts of the DEB epistemic group.

Lastly, the ESA Space Debris Mitigation for Agency Projects instruction of 2008 ESA/ADMIN/IPOL (2008) also represents a knowledge progress step in the 2000s besides the ECoC. Indeed, this ESA debris-relevant policy outcome came as a complementary debris mitigation tool to enhance the regional code of conduct for debris mitigation, namely the European Code of Conduct for Debris Mitigation (ECoC) so as to make it more efficient thanks to increasing knowledge about the debris issue and an ensuing learning process. Indeed, European debris knowledge-experts deemed necessary to adopt this administrative instruction for agency projects as an even more detailed tool with additional requirements specifications and implementation standards to better implement the Code.[489] This second

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487 European Code of conduct for Space Debris Mitigation, https://www.unoosa.org/documents/pdf/spacelaw/sd/European_code_of_conduct_for_space_debris_mitigation.pdf (accessed February 25th, 2020). https://www.esa.int/Safety_Security/Space_Debris/Mitigating_space_debris_generation

488 Alby, “30 Years of Space Debris Mitigation Guidelines in Europe,” 4.

489 Alby, “30 Years of Space Debris Mitigation Guidelines in Europe,” 7.

and enhanced debris governance outcome of the 2000s illustrates again the evolutionary and adaptative nature of the epistemic process observed in the debris case, its contribution to learning via an iterative knowledge construction process, ideas diffusion and institutionalization into guidelines, standards or other policy types of outcomes and its importance for debris governance. Indeed, the experts displayed a learning approach based upon users' feedback, expressing the learning by reshaping this agency projects policy outcome into an upgraded and more effective debris mitigation tools thanks to additional specifications and requirements more implementable than the European code ECoC. In the ensuing decade of the 2010s, the Space Debris Mitigation for Agency Projects instruction of 2008 will in turn be upgraded, namely in 2014, in order to be in line with ISO and ECSS standards,[490] illustrating once more this adaptive and evolutionary nature of the process of debris governance bearing epistemic marks.

Normative

The ECoC and its subsequent complementary tool the "ESA Space Debris Mitigation for Agency Projects" policy both represent a normative progress for debris governance for the period of the 2000s, following long-lasting efforts since the 1980s when the first de-orbiting maneuvers of the *Symphonie* A and B satellites in GEO in 1983 were observed and a trend of launcher upper stage passivation emerged, leading towards debris mitigation standards and

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[490] United Nations, "Compendium of Space Debris Mitigation Standards adopted by States and International Organizations," version 2019, "European Code of Conduct for Space Debris Mitigation," https://www.unoosa.org/documents/pdf/spacelaw/sd/European_code_of_conduct_for_space_debris_mitigation.pdf (accessed 19 March 2020) ; "ESA Space Debris Mitigation for Agency Projects", https://www.unoosa.org/documents/pdf/spacelaw/sd/ESA.pdf(Accessed March 19th, 2020), 1. Bonnal mentions an ECSS first standard in 1998 but indirectly covering debris provisions., JAXA 2018 ppt.

policies developments by the 1990s. Indeed, as explained in their respective texts,[491] both instruments have been developed in line with pre-existing international mechanisms such as the IADC Guidelines or provisions of the Outer Space Treaty and Liability Convention, expressing the consolidation of debris mitigation norms represented by all these instruments. For example, regarding the European Code for Space Debris Mitigation, the UN COPUOS Compendium of space debris mitigation standards adopted by states mentions the ECoC relation to earlier international mechanisms, such as the 2002 IADC Guidelines, the 1967 Outer Space Treaty and the 1972 Liability Convention, stating that:

> "The Code is consistent with the IADC Space Debris Mitigation Guidelines (which, in turn, were used as a foundation for the development of the Space Debris Mitigation Guidelines of the Committee), while <u>providing greater (technical) detail and explanations</u>. The Code, in its introduction, furthermore, refers to Articles I and IX of the Outer Space Treaty of 1967 and to the Liability Convention of 1972."

While, regarding the "ESA Space Debris Mitigation for Agency Projects" - the ECoC complementary mechanism-, the UN Compendium of space debris mitigation standards refers to the relation of this ESA debris policy with other international debris mitigation mechanisms both pre-existing and subsequent, such as the ECoC of 2004, the 2002 IADC Guidelines, the 2007 COPUOS Guidelines, and in the ESA's policy update of 2014, even with the 2011 ISO and 2012 ECSS standards, specifying that:

> "this administrative instruction [of 2014] fully replaces the 2008 version, fully aligning the ESA policy with ISO 24113 […] issued in May 2011 and adopted by the

[491] United Nations, "Compendium of Space Debris Mitigation Standards adopted by States and International Organizations," version 2019, "ESA Space Debris Mitigation for Agency Projects", https://www.unoosa.org/documents/pdf/spacelaw/sd/ESA.pdf, 1 (accessed March 19th, 2020).

European Coordination on Space Standardisation (ECSS) as the ECSS-U-AS-10C standard in 2012 ; [...] The European Code of Conduct for Space Debris Mitigation, the Inter-Agency Space Debris Coordination Committee (IADC) Guidelines for Space Debris Mitigation, the Space Debris Mitigation Guidelines of the Committee and the United Nations Treaties and Principles on Outer Space are referenced in the administrative instruction 'Space Debris Mitigation for Agency Projects' of the European Space Agency (ESA) Director General."

During this period of the 2000s, The European Code ECoC and its complementary ESA debris policy therefore further consolidated the existing normative consensus on debris mitigation shaped and promoted by space debris experts of the DEB community and also codified in the other above-mentioned debris instrument known as the reference debris instrument, namely the IADC Guidelines. The ECoC's normative contribution to debris governance progress in the 2000s results from long-lasting efforts of the same space agencies experts involving five space agencies since the 1980s and throughout the 1990s, especially under succeeding space debris working groups.[492]

Policy

Firstly, the 'European Mitigation Code (ECoC) was signed at the highest political levels within the five participating space agencies, expressing a strong policy commitment towards reducing debris proliferation by these heads of agencies,[493] and indicating that some "learning" occurred at the decision-making level. ECoC is found to be a strong example of the diffusion, promotion, and codification of ideas of the DEB community towards a debris

[492] Alby, "30 Years of Space Debris Mitigation Guidelines in Europe," 1, 3, 4. The five space agencies are ASI, BNSC, CNES, DLR and ESA.
[493] Alby, "30 Years of Space Debris Mitigation Guidelines in Europe," 4.

policy outcome at the European level in the form of a Code of Conduct for debris mitigation and in the additional Agency-project outcome offering specifications to better implement this Code. About the individuals involved it relates to the working groups of the 5 European space agencies of Italy ASI, France CNES, Germany DLR, United Kingdom and ESA level.

Secondly, the ECoC process also bears indications of the influences of the DEB community in the emergence of policy progress in terms of debris governance at the international level. Indeed, as reminded by Alby in 2014,[494] the European debris experts shaping ECoC were also strongly involved in shaping IADC Guidelines in a similar period from the 90s and early 2000s and even after for the shaping of the family of ISO debris standards shown in Figure 5-2.[495]

Thirdly, a strong debris governance policy gap progress as it is considered one of four "universal" debris mitigation instruments, consisting in one of the main internationally agreed instruments serving as a basis for debris mitigation efforts and even as a model for shaping another international instrument such as the ISO space debris standard 24113. As explained by Stubbe in 2017, the universal instruments have been developed and agreed-to at the international level and encompass the full range of typical space debris mitigation measures, while other instruments have narrower scopes.[496] ECoC, together with the IADC Guidelines of 2002, the UNCOPUOS Guidelines of 2007 and the soon to emerge ISO 24113 debris mitigation standard from 2010 are thus considered as the four universal debris

[494] Alby,"30 Years of Space Debris Mitigation Guidelines in Europe," 4.
[495] The main ISO standard for space debris is ISO 24113 and its sub-level standards including CDM as explained under the ISO section. There are about a half dozen more sub-level ones relating to ISO 24113, referred to as a "family" of standards and illustrated in Figure 5-2.
[496] Stubbe, *State accountability for space debris*, 233.

mitigation instruments with comprehensive scopes and applicability as shown in Table 6-1. The ITU-Recommendation of 1993 and the 2008 *ESA Space Debris Mitigation Policy for Agency Projects* belong also to body of international debris mitigation instruments mentioned in the UN Compendium,[497] counting as partial ones, as they address partial aspects of debris mitigation, such as GEO and post-mission disposal operations for the specialized ITU agency recommendation or procurement aspects for European stakeholders for the ESA Agency Projects policy.[498]

Fourthly**,** ECoC is considered the most developed of the 4 main debris instruments and even more detailed than the foundational and reference IADC Debris Mitigation Guidelines[499] and the most detailed of the four universal instruments agreed at an international level presented by Stubbe in 2017.[500] This represents therefore an even greater policy progress for debris governance under the classification of governance gap progresses in this doctoral research. European space debris experts like Holger Krag and colleagues mention indeed in 2014 that the ECoC were developed as "more technically specific" guidelines, building upon the IADC Guidelines.[501]

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[497] UN Doc. A/AC.105/2014/CRP.13. United Nations, "Compendium of Space Debris Mitigation Standards adopted by States and International Organizations," https://www.unoosa.org/documents/pdf/spacelaw/sd/Space_Debris_Compendium_COPUOS_25_Feb_2019p.pdf (accessed April 29, 2020). From 2014 to 2019, the number of national legislations grew from 22 to 30.

[498] Stubbe, *State accountability for space debris*, 233.

[499] unoosa.org/documents/pdf/spacelaw/sd/European_code_of_conduct_for_space_debris_mitigation.pdf, Stubbe, *State accountability for space debris*, 236, Viikari, *The Environmental Element in Space Law*, 105.

[500] Stubbe, *State accountability for space debris*, 233. While Stubbe focusses on what he considers to be the four 'main' debris mitigation instruments, the UNCOPUOS Compendium counts six international mechanisms: adding the ITU 'Recommendation ITU-R S.1003.2 (12/2010) Environmental protection of the geostationary-satellite orbit' and the ESA Space Debris Mitigation Policy for Agency Projects of 2014, a complementary tool to facilitate the European Code's implementation which build on earlier versions issued since 2008.

[501] Krag, H., Lemmens, S., Flohrer, T., "Global Trends in Achieving Successful End-Of-Life Disposal in LEO and GEO," *SpaceOps 2014* Conference, doi:10.2514/6.2014-1933, 2.

A fifth policy progress is entailed in the ECoC, which contains a provision covering intentional debris creation with stronger wording than in the other existing instrument found by 2004, such as the IADC Guidelines. Indeed, while the provision in the IADC Guidelines 5.2.3 mentions the need to "avoid" intentional destruction or conduct it at lower altitude, the European Debris Code calls for a prohibition, which is a much more ambitious statement. Indeed, The ECoC provision 4.1.2 regarding preventive measures stipulates that: "Intentional destruction of a space system or any of its parts in orbit is prohibited." [502]

Additionally, the fact that the ECoC served as a basis of policy innovation for the ISO standard, going beyond the reference IADC Guidelines is also deemed a policy step as an innovation. As mentioned by debris experts Alby in 2014,[503] Bonnal in 2016,[504] McKnight and Kawashima in 2019,[505] ECoC has been used as the initial text to shape the ISO debris mitigation work towards shaping standard ISO 24113 a few years later. ECoC derives from the EDMS issued in 2000. Therefore, ECoC represents an important policy progress step in terms of international debris governance. Alby explains that the same group of European space agencies which already worked "systematically" on debris mitigation efforts since 1987 and developed the EDMS and then the ECoC, will also contribute towards the development of ISO 24113 the international debris standard under the ISO forum in the following years, more precisely as a debris working group formed under the European

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[502] European Code of Conduct for Space Debris Mitigation, 5. https://www.unoosa.org/documents/pdf/spacelaw/sd/2004-B5-10.pdf (accessed April 29, 2020).
[503] Alby, "30 Years of Space Debris Mitigation Guidelines in Europe," 6 and 7.
[504] Christophe, Bonnal, "A Brief historical overview of space debris mitigation rules," Paper presented at CNES as chairman of the International Academy of Astronautics Space Debris Committee, *Clean Space Industrial Days*, ESTEC (23-27 May 2016), 11.
[505] Darren McKnight and Rei Kawashima, (eds), *A Handbook for Post-Mission Disposal of Satellites Less Than 100 kg*, (Paris: France, International Academy of Astronautics (IAA), 2019), 19.

Coordination on Space Standardisation group (ECSS). The ECSS Space Debris Working Group (ECSS SDWG) formed by 2002 is the European contribution within ISO for debris efforts and which assumed a leading role in drafting the ISO debris standard in coordination with IADC as the lead was sent to IADC to ensure coherence between the ISO draft and IADC Guidelines and other existing guidelines, enhancing the value and importance of the ECoC outcome as a policy governance gap progress for debris governance. Additionally, the ECoC step also is a policy progress which recognizes the important role of Europeans[506] in helping as a regional governance force towards international policy coordination on space debris mitigation at space agencies level since the 1980s, and mixing agencies and industry under the ISO forum as well when the ECSS[507] initiative was formed especially under the ECSS Space Debris Working Group for ISO debris work under SC14 from the early 2000s. Europeans worked together as groups of space agencies experts since the under ESA lead group of space agencies delegate as the Space Debris Working Group (SDWG) and a Space Debris Advisory Group (SDAG) both formed in 1986, then under a Network of Centres

[506] It will be explained under the ISO section that it was not only European space agencies but also under the ECSS debris working group involving European industrial partners contributions in helping to shape the ISO standard. However, as regards the ECoC, it is the result of decades of debris mitigation efforts conducted by the working group composed of the five major European space agencies since 1987, namely CNES, DLR, BNSC, ASI and ESA (see Alby, "30 Years of Space Debris Mitigation Guidelines in Europe," 6 and derived from EDMS, which was shaped under the European Coordination on Space Standardisation platform (ECSS). ECSS is seen as an important debris standard actor as confirmed also by several experts' interviews, including Christophe Bonnal and Bruno Lazarre.

[507] Youssef El Gammal, "ECSS - European Cooperation for Space Standardization." *Space Programs and Technologies Conference 1996*; and ECSS webpage, https://ecss.nl/ (accessed May 21, 2020). More info on ECSS can be found in Joseph N. Pelton and Ram Jakhu (ed.), *Space Safety Regulations and Standards* (Elsevier, 2010): 39-48. It is an industry-led initiative involving space agencies supporting, as a collective activity of space agencies experts and industry delegates towards shaping standards. Also interesting is the iterative process under all ECSS working groups to adapt standards to new commercial context mentioned in Jakhu and Pelton, (eds.), *Global Space Governance: An International Study*, 40 and in El Gammal.

(NoC) Space Debris Working Group (SDWG) by 1999.[508] Then, delegates from European space agencies continued to work as a regional group together with delegates from the European space industry in the 2000s and 2010s during the consolidation phase of this thesis under the ECSS Space Debris Working Group under ISO and it was the leader of this group which led the drafting process of the ISO 24113 standard stressing the important role of European contributions within the work of ISO on 24113.[509]

Moreover, the ECoC led to another policy progress with another instrument the ESA/ADMIN/IPOL (2008) "Space Debris Mitigation for Agency Projects," an ESA policy further contributing to debris governance at the European space agencies' level. Alby explains that the ECoC was firstly deemed difficult to implement and thus rapidly further elaborated. Therefore, in order to facilitate the applicability and usefulness of the Code, the ESA Space Debris Mitigation for Agency Projects[510] was issued by the ESA Director General in 2008 and updated in 2014.[511] This step represents another international debris mitigation instrument and further codification of debris mitigation efforts resulting in a policy outcome deemed as a complementary tool to ECoC and which was also issued at the space agency's highest policy level like ECoC.

Institutional

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[508] Alby, "30 Years of Space Debris Mitigation Guidelines in Europe," 3.

[509] Alby, "30 Years of Space Debris Mitigation Guidelines in Europe," and confirmed by other Debris experts' interviews.

[510] "European Space Agency: Space Debris Mitigation Policy for Agency Projects," https://www.unoosa.org/documents/pdf/spacelaw/sd/ESA.pdf (accessed March 19th, 2020).

[511] Alby, "30 Years of Space Debris Mitigation Guidelines in Europe," 7. Latest version of the ESA Mitigation for Space Agency dates from 2014, see UNCOPUOS Compendium version of 2019, https://www.unoosa.org/documents/pdf/spacelaw/sd/Space_Debris_Compendium_COPUOS_25_Feb_2019p.pdf and https://www.unoosa.org/oosa/en/ourwork/topics/space-debris/compendium.html (accessed March 19, 2020).

The European Code of Conduct for Space debris also enabled an institutional progress step for debris governance in the 2000s by consolidating one additional European platform, namely the ECSS which shaped the ECoC, to become another supporting "home" facilitating epistemic ideas and norm shaping and policy coordination, and to also become an internationally recognized debris governance body besides IADC, COPUOS, and ITU. A special group was created under ECSS for a united position for the preparation of the main ISO 24113 standard, increasing the institutional progress step aspect for ECSS as a debris governing platform conducive to epistemic communities influences in this ECoC example within Europe, and also bringing ideas beyond under the larger international body of ISO.[512]

Compliance

The stronger wording in the "intentional provision" under ECoC compared to the main debris mitigation instruments, the more specific and precise measures and the agency policy document accompanying it all facilitate the process for space stakeholders and encourage greater compliance thus deemed a governance progress for debris governance.

In terms of epistemic ideas and group influences, the main epistemic influences for emergence of ECoC are found from Debris Mitigation group and with some inherited influences from the Arms Control group by way of diffusion.

DEB

The shared ideas of the DEB group have been directly codified into the ECoC instrument following work at the European level under ESA network of centers in the 1990s as a

[512] The ECSS text served as basis for the ISO standard as explained earlier.

systematic debris coordination occurring since 1987 under ESA, as mentioned in earlier sections of this study. As regards which of the shared debris mitigation ideas are present in the ECoC instrument, the ECOC has been developed as one of the most comprehensive instrument and therefore it cover all of the main aspects of debris mitigation efforts from design phases, to launch operations and post-mission phases according to the issues of the early 2000s. Debris mitigation aspects of newer types of space operations emerging more recently such as On-orbit servicing are not present yet in ECoC and will be covered by additional best practices agreements conducted under other fora from the late 2010s as explained later.

The ECoC and its complementary ESA Space Debris Mitigation for Agency Projects policy contain most of the same set of ideas present in the IADC Guidelines, as they have been shaped thanks to the space debris mitigation group of experts who also belong to the wider DEB epistemic community, composed of and benefiting from European knowledge experts and from other foreign experts outside of Europe. The ECoC as debris instrument especially illustrates the direct influence of the DEB ideas and epistemic members in shaping debris instruments at the international level here the European level under ESA, simultaneously also under the IADC and UN COPUOS debris working group, as well as under the ECSS group contributing to the ISO standard development. Debris mitigation ideas which diffused in the 1990s under these earlier fora became codified under the IADC and ECoC instruments in the 2000s. Later on, thanks to contributions of the same space debris experts from Europe, these ideas will also diffuse to other international fora, resulting namely in the ISO main debris standard ISO 24113 and other ISO Standards. Delegates especially from the five main agencies of ASI, BNSC, CNES, DLR, and ESA contributed to the Orbital Debris Coordination Working Group (ODCWG) under ISO Technical Committee TC20/SC14 from 2003 onwards.[513]

Among the space debris experts from the DEB group in Europe involved with ECoC and ECSS and who also belong to IAA debris committees as acknowledged peers are Fernand Alby (CNES), Christophe Bonnal (CNES), Richard, Crowther (BNSC), Walter, Flury (ESA), Heiner Klinkrad (ESA), Luciano Anselmo (CNUCE, Italy).[514]

AC

As regards the AC group and its shared ideas and influences over the European Code, the study found indirect involvement ad inherited from arms control ideas of the AC group who influenced debris mitigation efforts besides the other DEB group efforts in the 1980s. Indeed, as explained in chapter 4, around the times of treaty proposals to ban anti-satellite weapons, which led to limited and temporary ASAT testing bans in the United States and Soviet Union, the AC group was found as supporting influence complementing the other DEB group influences over debris mitigation efforts.[515] A legacy of this earlier influence has been found in the ECoC debris instrument by way of diffusion and codification of AC restraint ideas under especially the ECoC provision 4.1.2, as mentioned in Table 6-2. Indeed, similarly to the IADC guidelines, ECoC also contains a provision covering "intentional" debris creation

[513] Heiner Klinkrad, Fernand Alby, Detlev Alwes, Claudio Portelli and Richard Tremayne-Smith, "Space Debris Activities in Europe," *Proceedings of the 4th European Conference on Space Debris* (ESA SP-587), 18-20 April 2005, ESA/ESOC, Darmstadt, Germany, 5.
[514] Klinkrad et al., "Space Debris Activities in Europe; and Fernand, Alby, Detlev, Alwes, Luciano Anselmo, Henri Baccini, Christophe Bonnal, Richard Crowther, Walter Flury, Rüdiger Jehn, Heiner Klinkrad, Claudio Portelli and Richard Tremayne-Smith, "The European space debris safety and mitigation standard," In *Proceedings of the Third European Conference on Space Debris*, 19-21 March 2001, Darmstadt, Germany, ESA SP-473, Vol. 2 (Noordwijk, Netherlands: ESA Publications Division, October 2001), 817 – 820.
[515] More details are provided in chapter 4 under the 1980s section of national progress steps.

aspects, illustrating the ASAT restraint ideas of the AC group. As mentioned earlier, the AC ideas found in the ECoC are even harsher than the "intentional" provisions found in other instruments such as the IADC guidelines or COPUOS Debris Mitigation guidelines of limiting the creation including ASAT testing to lower altitudes and if possible, to avoid them, but expressing a prohibition of all intentional debris creation. This expresses an even greater form of responsible behavior based on stronger restraint reinforcing the importance of this arms control idea and indirect influence found in the ECoC.

International Code of Conduct for Responsible Behavior in Space 2008

The European Union's International Code of Conduct initiative (ICoC) was intended as a response to a United Nations General Assembly resolution of 2006 [516] calling for concrete steps in support of arms control and transparency and confidence-building measures[517] in support of PAROS efforts which were at a standstill at the Conference for Disarmament. The policy changes under the US George W. Bush Administration resulting in the United States' withdrawal from the long-standing ABM treaty of 1972 in 2001,[518] the worrying space dominance views of the US Administration, and the increased space security tensions following the Chinese Anti-Satellite Test of 2007[519] all raised space security concerns and

[516] Transparency and confidence-building measures in outer space activities, UNGAOR, 61st Session, UN Doc A/RES/61/75 (2006).
[517] Sergio Marchisio, "Security in Space: Issues at stake," *Space Policy* 33 (2015), 68.
[518] Brünner and Soucek. *Outer Space in Society, Politics and Law*, 539; Michael Krepon, "Origins of and Rationale for a Space Code of Conduct" in *Decoding the International Code of Conduct for Outer Space Activities*, ed. Ajey Lele, Institute for Defence Studies and Analyses (ISDA), (New Delhi: Pentagon Press, 2012), 30-31.
[519] Jana Robinson, "Europe's Space Diplomacy Initiative: The International Code of Conduct, "In *Decoding the International Code of Conduct for Outer Space Activities*, ed. Ajey Lele, Institute for Defence Studies and Analyses (ISDA), (New Delhi: Pentagon Press, 2012), 27.

encouraged the emergence of this initiative, especially in a multi-lateral forum outside of the United Nations system deemed insufficient.

The idea a "code of conduct" for responsible use of outer space was circulated before the ICoC was proposed in 2008. The Code concept was proposed already in the early 1990s under a U.N. Group of Governmental Expert study on confidence building-measures.[520] An early space debris expert and strong debris mitigation supporter of ESA, Walter Flury, also promoted the need for a code of conduct to be established under the United Nations in 2000, especially to ensure space operations safety and manageability of debris growth in GEO encouraging compliance with ITU and IADC geostationary re-orbiting recommendations.[521] The idea gained momentum in the early 2000s in other fora, such as at the non-governmental level through papers presented at international conferences or within NGO-led working groups such as the Stimson Model Code[522] initiative between 2003 and 2007 led by Michael Krepon at the Henry L. Stimson Center,[523] and to which other NGO like the Eisenhower Institute and international experts also joined.[524] In 2000, a paper by ESA debris expert

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[520] France proposed a Code of Conduct in 1990 under the UN GGE study on CBM, see, Sergio Marchisio, "The Legal Dimension of the Sustainability of Outer Space Activities: The Draft International Code of Conduct on Outer Space Activities," *Proceedings of the International Institute of Space law* (Eleven international publishing, 2012): 8.

[521] In 2001, Flury promoted the idea of a UN-led code to improve space traffic management in GEO by reducing the risks of collisions by improving compliance with the recommendations of ITU and of the IADC report of 1999 for moving satellites at the end of their operations. See Walter Flury, "Activities on Space Debris in Europe," *Proceedings of the 3rd European Conference on Space Debris*, ESOC, Darmstadt, Germany, 19-21 March 2001(ESA SP-473, August 2001), 6.

[522] "Model Code of Conduct for space-faring nations," Stimson Centre, October 24, 2007, https://www.stimson.org/2010/model-code-conduct-space-faring-nations/ (accessed May 12, 2020).

[523] Ajey, Lele, *Decoding the International Code of Conduct for Outer Space Activities,* 30; Manpreet, Sethi, Code of conduct for outer space a strategy for India, Centre for Air Power Studies (New Delhi : KW publishers, 2016), 56-60.

[524] Alexey Arbatov, Vladimir Dvorkin, "Outer Space: Weapons, Diplomacy, and Security" (Carnegie Endowment for International Peace, 2010), 108.

Walter Flurry in 2000 called for "a code of conduct or UN regulation to prevent collision risks and more debris proliferation.[525]

The first EU draft Code was issued and presented in 2008, and the process unfolded in several consultation rounds producing revisions until 2014 towards greater consensus, yet momentum stopped after the last meeting in July 2015. In spite of not having reached a formal consensus and agreement, this EU diplomatic initiative has brought some governance progress in terms of space security and to the issue of space debris as recognized by experts, especially normative, policy and institutional steps contributing to in the evolution of debris governance and sustainability efforts, already in the 2000s decade as presented below.

Normative

The Code has been recognized by experts as having consolidated some norms of responsible behavior in space,[526] including the debris mitigation norm, which was already codified in other existing instruments such as IADC and COPUOS Guidelines. The ICoC 's normative value in its early days lies in the rounds of consultations started in 2008, which helped promoting the idea for a Code including debris mitigation ideas at another multi-lateral high-level forum outside of the UN system where no binding treaties were achieved for decades. The diplomatic multi-lateral space-agencies level of IADC produced guidelines,

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[525] Walter Flury, "Space Debris Issues in the Geostationary Ring," Paper AIAA 2000-1120, 18th AIAA International Communications Satellite System Conference and Exhibit, Oakland, CA, April 2000.

[526] Lucia Marta, "Code of Conduct on Space Activities : Unsolved Critiques and the Question of its Identity", *Note de la FRS* 26 (2015), Fondation pour la Recherche Stratégique ; Michael J., Listener, "The International Code of Conduct: Comments on changes in the latest draft and post-mortem thoughts", Monday, October 26, 2015, https://www.thespacereview.com/article/2851/1 (accessed March 12, 2020); Max M. Mutschler, and Christophe C. Venet, "The European Union as an emerging actor in space security?" *Space Policy* 28(2), 118–124.

so did COPUOS, yet both of these guidelines are voluntary and did not suffice to prevent the Chinese ASAT of 2007. This facilitation towards acceptance for the idea of the need for a "Code of Conduct", already observed in the United States during the Obama campaign in 2008,[527] following years of efforts by NGOs like work on the Stimson Model Code upon which the ICoC ideas were based[528] thus helped towards consolidating the norm of debris mitigation efforts.

Another normative progress of ICoC is found in the consolidation especially of the intentional debris creation ideas. The Code since the first draft in 2008 was proposing a slightly stronger stance on the arms control provision covering intentional debris creating events. Indeed, as pointed out by Sergio Marchisio in 2012, where the COPUOS Debris Mitigation Guidelines state that intentional destruction "should be avoided", the Code calls for "refraining" from intentional creations,[529] offering a normative consolidation step to this debris mitigation norm. This ICoC contribution to debris governance progress at the multi-lateral diplomatic level outside of the UN forum comes as a complementary normative effort in a period when numerous other initiatives helped consolidate debris efforts in the early 2000s at the other levels of the UN (COPUOS, ITU and CD), the multi-lateral arms control fora, the NGO level fora such as the Stimson foundation workshops, studies like the IAA and

[527] Alexey Arbatov, Vladimir Dvorkin, "Outer Space: Weapons, Diplomacy, and Security," 108.
[528] Michael Krepon, "Origins of and Rationale for a Space Code of Conduct," in Ajey Lele (ed.) *Decoding the International Code of Conduct for Outer Space Activities*, 33.
[529] Sergio Marchisio, "The Legal Dimension of the Sustainability of Outer Space Activities: The Draft International Code of Conduct on Outer Space Activities," *Proceedings of the International Institute of Space law*, (Eleven international publishing, 2012): 16.

IAASS Space Debris and Space Traffic Management studies[530] and standardization efforts at ISO, and finally also at the national level fora covered in the other parts of this thesis.

Policy

A first policy progress of the 2008 ICoC draft resides in its potential for promoting and consolidating the existing debris mitigation guidelines towards becoming binding measures and potentially a treaty as a second step following a tentative success of the Code in light of the worsening of the space security context and apparent inability of voluntary provisions to prevent incidents such as the 2007 ASAT. By conducting the process outside of the UN fora deemed unlikely to agree on binding measures, in contrast with the early space age when many space treaties and provisions were agreed-to, the EU diplomatic initiative with the ICoC counts as a policy innovation step.

The research also found that the early step towards policy change during the Obama campaign due to influence the Code discussions in 2008 also count as a policy progress step affecting the debris mitigation efforts. A Carnegie Report of 2010 argues that ideas circulating with the ICoC process which were similar to those shaped in the Stimson Model Code[531] helped generate change in the Obama campaign of 2008 towards acceptance for the idea of an international code of conduct for space including an Anti-Satellite Test Ban and

[530] The Stimson foundation workshops for a model code started in 2004, the final version was issued in 2007 as the "Model Code of Conduct for Space-faring Nations", Stimson Centre, October 24, 2007, https://www.stimson.org/2010/model-code-conduct-space-faring-nations/ (accessed May 12, 2020). The IAA Cosmic Study on Space Traffic Management, the IAASS "ICAO for space?" working group initiative, and the ISO space debris working group under SC14 also started in the mid-2000s.

[531] Michael Krepon, "Origins of and Rationale for a Space Code of Conduct" in *Decoding the International Code of Conduct for Outer Space Activities*, 33.

spearheaded by the US.[532] This national policy progress step contrasting from the Bush Administration's stance favoring space dominance and against any restraints will also open the way to further support later on during the Obama Administration by 2012, as will be seen later in this thesis.

Institutional

Another important progress identified regarding the ICoC initiative is its introduction of the European Union as a new actor in debris governance, representing an institutional step for this research achieved in the 2000s. Under the European Union's Common Security and Foreign Policy activities, the EU entered the scene of global space debris governance as an active actor engaged in debris mitigation efforts with the International Code of Conduct initiative. The European Union's space diplomacy role under ICoC is one of foreign policy at the level of the European Council, differing from the European Commission's role working more with the European Space Agency.[533] In the 2000s, the EU via its foreign affairs department, the European External Action Service (EEAS) thus emerged as a new forum influencing the promotion of ideas and shaping of instruments affecting the debris issue, as a supporting governance body besides the other influential debris governing bodies: the space-agencies IADC, the UN-level for a of COPUOS and ITU, the standardization platforms of ECSS and ISO and their special committees of technical experts, a role which the EU will continue to play in next decade.

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[532] Alexey Arbatov, Vladimir Dvorkin, "Outer Space: Weapons, Diplomacy, and Security," 76.
[533] Sergio, Marchisio, "The Legal Dimension of the Sustainability of Outer Space Activities: The Draft International Code of Conduct on Outer Space Activities," Proceedings of the International Institute of Space law, (Eleven International publishing, 2012), 9.

In terms of epistemic shared ideas and influences, the research found the presence of the main epistemically constructed ideas which have facilitated the emergence of and consolidated debris governance and sustainability progress, specifically the DEB ideas in the First EU Draft Code of Conduct for Outer Space Activities adopted by the Council of the European Union in December 2008.[534] Some early elements of LTS ideas, and some inherited AC influences were also found in the ICoC draft. The presence of these ideas into the first draft illustrates the diffusion process across various levels of fora and resulting in normative, policy and institutional consolidation mentioned above.

The next decade and ensuing draft versions of this ICoC will also show an evolution of the ideas found. Among the epistemic communities involved in the ICoC draft, the study found more indirect influences prior the initiative being started under the EU. Sergio Marchisio as the designated point of contact for the consultations process, assuming an executive function, belongs to several epistemic groups, including DEB, and also shares ideas the AC group and LTS group. Professor Marchisio is also head of the European Institute of Space Law (ECSL) under the European Space Agency, teaches at university, and publishes about space debris legal aspects and space sustainability. Belonging to some IAA Debris studies, he belongs to the experts carrying debris mitigation ideas across multiple fora. The research found that in the ICoC case, the fora of discussions where the regular EU consultations took place were not as conducive to epistemic communities influences as was

[534] First EU Draft Code of Conduct for Outer Space Activities, 8 December 2008, https://register.consilium.europa.eu/doc/srv?l=EN&f=ST%2017175%202008%20INIT (accessed June 30, 2020).

the case in other fora such COPUOS, IAA, IAC, IISL, ILA as per the rules of participation and the selection process of members, amongst other issues. Especially, this resulted in only a partial consensus around the problem definition phase under the "knowledge" governance gap. This lack of reaching a common understanding about the ICoC issue prevented to progress across the four other global governance gaps and limited the epistemic influence. As noted by Marta,[535] there was contestation over the understanding of the problem and its solutions. This research found that due to not enough knowledge progress, less learning and less norm consolidation could occur, preventing policy progress, as observed when the initiative was stalled just before the negotiation rounds. The epistemic influences over ICoC are therefore found as present in the early phases of discussions when conceptualizations of an international code were discussed across NGO fora and gathered under the Stimson Code Model initiative involving in the early to mid-2000s some AC group members, and limited for the DEB group to include debris mitigation ideas into the draft, but less significant compared with other debris mitigation instruments initiatives which led to successful policy outcomes such as IADC and COPUOS guidelines, ITU Recommendations and ISO Standards. The ICoC nevertheless achieved some level of normative progress and is therefore regarded in this research as limited though still as an initiative which supported debris governance efforts.

Arms Control (AC) ideas

[535] Marta, "Code of Conduct on Space Activities : Unsolved Critiques and the Question of its Identity."

Initiated by an international governmental entity, the EU's International Code of Conduct was meant as a transparency and confidence-building measure (TCBM)[536] supporting the CD's efforts to preventing an arms race in space without being per see an arms control instrument under the CD. Some arms control ideas (AC) are therefore also found throughout the first draft. In this first EU Draft Code of Conduct of 2008,[537] the AC ideas are expressed in various provisions, some covering debris issues, others more widely covering potentially harmful behaviours. In particular, AC ideas inherited from earlier influences especially ofund in the 1980s over the ASAT-testing ban issues and earlier over basic space governance treaties as explained in earlier sections are found in article 2.3 (preventing harmful interferences in outer space activities), article 2. 4 (prevent outer space from becoming an area of conflict), article 3.1. (Commitment to existing treaties, declarations, guidelines with arms control provisions: 1963 Declaration of Legal Principles, PTBT 1963, OST 1967, The International Ballistic Missile Code 2002, COPUOS Debris Mitigation Guidelines), article 4.1 (minimize harmful interferences) , article 4.2 (refrain from any intentional action which will or might bring about, directly or indirectly, the damage or destruction of space objects), article 5. 1(refrain from intentional destruction of any on-orbit space object or other harmful activities which may generate long-lived space debris), 6.1 (notify of potentially dangerous manoeuvres, re-entries, accidents, and collisions), 8.1 inform about policy and strategy to minimize harmful interferences). These provisions to avoid harmful interferences, prevent

[536] Marchisio, "The Legal Dimension of the Sustainability of Outer Space Activities: The Draft International Code of Conduct on Outer Space Activities."

[537] First EU Draft Code of Conduct for Outer Space Activities, 8 December 2008, https://register.consilium.europa.eu/doc/srv?l=EN&f=ST%2017175%202008%20INIT (accessed June 30, 2020).

armed conflicts, reduce debris creation are helping compliance with existing arms control relevant treaties and instruments, and enhancing transparency and confidence building through better communication.

Debris Mitigation (DEB) ideas

As one of the main purposes of the Code motivated by a worsening of the space security and of the space debris threat observed in the 2000s especially following the creation of the largest ever debris cloud by the Chinese ASAT of 2007 as seen in Table 1-1, Debris mitigation ideas DEB were also widely found in the ICoC ‘s first draft of 2008. Many direct references to DEB ideas are found and are in-line with the existing universal instruments at the time, namely the IADC Debris Mitigation guidelines of 2002 and the COPUOS Debris Mitigation Guidelines of 2007, as well as with other debris provisions found in earlier space governance treaties and declarations as explained earlier. The ideas of debris mitigation are present in the 2008 draft in its Preamble, paragraph 7 (recognition of debris threat), article 2.3 (prevent harmful interferences), article 3.1 (comply with existing instruments and treaties including COPUOS Debris Mitigation guidelines), articles 4 and 5 and 6 most paragraphs aiming to mitigate debris risks. Debris mitigation ideas are developed in more details in article 4.1 (minimize accidents, collisions, and harmful interferences), in 4.2 (refrain from intentional damage or destruction, comply with ITU rules), in 5.1 (refrain from intentional destruction and harmful activities generating long-lived debris), in 5.2 (implement COPUOS Guidelines), in article 6.1 (notify of risky manoeuvres, malfunctions, collisions and accidents). Also, article 8.1 covers debris mitigation (inform about policies and strategies to minimize accidents, collisions, harmful interferences, and debris creation).

LTS ideas

Lastly, the research found a reference to the idea of ensuring the long-term sustainability of outer space and of space activities shared by the LTS group in the first EU ICoC draft of 2008 under article 4.4. "The Subscribing States resolve to promote the development of guidelines for space operations within the appropriate fora for the purpose of protecting the safety of space operations and long-term sustainability of outer space activities." This shows that in 2008, the LTS ideas began to diffuse across various space community fora other than the COPUOS here at the EU level, and transitioned towards becoming a norm. The fact that the LTS concept was mentioned in existing debris instruments like the IADC and COPUOS Debris guidelines and found itself also in the ICoC first draft around the same time in 2008 illustrates again the turning point when the LTS group took shape and became more influential. It led to normative progress for LTS shared ideas becoming an accepted norm in several of the highest international political levels such as the multi-lateral diplomatic forum of the ICoC already by 2008, besides the UNCOPUOS where it also started to become a norm thanks to direct epistemic influences of the LTS and DEB group members as mentioned before.

5.2.4. Progress observed at national levels in the 2000s

This section provides a general overview of additional national debris governance outcomes in the 2000s deriving from the epistemic community group of DEB direct involvement since the 1980s, and started to diffuse the core debris mitigation ideas of the group embodied in the IG report of 1988, ESA report of 1988, JSASS report 1993 and NASA debris standard of 1995, all serving as inputs to shape the IADC guidelines and other national debris instruments emerging in the 1990s, as detailed in chapter 4.[538] The novelty is that these debris governance steps complete the body of national debris mitigation instruments with additional space debris legal instruments. Besides additional debris instruments in the U.S. the 2000s brought the emergence of the French Space Operations Act (FSOA) and the Basic Law and Basic Plan in Japan, as consolidating debris governance national steps of founding members of the IADC.

The 2000s decade consolidates the earlier DEB influences in the United States over debris governance, which had led to many U.S. national instruments emerging in the 1980s and 1990s as seen earlier. Successive national space policy issued by the Bush Administration were based upon similar DEB and AC ideas contained in the first U.S. National Space Policy under the Reagan Administration as analyzed by Brian Weeden, with a few changes over time towards increased space sustainability concepts.[539] The successive space policies build upon the core ideas inherited from the 1989 the Interagency report, largely developed by the DEB group as explained in the 1980s sections. The DEB experts in the U.S. keep participating in other fora of space debris governance in the 2000s and contribute to policy coordination via new assessment report and revision of instruments, under especially ITU,

[538] Even though it took longer to finalize and issue the IADC guidelines as an extensive exercise of international debris policy coordination between twelve space agencies issued only in 2002, the core ideas were already present in the 1990s and influencing several national debris standards in the 1990s especially of the IADC members. The IADC guidelines were largely based upon the NASA standard issued in 1995 and developed mostly out of the IG Interagency report of 1989 which had crystalized a consensus of the orbital debris community in the US.

[539] Brian Weeden, "The Evolution of U.S. National Policy for Addressing the Threat of Space Debris," Paper IAC-16-A6.8.3, *67th International Astronautical Congress* (IAC), Guadalajara, Mexico, 26-30 September 2016, Published by the International Astronautical Federation (IAF).

IADC, and COPUOS working groups. In particular, these working groups involving DEB experts in the 2000s were the COPUOS Space debris working group preparing the Debris Mitigation Guidelines, the TC20/SC13 and 14 developing the ISO industrial standard, and the COPUOS LTSWG proposed by the end of the decade. The DEB epistemic group members kept facilitating exchanges by keeping on hosting international debris meetings, keep up with updated knowledge and adapting the set of shared DEB ideas to national practices in the U.S. and as contributor for knowledge and further debris governance and learning progress from DEB members diffusing to other nations and learning from other nations.

Following national space policy emergence of the US and ESA in 1989, and in Russia in 1993, DEB shared ideas also diffused into Japan's first space policy in the 2000s decade, called the "Japan Basic Plan for Space Policy".[540] Debris is mentioned under the section 6 on protection of the environment, which is, like in Russia, a national policy. This illustrates the enduring influence of DEB group which was observed since the 1980s as explained earlier. The Basic Plan as a first national space policy in 2009 covering debris issues in Japan after the NASDA standard was issued in the 1990s also following coordination with other DEB group members under IADC work, is another example of continued diffusion of DEB ideas, but at a higher political level in Japan in the 2000s, similarly to what occurred also in France with its FSOA emerging in 2008. DEB ideas and DEB epistemic influences where also encourage by the external event of the Chinese ASAT of 2007. The Basic Law which

[540] Strategic Headquarters for Space Policy, "Basic Plan for Space Policy," June 2, 2009, https://www8.cao.go.jp/space/pdf/basic_plan.pdf (accessed June 28, 2021), 51.

was issued in 2008 and called for a national policy for Japan also entails debris issues under licensing rules.[541]

In France, the national debris governance steps of the 2000s expressing DEB epistemic influences are found in the national space act known as the French Space Operations Act of 2008 (FSOA).[542] The Act marks the continuation of the influences observed in the 1990s and which led to the CNES joining the IADC and developing a space agency standard in 1999 and contributing to IADC guidelines international policy coordination. Under the IADC, CNES expert continued to develop the IADC guidelines issues in 2002 and the ECoC and the UNCOPUOS Debris Mitigation Guidelines as developed also largely based on the same shared and consensually developed ideas which led to IADC guidelines, as explained in their respective sections.

5.3 Consolidating steps since the 2010s

5.3.1 International NGO Initiatives progress outside of the UN 2010s

This section presents debris governance progress at the international non-governmental level in the 2010s, mainly as new debris instruments emerging under the International Organization for Standardization, and the recent Space Safety Coalition and Consortium for Execution of Rendezvous and Servicing Operations initiatives.

[541] Aoki, Setsuko, "Domestic Legal Conditions for Space Activities in Asia," AJIL Unbound 113 (2019): 103–8 (doi:10.1017/aju.2019.14).

[542] French Space Operations Act n°2008-518 (FSOA) adopted in 2008 as "LOI no 2008-518 du 3 juin 2008 relative aux opérations spatiales," unoosa.org/documents/pdf/spacelaw/sd/France.pdf (accessed, June 29, 2021).

ISO 24113: space debris standard work in the 2010s

During the preceding decade in the 2000s, the research already found standardization efforts affecting debris governance under the International Organization for Standardization (ISO). One standard in particular, the *Orbit Data Messages* (ODM) applying partially to debris and one new working group namely the Orbital Debris Working Group (ODWG) to develop a comprehensive space debris mitigation standard were found under Technical Committee 20 Subcommittee SC13 and Subcommittee SC14. For this period of the 2010s, the research found further consolidation efforts of debris governance under the same two subcommittees of ISO/T20/SC/13 and SC/14. Under Subcommittee 13, an additional revision to ODM and the emergence of a complementary standard *Conjunction Data Message* (CDM), and under Subcommittee 14 the adoption of a comprehensive space debris instrument under SC14 as ISO 24113 accompanied by a series of sub-standards. The governance gaps filled for debris governance and the epistemic influences are explained below.

ISO Subcommittee 13 and CCSDS: ODM and CDM standards in the 2010s

As seen in the 2000s, two subcommittees have been working on debris mitigation aspects under ISO Technical Group 20, namely subcommittee 13 and subcommittee 14 (TC20:SC/13 and SC/14). This section looks into the work of SC/13 in the 2010s. Standards recommendations under SC/13 are prepared under the *Consultative Committee for Space*

Data Systems (CCSDS) navigation working group (NavWG),[543] and there has been coordination between SC/13 and SC/14 on standard development work since the early 2000s.

Normative

As seen in the previous decade, the CCSDS Navigation working group (NavWG) already contributed to debris governance normative progress with its *Orbit Data Messages (ODM*) ISO-22644:2006 "Space data and information transfer systems - Orbit data messages." Shortened as *Orbit Data Messages (ODM*) strengthening especially the collision avoidance aspects of DEB shared ideas represented in the main debris instrument IADC guidelines. Revised a first time in 2009, the 2010s decade brought a second revision to *Orbit Data Messages* as ODMv2,[544] which further consolidates the collision avoidance part of the debris mitigation norm codified under IADC guideline 5.4.

The 2010s decade brought a second standard under CCSDS and SC/13, namely *Conjunction Data Message*, CCSDS 508.0-B-1 (CDM), which complements ODM and further supports also the same partial collision avoidance norms of the DEB group and IADC guidelines 5.4. norm of better information exchanges regarding spaceflight safety since the 2000s first version in 2006, also supporting together with the next emerging CDM in the 2010s the collision avoidance provision 5.4 of the IADC guidelines.

Conjunction Data Message (CDM)[545] 2013

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543 CCSDS Navigation Working Group, https://cwe.ccsds.org/fm/Lists/Charters/DispForm.aspx?ID=24, (accessed March 13, 2021).

544 ISO-22644:2006 "Space data and information transfer systems — Orbit data messages revised in 2012 under ISO as: 26900:2012 Iso.org/standard/42722.html, (accessed May 21, 2020).

545 *Conjunction Data Message*, CCSDS 508.0-B-1, Blue Book, Issue 1, March 2012, http://public.ccsds.org/publications/archive/508x0b1e1.pdf (accessed March 12, 2021).

The CCSDS navigation working group affiliated with the ISO Subcommittee 13 as ISO/TC20/SC13 further consolidated debris governance in the 2010s with the publication of a second international standard useful for collision avoidance measures under debris mitigation instruments.

Policy

During the 2010s, this research found policy progress under the CCSDS, following its 2000s contribution to codify debris governance partial tools. The same policy progress observed with ODM in 2009 as an evolutionary step further consolidating debris governance has been observed in the 2010s with the second revision of ODM in 2012 becoming an ISO standard referred to as ISO 26900:2012.[546] This represents a progress for debris policy as an update to the *Orbit Data Messages* standard (ODM) of 2009 which had emerged as an additional partial debris instrument completing the other instruments outside ISO.

As another policy development under ISO for debris during the 2010s, a new standard was developed in coordination with subcommittee 14 as the *Conjunction Data Message* (CDM)[547] issued in 2013. As a complementary standard also reinforcing the IADC collision avoidance provision 5.4, this second partial debris instrument represents another debris policy progress step.

Institutional

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[546] Berry and Oltrogge, "The Evolution of the CCSDS Orbit Data Messages," and Berry and Finkelman, "The CCSDS Orbit Data Messages – Blue Book Version 2: Status, Applications, Issues." The revised version of ISO is 26900:2012, https://iso.org/standard/42722.html (accessed May 21, 2020.)

[547] *Conjunction Data Message*, CCSDS 508.0-B-1, Blue Book, Issue 1, March 2012, http://public.ccsds.org/publications/archive/508x0b1e1.pdf (accessed March 12, 2021).

In the 2010s, the CCSDS formally affiliated to ISO SC13 continues to act as a supporting institution consolidating debris governance and conducive to epistemic communities influence over shaping debris mitigation instruments. Indeed, the shaping of partial debris mitigation instruments such as ODM and CDM standards was achieved thanks to technical experts' interactions mostly of the main space agencies members and also with observer agencies technical experts allowed to contribute not to voting but to knowledge under the working groups.[548] Policy coordination between Subcommittee 13 with Subcommittee 14 also further helps increase ideas diffusions and policy coordination. The continued CCSDS standardization work of the 2010s therefore represents an institutional progress for debris governance, consolidating CCSDS's role and generally ISO's role as a debris governance platform conducive to epistemic influences of the DEB group, thanks to the additional standards affecting debris mitigation, besides the work of the other ISO subcommittee SC14 on ISO 24113.

Compliance

Under CCSDS, the eleven space agencies members required to make best efforts to apply the CCSDS recommended standards internally,[549] while about thirsty more observer agencies

[548] Consultative Committee for Space Data Systems (CCSDS), Observer Agencies participation https://public.ccsds.org/participation/observer_agencies.aspx (accessed March 13, 2021).

[549] Consultative Committee for Space Data Systems (CCSDS), Member Agencies participation. https://public.ccsds.org/participation/member_agencies.aspx, (accessed March 13, 2021). Observer Agencies, https://public.ccsds.org/participation/observer_agencies.aspx accessed March 13, 2021). In 2018, the membership of the CCSDS navigation group NavWG includes delegates from major space faring nations, most also member of IADC such as: the Centre National d'Etudes Spatiales (CNES, France), the Deutsches Zentrum für Luft- und Raumfahrt (DLR, Germany), the European Space Agency (ESA, European Union), the Japan Aerospace Exploration Agency (JAXA, Japan), the National Aeronautics and Space Administration (NASA, USA), the Russian Federal Space Agency (RFSA, Russia), and the UK Space Agency (UKSA, United Kingdom.

are also encouraged to comply.[550] This marks a small compliance progress for debris governance for the main space agencies and further encouragement for the many other observers thanks to the CCSDS developed standards of ODM and CDM adopted in the 2010s.

The main ideas and epistemic influences found for the CCSDS industrial standards ODM and CDM are those shared by the debris mitigation and long-term sustainability groups.

DEB and LTS

Experts from the DEB and LTS groups are found among the contributors to the CCSDS navigation working group from space agencies of the main space faring nations also most of them members of the IADC, with inputs of observing members contributing as individual technical experts to the CCSDS working group in charge, as well as from interacting with other epistemic members of the DEB and LTS groups under the other ISO subcommittee SC14. Oltrogge and Finkelman are examples of epistemic members sharing an interest in both debris mitigation and long-term space sustainability also belonging the IAA permanent debris committee. They actively promote CCSDS standard ideas across many fora reporting about initiatives in which they participate and publishing papers. These are experts other than space agencies, rather from associated research and consulting compagnies from the private sector. Some of the epistemic individuals from space agencies and industry members include chairpersons who actively promote DEB and LTS ideas across other fora outside of ISO CCSDS/SC13 and SC 14. Indeed, as was observed in many other debris instrument examples of this research, epistemic members have been actors in shaping instruments and then in

[550] Consultative Committee for Space Data Systems (CCSDS), Member Agencies participation. https://public.ccsds.org/participation/member_agencies.aspx, (accessed March 13, 2021).

promoting these instruments and norms and ideas contained by presenting and publishing across other debris or space governance fora. about these progress of these working groups on the standards at international conferences and at other space governance bodies such as the IADC, COPUOS Scientific and Technical Subcommittee (STSC), as also observed during the 2000s. For the 2010s period, the chairman of CCSDS is David Berry.

ISO Subcommittee 14: ISO 24113 and sub standards in the 2010s

Normative

The research found that the main space debris standard ISO 24113 represents several normative progress steps for debris governance. As an additional and comprehensive debris mitigation instrument, the ISO standard strengthens the existing debris regime presented in Table 6-1, completing the debris-specific instruments and basic provisions of space governance.

Also, due to the mixed nature of ISO TC20/SC14/WG7 membership involving industrial players in shaping the standard under the working group, this enables a wider norm promotion in the private sector, beyond space agencies or COPUOS members side as well. This is a trend observed especially over the last decade of this consolidation phase with an increasing industry participation in shaping and promoting debris instruments, even comprehensive best practices such as illustrated under the Space Safety Coalition Best Practices agreement.

Lastly, as explained in the next policy paragraph, ISO 24113 was developed to ensure coherence with the existing instruments and recommendations such as IADC guidelines while making some of them more stringent in the wording than IADC guidelines, consolidating them. ISO standard 24113 also comes as a normative step for debris mitigation governance efforts, consolidating the international debris mitigation consensus base codified in the ITU Recommendation, IADC Guidelines, the European Debris Mitigation Code (ECoC), the UN COPUOS Debris Mitigation Guidelines in the earlier two decades, and considered universally shaped and agreed debris instruments . As mentioned in the ECoC section, the ISO 24113 standard has been developed from the European Debris Code's text, which is in-line with the same norms achieved with the IADC and COPUOS instruments, the ISO standard being based upon it therefore represents a significant normative progress step as it is being recognized by an increasing number of spacefaring nations. As noted by Stokes, ISO 24113's normative promotion has been especially observed by the influence of its 2011 issue in many of the world space agencies national debris standards, even in China and Russia.[551]

Policy

The ISO standard 24113 labelled a "top-level" standard under the ISO hierarchy is a major policy outcome for debris mitigation efforts as it is considered by experts as one of the main universal and internationally agreed instruments of debris governance, besides the IADC Guidelines, the UN COPUOS Debris Mitigation Guidelines, and the European Code for Debris Mitigation.[552] The first version was issued in 2010, revised in 2011, and currently superseded by the 2019 version.

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[551] Stokes et al., "Evolution of ISO's Space Debris Mitigation Standards," 6.
[552] Stubbe, *State accountability for space debris*, 233.

As regards the policy innovations in the latest revision of the ISO standard in 2019 compared with the 2011 version are the emphasis on harsher provisions for ensuring better post-mission de-orbiting to clear the LEO, indicating an evolution in debris mitigation ideas via a learning process to include the new knowledge about the large constellations threat. For instance, the requirement for the probability of successful post-mission disposal is increased and must now demonstrate a higher percentage than the 90% recommended in the IADC guidelines. In addition to the stronger debris mitigation measure, the 25-year rule provision has also been enhanced with a slight shortening. Namely, the ISO 24113:2019 begins the counter of the operational lifetime from the launch and insertion into orbit, and no longer from the end of operations, for satellites unable to conduct collision avoidance maneuvers. Thus, the revised provision reduces the 25-year rule, even if no consensus has been reached on specifying a number of years yet. These policy innovations also illustrate policy progress by acknowledging and adapting the ISO standard to tackle the new threat of the large constellations of smaller often non-maneuverable satellites, expressing a true evolution.

Another Policy step of ISO 24113 concerns the level of wording. with more precise and more verifiable plus also one degree more of progress form “should” to “shall” making the ISO standard provisions more assertive than the IADC guidelines. This is a consolidation step, whereby the ISO standard comes as a strengthening instrument, developed in-line with existing ones of the IADC guidelines and COPUOS guidelines and other IAA recommendations, and which reinforced them all by being a little bit more assertive, marking a governance policy progress step in debris mitigation governance. Some debris experts explain ISO standards are also voluntary guidelines yet with a stronger normative value, meaning specifically that such documents are approved by a consensus of at least two thirds of the voting members, issued under the central secretariat, and specify practices which "must be done in order to satisfy this consensus" thanks to the use of "shall" rather than the conditional or discretionary "should" found in the IADC guidelines.[553]

Also, the ISO main standard is an industrial standard and represents a progress of stronger codification for debris governance. As noted in Oltrogge and Christensen, ISO standards are "commercially" viable and differ from the IADC and COPUOS guidelines or ITU recommendations.[554] This represents also a policy progress for debris governance rendering the regime tools such as standards more stringent as ccommercially or more precisely "contractually binding" nationally for companies operating under one state once that state has adopted it under its regulation. This is similar to the European Code (ECoC) provisions, binding contractually for European companies. The ECoC text has been used as reference text for shaping the ISO 24113 standard.[555]

Regarding the intentional debris creation provision, it is included similarly to the IADC guidelines up until its latest revisions in 2019, without being specifically more stringent. Yet it consolidates this policy progress for debris governance already achieved by ISO 24113:2011 on the part of the intentional provision, especially as an industrial standard for new commercial entities to observe, as a recent significant emerging threat for the debris problem as seen throughout this research. Stokes et al. report in 2019 no change to provision

[553] Qiang, Song, "ISO Standards and Space Debris," CALT Systems Engineering Division CALT Systems Engineering Division, Oct 2011, https://swfound.org/media/50900/song_iso.pdf (accessed March 15, 2021). Also confirmed by interviews with other space agencies delegates to ISO.
[554] Oltrogge and Christensen, "Space Governance in the new space era," 1.
[555] Alby, "30 Years of Space Debris Mitigation Guidelines in Europe," 6.

6.2.1, which still recommends to "Avoid intentional break-ups" with no evolution towards a stricter guideline.[556] The continued presence of this restraint provision keeps strengthening the policy progress of the 2011 version as an arms control provision found here under the ISO tools besides the other universal debris instruments, thus further consolidating the debris regime.

Another aspect of ISO standard facilitating better compliance lies in its drafting done in a more verifiable and precise manner than the main debris standards of other fora, acting as a complementary compliance enabler besides the main instruments like IADC guidelines. As confirmed by interviews, the standard ISO 24113 made IADC guideline 5.1 "Limit Debris Released during Normal Operations" more verifiable and precise,[557] consolidating debris governance as a policy progress and encouraging better compliance. ISO standards are deemed more precise and more verifiable than the IADC ones, especially for the example of IADC (5-1), which is less precise and less verifiable than the text formulated under ISO provision (6-1).[558] A similar process was observed in the context of the ECoC when the ESA Agency document was shaped into more details and issued later so as to make the ECoC more implementable.

Institutional

The study found that the continuous revision process of the main debris standard 24113 and the additional 10 sub-level standards developments occurring under ISO also enhance the role of ISO as a debris governance body in the 2010s. The ISO 24113 standard shaped

[556] Stokes et al., "Evolution of ISO's Space Debris Mitigation Standards," 7.
[557] Interview with CNES officer May 2020.
[558] As explained by space debris experts in research interviews.

under TC20/SC14, similarly to the CCDS ODM standard shaped by under TC20/SC13 - the other ISO subcommittee developing space standards-, the ISO main debris standard 24113 three consecutive versions issued in the 2010s also represent an institutional progress step for debris governance. It consolidated the role of ISO as a governing body with ODCWG supporting the shaping of debris governance instruments following the 2000s efforts, and conducive to epistemic involvement, besides IADC, COPUOS and ITU. The study found that the continuous revision process of the main debris standard 24113 and the additional 10 sub-level standards developments occurring under ISO also enhance the role of ISO as a debris governance body in the 2010s.

Compliance

The international industrial standard outcome at ISO represents two levels of compliance progress for debris governance, namely nationally and commercially. Indeed, the standards are adopted by ISO full members and corresponding members, and also as an increasing number of COPUOS member states. As reported in the UN Compendium of Space Debris Mitigation Standards, the diffusion of the ISO main space debris standard into national requirements has been improving with more than 20 nations out of 30 observing at least the second revision of ISO 24113:2011.[559]

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[559] United Nations, "Compendium of Space Debris Mitigation Standards adopted by States and International Organizations,"https://www.unoosa.org/res/oosadoc/data/documents/2019/aac_105c_22019crp/aac_105c_22019crp_14_0_html/AC105_C2_2019_CRP14E.pdf (accessed March 10, 2021).

Also as noted by Ailor and Taylor,[560] and by Mejía-Kaiser,[561] ISO standards are typically also widely observed by the private sector or "space industry stakeholders" and become part of national regulations, which represents a compliance progress from the IADC guidelines. Indeed, as a mixed membership involving industry delegates under technical committees working groups shaping the standards besides other space agencies delegates, ISO considers more of the commercial demands aspects than the other government fora who shaped the reference instruments such as IADC and COPUOS. Indeed, the structure of ISO as that of the European ECSS working groups are composed of delegates from both space agencies and space industry delegates, and in the case of ECSS the initiative was a direct result from the demands for harmonization of all space standards called for by European space industry associations.[562] This unique aspect of the standardization organizations like ISO and ECSS helps incentivize the observance of these standards and thus helps fill debris mitigation compliance gaps. With the latest revision of ISO 24113 in 2019, the standard benefitted from inputs of ECSS and ISO working groups regarding the specific problem of low compliance behaviour with post-mission disposals in the LEO protected region, especially with the 25-year rule.[563] The policy coordination around the standard's revision resulted in shortening that 25-year rule and encourages better compliance as it defends their interest by protecting the sustainability of their commercial activities in the space environment. Given the recent *New Space* companies disrupting space business with their mega-constellations, the incentive

[560] William, Ailor and Emma, Taylor. "ISO Standards: The Next Step for Orbital Debris Mitigation." Paper IAC-05-B6.3.09 presented at Fukuoka, Japan, 56th International Astronautical Congress. 2005, 3.
[561] Martha, Mejía-Kaiser. "Informal Regulations and Practices in the Field of Space Debris Mitigation," *Air and Space Law* 34, no. 1 (2009): 27-28.
[562] This is further explained under the European Code for Debris Mitigation section under the 2000s' chapter.
[563] Stokes et al., "Evolution of ISO's Space Debris Mitigation Standards," 9.

is even greater now in 2020 to protect the future of the space industry with updated and stronger standards. As observed for CONFERS and SSC, the ISO standards involving industry in shaping standardization initiatives consolidates compliance rates and it has been observed already over the last decade. Besides increased observance with ISO 24113 by more nations and companies, Stokes et al. report how ISO monitored these implementation levels and received feedback from industry also about potential improvements for better compliance.[564]

In terms of epistemic group and ideas involved, as was observed above for ODM and CDM and in many other debris instrument examples of this study, direct influences of epistemic members have been again observed especially of DEB and LTS members in the shaping of the ISO debris instrument, under the Subcommittee 14 as ISO 23113 and its "family" of other sub-level standards. Experts from these two epistemic groups have directly affected the shaping of these additional debris instruments and promoted ISO 24113 and respective norms and codified ideas by further presenting and publishing across other debris or space governance fora. In the case of the main space debris mitigation standard of ISO 24113 and its sub-standards, the chairperson of working group acting as its "convenor" was mandated to liaise with IADC to ensure consistency with the guidelines and also benefitting from DEB and LTS ideas circulating in that forum and bringing them to the ISO platform since the beginning of the ODCWG in 2003. This shows the diffusion process of the DEB group ideas and LTS group as well in the 2010s and their involvement in shaping ISO

[564] Stokes et al., "Evolution of ISO's Space Debris Mitigation Standards," 6.

instruments together with industry representatives acting as technical experts as well, representing a special feature of the ISO forum.

Progress on the ISO standards were presented regularly at the IAA level and at international conferences also by members such as Christophe Bonnal in his quality of chairperson of the IAA Debris committee for instance. The ISO standard progress was also presented in papers by Hedley Stokes as the chairperson of SC 14/WG7 at the IOC conference in 2019.[565]

Bonnal, Stokes, Oltrogge and Finkelman are peer members under the IAA debris working group or IAA Permanent debris committee, Bonnal as co-chair [566] also covering LTS issues, and belong as epistemic community members to the DEB and LTS groups as per their interest in and promotion of DEB and LTS ideas, regular meeting with others under supporting debris governance institutions such as here ISO but also COPUOS STSC, SSC, and various discussions NGO platforms, and with their executive roles in the various working groups and initiatives leading to the shaping of debris instruments.

The work towards ISO 24113 also involves regular liaison with several of the main debris governance platforms facilitating the diffusion of ideas and norms such as ASD-STAN (Aerospace and Defence Industries Association of Europe), Consultative Committee for Space Data Systems (CCSDS related with SC 13), Committee on Space Research (COSPAR), European Coordination on Space Standardisation initiative under ESA-ESTEC (ECSS), European Space Agency (ESA), International Academy of Astronautics (IAA),

[565] Stokes et al., "Evolution of ISO's Space Debris Mitigation Standards."
[566] https://iaaspace.org/about/permanent-committees/#SA-PERMCspacedebris (accessed March 18, 2021).

International Telecommunication Union (ITU).[567] ISO 24113 therefore illustrates the direct involvement of debris mitigation and sustainability epistemic members in its shaping and revisions, strengthening debris governance progress in the 2010s. Several members of the ISO Subcommittee 14 WG7 involved in ISO 24113[568] are members of the IAA Permanent Space Debris Committee, most are also part of the newly created IAF Committee on Space Traffic Management as a joint IAA, IISL and IAF initiative,[569] and some are members of both such as Stokes, Oltrogge and Bonnal. Under the ISO platform, Stokes, Bonnal and Oltrogge are experts diffusing results of the work across the other fora, acting as the influential epistemic members of DEB and LTS groups, with Berry for CCSDS as well as seen in the above section.

Space Safety Coalition and Best Practices Agreement 2019

The Space Safety Coalition (SSC)[570] is a non-governmental organization created in 2019 as a consortium of mostly space industry private actors such as traditional and new commercial operators of space assets,[571] space operations insurance companies, and also civil society associations, research institutes and foundations.[572] It produced a best practices

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567 ISO/TC 20/SC 14 Space systems and operations, Organizations in Liaison, https://www.iso.org/committee/46614.html#secretariat (accessed March 23, 2021).
568 Stokes et al., "Evolution of ISO's Space Debris Mitigation Standards," https://www.hou.usra.edu/meetings/orbitaldebris2019/pdf/6053.pdf (accessed March 23, 2021).
569 IAF Committees, https://www.iafastro.org/about/iaf-committees/technical-committees/space-traffic-management-committee.html (accessed March 23, 2021).
570 Space Safety Coalition, https://spacesafety.org/about/ (accessed February 26, 2020).
571 Some of the traditional satellite operators include Inmarsat, Intelsat and SES, who also initiated the Space Data Association initiative a decade earlier. Examples of new operators include Planet, OneWeb and SpaceX to name only a few.
572 Space Safety Coalition Endorsees: https://spacesafety.org/endorsees/ (accessed February 26, 2021).

agreement, namely the SSC Best practices for the sustainability of space operations[573] found to illustrate the direct influence of epistemic communities in shaping a debris governance instrument. The SSC organization and its agreement are found to express a new trend in debris governance such as involving some NGO fora platforms involving more the private sector participating also in policy coordination efforts to shape debris governance instruments. The Space Safety Coalition's initiative reflects a new trend in the evolution of debris governance such as increasing industry-led and industry involving initiatives with mixed memberships under non-governmental fora especially in the last decade of this consolidating period as observed in other sections with the initiative of the Consortium for Execution of Rendezvous and Servicing Operations CONFERS and inspired by the Space Data Association. The SSC instrument contributes to fill several global governance gaps applicable to debris governance, such as normative, policy, institutional and compliance governance gaps as explained below.

Normative

The Space Safety Coalition Best Practices firstly consolidate the existing debris normative progress achieved under the UN, IADC and ISO main instruments here in an additional forum. As a supplemental debris relevant instrument endorsing IADC Guidelines, COPUOS Guidelines and the ISO standard, the Coalition's agreement comes as a complementary initiative, and its holistic approach under the wider space sustainability initiative further strengthens the debris normative progress.

[573] Space Safety Coalition, "Best practices for the sustainability of space operations," 16 September 2019. https://spacesafety.org/wp-content/uploads/2019/09/Endorsement-of-Best-Practices-forSustainability_v20.pdf (accessed February 26, 2020).

Also, the best practices document was initiated and signed especially by the space industry actors showing that the SSC agreement consolidates normative progress of debris mitigation ideas expanding now to the private sector, as an additional stakeholder in the debris system beyond governmental levels. The signatories comprise commercial space stakeholders including associations and fora discussing or even representing the interests of their relevant activities, among them are some important players for debris issues such as satellite operators of the largest fleets and satellites manufacturers including key newcomers as well.[574] This is important especially as these commercial endorsees have emerged as the crucial players in the debris issue with their mega-constellations, while new companies also emerged for de-orbiting services known as On-Orbit Services (OOS) representing potential solutions. Debris experts have expressed their concerns in recent years over tiny and simpler satellites in mega-constellations representing high risks of debris proliferation. Whether due to their non-manoeuvrable designs and associated challenges for deorbiting or numerous potential malfunctions, some experts even consider the threat of mega constellations higher than the proliferation threat resulting from Anti-Satellite tests.[575] This is why the debris norms acceptance by such commercial newcomers greatly affecting the debris environment represents an important normative progress for debris governance.

Also, by promoting over forty additional provisions than these instruments,[576] some of them stricter on lifetime in orbit or rate of disposal as will be explained below under policy

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[574] Space Safety Coalition Endorsees: https://spacesafety.org/endorsees/ (accessed February 26, 2021). Planet is an example of such newcomer operating a large fleet.

[575] Confirmed by secondary sources and attendance at debris session discussions and confirmed by interviews conducted during debris session of the IACs and over the phone.

[576] Daniel, Oltrogge, "The Space Safety Coalition in the context of international space cooperation," Vienna, UN COPUOS STSC Session, February 2020, 5-6.

progress, or covering more aspects, these best practices clearly enhance debris and sustainability normative progress.

Policy

The Space Safety Coalition's Best Practices Agreement is found to represent several policy progresses for debris governance in the decade of the 2010s involving epistemic communities' members and knowledge.

In the first place, the SSC Best Practices document counts as policy progress highlighting a new trend in debris governance specifically the growth of industry-led initiatives and initiatives involving industry under mixed public-private membership consortia observed especially over the last decade of the consolidating phase, as also acknowledged in recent space debris governance literature and COPUOS reports.[577] Brian Israel conceptualized it as a third level of governance namely "space governance 3.0", where private organizations and civil society shape norms of behaviour as different governance tools than those developed and agreed-to at states or international governmental organizations level, as top-down rules.[578] SSC Best Practices endorsees include manufacturers, launch providers, satellite operators, insurers, industry associations and civil society institutes and foundations, all supporting debris efforts under the Space Safety Coalition as a forum of non-governmental

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[577] Daniel L. Oltrogge and Ian A. Christensen, "Space governance in the new space era," *Journal of Space Safety Engineering*, Volume 7, Issue 3, 2020: 432-438. https://doi.org/10.1016/j.jsse.2020.06.003 (accessed February 27, 2021).

[578] Brian R., Israel, "Space Governance 3.0," 48 *Georgia Journal of International and Comparative Law* 715 (2020), https://digitalcommons.law.uga.edu/gjicl/vol48/iss3/7 (accessed February 26, 2021): 715-730. "Space Law 1.0" is described as the traditional international states-level top-down approach to space governance. "Space Law 2.0" expresses the integration of international space treaties provisions at national levels. "3.0" involves space operators and civil society without hierarchy and as non-governmental actors, and as different instruments.

actors. This is a new kind of NGO platform conducive to epistemic community member's involvement and of ideas diffusion as a mixed-NGO type with a stronger focus on aspects of commercial operations.[579]

Relating to this policy progress of complementary debris regime developing platform by industry-led and industry involved fora, the commercial sector is also increasingly seen as the next promising promoters of responsible behaviour norms including debris mitigation aspects,[580] beyond the current platform promoting the existing guidelines of IADC, COPUOS and ISO as additional supporting forces. This view gained momentum especially after the stalling of ICoC or the latest Indian ASAT of March 2019 and concerns security-related aspects of intentional debris creation, the commercial actors and their initiatives increasingly deemed as platforms for strengthening TCBMs.

Secondly, the Best Practices also reflect a new approach to debris governance characteristic of the last decade of the consolidating phase of debris governance, namely the 2010s, which is the trend of addressing debris mitigation effort under a more holistic approach. Indeed, following the first steps pointing to this new comprehensive approach initiated with the LTS initiative, which incorporated work on debris provisions under the wider LTS guidelines efforts, the Space Safety Coalition best practices for the sustainability

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[579] As a mixed NGO platform, the SSC involves a diverse set of space industry stakeholders categorized as associations and foundations, consulting and analytical services, providers of flight safety, space situational or space traffic management data, launch providers, manufacturers of spacecrafts or parts, governmental operators, commercial operators, orbital service providers for RPO and OOS operations, disposal service providers, insurers, system, and tools suppliers.

[580] Laura Grego, "Why we need to avoid more anti-satellite-tests?" 16 April 2019, *Spacenews*, https://spacenews.com/why-we-need-to-avoid-more-anti-satellite-tests/, (accessed August 7, 2019); Massimo Pellegrino and Gerald Stang, *Space security for Europe*, European Union Institute for Security Studies, Report no. 29, July 2016, EUISS Task Force on 'Space and Security' from September 2015 until June 2016.

of space operations are also representative of a policy progress consolidating debris governance with this additional comprehensive instrument. This policy progress is yet another codification and further consolidation of the debris governance regime supplementing the earlier regime and reflects the diffusion of ideas promoted by the DEB group and LTS experts reaching the Space Safety Coalition forum.

Thirdly, the SSC best practices' provisions represent policy innovation and progress, with many supplementary requirements and some much stricter than the main debris instruments further consolidating debris governance in the 2010s and fitting it under the comprehensive instruments in Table 6-1. As pointed out by Daniel Oltrogge,[581] the SSC Best Practices Document supplements the international provisions in UN treaties and guidelines, IADC Guidelines, ISO standards and national regulations with more than forty requirements. Regarding the harsher requirements, the stricter one achieved relates to the LEO post-mission disposal 25-year rule and the percentage of mission success. to de-orbit, it just mentions that a shorter duration is needed of less than 25 years for the large constellations as a special case but not as short as the 5 years recommended in the SSC best practices and the CONFERS ones. The mission success rate for de-orbiting at the end-of-life is 90% for IADC Guidelines and are a bit higher at 95% in the SSC recommended practices. While the IADC latest revised guidelines only mention that for mega-constellations, the 25-year rule "may be necessary" to be shorter or that the probability of successful post-mission disposal "may be necessary" to be higher than 90%,[582] IADC guideline revisions represents a modest progress compared to

[581] Daniel, Oltrogge, "The Space Safety Coalition in the context of international space cooperation," UN COPUOS STSC Session, Vienna, February 2020, 3-6.
[582] IADC Guidelines IADC-02-01 revision 2 March 2020, 12.

the SSC best practices. Then the ISO 24113:2019 revised debris standard mentions that for non-manoeuvrable satellites such as those in mega-constellations, the 90% probability for successful post-mission disposal should be higher, and the 25-year-rule should be counted from injection into orbit and not end-of-life making it less than 25 years, representing a slight progress from the IADC Guidelines yet also modest. The COPUOS Debris Mitigation guideline 6 does not specify any duration for removing satellites from LEO after their operational lifetime neither, only that they should "not be left in LEO for long-term" and mentions noting yet regarding the specific operations of mega constellations in LEO[583] In 2007, this new commercial development with large constellations was not significant yet. Therefore, signatories of the SSC Best Practices document agreed on significantly stronger debris mitigation measures than IADC, COPUOS and ISO deemed more efficient to ensure sustainability in the LEO region especially, such as to shorten the 25-year rule down to 5 years and to an increased probability of success for post-mission disposal de-orbiting manoeuvres to 95%[584] from the 90% required by IADC Guidelines.[585] SSC Best Practices with detailed and stronger requirements are thus a good complement and policy progress for the body of debris mitigation instruments mentioned in Table 6-1. SSC best practices strengthen debris mitigation norms by complementing their codification more comprehensively and as an industry targeted instrument signed by 48 members which

[583] Guideline 6: Limit the long-term presence of spacecraft and launch vehicle orbital stages in the low-Earth orbit (LEO) region after the end of their mission, https://www.unoosa.org/documents/pdf/spacelaw/sd/COPUOS-GuidelinesE.pdf (accessed, March 21, 2020).

[584] SSC Best Practices document, section 4, paragraph a), 11: "Disposal process providing a probability of successful disposal of 95%.

[585] IADC Space Debris Mitigation Guidelines, IADC-02-01, Revision 2-March 2020. Provision on Post Mission Disposal, 5.3.2, 12.

comprise about 80% of the operations in LEO. With the signatories as major players in the LEO orbit endorsing these more comprehensive and stringer instrument makes this policy progress in debris governance a significant one as well and reflects the influence of knowledge and ideas epistemically constructed in the main debris fora having been promoted and diffusing into SSC by epistemic members as administrators of such initiatives or within the signatory members as explained under the ideas and epistemic influences section below.

Institutional

The research observed that the Coalition acted as a new platform additionally supporting debris mitigation efforts representing institutional progress for debris governance. The creation of this coalition gathering industry actors and its mandate to develop a 'best practices document' add the Space Safety Coalition to the growing list of governing bodies helping to further consolidate the debris regime. A new type of NGO forum emerging especially over the last decade, SSC aggregates to SDA and CONFERS as other industry-led or mixed industry-government consortia as supporting fora for debris governance, to ISO as another NGO forum with some industry representation, and lastly to long-time supporting fora debris discussions such as IAF, IAA, IAASS, IISL, ILA, COSPAR, with also newer contributions in the 2010s from SWF, UNIDIR, ECSL, IASL McGill and IASL Cologne,[586] ESPI, and the Institute for Defence Studies and Analyses of India (IDSA), all acting as enabling platforms of epistemic influences over debris governance.

[586] Institute of Air and Space Law (IASL) of McGill University, and Institute of Air and Space Law (IASL), University of Cologne.

With members of epistemic communities of DEB and LTS involved across several other fora and with the SSC as signatories and in the management of the initiative, the SSC platform became a catalyzer of epistemic communities' influences, as detailed below in the ideas section. The Space Safety Coalition example illustrates how the SSC served as a debris governance platform as a kind of nurturing and sheltering "home", enabling, and protecting the development of ideas not having reached consensus yet among the main actors here especially at the state level. Such "home" function was also identified in Adler's arms control study.[587]As explained in the policy section above, the Post-Mission Disposal issue of how long a defunct satellite should remain in LEO orbit is key for debris mitigation efforts and has been a sensitive issue, where consensus was hard to reach especially at the space-agencies level of IADC, able to agree on a "shorter than 25 years" improvement only. The consensus on 5 years is one example of controversial points where support is needed and the SSC as well as CONFERS fora do provide such support for difficult ideas to gather consensus, emerge as new norm, and become codified into an instrument. The Space Safety Coalition became a new platform for space governance, in particular debris governance and as a catalyzer of epistemic communities' members influences promoting ideas and facilitating codification into policy outcomes including of non-binding nature such as best practices agreements among private stakeholders of the space industry. The SSC as a governing forum

[587] Adler, "The Emergence of Cooperation: National Epistemic Communities and the International Evolution of the Idea of Nuclear Arms Control," 126 and 130. The supporting "home" facilitated the acceptance of arms control ideas towards becoming norms while in the beginning the concept was not accepted as belonging with disarmament efforts. The novelty and controversial aspect of the shared ideas of arms control could grow and epistemic community influences could succeed thanks to existence of supporting "home" fora such as international conferences and advisory bodies.

complements the other debris governance supporting bodies at national and multi-lateral state-level, reinforcing the global governance aspect in debris governance.

Compliance

Lastly, with 48 endorsees committing themselves to the SSC best practices, the Coalition members encourage better compliance with debris mitigation measures by creating incentives for compliance. As noted by Reesman *et al.*, SSC expresses an incentivizing trend observed across other industries to increase compliance with sustainable best practices, for instance in the airlines, construction, food, home furnishing and even fashion industries.[588] The benefits of compliance take the form of higher company credibility, reputational benefits, social capital, all criteria which matter for a commercial entity to sustain business.

Arguably, only the future will tell how well these best practices will be observed by the coalition signatories and by others, and if incentivizing will pay off. So far, the adherence of many commercial actors is promising while some interesting development was found also when even a non-signatory member was quick to voice its willingness to cooperate and comply with responsible behaviour after a close-call collision avoidance incident. When SpaceX's *Starlink* 44 satellite almost collided with an ESA Aeolus Satellite and a manoeuvre became necessary, the operator was quick to apologize and express its respect of responsible behaviour deploring a malfunction. It was not due to its non-acceptance of the debris and sustainability norm but attributed to a bug in its warning system which prevented proper

[588] Rebecca Reesman, Michael P. Gleason, Layla Bryant, Colleen Stover, "Slash the Trash: Incentivizing deorbit," Aerospace Corporation Center for Space Policy and Strategy. https://aerospace.org/sites/default/files/2020-04/Reesman_SlashTheTrash_20200422.pdf, (accessed June 2, 2020), 8.

handling of the situation. SpaceX expressed its willingness to improve its response for future collision avoidance measures.[589] Hitchens reports that “when asked, they said they would have been cooperating if their system did not have failed to inform them.” This indicates a sustainability norm acceptance and a small progress, at least in intentions, conducive to compliance progress for debris governance in this last decade of the consolidating phase.

The Best Practices for the Sustainability of Space Operations or SSC Best Practices illustrate the shared ideas and direct involvement of members of the DEB and LTS epistemic communities. The epistemic members’ influence found in the Best Practices agreement are explained below. Some traces of AC ideas are also found as implied and as inherited from earlier influences over space governance.

DEB and LTS

The SSC Best practices express debris mitigation and long-term sustainability shared ideas and show direct epistemic communities’ involvements in the process of this debris governance instrument by the presence of members of the DEB and LTS epistemic communities among the endorsing organizations and in the leadership, such as the administrator of the initiative himself.

Launching the Space Safety Coalition during a debris-related conference more widely an SSA conference the AMOS in September of 2019, Daniel Oltrogge represents AGI as a signatory member and is the SSC administrator. Oltrogge is a space operations safety expert

[589] Theresa Hitchens, “New Space Debris Rules Stalled By Year-Long Interagency Spat,” *Breaking Defense*, September 2019, https://breakingdefense.com/2019/09/new-space-debris-rules-stalled-by-year-long-interagency-spat/ (accessed, June 2, 2020).

involved in several of the main debris mitigation instruments shaping initiatives such as the UN COPUOS Guidelines, the main debris standard ISO 24113 and in the CONFERS initiative and the earlier GVF Global V-Sat forum initiative of 2018, which was set aside later in favour of the Space Safety Coalition initiative. Belonging to the DEB as well as the LTS group, his roles have varied depending on the debris governance supporting fora. For instance, Oltrogge was an observer at COPUOS, a developer of standards at ISO and CONFERS, is an administrator under SSC,[590] while also participating as a member of the IAA Permanent Space Debris Committee. Membership selection for working groups under the IAA studies typically only accept recognized experts in the field studied, validating Oltrogge as a peer in the debris issue. Active across multiple debris governance supporting fora, Oltrogge regularly reports to UN COPUOS sessions, publishes papers in academic journals, presents at many debris and sustainability conferences thus actively contributing to the diffusion process, the promotion of norms and the shaping of debris governance.

Some members of the Secure World Foundation (SWF), another Coalition signatory of the SSC Best Practices also belong to DEB and LTS epistemic communities such as Brian Weeden or Ian Christensen.[591] Weeden has been active in chairing active debris removal or sustainability working groups under SWF initiatives, promoting norms across various other fora supporting debris governance including many debris conferences such as IAC debris sessions, sustainability conferences in Japan, ones, the AMOS conference and various other

[590] As found originally in reports from COPUOS sessions on the Space Safety Coalition and further confirmed by interviews.
[591] The memberships of the DEB and LTS groups keep growing over time especially over the last decade so an exhaustive list would be challenging to present.

debris-related conference, under IAA working groups on debris, and reporting as observer organization at COPUOS sessions.

The Chief Executive Officer of another coalition member and SSC best practices signatory, namely Astroscale, Nobu Okada, was also involved in shaping debris governance tools and can be regarded as a member of the DEB and LTS epistemic community. Indeed, as the research found to be the case for several epistemic community members over the years, including the DEB group, Okada has also earned an award for his contribution to promote space sustainability efforts, validating his expertise in the space community. Examples of his other normative diffusion efforts include under the IAF, the World Economic Forum Space Sustainability Rating initiative (SSR) and the Consortium for Execution of Rendezvous and Servicing Operations (CONFERS) besides the Coalition.[592] Okada has been actively participating in debris fora including in several leading positions in management such as Vice President, Co-chair and developer: VP of "Space Economy and Sponsorship" at the International Astronautical Federation, co-chair and developer of the concept of a Space Sustainability Rating (SSR) under the World Economic Forum's Global Future Council on Space for instance, while presenting at various space sustainability conferences such as IACs, Japan Space Forum Sustainability Symposia and others.

AC

[592] "Astroscale Founder & CEO Nobu Okada Named Leader of the Year by SpaceNews" December 14, 2020, News and Press Releases, https://astroscale.com/nobu-okada-awarded-by-spacenews/#:~:text=Nobu%20Okada%2C%20Founder%20and%20CEO,SpaceNews%20Awards%20for%20Excellence%20%26%20Innovation.n (accessed February 27, 2021). The 2020 SpaceNews Awards winners, by SpaceNews Editor, December 14, 2020, https://spacenews.com/the-2020-spacenews-awards-for-excellence-and-innovation-winners/ (accessed February 27, 2021).

Elements of earlier influences from the AC group over debris mitigation efforts especially around the 1980s were observed around the limiting of ASAT testing in order to also reduce the creation of new and of long-lived space debris in protected orbits as explained earlier. Such practice of restraint encouraged by arms control groups besides debris group efforts led to restraint provisions in the main ensuing debris instruments and were also found as underlying in the SSC agreement in the first pages by reference to the existing debris instruments,[593] References namely to the UN COPUOS and IADC Guidelines, ISO main debris standard and associated Consultative Committee for Space Data Systems (CCSDS) data exchange for safety of spaceflight standard mentioned in Figure 5-1. The presence of AC shared ideas is thus only implied under SSC Best practices by reference to the main debris instruments which codified the AC restraint ideas of limiting the creation of new debris under their respective "intentional" provisions summarized in Table 6-2.

Consortium for Execution of Rendezvous and Servicing Operations

Created in 2018, the Consortium for Execution of Rendezvous and Servicing Operations (CONFERS) is a consortium devoted to developing satellite servicing standards,[594] as a mixed public-private platform created by the US government to develop new international standards with various experts participating in working groups and stemming from industry, academic research institutions and nonprofit organizations, and government as observers.

[593] Space Safety Coalition, "Best practices for the sustainability of space operations," 16 September 2019. https://spacesafety.org/wp-content/uploads/2019/09/Endorsement-of-Best-Practices-forSustainability_v20.pdf (accessed February 26, 2020) , 2 and 9.

[594] Brian Weeden, "Update on the Consortium for Execution of Rendezvous and Servicing Operations, (CONFERS)," Japan Space Forum SSA Symposium, Tokyo, Japan February 27-28, 2020, https://swfound.org/media/206949/bw_confers_jsf_feb2020.pdf (Accessed April 10th, 2020).

Most of its current membership is composed of international commercial stakeholders of the satellite servicing community with traditional and emerging space companies and insurers. CONFERS focusses on Rendezvous and Proximity Operations (RPO) and On-Orbit Servicing operations (OOS) dealing with the safety of operations in orbit, especially GEO, and on promoting responsible commercial operations standards affecting the debris issue under a sustainability approach. CONFERS represents a new type of non-governmental platform as an emerging trend of best practices in debris governance observed in this consolidating phase, and conducive to epistemic communities influences and debris governance progress. CONFERS is filling knowledge, normative, policy, institutional and compliance governance gaps in debris governance and involves direct epistemic communities' participation, as explained below.

Knowledge

The CONFERS initiative firstly expresses knowledge progress in terms of debris mitigation and governance efforts enriching and completing knowledge about a new type of commercial operations involving risky technology. Progress is achieved via the dedicated expert workshops aimed at shaping an international technical standard. These working groups involve experts amongst which some belong to epistemic communities, especially DEB and LTS as explained later. CONFERS Principles and Practices add to the debris knowledge by covering a new aspect affecting debris due to new technological development, in turn creating new debris-related uncertainties and calling for policy solutions. At the knowledge gap level, the CONFERS standard initiative brings progress by enabling the formation of a set of knowledge about the new problematic of commercial servicing operations, and policy innovations of on how to shape responsible design and operational behaviors in this new type of potentially debris-generating activity pressuring space sustainability. Growing the body of knowledge about these new operations helps refine the contours of the OOS and RPO commercial operations responsible behavior issue and serves as a basis for defining its policy solutions, and as knowledge input in for standardization initiatives under ISO.

Another level of debris knowledge progress is observed due to the learning among the members of the consortium members referred to as a "learned" society where learning about responsible behavior occurs between the members under the working group and learning from the more experiences' experts. Company executives which are not yet member of the DEB community can learn as well, then further promote the norms at the international level, as observed in interviews of these commercial members executives during IACs or from by the sponsoring of dedicated workshops.[595]

Normative

The normative progress of the CONFERS initiative is found through the promotion of space safety ideas relating to debris mitigation efforts across several fora, representing a consolidation of existing debris mitigation norms, as an additional debris mitigation norm under the family of standards covering debris. Indeed, by offering additional debris mitigation norm promotion thanks to safer RPO and OOS operations, the CONFERS

[595] Examples of OneWeb actively engaged in promoting better debris standards compliance is a sponsoring event workshop with SWF in 2019 https://swfound.org/news/all-news/2019/08/summary-report-from-workshop-on-norms-of-behavior-in-space/?mc_cid=374a0744a4&mc_eid=b1d582bcf1, (accessed September 6, 2019).

initiative reinforces especially the debris mitigation norm, the progress on the Long-Term Sustainability norm and also to a certain degree arms control norm. Specifically, the draft standard helps promote some confidence-building measures such as increased transparency regarding RPO and OOS, whose dual-use aspects have long been recognized as a source of potential misinterpretations and hampered progress. Indeed, maneuvers involving close proximity between satellites could be deemed as hostile acts against space assets. One of the draft LTS Guidelines covers RPO and OOS operations, yet it has not reached consensus yet. The CONFERS initiative thus helps as a normative contribution to promote additional ideas under the general debris mitigation norm under the holistic approach to space sustainability, specifically with norms of space safety design and operations for OOS and RPO commercial operations. This extension of the debris norms and consolidating efforts of this other instrument of LTS guidelines draft guidelines also promoting this emerging debris mitigating and safety norm affecting satellite servicing activities. The promotion of these OOS and RPO debris mitigation relevant ideas are diffused by CONFERS members across other non-governmental platforms such as the IAC annual conferences, International Symposium on Ensuring Stable Use of Outer Space and Japan Space Forum SSA Symposium held in Japan, working groups under ESA Clean Space Industry days, the ISO subcommittee on debris ISO TC 20/SC 14/WG3, showing normative diffusion filling the normative gap for this satellite servicing aspect of the debris mitigation norm.[596]

Policy

[596] Brian Weeden, "Update on the Consortium for Execution of Rendezvous and Servicing Operations, (CONFERS)," *JSF SSA Symposium*, 10.

This study finds that CONFERS fills important policy gaps in debris governance thanks to its several consensually built outputs such as CONFERS Guiding Principles of 2018,[597] CONFERS Recommended Design and Operational Practices of 2019,[598] and CONFERS On-Orbit Servicing (OOS) Mission Phases of 2019.[599]

Firstly, the international standards developed under CONFERS involve the commercial stakeholders and build upon their commercial operations experience. As also recognized by Larsen,[600] Oltrogge and Christensen[601] and Reesman et al.,[602] the CONFERS example reflects a trend emerging in the 2010s, found also for the Space Safety Coalition example, of incentivizing responsible behavior with increasing participation of the commercial actors in developing additional debris governing instruments and consolidating debris policy outcomes. This wider participation in debris governance from the commercial sector illustrates an even more "global" debris governance trend, with a larger involvement of the private sector in the governance.

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597 "Guiding Principles for Commercial Rendezvous and Proximity Operations (RPO) and On-Orbit Servicing (OOS)," https://www.satelliteconfers.org/wp-content/uploads/2018/11/CONFERS-Guiding-Principles_7Nov18.pdf (accessed August 5, 2021).

598 "CONFERS Recommended Design and Operational Practices," Consortium for Execution of Rendezvous and Servicing Operations, https://www.satelliteconfers.org/wp-content/uploads/2019/10/CONFERS_Operating_Practices.pdf (accessed August 5, 2021).

599 "CONFERS On-Orbit Servicing (OOS) Mission Phases," Consortium for Execution of Rendezvous and Servicing Operations, 1 October 2019, https://www.satelliteconfers.org/wp-content/uploads/2019/10/OOS_Mission_Phases.pdf (accessed August 5, 2021).

600 Paul B. Larsen, "Minimum International Norms For Managing Space Traffic, Space Debris, and Near-Earth Object Impacts," 83 J. Air L. & Com. 739 (2018), https://scholar.smu.edu/jalc/vol83/iss4/3 (accessed June 2, 2020).

601 Daniel L. Oltrogge and Ian A. Christensen, "Space governance in the new space era", *Journal of Space Safety Engineering*, (Volume 7, Issue 3, 2020): 432-438 (accessed February 28, 2021).

602 Reesman et al. 2020, "Slash the Trash: Incentivizing deorbit", Aerospace Corporation Center for Space Policy and Strategy, p 8. https://aerospace.org/sites/default/files/2020-04/Reesman_SlashTheTrash_20200422.pdf (accessed June 2, 2020).

Relating to this trend of greater industry participation in debris global governance, the CONFERS contribution to developing an international standard under the ISO forum helps also as a policy progress step by consolidating the body of ISO debris standards. Indeed, CONFERS further consolidates the representation of industry with its direct input to ISO Draft Standard 24330 under SC14 the subcommittee dealing with debris mitigation standards. Indeed, recognized as new important space standardization organization for setting space standards besides ISO,[603] CONFERS even consolidates ISO standards by providing input to SC TC 20/SC 14/WG3 for shaping the new ISO Draft Standard 24330,[604] growing the family of ISO standards affecting debris found in Figure 5-1, thus representing another important policy progress for debris governance.

Another important policy gap covered by the CONFERS standardization initiative of RPO and OOS operations lies in its complementary nature with regards to the existing international debris mitigation instruments of the IADC and COPUOS debris mitigation guidelines and the ISO debris standard, who do not yet include the servicing operations in their provisions. Indeed, these main debris instruments focus more on the limitation of generating debris or mitigating risks of collisions, while not including yet provisions for close proximity between two space objects in the event of servicing missions which is a more recent technology.[605] As for the COPUOS LTS Guidelines, one of the non-agreed provisions or “draft” provision covers proximity operations, but as a general statement and it remains to be adopted. Also,

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[603] Larsen, “Minimum International Norms For Managing Space Traffic, Space Debris, and Near-Earth Object Impacts,” 2018.

[604] Brian Weeden, “Update on the Consortium for Execution of Rendezvous and Servicing Operations, (CONFERS),” *JSF SSA Symposium*, 9.

[605] David A. Barnhart and Rahul Rughani, “On-orbit servicing ontology applied to recommended standards for satellites in earth orbit,” *Journal of Space Safety Engineering* 7, Issue 1 (March 2020): 83-98.

this draft provision stipulates that states should “Observe measures for the safe conduct of proximity space operations”, without giving more specifics. CONFERS standards therefore serve as policy innovation and as the first codification and consensus reached regarding OOS and RPO responsible servicing ideas, represents an additional debris mitigation instrument found in Table 6-1. The CONFERS best practices are recognized as a governance progress,[606] complementing the institutionalization of additional debris mitigation ideas, counting in this study as a policy progress for debris governance improving space sustainability.

A last policy progress highlighted by the CONFERS best practices for debris governance concerns the presence of a transparency provision to clarify intent and avoid misinterpretations,[607] representing a progress as a TCBM step, and reminding of the “intentional” debris provision seps achieved in the main instruments of IADC and COPUOS Guidelines and ISO standard 24113 and ECoC. As noted in recent reports of the Secure World Foundation, the co-orbital ASATs have resumed and being developing by more nations over the past decade representing a higher risk for debris creation as reminded in Table 1-5, Table 1-6, and Table 1-7. This clarification encouraging best practices impacting on the co-orbital ASAT type activities as well shows that agreement among commercial actors has been possible for responsible behavior on a security sensitive aspect of RPO operations. This is another policy progress for debris governance achieved under CONFERS

[606] Peter, Martinez, “Remarks delivered by Dr Peter Martinez at the informal consultative meeting of the GGE on PAROS” UN, New York, 1 Feb 2019, Secure World Foundation.

[607] Brian Weeden, “Update on the Consortium for Execution of Rendezvous and Servicing Operations, (CONFERS),” *JSF SSA Symposium*, 3; “CONFERS Principles and practices,” https://www.satelliteconfers.org/publications/ (accessed March 3, 2021).

and complementing the other instruments shaped in the other fora and displaying an ongoing trend for debris governance of overcoming some political hurdles on aspects of space security. CONFERS illustrates the involvement and influence of epistemic experts of the DEB and LTS groups as explained later and of facilitating the incremental building of consensual knowledge on minimum requirements of best practices in commercial fora in the 2010s especially, such as also observed under ISO and which are completing the IADC and COPUOS guidelines instruments thanks to these extra RPO and OOS provisions.

Institutional

The CONFERS initiative also represents an institutional progress for debris governance. As seen earlier, the Consortium has been recognized as an additional and valuable space standardization platform, besides ISO.[608] CONFERS as a permanent body holding regular working groups with experts of debris and space sustainability issues is an enabler for epistemic influences in shaping OOS and RPO ideas and codifying them into standards, growing the body of debris governance. CONFERS acts as another debris governance supporting forum reminding of Adler's institutional "home" concept, facilitating the development or consolidation of epistemic knowledge and norms, especially when innovative or sensitive ideas come into play.[609] As explained under the policy paragraph above, CONFERS acts as a supporting home for policy innovation and codification of ideas into a debris governance instrument for commercial satellite servicing operations. As a new

[608] Paul B. Larsen, "Minimum International Norms For Managing Space Traffic, Space Debris, and Near-Earth Object Impacts", 83 J. Air L. & Com. 739 (2018), https://scholar.smu.edu/jalc/vol83/iss4/3 (accessed June 2, 2020), 781.

[609] Adler, "The Emergence of Cooperation: National Epistemic Communities and the International Evolution of the Idea of Nuclear Arms Control," 130.

mixed institution facilitating epistemic ideas shaping, codifying, and promoting among commercial actors and across other institutions, CONFERS represents an institutional progress in debris global governance, with its catalysing of ideas and governing instruments of the debris governing system.

Compliance

Some level of compliance progress for debris governance is also found with the CONFERS initiative. Firstly, key players for these new services have joined and committed themselves to these best practices, setting a benchmark and acting as a pulling-force. These involve Astroscale as servicing company, operators of emerging mega constellations such as OneWeb, and major satellite manufacturers and operators such as Airbus, Thales Alenia Space, Lockheed Martin, Maxar, and insurers like AXA.

Compliance progress is further encouraged because as commercial actors, CONFERS members are driven by a logic of sustaining their activities in line with the best practices, making them fast learners and favoring compliance. Reesman et al. note that in other industries like airlines, construction, food or fashion, complying with sustainable best practices brings additional benefits such as higher company credibility, reputational benefits, social capital.[610] The Consortium's consensual standards agreed so far therefore represent compliance progress among the satellite servicing industry, and progress for debris

[610] Rebecca Reesman, Michael P. Gleason, Layla Bryant, Colleen Stover, "Slash the Trash: Incentivizing deorbit", Aerospace Corporation Center for Space Policy and Strategy, https://aerospace.org/sites/default/files/2020-04/Reesman_SlashTheTrash_20200422.pdf, (accessed June 2, 2020), 8.

governance as an additional instrument, besides other industry-involving initiatives such as the Space Safety Coalition best practices also covered in this dissertation.

The CONFERS initiative bears the mark of direct epistemic community members influences over the shaping of this partial debris instrument, especially from the LTS and group and with DEB influences and some AC inherited ideational influences. The shared ideas found in the CONFERS Guidelines and practices as explained above entail expanding aspects of debris mitigation and long-term sustainability shared ideas, such as the emerging services in orbit known as OOS and RPO and operation, still belonging to the overall DEB and LTS shared ideas of the respective debris mitigation and long-term space sustainability epistemic communities. Some AC ideas mentions have been found similarly to AC ideas diffused into the main debris mitigation instruments, which the CONFERS members are encouraged to observe.

Arguably, arms control ideas are found under the CONFERS Guiding Principles of 2018 and the CONFERS Recommended Practices for Design and Operations of 2019 as shown in Table 6-2. Some arms control ideas of restraint are included in the “intentional” provisions under the UN, IADC and ISO and ECoC as main debris instruments, and cover anti-satellites activities even co-orbital ASATs. The CONFERS instruments while not using the “intentional” wording, also entail such an “intentional” provisions expressing restraint ideas. CONFERS thus further illustrates the legacy of the AC group’s earlier involvement over the foundational space governance treaties and during the 1980s illustrated in Figure 6-1 as well under CONFERS’ Guiding Principles provision “III, b) avoiding collision(s) and generating space debris" and the provision "1.4.2. Avoid physical or electro-magnetic interference" of the Operational *Practices* document. This section specifies the following aims:

> "Avoid physical or electro-magnetic interference: In addition to coordination of RPO and OOS activities with client space objects, servicers should also exercise all reasonable measures to avoid physical or electromagnetic interference with other sanctioned space activities during all operational phases. Servicers should take reasonable measures to ensure that other entities (i.e., Entities not associated with the RPO/OOS activities) that may have reason for concern about intentions or interference due to proximity are provided adequate notice."[611]

This provision detailing collision avoidance comes with transparency aspects clarifying the intent of operations. This recommendation mitigates risks of misinterpretation especially in close proximity operations where satellites come close to each other during these RPO/OOS activities. The CONFERS On-Orbit Servicing (OOS) Mission Phases document also contains a transparency provision:

> "3.5 Inform and Coordinate with other stakeholders as appropriate: The Servicer and Client ensure necessary regulatory bodies and reasonably affected space actors are informed of the plan and intentions to the level of detail required to provide adequate transparency."[612]

These transparency provisions also count as a form of restrain under arms control idea, since close proximity operations can easily create collisions in orbit, resulting in physical harm and debris creation.

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[611] "CONFERS Recommended Design and Operational Practices," Consortium for Execution of Rendezvous and Servicing Operations, https://www.satelliteconfers.org/publications/ (accessed March 8, 2021), 3.
[612] "CONFERS On-Orbit Servicing (OOS) Mission Phases," Consortium for Execution of Rendezvous and Servicing Operations, 1 October 2019, https://www.satelliteconfers.org/publications/ (accessed March 8, 2021), 2.

The shared ideas of the Long-Term Sustainability group are expressed in the last provision of the Operating Principles, which specifies that:

> "4.2. To the extent allowed by law, collaborate with State authorities and the broader space community to identify emerging space sustainability challenges and participate in the development of future guidelines and standards that enhance space sustainability."[613]

This provision shows that CONFERS is not only a forum where learning by normative diffusion happens from ideas contained in other instruments and of earlier epistemic groups influences, but in turn, it is meant as a complementary debris governance platform conducive to epistemic dynamics, encouraged to shape debris governance further with policy innovations, adaptation further promoting these ideas and norms.

An interesting feature of the CONFERS industry initiative is that member states cannot become formal members, because it is composed of industry, academic research institutes and other non-governmental organizations. Governmental actors can however contribute by sending experts in technical workshops in their individual capacities,[614] conducive to epistemic knowledge growth and to direct influence of knowledge experts in this building process. Direct influence of the DEB and LTS epistemic communities are found under the CONFERS example.

Indeed, the promotion of ideas and norms has been facilitated by members of CONFERS belonging to the DEB and LTS epistemic communities, such as the administrator of the

[613] "CONFERS On-Orbit Servicing (OOS) Mission Phases," Consortium for Execution of Rendezvous and Servicing Operations, 1 October 2019, https://www.satelliteconfers.org/publications/ (accessed March 8, 2021).
[614] Brian Weeden, "Update on the Consortium for Execution of Rendezvous and Servicing Operations, (CONFERS)," Japan Space Forum SSA Symposium, Tokyo, Japan February 27-28, 2020, https://swfound.org/media/206949/bw_confers_jsf_feb2020.pdf (accessed April 10th, 2020), 11.

initiative and some of the membership partners. Regarding members, Astroscale CEO Nobu Okada has himself been acting as an active promoter of DEB and LTS norms and shaper of debris governance or wider sustainability governing instruments as seen under the Space Safety Coalition section of this thesis. Similarly, Daniel Oltrogge of AGI another member of CONFERS has also been actively participating in promoting these same sets of shared ideas pertaining to DEB and LTS as a member himself also of these two groups. And lastly, as part of the managing team under CONFERS, acting as its Executive Director, Brian Weeden of the SWF is also an epistemic community expert of the DEB and LTS groups, as explained under the SSC section.

These individuals are examples of driving epistemic community members actively involved in this process of shaping debris governance instruments facilitated under several fora such as here under CONFERS, as well as under SSC, or SSR as well. They know each other by meeting regularly under for a such as the IAC meetings, IAF meetings, presenting at debris many and sustainability conferences sessions, reporting at UN COPUOS sessions, as organizers of summits workshops or conferences, and sometimes as initiators of policy innovative concepts.[615] Their peer validity is recognized under the IAF platform including IAA debris working groups or as Vice President in one of the IAF board for Okada. The role of these experts to consolidate debris governance and shape its instruments has been observed under CONFERS as facilitators of working groups discussions. This example shows Okada being an executive of the commercial sector, acting as an active epistemic community

[615] Examples for Okada of Astroscale include his contribution to the Space Sustainability Rating initiative under the World Economic Forum.

member not only promoting of DEB and LTS ideas but also contributing directly to shaping new instruments for debris governance.[616]

5.3.2 UN progress steps in the 2010s

This section presents debris governance progress at the UN-level in the 2010s, as an additional recommendation under the report of the UN Group of Governmental Experts (GGE) of 2013 and the emergence of the LTS Guidelines under the Committee of the Peaceful Uses of Outer Space.

The Long-Term Sustainability of Outer Space Activities" initiative at the UN

Launched in the late 2000s under the UNCOPUOS and covered in the previous section, the Long-Term Sustainability (LTS) Initiative, reached significant progress in the 2010s thanks to the work of its dedicated working group started in 2010, similarly to the debris governance process, which generated the COPUOS Debris mitigation guidelines. The research found that the progress steps of LTS contributed to consolidate debris governance as well, especially thanks to several steps of consensus reached on guidelines during this decade. In this decade of the 2010s, the Long-Term Sustainability of Outer Space Activities initiative (LTS) achieved consensus on a great number of best practices guidelines, highlighting normative, policy, institutional and compliance progress steps also affecting debris governance, as explained below.

[616] Members of the private sector have been involved as engineers from research and development and software firms making calculations and contributing with their technical knowledge to DEB ideas as consultants and non-space agency people and norm promotion in other cases, under ISO efforts, under IAA studies. Finkelman, McKnight and Oltrogge are a few of such examples.

Normative

The LTS guidelines agreed-to in 2016 and 2018-2019 represent normative consolidation steps for debris governance, reinforcing ideas present in the existing debris instruments, and complementing them with additional ideas to improve debris mitigation not covered in these instruments. For instance, some of the space debris provisions under the agreed LTS guidelines also cover space weather aspects, sustainability on Earth aspects and take regulatory measures one step further than the main instruments of COPUOS and IADC while the seven remaining draft guidelines also cover additional aspects such as Rendezvous and Proximity Operations (RPO), Active Debris Removal (ADR), cyber interferences and environmental modification techniques. The broader approach to debris issues under the LTS guidelines therefore helps to grow normative support for additional debris mitigation ideas and to consolidating existing debris norms already present in the existing debris instruments mentioned in Table 6-1.

Also, the recent agreement to make LTS a permanent agenda item, to continue negotiations on the remaining draft guidelines, and to include in the next LTSWG the goal of shaping recommendations for large constellation operations also represent normative progress for debris governance efforts. This COPUOS LTS initiative helps as a norm consolidation effort to strengthen again at a higher political level the latest debris mitigation idea present in the 2020 revised IADC Guidelines, and as supporting effort to other NGO fora best practices instruments entailing the large constellation provisions.[617] This is a similar

[617] One example is the Space Safety Coalition's agreement of 2019.

process observed in the 2000s when COPUOS Debris Mitigation Guidelines helped strengthen the norms codified in the first IADC 2002 guidelines, highlighting the COPUOS forum's role as a supportive institution to epistemic influences and to increase normative progress for debris governance in the 2010s decade as well. Sustainability ideas also are found at ITU, as noted in an interview of Peter Martinez about ITU and newcomers and sustainability, as diffusion of LTS ideas guidelines to ITU.[618]

Policy

Firstly, during the 2010s, the LTS initiative helped to further fill the policy gap in debris governance by providing an additional debris mitigation instrument further codifying debris mitigation ideas and norms. Indeed, also containing debris-relevant provisions, the LTS guidelines adopted by consensus at COPUOS in June 2019 by more than 90 countries[619] are further consolidating the earlier achievements of debris governance expressed by the body of basic provisions, partial and comprehensive international debris mitigation instruments mentioned in Table 6-1. The fact that these additional guidelines were agreed-to at the high political level of the UN COPUOS strengthens the value of this policy progress step. A first milestone was achieved in 2016 with an agreement on twelve guidelines by over 80 member-states.[620] A second milestone was reached in 2018 when a consensus built up on nine

[618] https://news.itu.int/safe-and-sustainable-space/ (accessed June 23, 2021).
[619] As at June 2019, COPUOS membership included 92 member states, 95 after December 2019 https://www.unoosa.org/oosa/en/ourwork/copuos/members/evolution.html(accessed July 28, 2020).
[620] 2016 first set of 12 guidelines approved (A/71/20, annex)

additional guidelines and a preamble,[621] which was confirmed by a third milestone in 2019 when the preamble and the total of twenty-one guidelines were adopted.[622]

Secondly, the agreements to continue with a new working group labelled 2.0" in reference to the new 5 years LTS WG[623] also represents a policy progress as it encourages further policy coordination to occur and positively affect debris governance efforts. Also, from being a temporary agenda item in the previous decade when work on the LTS initiative started, LTS became a permanent agenda item at the COPUOS in 2018,[624] marking a further policy step allowing for further institutionalization of the debris-relevant ideas codified in the main debris instruments already and further institutionalized under the LTS guidelines. The mandate of the new working group will focus on the remaining seven draft guidelines, on the implementation of the other 21 agreed guidelines, and include the large-constellation operations as well.

Regarding the debris provisions entailed in the 21 LTS guidelines, they are found especially under category B, which was the thematic priority for "Space debris, space operations, and tools to support collaborative space situational awareness", as well as in other guidelines, such as under categories A and D as presented in more details in the ideas-section below. The debris relevant LTS guidelines represent policy progress as additional

[621] 21 guidelines and the preamble were reaching consensus (A/AC.105/1167, annex III)

[622] June 2019, the 21 guidelines and preamble were adopted at COPUOS (A/74/20 annex II)

[623] Peter Martinez, "First Fruits of the Long-Term Sustainability discussions in UN COPUOS: From guideline development to guideline implementation."

[624] Guidelines for the Long-term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space A/74/20, para 163 and Annex II. The 21 adopted guidelines document for 2019: adoption by the Committee at its sixty-second session of the Guidelines for the Long-term Sustainability of Outer Space Activities (A/74/20, annex II), https://www.unoosa.org/oosa/en/oosadoc/data/documents/2019/a/a7420_0.html (accessed July 28, 2020).

contributions to improving debris governance in support of existing debris mitigation efforts, further codifying the debris mitigation ideas, which have been consolidating for decades, and reinforcing especially better information exchanges about space objects, measures to prevent or reduce collision risks as well as regulatory upgrades.

Thirdly, as the LTS guidelines include space debris as part of a more comprehensive approach to space sustainability, they also provide a few policy innovations which complement the main debris instruments. For instance, the LTS guidelines adopted in the 2010s cover additional aspects such as space weather, sustainability on Earth and regulatory enhancements. Thus, the succeeding agreements on the guidelines from 2016 to 2019 and the continued work on the seven draft guidelines addressing even more gaps of the main debris instruments, all highlight policy progress for debris governance during the 2010s decade.

The policy innovations under the agreed 21 LTS guidelines are found in the B series augmenting existing debris instruments by adding aspects non covered in the main instruments such as pre-launch conjunction assessment (B.5 Develop practical approaches for pre-launch conjunction assessment), space weather effects forecasting (B.6 Share operational space weather data and forecasts and B.7 Develop space weather models and tools and collect established practices on the mitigation of space weather effects), or harm from laser-beam use (B.10 Observe measures of precaution when using sources of laser beams passing through outer space). Guideline A.5 for improving registration of space objects could arguably also count as policy progress.[625]

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625 A/AC.105/2018/CRP.20.

The policy innovations addressed by the seven remaining LTS draft guidelines cover other gaps of the existing debris mitigation instruments such as ensuring responsible behavior and best practices for Active Debris Removal (ADR) operations, Rendezvous and Proximity Operations (RPO) operations, environment impacting operation included under the ENMOD Convention - Preventing environmental modification techniques - and for cyber-attacks on space operations.

The third of the seven LTS remaining draft guidelines concerns active debris removal operations (ADR), complementing the other main debris mitigation instruments such as the IADC Guidelines and the COPUOS Guidelines not covering this aspect of space operations. Specifically, draft guideline 3 calls on signatories to adopt a responsible behavior in the planning and operational phases of ADR operation: "Observe procedures for preparing and conducting operations on active removal [and intentional destruction] of space objects"[626]

The fifth of the seven-remaining draft LTS guidelines "in progress" and representing a policy innovation for debris governance concerns the Rendezvous and Proximity Operations (RPO) for instance covers new types of operations not yet included in the main debris instruments of IADC, COPUOS Debris Mitigation Guidelines and ISO standards. Draft guidelines 5 calls on states to adopt responsible behavior for RPO such as: "Observe measures for the safe conduct of proximity space operations".[627]

[626] Thomas Schildknecht, "Working Group on the Long-term Sustainability of Outer Space Activities, Report to IAA Space Debris Committee", October 19, 2019, COPUOS, A/AC.105/2018/CRP.21, 9.
[627] Schildknecht, "Working Group on the Long-term Sustainability of Outer Space Activities, Report to IAA Space Debris Committee", October 19, 2019, COPUOS, A/AC.105/2018/CRP.21, 9.

The sixth of these seven guidelines left to be agreed upon and representing a policy innovation for debris governance concerns environmental modification techniques. It proposes to extend the scope of the 1970s ENMOD Convention to include peaceful uses in addition to military purposes present in the original convention. In particular, this guideline calls on nations to: "Observe measures of precaution when using of natural space environment modification techniques for peaceful purposes."[628] This draft LTS guideline fills a gap of the ENMOD Convention signed in 1977 for debris mitigation purposes. Indeed, deemed as a suitable debris mitigation piece of legislation by Baker in 1989, and Stubbe in 2017, it was considered flawed by the limitation of the banning of environmental modification techniques to military uses only and not covering the peaceful uses.[629] The draft LTS guidelines would therefore fill this policy gap in the scope of this instrument and enhance its value as a partial debris mitigation provision.

The seventh LTS draft guideline covers cyber-attacks and represents policy innovation as well compared with the main debris instruments not including any specific mention about such operations other than indirectly under the avoidance of harmful interferences. This draft guideline aims for states to:

[628] A/AC.105/2018/CRP.21, Conference room paper by the Chair of the Working Group on the Long-term Sustainability of Outer Space Activities "Draft guidelines for the long-term sustainability of outer space activities" 27 June 2018.

[629] Baker, *Space Debris: Legal and Policy implications*, 102 and 105; Stubbe, *State accountability for space debris*, 183; Reibel" Prevention of Orbital Debris" Proceedings of the 30th Colloquium on the Law of Outer Space, Brighton, UK, 1987, IISL 1988, 63.

> "raise awareness of the need to exclude the use of information and communications technology products compromising the safety and security of space objects and related equipment."[630]

Some additional policy progress steps affecting debris governance and worth mentioning under the LTS initiative in the 2010s relate to policy preferences changes on the part of two main space powers of Russia and the United States. In 2019, Russia switched from vetoing the 21 guidelines to support them while the United States started to support for LTS becoming an agenda item allowing for consensus and policy progress. As explained by space security expert and former UNIDIR director Theresa Hitchens in 2019,[631] these changes of policy preferences enabled great progress for the LTS guidelines and space sustainability governance. A landmark was achieved when Russia decided to support these 21 guidelines even if the remaining seven it proposed did not get agreed yet, and when the US agreed for the agenda item to be permanent. These policy changes observed under the LTS initiative process illustrate well the value of these LTS guidelines as a significant policy progress given that rival nations like Russia, the United States, China and even Iran all members of COPUOS have managed to agree on these 21 guidelines. Even if they could not agree yet on the remaining 7 draft guidelines entailing some security-sensitive aspects, they agreed on continuing to discuss them under a new working group and under a permanent agenda item, showing some progress.

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[630] Schildknecht, "Working Group on the Long-term Sustainability of Outer Space Activities, A/AC.105/2018/CRP.21, 9.

[631] Theresa Hitchens, "Fearing Isolation, Russia Caves on UN Space Guidelines," *Breaking Defense*, June 25, 2019, https://breakingdefense.com/2019/06/fearing-isolation-russia-caves-on-un-satellite-guidelines/ (accessed July 3rd, 2019).

Lastly, LTS guidelines also represent a form of policy progress for arms control issues even if the AC ideas are mostly implied and that the guidelines focus rather on space operations safety. As pointed by several experts over the years, LTS guidelines count as a transparency and confidence building measure (TCBM),[632] similarly to other instruments with provisions calling for avoiding intentional debris creation including space weapons test as seen in Table 6-2, such as COPUOS Debris Mitigation Guidelines for instance. TCBM are recognized by the UN as mechanisms promoting arms reduction and nonproliferation and can take the form of exchanges of information or strategic intentions, such as notification of space launches, the organization of space dialogues between strategic rivals.[633] TCBM include for instance : informational, consultative or notification requirements, some level of constraint or restraint mechanisms; and access measures such as on-site visits or access to information.[634] In this way, LTS guidelines expand COPUOS's role as an additional contributing forum for space TCBM-related issues.[635] The applicability of LTS guidelines as TCBM is further mentioned in the preamble under paragraph 13 referring to the UN GGE Report on TCBMs of 2013 and mentioning how these LTS guidelines can be seen as TCBMs

[632] Martinez et al., "Reflections on the 50th anniversary of the OST," *Space policy* 47 (2019), 30; Jana Robinson, "Transparency and confidence-building measures for space security" *Space Policy* 37 (2016), 138; Theresa Hitchens, "Fearing Isolation, Russia Caves on UN Space Guidelines," *Breaking Defense,* July 2019.
[633] Marchisio, "The Legal Dimensions of the Sustainability of Outer Space Activities," IISL 2012, 7 and Marchisio, "Space Security: Issues at Stake," *Space Policy* 33 (2015), 69; A. Vasiliev and A. Klapovsky, "Transparency and Confidence-Building Measures in Outer Space, in Building the Architecture for Sustainable Space Security" Conference Report, 30–31 March 2006: 139-143.
[634] Robinson, "Transparency and confidence-building measures for space security,"134.
[635] Marchisio, "The Legal Dimensions of the Sustainability of Outer Space Activities," 7 and Marchisio, "Space security Issues at Stake," *Space Policy* 33 (2015), 67-69; Hitchens, "Fearing Isolation, Russia Caves on UN Space Guidelines," *Breaking Defense*, July 2019.

as well.[636] Paragraph 10 of the LTS guidelines introduction concerns the avoidance of harm principle and also implies a level of restraint which counts as a potential TCBM.

In the adopted LTS guidelines text, arms control ideas are implied in the background, definition, objectives, and scopes of the guidelines under paragraph 10 and 13 especially[637] and under Guideline A.2. especially paragraph b) e) and f) calling on states to improve their national frameworks and observance of existing international debris mitigation instruments, which do contain a procedure limiting intentional long-lived debris creation. Guideline A.2 especially refers to COPUOS Debris Mitigation Guidelines (para b), NPS Principles (e), IADC Guidelines and ISO standard (f) containing one provision calling for restraint on intentional destructive behavior creating space debris. Therefore, this LTS guideline A.2 represents a policy consolidation of a limited arms control idea, namely intentional debris creation, found in all of the main international debris mitigation instruments, such as the IADC Guidelines, the COPUOS Debris Mitigation Guidelines, the ISO Standard 24113 and even the European Debris Mitigation Code ECoC as shown in Table 6-2.

Regarding the remaining 7 guidelines, the first LTS draft guideline contains an underlying space arms control (AC) idea, calling on member states to: "Provide, in national legal and/or policy frameworks, for a commitment to conducting space activities <u>solely for peaceful purposes.</u>"[638] This provision calls for a further commitment of nations to ensure an additional level of binding regulations at national level, to consolidate compliance with the existing international space treaties. The sustainability of space operations being increasingly

[636] A/AC.105/2018/CRP.20, 3.
[637] A/AC.105/2018/CRP.20, 1-3.
[638] A/AC.105/2018/CRP.21, 1.

threatened by space security tensions, this draft guideline encourages with stronger observance of peaceful space operations the limitation of space arms races and of risks of conflicts to erupt in outer space, concepts often referred to as “space weaponization”, representing therefore an arms control idea.

Another LTS draft guideline containing arms control ideas AC is the LTS draft guideline 3, referring to intentional destruction of space objects, calling on states to: “Observe procedures for preparing and conducting operations on active removal [and intentional destruction] of space objects.”[639] This draft LTS guideline covers the intentional destruction of space objects such as destructive anti-satellite activities, which recommends adopting a “responsible behavior”.

A last LTS draft guideline also entails an arms control idea, namely guideline 7, calling upon states to: “Raise awareness of the need to exclude the use of information and communications technology products compromising the safety and security of space objects and related equipment.”[640] This draft provision also tackles another aspect of space arms control idea not yet specifically addressed in the main existing international space debris mitigation instruments, in particular, the cyber-attacks only covered under harmful interferences in general terms. Indeed, these “information and communications technology products” are a form of non-kinetic counterspace operation,[641] which include cyber-attacks

[639] Schildknecht, “Working Group on the Long-term Sustainability of Outer Space Activities, A/AC.105/2018/CRP.21, 9.
[640] Schildknecht, “Working Group on the Long-term Sustainability of Outer Space Activities, A/AC.105/2018/CRP.21, 9.
[641] For more details on Cyber Counterspace Capabilities see Samson and Weeden, eds. “Global Counterspace Capabilities: An Open-Source Assessment,” Secure World Foundation, April 2020, 125.

also counting as a military attack indicative therefore of the arms control aspect of this draft guideline.

Institutional

Following a first debris mandate under the dedicated working group "Space Debris Mitigation Guidelines Working Group" established in the 1990s and active in the 2000s under COPUOS STSC, the Long-Term Sustainability Working Group represents another debris governance mandate in the 2010s decade, further consolidating the role of COPUOS. Indeed, the United Nations Committee on the Peaceful Uses of Outer Space as a major space debris governance actor achieved the successive agreements on LTS guidelines in 2016 and 2018-19, permanent agenda item status and latest mandate LTS 2.0 as institutional progress steps for debris mitigation efforts. The steps in the 2010s consolidated the role of COPUOS as a supporting forum conducive to epistemic influences of especially the DEB and LTS groups, facilitating the shaping of debris governance tools thanks to international policy coordination, and generating governance progress with debris and sustainability instruments. The supporting role of COPUOS as a contributing forum to enhance space safety and sustainability is also noted by Jim Green in 2018[642] and Peter Martinez in 2019.[643]

Compliance

[642] Statement by Dr. Jim Green, U. S. Representative to the 61st Session of the UN Committee on the Peaceful Uses of Outer Space on Agenda Item 6, "UNISPACE+50 National Statement", June 20, 2018, https://vienna.usmission.gov/statement-by-dr-jim-green-u-s-representative-to-the-61st-session-of-the-un-committee-on-the-peaceful-uses-of-outer-space-on-agenda-item-6/ (accessed July 22, 2021).
[643] Peter Martinez, "First Fruits of the Long-Term Sustainability discussions in UN COPUOS," 8.

The agreement on 21 LTS guidelines was reached at COPUOS by 92 member states,[644] composed of the main space-faring nations and many more representing a compliance support step for debris governance. As noted by Peter Martinez former Chairman of the LTSWG in 2019, there has been much greater interest displayed by nations to join efforts in support of LTS, and even prior to the starting of LTS 2.0, some nations have already reported to COPUOS on their efforts to implement the 21 agreed guidelines.[645] This is illustrative of the social pressure already exerted by the LTS guidelines towards normative and compliance improvements and since these guidelines involve many debris mitigation aspects this evolution highlights the presence of some level of compliance progress with debris governance measures achieved thanks to the LTS initiative by the end of the 2010s.

The LTS initiative is another example of epistemic communities' members direct contribution to debris governance in the shaping of debris mitigation provisions and instruments. The preparation of the LTS proposal under the UN COPUOS represents a turning point for the emergence of the LTS group as a result of DEB group members initiatives and involvement. The LTS group took shape at the end of the 2000s decade with the beginning of the LTS initiative at COPUOS and of other emerging initiatives in the mmid-2000s at the NGO level such as the IAASS, Secure World to name only a few as more will emerge by the end of the 2010s. The membership of LTS will grow and include as other groups space scientists and engineers, lawyers and political scientists and even

[644] A/74/20, 4.

[645] Peter Martinez, "First fruits of the Long-Term Sustainability discussions in UN COPUOS: From guideline development to guideline implementation," Paper IAC-19-E3.4.1 presented at the 70th, International Astronautical Congress (IAC), Washington D.C., United States, 21-25 October 2019 (published by IAF), 4 and 8.

businessmen.[646] As noted in Table 6-3, Gérard Brachet, Peter Martinez, Kai-Uwe Schrögl and Ram Jakhu were early members of the newly forming LTS group. They were involved in or led the first initiatives consolidating the LTS group across UN COPUOS, IAA, IAASS, involving ESPI and SWF fora. Schrögl and Brachet were involved in a study on space traffic management under IAA, Ram Jakhu was involved in another space traffic management covering also aspects of debris and sustainability under IAASS published by ESPI together with Schrögl and published by ESPI, [647] and several of the early members of the DEB group and emerging LTS group were involved under a 2008 conference co-organized by IAA, ESPI and SWF, whose findings led to a book publication.[648] From his time as Director of the European Space Policy Institute (ESPI) from 2007 until 2011 further publications promoted debris mitigation and LTS ideas in the late 2000s.[649] These studies were the starting point for

[646] Nobu Okada became an LTS and DEB members in the late 2010s, joining other representatives of the corporate world, for instance among the managers of satellite operator who started promoting LTS and DEB ideas for better practices such as One Web with managers promoting ideas in press interviews and joining IAC debris sessions as speakers promoting better standards since the mid-2010s.

[647] IAASS working group ICAO for space book published by ESPI, Schrögl as president of ESPI was member of the WG and facilitated the promotion of DEB and Sustainability under his presidency of ESPI from 2007 to 2011 the nascent period for the emergence of the LTS group and later in the 2010s during the consolidation of the LTS group as chair of the LSC subcommittee at COPUOS from 2014 to 2016. Jakhu and Schrögl got even more involved in promoting DEB ideas. Schrögl belongs to several epistemic groups and increased his participation further in debris-related initiatives and discussions in the 2000s as President of ESPI, publishing also on space sustainability, and joining in working groups in some IAA debris-covering reports such as the IAA 2006 Cosmic Study, or the IAASS "An ICAO for Space" Working group together with Ram Jakhu another debris expert and member of several groups, namely DEB and later LTS.

[648] The members included Perek, Williamson, Brachet, Schrögl.

[649] The UN Committee on the Peaceful Uses of Outer Space: Adoption of the Resolution on Enhancing Registration Practice and of the UNCOPUOS Space Debris Mitigation Guidelines, in: *Zeitschrift für Luft- und Weltraumrecht (Journal of space law)* (57, 3) 2008, 335-353 (Marietta Benkö/Kai-Uwe Schrögl). In the 2010s, Schrögl keeps publishing "The 2007 Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space (COPUOS SDM Guidelines)", in: Stephan Hobe, Bernhard Schmidt-Tedd, and Kai-Uwe Schrögl (eds.): Cologne Commentary on Space Law, vol. 3 Principles and Resolutions, (Köln: Carl Heymanns Verlag, 2015), 605-657, (Peter Stubbe/Vladimir Kopal/Kai-Uwe Schrögl/Alexander Soucek).

Brachet to initiate the LTS work at COPUOS.[650] Other examples of LTS members who were also promoting debris mitigation ideas include Ray Williamson and Sergio Marchisio who became LTS members and also actively promoted space sustainability ideas by chairing discussions under conferences or coordinating initiatives,[651] publishing group studies reports, book series or papers.

Gérard Brachet was involved as a debris expert under IAA studies in the 2000s. As former CNES Director General he signed the European Code of Conduct for Space Debris Mitigation (ECoC) in the first half of 2000s, and then proposed the Long-Term Sustainability Working Group (LTSWG) initiative at UNCOPUOS during his time as chairman. Peter Martinez, in his time as the first chairman of the LTSWG was also a member of the IAA and published about space debris. He keeps promoting LTS shared ideas in his current executive director position at Secure World Foundation, a private organization whose' mandate is devoted to space sustainability issues. Ram Jakhu was part of a working group under IAASS on space traffic management whose report led to an IAASS Manifesto promoting space sustainability, published on debris issues since the 1980s and 1990s, co-organized an International Interdisciplinary Congress involving McGill University and is also involved in IAA working groups covering debris and sustainability issues.

Brachet and Martinez where the leading figures promoting the DEB and LTS ideas also beyond COPUOS at international conferences such as the IACs and in peer-reviewed publications.

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[650] Brachet, 'The Origins of the "Long-term Sustainability of Outer Space Activities" Initiative at UN COPUOS,'161.

[651] Marchisio was coordinator for the EU ICoC initiative from 2008.

Sergio Marchisio also promoted debris mitigation ideas and the new LTS more comprehensive ideas as a member of both DEB and LTS groups, as well as of the AC group, and he heads the group on regulatory aspects under LTSWG. Richard Crowther a validated debris expert member of the IAA Permanent Debris Committee and involved with European efforts under ECoC and ECSS and under IADC as chairman is heading the debris group under LTSWG also further promoting DEB ideas under LTSWG and working to consolidate debris governance and increase space sustainability. These experts of DEB and LTS have been working together also under the GGE on TCBM group, which led to the 2013 report also promoting their shared ideas and have published and diffused them in international conferences fora such as IAC as mentioned in other sections of this these, highlighting the strong direct epistemic involvement of these communities for the LTS guidelines example.[652]

Involvement of the other AC group is also found in the comprehensive LTS guidelines, yet the diffusion process occurred more indirectly, as a heritage from earlier influences which lead to provisions in the existing debris instruments after basic space governance provisions and perdure especially as draft guidelines by reference to earlier achieved provisions mentioned in the LTS guidelines. It is important to note that most of the members of the LTS group share and promote DEB and AC group ideas, and especially DEB members most of them share the inherited AC ideas which diffused into space governance since the 1960s. The research found that in the late 2010s, the epistemic influences AC are expressed by the

[652] Martinez, Peter, Richard Crowther, Sergio Marchisio and Gérard Brachet, "Criteria for developing and testing Transparency and Confidence-Building Measures (TCBMs) for outer space activities," *Space Policy* (2014), http://dx.doi.org/10.1016/j.spacepol.2014.03.006 (accessed 2April, 23,2014).

ongoing legacy of earlier achieved instruments which are referred to in the LTS guidelines such as IADC guidelines, COPUOS guidelines and other treaty provisions.

In terms of the shared epistemic ideas found in the Long-Term Sustainability Guidelines, the presence of the three epistemic groups DEB, AC and LTS are found and highlight a strong epistemic influence over the achievement of this outcome. Indeed, from the analysis of the preamble, the 21 guidelines and the 7 proposed draft guidelines, the study observed the presence of all these influential ideas of DEB and LTS being codified under these guidelines, as well as Arms Control, as presented below.

Arms Control (AC)

Arms control ideas have been found both in the core text of the COPUOS 21 agreed guidelines indirectly, and directly in the 7 draft guidelines which remaining to be agreed-upon.

The core text mentions arms control ideas indirectly by way of reference to earlier space governance or debris governance instruments in some paragraphs, such as in the background, definition, objectives, and scopes in paragraphs 10 and 13 under Guideline A.2 especially paragraph b), e), and f),[653] calling on states to improve their national frameworks and observance of existing international debris mitigation instruments which do contain intentional provisions.

Firstly, A.2 paragraph 10 reminds that the LTS guidelines intend to help parties to cooperate in order to reduce harmful interferences.

[653] A/AC.105/2018/CRP.20, 1-3.

"A.2 §10; […]to a minimum or, as feasible, avoids causing harm to the outer space environment and the safety of space operations"[654]

The harmful behaviors to be avoided include intentional space debris creation resulting in pollution, interferences, and potential collisions, thus, paragraph 10 arguably calls for some degree of restraint expresses arms control ideas in outer space.

Secondly, A.2 paragraph 13 mentions the UN GGE Report on TCBMs of 2013 and posits that the LTS initiative could represent a transparency and confidence-building measure as well, which is an arms control tool relating to the Prevention of an Arms Race in Outer Space (PAROS) efforts:

> "A.2 §13. The guidelines duly take into account the relevant recommendations contained in the report of the Group of Governmental Experts on Transparency and Confidence-Building Measures in Outer Space Activities (A/68/189) and could be considered as potential transparency and confidence-building measures."[655]

Moreover, Guideline A.2 refers to COPUOS Debris Mitigation Guidelines (para b), *NPS Principles* (e), IADC Guidelines and ISO guidelines (f), three of them containing the restraint provision on intentional destructive behavior creating space debris, shortened as "intentional" provision in this study, as illustrated in Table 6-2. Therefore, LTS Guidelines signatories would also indirectly observe the arms control provision contained in these instruments.

Lastly, the 7 draft guidelines address potential debris creating activities, which could cause debris proliferation resulting from intentional and irresponsible behaviors in space

[654] A/AC.105/2018/CRP.20, 2-3.
[655] A/AC.105/2018/CRP.20, 3.

operations, relating them to the security-related aspect of debris mitigation efforts, and underlying a presence of arms control ideas.

Debris Mitigation (DEB)

Debris mitigation ideas DEB are largely found in the LTS guidelines both within the 21 agreed guidelines and in the draft guidelines in an indirect way as the draft guidelines. Among the 21 agreed guidelines, DEB ideas are most evident in the guidelines of group B, which was the focus group of space debris experts from 2012 to 2014.[656] Especially guidelines B 1 to B.10 deal with space operations safety and measures to minimize debris creating risks by avoiding collisions especially with better information exchanges and notifications.

The main focus of these guidelines B1 to B10 are as follows: Guideline B.1: Provide updated contact information and share information on space objects and orbital events; Guideline B.2: Improve accuracy of orbital data on space objects and enhance the practice and utility of sharing orbital information on space objects; Guideline B.3: Promote the collection, sharing and dissemination of space debris monitoring information; Guideline B.4: Perform conjunction assessment during all orbital phases of controlled flight; Guideline B.5: Develop practical approaches for pre-launch conjunction assessment; Guideline B.6: Share operational space weather data and forecasts; Guideline B.7: Develop space weather models and tools and collect established practices on the mitigation of space weather effects; Guideline B.8: Design and operation of space objects regardless of their physical and operational characteristics; Guideline B.9: Take measures to address risks associated with

[656]Group B - Space debris, space operations, and tools to support collaborative space situational awareness.

the uncontrolled re-entry of space objects; Guideline B.10: Observe measures of precaution when using sources of laser beams passing through outer space.[657]

DEB ideas are also found as references to debris mitigation instruments and basic space governance provisions in LTS guidelines A.2, A.4, A.5, guideline A.4 ITU Constitution, Radio Regulations and ITU-R, guideline A.5 Outer Space Treaty and Registration Convention, recalling debris mitigation instruments both and comprehensive ones, and in guideline D. 2. calling for further research and development affecting debris knowledge and efforts.

Lastly, DEB ideas are also implied under the seven remaining LTS draft guidelines, as all of them consist in preventive measures either avoiding bad behaviors which could potentially create additional space debris or calling for increased observance of best practices or responsible behaviors. This above illustration of the presence of debris ideas in more than half of the LTS agreed guidelines confirms the influence of the debris ideas and governance model in shaping the LTS effort helping progress towards space sustainability.

Overall concerning the ideas found, the solid presence of DEB ideas together with an underlying presence of AC ideas within the LTS guidelines illustrate once more the finding of this study that the DEB epistemic group has facilitated LTS ideas emergence and has also benefitted from ideational diffusions of the AC group into space governance basic provisions, and into debris instruments. Debris governance outcomes and the DEB group have acted as catalyzers space sustainability progress, observed with the agreement of these additional LTS guidelines. This process of pluri-epistemic influences or “epistemic group dynamics” over

[657] A/AC.105/2018/CRP.20, 10-17.

space sustainability progress found for the 2010s involved the two groups of DEB and LTS as main actors, with some underlying inherited influence of the AC group.

U.N. Group of Governmental Experts Recommendations 2013

The United Nations Group of Governmental Experts (GGE) report on Transparency and confidence building measures for outer space of 2013[658] is another example of direct influence of epistemic communities affecting debris governance. This GGE study group emerged in response to significant changes observed in the space policy context of the early 2010s. The need for policy analysis came especially from additional uncertainties deriving from increased threats to space sustainability due to the growth of space technology uses for an increasing number of strategic activities and by an increasing number of actors both private and governmental, including emerging space-faring nations.[659] Conducted from 2012 to 2013, the report produced several recommendations on TCBMs with one specifically including space debris issues. The GGE 2013 report recommendations represent normative, policy, and institutional progress steps for debris governance during the 2010s as will be explained below.

Normative

The GGE report recommendations of 2013 represent a normative step for debris governance efforts in the 2010s. The report illustrates direct epistemic communities'

[658] "Report of the Group of Governmental Experts on Transparency and Confidence-Building Measures in Outer Space Activities" A/68/189, June 2013.
[659] Report of the Group of Governmental Experts on Transparency and Confidence-Building Measures in Outer Space Activities" A/68/189, June 2013, 5.

involvement in diffusing ideas into another discussion forum under the UN and its GGE report existing debris and sustainability ideas towards becoming stronger norms. reinforcing the debris mitigation norms into the working group working directly on shaping the recommendations. There were especially two epistemic groups represented within this 2013 GGE on TCBMs report, namely the DEB epistemic group and the LTS epistemic group best represented by the GGE members Gérard Brachet, space debris, space security and long-term sustainability key expert, Sergio Marchisio.

Some of these debris mitigation ideas diffused by these epistemic experts into the GGE were already codified into earlier debris mitigations instruments such as the IADC Guidelines and the COPUOS Debris Mitigation Guidelines, with which the report encourages states to conform.

The GGE 2013 report considers norms of "behavior for spaceflight safety" as a transparency and confidence-building measure, defining these norms as a set of "launch notifications and consultations that aim at avoiding potentially harmful interference, limiting orbital debris and minimizing the risk of collisions with other space objects" as mentioned in paragraph 27 e). These measures cover a wide scope of debris mitigation ideas and support the notion of a code of behavior or code of conduct reinforcing the normative progress nature of the GGE report as reminded by Brachet.[660]

The report also calls upon signatories to notify other nations in case of risky scheduled maneuvers under para.42, in case of risky uncontrolled re-entries in para. 43, in case of emergencies following malfunctions, loss of control or hazardous re-entries including

[660] Gérard Brachet, "The Security of Space Activities," *EU Non-Proliferation Papers* no. 51 (July 2016), 8.

potential radioactive contamination in para. 44 and in case of intentional orbital break-ups under para. 45. These provisions address debris mitigation ideas already found in most of the other international and national instruments which have been emerging in the previous decades, thus further consolidating the growing body of debris mitigation ideas and norms.

Moreover, the GGE report's paragraph 45 on intentional aspects is of particular importance as a normative progress step during the 2010s decade as the basis upon which other recent efforts were built such as the proposal for a limited ASAT-ban treaty by UNIDIR and is deemed as a help towards consolidating this aspect of the debris mitigation norm covering restraint for anti-satellite weapons 's tests destructiveness.[661]

Policy

The GGE report of 2013 also highlights policy progress for debris governance, especially as two progress steps.

One step is reflected by the agreement between space powers with diverging views on PAROS, space security, acceptable norms of debris behavior or the idea for a code of conduct. After a long period of deadlock under the UN Conference on Disarmament of about two decades, these space nations were able to converge on these issues through the adoption of the GGE 2013 study, counting as the "first positive policy outcome in two decades" as pointed by Marchisio.[662] Also, as mentioned by Rose,[663] the GGE report even generated the

[661] UNIDIR, Daniel Porras, "Towards ASAT guidelines," 2018 space dossier file 2.

[662] Sergio, Marchisio, "The final frontier: Prospects for arms control in outer space," *Global Security Policy Brief*, July 2019, European leadership Network, 4.

[663] Frank Rose, "Safeguarding the heavens: the United States and the future of norms of behavior in outer space," *Brookings Policy brief*, June 2018, https://www.brookings.edu/wp-content/uploads/2018/06/FP_20180614_safeguarding_the_heavens.pdf (accessed July 2, 2020).

first U.N. General Assembly resolution on space security which was co-sponsored by the United States, Russia and China together, and calling on other nations to implement these recommendations. The fact that the recommendations in this report were agreed at the First Committee and the UN General Assembly level, at high international political level, also reinforces the value of this GGE report as a political progress step consolidating debris governance efforts.

The other policy step lies in the intentional provision found under paragraph 45 of the GGE 2013 report, representing an additional codification of this idea also present in the other existing instruments like IADC and COPUOS Guidelines also adopted by these same space powers of the US, Russia and China all members of both IADC and COPUOS, thus marking a further high-level political consolidation for debris mitigation efforts. Paragraph 45 of the GGE report of 2013 recommends the following:

"Notification of intentional orbital break-ups

> §45. Intentional destruction of any on-orbit spacecraft and launch vehicle orbital stages or other harmful activities that generate long-lived debris should be avoided. When intentional break-ups are determined to be necessary, States should inform other potentially affected States of their plans, including measures that will be taken to ensure that intentional destruction is conducted at sufficiently low altitudes to limit the orbital lifetime of resulting fragments. All actions should be carried out in conformity with the Space Debris Mitigation Guidelines of the United Nations as endorsed by the General Assembly in its resolution 62/217, entitled "International cooperation in the peaceful uses of outer space."[664]

[664] "Report of the Group of Governmental Experts on Transparency and Confidence-Building Measures in Outer Space Activities" A/68/189, (para 45), 17.

This GGE report example highlights the process of direct epistemic community influence in diffusing ideas which became part of the GGE report recommendations. Namely, the idea of "limiting intentional debris creation", which, as seen previously, is shared especially by the debris mitigation epistemic community, and was codified in the 1990s in debris instruments such as national space agencies standards of the US, Japan and France and even Russia as noted by Kato[665] and in the 2000s in the main international debris instruments of the IADC and COPUOS debris Mitigation guidelines and 2010s under ISO industrial standards as summarized in Table 6-2. This shared idea within the DEB group has been brought into the GGE 2013 report by several experts of the Debris epistemic community involved in the GGE study, especially by Gérard Brachet and Richard Crowther.

Institutional

The GGE 2013 report also represents a small institutional progress step as it consolidates the role of the UN forum as a debris governance entity. Indeed, the agreed report reminds that the UN body continues to contribute by further shaping debris governance efforts during the 2010s decade, besides its other ongoing effort with the COPUOS LTS working group including the debris issues as well and following earlier steps achieved during the 2000s such as the UNCOPUOS Debris guidelines of 2007.

Compliance

Arguably, the agreements made under the 2013 GGE report on TCBMs for outer space cover many debris mitigation aspects, including even the intentional destructive aspects

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[665] Akira Kato, "Comparison of National Space Debris Mitigation Standards." *Advances in Space Research* 28, no. 9 (2001): 1447-1456.

could be seen as a supporting outcome encouraging compliance with the debris mitigation norm. As seen in the behavior of space-faring nations observed following the 2007 Chinese test, all succeeding ASAT tests have been conducted either in lower orbits or without engaging targets in order to minimize or avoid creating long-lived debris as reminded in Table 1-4 and showing some increasing level of compliance with the norm of "more responsible ASAT tests."

The GGE report of transparency and confidence-building measures of 2013 contains the main shared ideas which have influenced the emergence and consolidation of debris mitigation ideas, efforts, and norms, namely the Debris Mitigation group ideas and Long-Term Sustainability ideas, and the Arms Control ideas.

The epistemic communities involved directly are especially the DEB and LTS groups, as observed from the mentioned governance progress steps above, and the AC group via indirect diffusion. In particular, the code of conduct is an idea discussed a lot under the space security debate and is a shared idea among the DEB members and among the LTS members. The intentional provisions shared by DEB and codified into the IADC, and COPUOS debris mitigation guidelines are also shared by LTS epistemic communities' members. The epistemic communities' members involved in the GGE report of 2013 are especially Brachet, Crowther, Martinez and Marchisio. All of these experts have been involved in debris efforts in a managerial role as seen throughout the thesis. Brachet as COPUOS Chairman, Crowther as IADC Chair, Martinez as LTSWG Chair, and Marchisio as leader of the ICoC negotiations. All are further promoting their shared ideas into the report under this UN group and publishing to promote this report outside of the UN GGE platform as well acting as norm promoters and policy coordination experts shaping recommendations affecting debris governance.[666]

Arms control (AC)

As a TCBM focused report aiming at helping towards the prevention of an arms race in outer space, the GGE report also contains arms control ideas. AC ideas diffused into the main space governance treaties and rules since the 1950s, especially reinforcing the norms of restraint from harmful interferences found in most space governance tools listed in Table 6-1. AC ideas are found under the GGE recommendations under paragraph 45 relating to debris mitigation and space safety efforts such as the avoidance of intentional destruction and harmful activities. The intentional destruction provision represents specifically a direct influence of the AC group observed over debris governance around ASAT testing limitations during the 1980s as explained earlier. Another component of AC ideas is also found in the recommendation for universal participation in, implementation of and full adherence to arms control treaties relating to space governance and other instruments containing arms control provision. These are expressing the legacy and heritage of arms control ideas diffusion and AC group influence over space governance instruments for many decades, such as in the Partial Test Ban Treaty of 1963, the Outer Space Treaty of 1967, and in the COPUOS debris mitigation guidelines of 2007 on pages 18 and 22.

Long-Term Sustainability (LTS)

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[666] Martinez, Peter, Richard Crowther, Sergio Marchisio and Gérard Brachet, "Criteria for developing and testing Transparency and Confidence-Building Measures (TCBMs) for outer space activities," *Space Policy* (2014), http://dx.doi.org/10.1016/j.spacepol.2014.03.006 (accessed 2April, 23,2014).

The GGE report also entails long-term sustainability ideas with references to the interest of protecting space for future generations on p 10 § 9 "safeguarding the use of outer space for [..]future generations," [667] and in numerous references to sustainability and the LTS initiative on p 2, on p 10 §10, on p 11 § 12, § 13, on p13 § 25, on p 14 §31, on p 22 § 72 indicating the support of the report for this initiative and the acceptance of LTS ideas as a norm under the GGE group forum, before the first COPUOS LTS guidelines were endorsed.

Debris Mitigation (DEB)

The debris mitigation ideas found in the GGE report are a set of risk reduction notification mechanisms found under paragraphs 42 to 45 comprising namely notifications on scheduled maneuvers that may result in risk to the flight safety of other space objects, notifications and monitoring of uncontrolled high-risk re-entry events, notifications in the case of emergency situations and notifications of intentional orbital break-ups.

The significance of finding the ideas of AC, DEB and LTS in this GGE report illustrate the respective epistemic groups' influences over shaping the GGE report and recommendations, as a debris governance tool. It strengthens one main and ongoing finding of this thesis research about the important role played by several epistemic communities and their experts in diffusing their respective shared ideas and helping to shape debris governance as a socially constructed global governance. The GGE on TCBM report of 2013 reflects the direct role of epistemic communities promoting their knowledge or constructed worldview

[667] A/68/189, 10.

about an issue area, here at the highest international political level under the UN, facilitating international policy coordination and debris governance progress.

5.3.3 Multi-lateral Governmental Initiatives progress outside of the UN 2010s

This section presents debris governance progress at the multi-lateral level outside of the Unites Nations in the 2010s, mainly as revisions of the 2002 IADC Space Debris Mitigation Guidelines and some continued European Union level efforts around the International Code of Conduct initiative launched in 2008.

IADC Progress in the 2010s

Following the urgency to address the emerging threats of large constellations in the 2010s, the IADC worked on a study released in 2013,[668] issued a statement in 2017 and revised its guidelines version of 2007 in March of 2020 filling knowledge, normative, policy, institutional and compliance governance gaps. The IADC updated version and statement further illustrate direct epistemic communities influences over debris governance here as drivers for upgrading the debris instrument of the IADC Guidelines, which they had helped shape during the consolidating phase.

Knowledge

IADC's latest developments, both the statement and the revised guidelines after more than ten years since the 2007 version reflect knowledge progress as they provide new information

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[668] J.-C. Liou, A.K. Anilkumar, B. Bastida Virgili, T. Hanada, H. Krag, H. Lewis, M.X.J. Raj, M.M. Rao, A. Rossi, R.K. Sharma, "Stability of the future of the LEO Environment," *6th European Conference on Space Debris*, Darmstadt, Germany, April 2013, (doi: 10.13140/2.1.3595.6487).

on the debris issues such as the uncertainties and threats creating pressure on the debris issue resulting from the exponential growth of large constellations in LEO over the past years,[669] an already crowded orbital region. As presented in the introduction of this thesis, the threat of debris proliferation from these constellations results from two aspects, the very large number of satellites, hundreds sometimes thousands of small satellites and of their lesser or absent maneuverability capabilities to avoid collisions due to their simpler technology nature. The Statement in 2017 was a first step recognizing the emergence of a new threat calling for a policy response, while the latest revision of the IADC Guidelines in 2020 incorporated the newly shaped debris mitigation knowledge or idea, namely that measures need to be taken to mitigate large constellations risks. This adaptative and evolutionary process occurring in debris governance at IADC is characteristic of the epistemic process of learning through constructing knowledge with experts' ongoing research and diffusion of findings process within IADC but also benefiting from inputs and exchanges with other fora also discussing debris governance issues. This process occurring at IADC also observed in other main debris governance fora such as ITU, ECSS, ISO in this thesis highlight these fora's contributions to knowledge progress steps for debris governance.

The shaping of this latest debris knowledge will in turn help normative and policy progress steps by promoting this idea as norm and codifying it into a consensually agreed-to international instrument in the IADC Guidelines latest version. A presentation by the IADC chair in 2016 provides a reminder of the enduring role of the committee as a contributor to

[669] Inter-Agency Space Debris Coordination Committee (IADC), "IADC Statement on Large Constellations of Satellites in Low Earth Orbit," IADC-15-03, September 2017, https://www.iadchome.org/index.cgi?item=docs_pub (accessed June 30, 2021).

debris knowledge and of shaping policy solutions in the 2010s decade. The concluding remarks stated the following: “IADC will continue to advance the knowledge of space debris and to develop environment management strategies to preserve the near-Earth space for future generations.[670]

These knowledge progress steps of the 2010s also attest of the long-term influence of the epistemic ideational process at the IADC level, which has been going on for three decades.

Normative

The IADC statement its 2020 revised guidelines provide a normative progress step for debris governance as a continued support and promotion of existing the debris mitigation ideas already codified in the earlier versions. An additional level of normative progress is also achieved by the IADC latest outcomes thanks to specification of new requirements for improving the existing debris norms in response to the new large constellation challenge. The large constellation operations are considered a special category of operations, which call for additional safety requirements. The new threat and resulting debris knowledge led to harsher requirements especially on the existing provisions for post-mission disposal and removal of satellites or space objects at the end of their operational lives in protected orbits. The revised guidelines which include the specific operations of large constellations, specify under the provision “5.3.2 Objects Passing Through the LEO Region: […] For specific operations such

[670] Richard Crowther, UKSA, United Kingdom IADC Chair and Holger Krag, ESA/ESOC, incoming IADC Chair, “ The Inter-Agency Space Debris Coordination Committee (IADC): An overview of the IADC annual activities,” Presentation at *2nd ICAO/UNOOSA Symposium* held 16 March 2016, Abu Dhabi, United Arab Emirates, https://www.icao.int/Meetings/SPACE2016/Presentations/2%20-%20H.%20Krag%20%20IADC.pdf (accessed June 29, 2020), 18.

as large constellations, a shorter residual orbital lifetime and/or a higher probability of success may be necessary."[671]

Policy

The 2017 statement resulted from a working group studying the impact of the rapid growth of large constellations of smaller and often non-maneuverable satellites in LEO and the risks for debris proliferation since 2015. This led to a revision process of the IADC Guidelines concluded by March 2020. Both outcomes, the statement and the revised guidelines represent knowledge, normative and policy progress steps. The statement and the revised 2020 IADC Guidelines represent a policy innovation step as they consider the new threats to the debris issue, namely the mega-constellations. The statement was a first step of a recognition in the 2017 of a need to adapt the guidelines and to consider shortening the 25-years rule for the case of mega-constellations in order to ensure more efficiency of the debris guidelines and better space sustainability.[672]

The 2020 version of IADC Guidelines specifies in its provision "5.3.2 Objects Passing Through the LEO Region: […] For specific operations such as large constellations, <u>a shorter residual orbital lifetime and</u>/<u>or a higher probability of success</u> <u>may be necessary</u>". This guideline implies that for the operations in large constellations considered a "special type of operations", there is a <u>need for</u> <u>a shorter period than 25 years</u> for the space object to be left in the busy LEO region or susceptible to interfere with the LEO region. This provision shows

[671] IADC Space Debris Mitigation Guidelines, IADC-02-01, Revision 2, March 2020, 12.
[672] Inter-Agency Space Debris Coordination Committee (IADC), *IADC Statement on Large Constellations of Satellites in Low Earth Orbit*, IADC-15-03, September 2017, https://www.iadc-home.org/index.cgi?item=docs_pub (accessed June 30,2021), 6

the diffusion of the shortening the 25-year rule also observed in other fora presented in this thesis such as the Space Safety Coalition, CONFERS, and ISO.

Moreover, this adaptative move also reiterates the evolutionary process occurring in debris governance at IADC, characteristic of the epistemic process of learning through constructing knowledge with experts' ongoing research and diffusion of findings process within IADC but also benefiting from inputs and exchanges with other fora also discussing debris governance issues. As a policy contribution to debris governance, the IADC forum's evolutionary process allows for epistemically constructed ideas to become codified in its instrument, and some experts have highlighted this process at the IADC level, showing that IADC is receptive to global consensus built across several other fora and the 2020 revised guidelines do illustrate this process. Indeed, a recent article by Oltrogge and Christensen in 2019 mentions the iterative nature of IADC's work,[673] reminding of the process also happening under ECSS as explained in the previous section. The authors explained that delegates of IADC would agree to upgrade the IADC Guidelines in the even that a global consensus would emerge on stricter measures than their guidelines in order to ensure the sustainability of space operations for the long-term. Such consensus could for instance emerge from agreements outside of the IADC forum among either all space-faring nations or all space operators, and the IADC would then deem appropriate to upgrade its debris mitigation guidelines as well.[674] This is what happened for the 25-year rule, whereby in other fora like the NGO-level Space Safety Coalition (SSC) and ISO, a global consensus emerged

[673] Oltrogge and Christensen, "Space governance in the new space era," Paper presented at the *First International Orbital Debris Conference*, Sugar Land: Texas, December 2019, 3.
[674] Oltrogge and Christensen, "Space governance in the new space era," 2019, 3.

on the need for harsher measures, for instance for mega-constellations in LEO such as shortening the 25-years to around 5 years where SSC and ISO members agreed in their own formulated guidelines. This led IADC to revise its guidelines too in 2020. The 2010s decade thus further consolidated the ongoing value of IADC's policy contributions to debris governance.

Institutional

These above-mentioned policy contributions of IADC in the 2010s further consolidate the legacy of IADC as the main debris governing platform, besides the other multiple initiatives emerging in other fora. In the 2010s, especially non-governmental levels including professional industry associations, and consortia involving a mix of stakeholders from academia, professional associations, governmental entities, and commercial actors and as covered in other sections are also providing debris instrument initiatives, yet usually they continue to refer to the IADC guidelines as the authoritative international main debris instrument. Some space experts have recognized the governance achievements of the Committee as a successful global governance body, considering their guidelines "a successful international cooperative outcome."[675]

Compliance

The latest IADC policy outcomes of the 2010s, namely the statement of 2017 and the March 2020 revised IADC Guidelines also represent some level of compliance progress. Indeed, reflecting consensus and agreements between the IADC's 13 space agencies

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[675] Jakhu, Ram S. and Joseph N. Pelton, (Eds.), *Global Space Governance: An International Study. Space and Society* (Cham: Springer International Publishing, 1st edition, 2017), 38.

members,[676] these outcomes further encourage members compliance with debris mitigation provisions, now including the emerging risk of special operations of mega-constellations. Even though mega-constellations are typically launched by new commercial actors in the space community, their activities remain regulated under the nations where they are registered, such as the respective launching states from where they launch these satellites. Therefore, as the majority of launching states are members of IADC and given that many of them also have adopted national debris regulations in line with IADC Guidelines, increased compliance is likely to be observed, even if full compliance is not observed yet.

The direct involvement of epistemic community members of the DEB and LTS groups are found again such as Bonnal, Crowther for example mentioned in other sections. Over the years, these communities' memberships have significantly grown. A permanent debris committee has been created under the IAA, and various working groups are conducting debris-related or space sustainability related studies. The membership of IAA working groups such as the IAA Permanent Space Debris Committee for instance encompasses a large part of epistemic members of the DEB group, even though this IAA committee still does not include of the DEB group members. As experts can share more than one particular set of ideas and can belong to more than one epistemic group at the same time, this multi-epistemic

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[676] IADC Terms of Reference (TOR), IADC-93-01 (rev. 11.5) latest version of 2018. https://www.iadc-home.org/terms_reference, accessed July 5th, 2020. The 13 IADC member agencies are: ASI (Agenzia Spaziale Italiana), CNES (Centre National d'Etudes Spatiales), CNSA (China National Space Administration), CSA (Canadian Space Agency), DLR (German Aerospace Center), ESA (European Space Agency), ISRO (Indian Space Research Organisation), JAXA (Japan Aerospace Exploration Agency), KARI (Korea Aerospace Research Institute), NASA (National Aeronautics and Space Administration), ROSCOSMOS (State Space Corporation "ROSCOSMOS"), SSAU (State Space Agency of Ukraine, UKSA (United Kingdom Space Agency).

group memberships make it hard to categorize such experts under only one group, one project or one study topic only. It is especially the case for debris and sustainability groups as these global issues cover many sub aspects such as debris removal besides mitigation, space traffic management, space situational awareness, therefore these experts are involved across multiple study groups and also multiple fora outside of the IAA.

As seen in the previous section, the ideas found in the first IADC Guidelines ideas of 2002 where DEB and LTS ideas, with some AC inherited ideational influences. The same ideas were found in the latest IADC Guidelines revised version of 2020, plus some additional concept was added to the DEB group of shared ideas.

Debris Mitigation (DEB)

In the first guidelines, the debris mitigation ideas (DEB) were found across all provisions as it was means as a universal comprehensive debris mitigation instrument. In the 2020 IADC Guidelines version, some DEB ideas have been strengthened, especially concerning the operations of large constellations. Indeed, under section 5.3.3 Objects passing through the LEO region, two requirements were strengthened in order to enhance space safety and reduce debris risks. Namely, the 25-year rule was shortened for mega-constellations operations, and the requirement of the probability of disposal success for the de-orbiting or re-entry was increased above 90% illustrating the diffusion of these latest debris mitigation ideas, circulating in several other fora over the past few years such as debris conferences and the IAA forum,[677] besides the IADC as well. These latest DEB ideas emerged as a response to

[677] McKnight and Kawashima IAA report, *Handbook on Post Mission Disposal*, 23; Stokes et al. "Evolution of ISO's Space Debris Mitigation Standards."

address an urgent aspect of the debris issue as reminded in the summer of 2019 by a collision warning close call between a Space X *Starlink* satellite and a much larger Earth Observation satellite *Aeolus* from ESA. Section 5.3.2 states that: "For specific operations such as large constellations, a shorter residual orbital lifetime [than 25-year] and/or a higher probability of success may be necessary [more than 90%]."

Arms Control (AC)

The arms control ideas of AC were found in the IADC revised guidelines of 2020 again as previous in the original ones as inherited from earlier influences of the AC group especially in the 1980s and also previously over ASAT testing limit debates and basic space governance treaties as explained earlier. Similarly to the previous IADC guidelines in the 2000s, these arms control restraint ideas are expressed under the "intentional" provision "5.2.3 Avoidance of intentional destruction and other harmful activities," and as unchanged.

Long-term sustainability ideas (LTS)

The LTS ideas regarding the long-term sustainability of the space domain and the concern for preserving the environment whether outer space or Earth environments for the next generations are found on again in the introduction ("the implementation of debris mitigation measures today is a prudent and necessary step towards preserving the space environment for future generations.") and under provision 3.3.2. ("any activity that takes place in outer space should be performed while recognising the unique nature of the following regions, A and B, of outer space, to ensure their future safe and sustainable use.") of the IADC 2020 revised guidelines, similarly to the previous IADC Guidelines versions of 2007 and 2002. The IADC chair's concluding remarks in 2016 mentioned above also indicate the normative acceptance of LTS ideas and epistemic influences of the LTS group expressed as concerns for the future generations and their ability to keep using the near-Earth space environment resource included under the IADC's core mandate. This marks a continuity in the presence of LTS ideas: "IADC will continue to advance the knowledge of space debris and to develop environment management strategies to preserve the near-Earth space for future generations."[678]

The presence of these same groups of ideas of DEB and LTS with still some inherited AC ideas presence in this latest 2020 version of the IADC instrument, besides being also present in most of the other debris instruments in other for a, including the recent ones in the 2010s. These new debris instruments such as the Space Safety Coalition Best Practices 2019 document or the ISO 2019 revised standard further illustrate the research finding about an ongoing influence of several epistemic communities over debris governance observed over several decades, and as enablers of global governance progress increasing space sustainability.

EU ICoC and continued efforts in 2010s

The first half of the 2010s saw significant momentum for the ICoC, launched as a concrete TCBM instrument of space governance in response to a UN resolution of 2006 and further motivated by the UN GGE on TCBM study of 2013 recommendations to prevent an arms

[678] Prof. Richard Crowther, UKSA, United Kingdom IADC Chair and Holger Krag, ESA/ESOC, incoming IADC Chair, " The Inter-Agency Space Debris Coordination Committee (IADC): An overview of the IADC annual activities," Presentation at *2nd ICAO/UNOOSA Symposium*, 16 March 2016, https://www.icao.int/Meetings/SPACE2016/Presentations/2%20-%20H.%20Krag%20-%20IADC.pdf, (accessed June 29, 2020), 18.

race in space.[679] A series of consultative meetings and updated drafts took place from 2012 to 2014 to satisfy more participating nations. Some level of progress was achieved by getting closer to a negotiation phase by 2015. However, the initiative was stalled after the last meeting held at the United Nations headquarters in 2015. That step followed the multi-lateral and open-ended consultations and ensuing 4 revisions to the ICoC draft. The ICoC initiative's last meeting took place in New York from 29 June-2 July 2015. After that, the European Union issued a statement in 2017 indicating a willingness to continue its efforts towards supporting space sustainability with a Code, yet no additional action on a Code has been undertaken since.[680] The EU stated the following:

> "We remain convinced that Transparency and Confidence Building Measures can make an important contribution to the security, safety and sustainability of activities in outer space to preserve the integrity of space environment for all. This is the reason why the EU proposed some years ago an international code of conduct for outer space activities. The EU continues to believe that a non-legally binding agreement negotiated within the United Nations could be a way to proceed. Globally shaped principles of responsible behaviour across the full range of space activities should serve long term goals: to increase international cooperation in space, to commit mutually to non-interference in the peaceful exploration and use of outer space, to facilitate an equitable access to outer space and increase transparency in the conduct of space activities. The EU and its Member States will continue to show commitment in these areas, which are important to our security and prosperity."[681]

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[679] Sergio Marchisio, "Security in Space: Issues at stake," *Space Policy* 33 (2015), 68.
[680] Rong Du ,"China's approach to space sustainability: Legal and policy analysis," *Space Policy* 42 (2017), 16; and confirmed by interviews with experts involved in the ICoC initiative at the EU level.
[681] EU statement at the 2017 session of the Conference on Disarmament, Geneva, January 31, 2017. https://eeas.europa.eu/headquarters/headquarters-homepage/19599/2017-session-conference-disarmament-eu-statement_en (accessed June 30, 2020).

Further illustrations of the ongoing commitment of the EU in this direction supporting debris and sustainability efforts with a voluntary Code are found also in an announcement of another initiative in 2019 of the EU's EEAS foreign affairs office, called the "Safety, Security and Sustainability of Outer Space" (3SOS),[682] and in a publication by Sergio Marchisio following the Indian Anti-Satellite test occurring in the Spring of 2019 who was a leading member of the ICoC process reminding of the need for a Code.[683] While having reached international consensus on the Code supported by many major spacefaring nations, the research finds that the ICoC initiative contributed to debris governance by consolidating three levels of governance progress, in particular normative, policy and institutional steps as explained below.

Normative

Despite the lack of full agreement reached on the ICoC, the process is still recognized as a significant normative progress step positively impacting debris efforts by several space

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[682] EEAS "SOS SOS SOS : EU calls for ethical conduct in space to avoid collision and orbital debris," 19 September 2019, https://eeas.europa.eu/topics/security-defence-crisis-response/67538/sos-sos-sos-eu-calls-ethical-conduct-space-avoid-collision-and-orbital-debris_en (accessed March 13, 2020); Jeff Foust, "EU agency starts space sustainability initiative, 15 September 2019 https://spacenews.com/eu-agency-starts-space-sustainability-initiative/ (accessed March 13, 2020).
The EU launched another initiative supporting debris mitigation and debris governance efforts after ICoC: the Safety, Security and Sustainability of Outer Space (3SOS) public diplomacy initiative. Specifically, EEAS launched this new 'public diplomacy' initiative known as the 3SOS as a dialogue aiming at responsible behavior in space and building upon the 21 guidelines approved under the LTS efforts, to ensure that the space environment remains 'safe, secure and sustainable' in the face of the dramatic rise of threats expressed by the ESA/Starlink satellites close call collision and Indian ASAT test incidents in 2019.
[683] Sergio Marchisio, "The final frontier: Prospects for arms control in outer space," *Global Security Policy Brief*, July 2019, *European Leadership Network*.

policy experts.[684] Montserrat Filho for instance considers the ICoC as a form of progress,[685] confirming this research finding that ICoC consolidated the emerging trend of space sustainability and debris efforts in the early 2010s. These policy experts also consider that even without having been signed as an agreement, the ICoC process already consolidated debris mitigation ideas and sustainability ideas by gathering a wider support from additional spacefaring nations, thus building them into stronger norms especially in the first half of 2010s via the momentum created by rounds of consultations held in May 2013 in Kiev, November 2013 in Bangkok and March 2014 in Luxembourg, which generated several drafts. Following the first EU Draft Code of Conduct for Outer Space Activities issued on 8 December 2008, the consultations produced several revised drafts. Specifically, the first EU Draft Code of Conduct for Outer Space Activities issued on 8 December 2008 was revised following rounds of consultations produced in the 2010s generating a second draft on 27 September 2010, third draft on 5 June 2012, fourth draft on 16 September 2013 and the Fifth EU Draft Code of Conduct for Outer Space Activities on 31 March 2014, which is the latest version. These consultations and the EU's efforts to include feedback in the ensuing revisions have enabled debris mitigation ideas consolidation into more widely shared norms. Also following first years of skepticism in the late 2000s among the major space powers like still with the Obama Administration struggling internally with opposing Congress views, and

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[684] Lucia Marta, "Code of Conduct on Space Activities : Unsolved Critiques and the Question of its Identity," *Note de la FRS* 26 (2015), Fondation pour la Recherche Stratégique; Michael J., Listener, "The International Code of Conduct: Comments on changes in the latest draft and post-mortem thoughts", Monday, October 26, 2015, https://www.thespacereview.com/article/2851/1 (accessed March 12, 2020); Max M. Mutschler, and Christophe C. Venet, "The European Union as an emerging actor in space security?" *Space Policy* 28(2) (2012): 118–124.

[685] José Monserrat Filho, "Code of Conduct for Space Activities: Evolution or Regression?" IAC-09-E8.2.4., IAC 2009.

China and Russia skeptical of a Code suspecting it could prevent their wider Treaty initiative (PPWT),[686] the ICoC process brought some level of normative progress especially as regards debris governance in the 2010s, towards gathering greater acceptance for the need of an International Code of Conduct for space activities, [687] and as a general additional acceptance for the need of restraint from intentional debris creation.

Policy

Despite the stalling of the process, the ICoC initiative did generate several policy progress outcomes in the 2010s such as gathering a wider support for the Code by 2014. Indeed, following the EU organized consultation rounds, the inclusion of participating nations' feedback in the revised draft have enabled to build a greater support and to reach at least a consensus on the recognition that there is the need for such a Code.[688] Policy preference changes from skepticism towards support for the Code has been observed especially in two major space powers: The United States from 2012 and China from 2013.

Following the launch of the initiative in 2008, the ICoC consultation rounds produced several revised drafts and succeeded in gathering some wider support for the Code by the mid-2010 in comparison with the low level of support observed in the late 2000s. Indeed,

[686] Draft Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force Against Outer Space Objects (PPWT) by China and Russia on February 12, 2008 at the CD.
[687] Michael Krepon, "Space Code of Conduct Mugged in New York," Aug. 4, 2015, *Arms Control Wonk*, http://krepon.armscontrolwonk.com/archive/4712/space-code-of-conduct-mugged-in-new-york (accessed July 3, 2020).
[688] Rajagopalan and Porras, "EU Courts Support for Space Code of Conduct," Rajeswari Pillai Rajagopalan and Daniel A. Porras, *Spacenews*, July 14, 2014, https://spacenews.com/41254eu-courts-support-for-space-code-of-conduct/ (accessed July 3, 2020); Michael Krepon, "Space Code of Conduct Mugged in New York," Aug. 4, 2015, *Arms Control Wonk*, http://krepon.armscontrolwonk.com/archive/4712/space-code-of-conduct-mugged-in-new-york (accessed July 3, 2020).

following years of national debates and some Congressional opposition, the US administration clearly expressed its support for the Code from 2012 onwards. A turning point was observed especially in January 2012 when then US Secretary of State Hillary Clinton officially announced that: "the United States would lend its support to international efforts to craft a Code of Conduct for responsible space-faring nations.[689] That support also extended to Air Force Space Command chief General William Shelton and to Strategic Command chief General Robert Kehler.[690] Prior to 2012, the United States was not fully supporting the Code displaying reservations.[691] While in the case of China, the stance also changed by 2013 towards less skepticism when the nation started to join the rounds of consultations.[692] India, another space-faring nation and launching state was expressing reservations in the first years regarding several aspects such as lack of consultation and non-binding nature of the instrument[693] but then has become more supportive of the ICoC since 2012.[694]

Institutional

Despite the ICoC initiative's deadlock by July 2015, the active contribution of the EU European External Action Service (EEAS) leading consultations and reworking the first draft

[689] Hillary Rodham Clinton, Secretary of State, "International Code of Conduct for Outer Space Activities," Press statement, 17 January 2012, https://2009-2017.state.gov/secretary/20092013clinton/rm/2012/01/180969.htm (accessed July 1, 2020).
[690] Joan Johnson-Freese, "Testimony before the U.S.-China Economic and Security Review Commission "China's Space & Counterspace Programs," February 18, 2015, 2.
[691] Jana Robinson, "Europe's Space Diplomacy Initiative: The International Code of Conduct," in *Decoding the International Code of Conduct for Outer Space Activities*, ed. Ajey Lele, Institute for Defence Studies and Analyses (ISDA) (New Delhi: Pentagon Press, 2012), 28.
[692] Du Rong, "China's approach to space sustainability: Legal and policy analysis," *Space Policy* 42 (2017), 15.
[693] Gabriella Irsten, "The consultation process for the International Code of Conduct for Outer Space Activities ends," *Reaching Critical Will*, 2014, https://reachingcriticalwill.org/news/latest-news/8907-the-consultation-process-for-the-international-code-of-conduct-for-outer-space-activities-ends (accessed June 30, 2021).
[694] Ajey Lele, "India in Space: A Strategic Overview," In Schrögl (ed.), *Handbook of Space Security*, 16.

into five revisions during the first half of the 2010s period illustrates the emerging role of the European Union in debris governance. The research therefore also finds the ICoC initiative to represent an institutional progress step, whereby the EU made its entrance as a new forum helping to shape yet another debris governance instrument, consolidating the role of the EU as a space debris governing body in addition to having been recognized as an emerging space normative and governing body since it gained a space mandate in the late 2000s following the Lisbon treaty.[695] Despite the stalling of the ICoC initiative, the EU remained engaged in promoting sustainability efforts throughout the second half of the 2010s with additional publications[696] and the launch of a new initiative the "3 SOS" covered in the next section, confirming its enduring active role as a space debris governance body in the whole 2010s decade.

Since the first draft of 2008, the ICoC has been revised four times and in its latest version from March 2014,[697] the same group of epistemically constructed ideas present in the main space debris mitigation instruments were found again, namely DEB and LTS, with inherited AC ideas. Some differences were found between the first draft version in 2008 and the 2010s

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[695] Max M. Mutschler, and Christophe C. Venet, "The European Union as an emerging actor in space security?" *Space Policy* 28(2) (2012): 118–124.

[696] Sergio Marchisio, "The final frontier: Prospects for arms control in outer space," *Global Security Policy Brief*, July 2019, European Leadership Network; EU statement at the 2017 session of the Conference on Disarmament. Geneva, January 31, 2017. https://eeas.europa.eu/headquarters/headquarters-homepage/19599/2017-session-conference-disarmament-eu-statement_en (accessed June 30, 2020); Pellegrino, Massimo, and Gerald Stang, "Space Security for Europe", Institute for EU Security Studies, Report #29, July 2016. http://www.css.ethz.ch/content/dam/ethz/special-interest/gess/cis/center-for-securitiesstudies/resources/docs/EUISSSpace%20security%20for%20Europe.pdf (accessed June 30, 2020).

[697] EU ICoC Draft 2014, http://www.eeas.europa.eu/archives/docs/non-proliferation-and disarmament/pdf/space_code_conduct_draft_vers_31-march-2014_en.pdf (accessed April 29, 2020), 6.

versions indicating stronger diffusion and progress regarding especially the LTS ideas. The presence of DEB and AC ideas were found present in both drafts.

Debris Mitigation (DEB)

The debris mitigation DEB ideas are found in many provisions of the ICoC similarly to the 2008 draft. Namely, under article 4.2 (avoid destruction except to exercise right of self-defense), 4.3 (minimize during normal operations) and 5.1 (pre-notification of potentially dangerous activities including destruction of satellites), article 2 General principles, paragraphs 25, 27 and 28 (avoid harmful interferences), and under Article 3.1 paragraph 45 (commitment to the COPUOS Space Debris Mitigation Guidelines of 2007), article 6.1 (inform on policies and strategies to minimize harmful interferences and creation of debris).

Arms Control (AC)

As it was intended to be a transparency and confidence building instrument, the ICoC includes many references to arms control ideas AC in the 2014 ICoC draft, just like in the 2008 version. The 2014 Draft "intentional" provision under 4.2 has been reframed and the word "intentional" has been removed, yet the essence of the restraint ideas remains present and reflect the ongoing diffusion of arms control ideas and ongoing influence of the AC group over space governance initiatives here counting as well as a debris governance supporting instrument. AC ideas are encompassed under article 4.1 (minimize harmful interferences) and 4.2 (2008 draft **"**refrain from intentional destruction of any on-orbit space object or other harmful activities, which may generate long-lived space debris"; in 2014 "refrain from any action which brings about, directly or indirectly, damage, or destruction, of space objects unless such action is justified") and under 5.1 (2008: "refrain from intentional destruction of any on-orbit space object or other harmful activities which may generate long-lived space debris"; in 2014: pre-notification of potentially dangerous activities including destruction of satellite) in article 6.1 (inform on policies and strategies to minimize harmful interferences and creation of debris) and sometimes covering wider aspects like in the Preamble paragraph 6 ("Noting the importance of preventing an arms race in outer space"); article 1.3 (recognition of TCBMs to prevent confrontation and foster national, regional and global security and stability); article 2. General principles, paragraph 28 ("prevent outer space from becoming an arena of conflict", paragraphs 25 and 27 (avoid harmful interferences), and under Article 3.1 regarding compliance with existing arms control instruments found in paragraph 32 (The Outer Space Treaty of 1967), paragraph 37 (the Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and under Water (1963) and the Comprehensive Nuclear Test Ban Treaty (1996)), paragraph 40 (the Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space adopted by UNGA Resolution 1962 (XVIII) (1963) and paragraph 43 (the International Code of Conduct against Ballistic Missile Proliferation (2002).

Long-Term Sustainability (LTS)

As regards ideational progress compared with the previous decade, some stronger presence has been found in the latest ICoC draft in particular for the ideas of ensuring long-term sustainability of the space domain or LTS. Indeed, LTS ideas are referred to much more often throughout the 2014 draft indicating a much stronger emphasis on this goal and illustrative of a consolidated diffusion, normative progress and codification of the LTS idea into the ICoC draft. Indeed, in the beginning of the ICoC process, the LTS ideas was just shaping itself into a formal COPUOS initiative starting to be discussed at the COPUOS level. Knowledge shaping around the LTS idea and normative diffusion were just emerging as observable in the first draft of 2008 which only barely mentioned the long-term sustainability idea once in the entire ICOC draft text. After several years of the LTSWG at COPUOS starting in 2010, the idea of ensuring the sustainability of the space environment became more widely known and shared by the participants to the EU consultation rounds around the Code whose feedback was taken into account for the revisions to ICoC, as reflected by the presence of LTS ideas in almost every page of the latest 2014 ICoC draft illustrating the diffusion of the LTS idea as explained under the normative governance gap progress above. In the 2014 draft,[698] LTS ideas are found in the Preamble paragraph 1, 8, 10, 11, 13, in article 1, Article 2, article 3 and article 6. Preamble para 1 (the concerns for future generations to be able to use the space environment) “In order to safeguard the continued peaceful and sustainable use of outer space for current and future generations”; Preamble paragraph 8 (“Taking into account that space debris affects the sustainable use of outer space, constitutes a hazard to outer space activities and potentially limits the effective deployment and utilisation of associated outer space capabilities” ; Preamble paragraph 10 (“Convinced that a multi-lateral code of conduct aimed at enhancing the safety, security, and sustainability of outer space activities could become a useful complement to international law as it applies to outer space, as recommended by the Report of Group of Governmental Experts on Transparency and Confidence Building Measures in Outer Space Activities established in

[698] The ICOC March 2014 draft is the latest version consulted for this study: http://www.eeas.europa.eu/nonproliferation-and-disarmament/pdf/space_code_conduct_draft_vers_31-march-2014_en (accessed June 30, 2020).

response to the UN General Assembly Resolution 65/68"; Preamble Paragraph 11 (Considering that spacefaring States have acquired knowledge regarding general practices to enhance the safety, security and sustainability of outer space activities that could usefully be made available to other Subscribing States, for the benefit of all); Preamble Paragraph 13 ("Recognising the necessity of a comprehensive approach to safety, security, and sustainability in outer space"), in article 1 "Purpose and Scope," Section 1.1: ("The purpose of this Code is to enhance the safety, security, and sustainability of all outer space activities pertaining to space objects, as well as the space environment."), in article 2. General Principles paragraph 25 ("consistency with existing instruments and avoiding harmful behavior) in article 3.2. (The Subscribing States resolve to promote the development of guidelines for outer space operations within the appropriate international fora, such as the UN Committee on the Peaceful Uses of Outer Space and the Conference on Disarmament, for the purpose of promoting the safety and security of outer space operations and the long-term sustainability of outer space activities") and in article 6.1: ("The Subscribing States resolve to share, on an annual basis, where available and appropriate, information with the other Subscribing States on their space strategies and policies, including those which are security-related, in all aspects which could affect the safety, security, and sustainability in outer space").

5.3.4. Progress observed at national levels in the 2010s

This section presents the further consolidation of national debris governance progress occurring in the 2010s and which are mostly found under the UNOOSA Compendium of space debris mitigation standards adopted by States and international organizations.[699] The novelty of these national debris steps is that these national legislations emerged across many more nations than the founding members of the IADC group which started to adopt debris regulations and laws in the 1990s and 2000s. All the 2010s national examples are consolidating normative and policy progress in debris governance, further enriching the international debris governance regime illustrated in Table 6-1. Also, these governance gap filling efforts were enabled thanks to the continued normative diffusion of the DEB epistemic community across international fora such as the United Nations, ongoingly encouraging better national compliance and regulatory progress during its UNCOPUOS sessions for instance.

Further National space debris legal progress deriving from the DEB group influences since especially the 1990s will diffuse much widely in the 2000s with over 30 nations observing the main international space debris mitigation instruments summed up in Table 6-1 such as the ITU-R partial debris instrument covering GEO orbits and the IADC guidelines, the European ECoC, UNCOPUOS guidelines and ISO standard all developed in coordination with IADC delegates and in line with the IADC instrument, thus involving the DEB community members.

In the 2010s, national debris expertise has largely increased and covers experts in many more nations. The members of the Inter-Agency Space Debris Coordination Committee

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[699] United Nations, "United Nations Compendium of space debris mitigation standards adopted by States and international organizations," A/AC.105/2014/CRP.13, https://www.unoosa.org/documents/pdf/spacelaw/sd/Space_Debris_Compendium_COPUOS_25_Feb_2019.pdf (accessed April 29, 2020). From 2014 to 2019, the number of national legislations grew from 22 to 30.

gather institutions in over 10 spacefaring nations, including all of the launching states. Also, by the 2010s, debris awareness and participation to debris governance also involves a larger number of experts of the private space actors nested under these national jurisdictions and shaping best practices under international non-governmental associations. The research found that in the past decade of the 2010s, the norm diffusion by DEB experts has increased and generated a much larger membership of the epistemic group of DEB especially, and facilitated the emergence of the LTS as an epistemic group also influencing progress for debris mitigation internationally. These experts have consolidated and diffused their respective epistemic ideas such as updated or new debris mitigation knowledge and norms across several fora, sometimes also as part of more comprehensive ideas such as under LTS ideas. A total of about thirty nations do now entail some level of debris basic regulatory or policy provisions and reflect the diffusion and normative progress achieved in national debris governance. Due to constraints of conciseness, this thesis does not present them here, as it focusses on the epistemic influences in facilitating debris governance progress, which is found to have been developing earlier as explained in other sections especially in the 1980s and 1990s.

The national debris governance outcomes found in the 2010s still include progress in debris policy updates of the same founding members of the IADC, namely the United States, European Space Agency (ESA) and national agencies involved since the 1980s, and Japan and Russia, while decades of norm diffusion at national and international generated debris governance outcomes across 30 space faring nations. These national debris outcomes are observable as basic provisions or national regulatory and policy steps in the UNOOSA compendium created in 2014 and updated in 2019. The research found that national debris outcomes have flourished in the 2010s, reaching way beyond the founding members of IADC and have benefited from ongoing influences of the DEB and LTS epistemic groups interacting across multiple fora.

The further consolidation of national debris governance step in the 2010s and illustrated by the UN Compendium of space debris mitigation standards adopted by States and international organizations[700] illustrates well the influence of epistemic communities into facilitating space governance and here debris governance progress. Indeed, by the 2010s, the norm diffusion and increased institutionalization of debris mitigation ideas has been facilitated by a much larger DEB epistemic group and an emerging LTS group. These two space groups with inherited influences from the external AC group as additional supporting ideas conducive to space governance and debris progress provided the conditions for national debris governance progresses to endure. These epistemic influences were facilitated by supporting national and international institutions acting as "homes" for learning and exchanges and ideas and normative promotion in two directions, nationally and internationally. Outside of the continued progress with updates to current national standards for instance among the main member agencies of IADC, the research found national debris outcomes to be the result mostly from international influences, such as continued norm promotion of DEB ideas supported by the UNCOPUOS as platform with its ongoing calls to

[700] United Nations, "Compendium of Space Debris Mitigation Standards adopted by States and International Organizations," A/AC.105/2014/CRP.13, https://www.unoosa.org/documents/pdf/spacelaw/sd/Space_Debris_Compendium_COPUOS_25_Feb_2019p.pdf (accessed April 29, 2020).

better implement its guidelines nationally, and by other INGO fora such as ISO, IAASS, IAA, SDA, CONFERS, SSA, WEF/SSR who also further supported debris efforts with their promotion of the broader long-term sustainability concepts.

6. CONCLUSION

The structure of this concluding chapter is as follows. Section 4.1 presents the main findings of this research on debris governance, answering the four research questions and testing the hypothesis. Section 4.2 mentions findings concerning several perceived limitations for debris governance. Section 4.3 covers policy implications for theory, policy, and future research.

Hypothesis: Epistemic influences enabled the emergence of international cooperation around the debris issue generating governance progress towards increased space sustainability.

The research confirmed that epistemic communities influence did occur and did help bring about international cooperation in the form of policy coordination and outcomes in debris governance, consolidating progress towards space sustainability.

The study illustrated the involvement of several epistemic communities in the space debris policy process, especially in the emergence and evolution of international cooperation. The epistemic communities and their key members acted as direct catalyzers for debris and space sustainability progress, and other members as indirect contributors by diffusion, as observed by the presence of several groups of ideas across the various debris instruments. These influences, which contributed to debris governance emergence and evolution did not occur in a vacuum though. Several external and internal events were found to increase epistemic influences, from accidental and intentional orbital collisions to successive manned space programs over the seven decades of spaceflight history.

The core of the research findings is summarized in a combination of several tables such as especially Table 6-1, Table 6-2, Table 6-3, and Figure 6-1. These main findings tables show the space debris governance regime achieved in Table 6-1, the presence of arms control ideas under intentional debris creation provisions across several debris mitigation instruments and other basic elements in space governance treaties and conventions is represented in Table 6-2. The epistemic communities found, namely the DEB and LTS as main groups impacting debris governance, with contributions of the AC community are presented in Table 6-3, while a chronology of their influences is given in Figure 6-1. These research findings are presented in more details below, matching the research questions of the introduction chapter.

6.1 Main findings

6.1.1 Answer to Question 1: Which epistemic community or communities have been involved in debris governance?

1.1. Debris governance progress benefitted from pluri-epistemic communities influences

This research found that more than one epistemic community enabled the emergence and progress of a debris governance regime, and that specifically three groups were involved. It looked beyond emerging space literature on epistemic communities such as Moltz, Mutschler and Machon mentioning about a single epistemic community' influence over one single debris policy outcome. Moltz considered a partial influence of certain groups such as debris experts in the mid-1980s,[701] and of an earlier arms control scientists group impacting the PTBT in the 1960s and later the ABM Treaty in the 1970s, as also noted by Mutschler.[702] With a deeper epistemic study of debris experts and identification of main institutions involved, Machon et al. provided a useful basis to establish the existence and influences of a debris mitigation (DEB) group. This thesis expanded their scope from the 1970s until the COPUOS Space Debris Mitigation Guidelines outcome in 2007,[703] revealing wider scopes of epistemic influences, for instance with additional epistemic groups involved in debris governance progress over a longer period of time. This thesis found three epistemic communities involved in facilitating debris governance, preceding, and following the COPUOS Debris Mitigation Guidelines of 2007, thus as a more comprehensive debris governance study, strengthening the argument of epistemic communities and shared ideas as enablers for space governance progress and for the emergence of a global debris governance regime. Also, this study places the debris group and debris governance analysis as part of a larger exercise of evaluation of overall progress in space sustainability. These epistemic groups are the Debris Mitigation group (DEB) and the Long-Term Sustainability group (LTS), and the Arms Control group (AC).

[701] Moltz, *The Politics of Space Security: Strategic Restraint and the Pursuit of National Interests*, 339-341; Mutschler, *Arms Control in Space: Exploring Conditions for Preventive Arms Control*.
[702] Moltz, *The Politics of Space Security: Strategic Restraint and the Pursuit of National Interests*, 339-341; Mutschler, *Arms Control in Space: Exploring Conditions for Preventive Arms Control*.
[703] Machoň et al., "Epistemic Communities and their Influence in International Politics: Updating of the Concept,"1-15.

The epistemic communities are divided into two categories of "space" and "external" or non-space embedded epistemic groups.

The first category of epistemic groups is the "space" epistemic communities, emerging within the space community. The "space" epistemic groups, such as the Debris Mitigation group (DEB) and the Long-Term Sustainability group (LTS) were found to be directly affecting debris governance and space sustainability. Some early individuals belonging to these space groups are mentioned in Table 6-3, especially those who helped create new initiatives. No exhaustive list can be provided due to the evolving nature of these groups' shared ideas and members over time, typically growing their memberships and changing the people in executive roles.

The second category is the "external" epistemic communities, qualifying groups emerging outside of the space community but whose ideas diffused into space governance, whether in the early space regime instruments, such as arms control and space treaties and conventions or later affecting debris governance instruments. The study found the Arms Control group to be an "external" epistemic community as regards the debris governance system.

The research gives an idea of the most visible epistemic members within their respective groups and explores especially the "space community" epistemic groups. The key members presented in the thesis and many of them in Table 6-3 are typically those who most visibly contributed to building space governance and debris governance rules and institutions in executive roles or as leading new initiatives or working groups, besides presenting at conferences and publishing. It was deemed less pertinent to try and identify exhaustively the exact contours and memberships of these groups. Indeed, memberships were found to keep changing over time when senior members retire, and new members join. Also, epistemic members keep meeting across multiple discussion platforms rather than being identifiable under only one specific committee, making it hard to settle on a definite border for each group. For instance, the debris epistemic community (DEB) is not limited to the sole Inter-Agency Space Debris Coordination Committee (IADC), nor to a single working group or committee of the International Academy of Astronautics (IAA) working group or committee.

The study therefore recognizes especially the role of epistemic members who were involved in the shaping and then the promotion of shared ideas and norms within and outside multiple fora, governmental, non-governmental and sometimes even mixed fora holding executive positions. It recognizes especially the experts who organize discussions, workshops, and conference, or who chair various committees or working groups to shape space governance and debris governance instruments. Also, the dissertation highlights how these experts promote debris ideas and instruments by publishing papers in peer reviewed journals, presenting at international conferences, sometimes also teaching in academia, consolidating knowledge, and learning, besides their participation in shaping instruments, new organizations, or discussion groups.

The epistemic members involved in space and debris governance progress have been changing significantly over time. Their numbers have been growing significantly over the various decades according to their various functions and involvement in different topics, study groups, organizations, and projects. Also, often these experts have been found to belong to more than one epistemic group at the same time. Therefore, the study gave examples of epistemic community members according to the debris outcomes to which they relate to at specific times, rather than providing a list that would be non-exhaustive. Also, often these experts have been found to belong to more than just one epistemic group at the same time.

6.1.2 Answer to Question 2: Where and how did epistemic influences occur in debris governance?

2.1 Epistemic experts helped shape global governance rules and institutions

Epistemic experts were involved in global governance progress firstly in the shaping of space governance with basic provisions applicable to the debris issue, and then in shaping debris governance rules and institutions. The research found that this involvement of epistemic communities in debris governance goes beyond individuals being influential personalities, or about their abilities to persuade and be influential in promoting norms in any governance system. Rather, this thesis uncovered that these "knowledge" individuals were involved through representing the various groups they belong to, meeting under a governance system with institutions both conducive to epistemic knowledge building and to learning, and which these experts also helped to shape.

Indeed, these experts helped to construct debris-relevant "knowledge", to support and promote it under "home" institutions, conducive to epistemic experts' regular exchanges, protecting innovative ideas and enabling policy innovations to emerge, with selective memberships, and with shared policy enterprise revolving around the benefit of humankind and society at large. The epistemic experts could be socially constructing ideas and contributing to create space governance treaties and debris instruments as rules, under a governance system which they were also involved in shaping. As seen since the first decade of the space age in the 1950s, epistemic experts were involved in creating supporting fora such as the IAF, COSPAR, COPUOS, IAA, IISL and IADC. Epistemic experts also helped expand the scopes and mandates of existing governing platforms to include space mandates such as by expanding the ITU mandate to include space, by creating COPUOS under the UN, by expanding the standardization scope of the ISO to include space debris, or by bringing space debris under the COPUOS STSC and LSC agendas. With time especially in the debris governance phases, experts enabled the upgrading of the governance system especially through additional non-governmental organizations such as the IAASS and the Space Safety Coalition, and new sub-groups under larger organizations such as the IAA Permanent Debris Committee, to name just some of the examples presented throughout this thesis.

2.2 Epistemic influences affecting debris occurred across many decades

The study revealed the influence of several epistemic communities over space debris governance and across five decades. In this period of analysis from the 1970s until presently in the early 2020s, the research found two phases of epistemic influences over debris governance progress. The "emerging" phase of debris governance from the 1970s and 1980s, and the "consolidating" phase of debris governance progress from the 1990s, the 2000s and the 2010s. The phases of the research indicated some similarities and some differences in the epistemic groups' dynamics within these phases. Figure 6-1 shows a chronology of epistemic influences over space governance and debris governance.

As explained in the study, the emerging phase saw an epistemic dynamic play of mostly two groups of AC and DEB as supporting each other's influences and especially in the 1980s leading to provisions involving restraint around ASAT-testing in both arms control agreements and first debris guidelines especially in the United States and Soviet Union the two spacefaring powers at the time.

In the consolidating phase, the epistemic group dynamics were also involving a third group of LTS especially from the late 2007 and in the 2010s also influencing debris governance with additional working group efforts and LTS guidelines also covering debris mitigation.

Each phase expresses distinct epistemic community "group dynamics" over the emergence or consolidation of debris governance outcomes. Following the shaping of space governance when basic provisions, UN resolutions, space and arms control treaties appeared as a pre-phase, the study analyzed the emergence of partial and then comprehensive international debris mitigation instruments.

In the "emerging" phase, the study found that a dedicated debris epistemic community (DEB) could emerge and benefit from ideational support from the earlier Arms Control epistemic group influencing the shaping the first debris instruments and contours of dedicated debris governance. In this phase especially in the 1980s, a direct influence from the AC group over debris provisions such as ASAT testing limits were also found. The research also found that the epistemic communities of Arms Control, which created the foundations for space governance in the 1950s and 1960s also kept an underlying and ongoing influence over debris governance with continued ideational diffusion of their shared ideas into debris instruments.[704]

[704] The assumption of this thesis starts with achievements built during a "preliminary" phase in the 1950s and 1960s when space governance rules were shaped, and epistemic influences of the Arms Control (AC) group and respective shared ideas diffused into these basic elements of the space regime. This period of space

In the phase of consolidating efforts since the 1990s, the research found that the DEB group was the principal influence for shaping debris governance as a form of "global governance" by enabling cooperation and agreement on debris-specific instruments. This consolidating phase also revealed that the debris community enabled the emergence of the Long-Term Sustainability epistemic community, whose comprehensive approach will further stimulate debris governance progress through initiatives and instruments. The research's epistemic group dynamics for this last phase further showed that the LTS group in turn consolidated further the DEB group shared ideas and the debris governance regime, with additional and more comprehensive approach under space sustainability initiatives and instruments such as the UNCOPUOS LTS Guidelines and the Space Safety Coalition's (SSC) Best practices instruments. Lastly for the consolidating phase, the study revealed that the DEB group benefitted from earlier epistemic progress achievements, especially from the AC group, whose shared ideas codified earlier in basic space governance provisions and by the 1980s in additional arms control outcomes were further incorporated into the main debris instruments either directly or by reference.

2.3 Epistemic influences were reinforced by trigger events

This research on the debris issue has revealed that epistemic influences over space governance have occurred since the birth of the space age and have led to incremental progress towards a global debris governance regime. This research found several examples of trigger events which have been stimulating epistemic influences acting as force multipliers

governance preceding debris governance is important for debris policy in the next periods, as it has been laying some ideational foundations found to endure under ensuing debris governance instruments.

for debris governance progress over the period covered. These trigger events have been in the form of orbital collisions both, intentional and accidental, as well as of national policy announcements. Especially for manned space programmes, these announcements were found to boost debris research, especially in the United States, the Soviet Union, Europe and Japan.

As also noted by Moltz,[705] this research on space debris confirms as well that "trigger events" can augment epistemic influences and generate policy outcomes. Moltz argues that two phases of learning occurred in the 1960s and 1980s, where two trigger events increased that learning and were conducive to cooperation and policy outcomes affecting the space environment, and debris proliferation. These events were the *Starfish Prime* nuclear test in orbit in 1962 and the *Solwind* 1985 ASAT., which respectively affected the PTBT emergence and some ASAT partial restraints in the US and USSR. Influences of trigger events such as orbital collisions creating large and numerous long-lived debris or re-entry events have been found several times in this research to have acted as stimuli for debris governance progress, especially in the form of growing demand for epistemic expertise or by increasing the impact of epistemic ideas in the shaping or updating of instruments.

In the emerging phase, major trigger events occurred in the late 1970s, such as the crash of the nuclear-powered satellite *Cosmos* 954 over Canadian Northern Territories in 1978, the *Skylab* uncontrolled re-entry scare in 1979, the *Solwind* 1985 ASAT test, and the *Ariane* upper stage break-up in 1986. These all helped to significantly raise urgency about space debris in discussions, studies, working groups, and at the UN from the UNISPACE II conference of 1982 onwards. Space debris entered the agenda of several governing

[705] Moltz, *The Politics of Space Security: Strategic Restraint and the Pursuit of National Interests*, 63-64.

supporting bodies such as IAA and ILA, leading to proposals and progress. The *Ariane* upper stage break-up in 1986 especially helped along epistemic influence from the DEB group as it led to a systematic debris effort within Europe and between ESA and NASA, generating the start of regular inter-agency discussions drawing the contours of the creation of the Inter-Agency Space Debris Coordination Committee (IADC).

In the consolidating phase starting in the 1990s, several trigger points pushed the debris mitigation efforts forward and supported the influence of the DEB group in shaping debris governance progress. The first event was the *Salyut-7* re-entry in 1991. Then came the *Cerise* satellite collision with an *Ariane* fragment in 96, followed by the Chinese ASAT of 2007, the *Cosmos/Iridium* collision in 2009, and the Starlink 44 close-call collision avoidance incident with an ESA Aeolus Satellite in 2019. These events all stimulated debris governance progress by increasing the epistemic groups voices and impacts, especially of the DEB and LTS groups, in shaping more instruments, and revising existing ones with additional provisions.

2.4 Epistemic influences as complementary and consolidating rather than competing

This research on space debris adds to the international relations literature covering conflicting epistemic communities' relationships around one issue.[706] Indeed, unlike Higushi or Barletta's works on nuclear arms control issues, the debris case did not reveal the presence of competing epistemic groups despite the diversity of epistemic groups found. Rather, complementary, and supportive pluri-epistemic dynamics of influences acted as enablers for debris governance progress over the years. This study uncovered that two main epistemic

[706] Barletta, "Pernicious Ideas in World Politics: 'Peaceful Nuclear Explosives'"; Toshihiro Higuchi, "Epistemic frictions: radioactive fallout, health risk assessments, and the Eisenhower administration's nuclear-test ban policy", 1954–1958, *International Relations of the Asia-Pacific* 18, no.1, 1 (January 2018): 99–124.

groups have been increasingly consolidating and aggregating each other's influences in the years of debris-specific governance, namely Debris Mitigation and Long-Term Sustainability, while the Arms Control group has also provided ideational support, as illustrated in Figure 6-1. The interactions of these epistemic groups with other kinds of groups such as advocacy groups were outside of the scope of this debris study and represent an interesting avenue for future research, especially as supporting forces for building winning coalitions combining different kinds of transnational groups.

2.5 Epistemic influences at national and international levels, diffusing both ways

Adler's seminal study of the U.S. arms control epistemic community's influence over national policy and preference changes showed how arms control ideas were shaped nationally first and then consolidated internationally, and were diffused also on the Soviet side.[707] Peter Haas' work on environmental epistemic influences presented a view of epistemic diffusion from ideas shaped at the international level and then diffusing into national provisions.[708] This space debris study revealed both aspects, as a bi-directional example in the epistemic literature. Namely, the main ideas shaping the international instrument of the IADC Guidelines are not solely a product of U.S. debris experts' efforts thanks to the emergence of a national debris community DEB in the 1970s and 80s helping to create the IADC and basing its guidelines on the first NASA standard of 1995. Rather, the analysis found that a group of United States experts as some of the founding members of the

[707] Adler, "The Emergence of Cooperation: National Epistemic Communities and the International Evolution of the Idea of Nuclear Arms Control," 126, 130.

[708] Peter M. Haas, "Introduction: Epistemic Communities and International Policy Coordination," *International Organization*, Vol. 46, No. 1 (Winter 1992): 1–35.

DEB group led the space debris mitigation efforts firstly as national efforts and soon inviting international experts to workshops, helping to shape an epistemic community of debris experts and debris mitigation ideas as transnational group. The U.S. DEB members influenced other national space agency efforts, while additional influences also came as inputs from other national experts in the shaping of the IADC guidelines, as an international debris policy coordination effort and from a community wider than the main space agencies of the time. The research found that the IADC Guidelines were certainly inspired by the NASA 1995 standard, while other contributions were made by other agencies building upon ideas circulating in international fora in the 1970s, 1980s and early 1990s. These contributions were inter-agency reports such as the 1988 ESA debris report, the 1989 U.S. *Interagency Group (Space) Report on Orbital Debris*, the Japan Society for Aeronautical and Space Sciences (JSASS) report of 1993, the American Institute of Aeronautics and Astronautics (AIAA) debris report of 1981, and the International Academy of Astronautics (IAA) debris report in 1993. The international DEB community influences brought additional provisions which were harsher than the ones contained in that NASA instrument, especially regarding the intentional debris creation provision as observable in the CNES standard, the NASDA standard, the EDMS European standard and ECoC and in the Russian standard. As founding members of IADC, these delegations worked as policy coordination exchanged ideas and also contributed to shape consensually the international IADC Guidelines. The ECoC draft while in-line with the NASA standard of 1995 and the ensuing IADC guidelines of 2002 has strong requirements than both debris instruments. ECoC was used as the basis to prepare the ISO family of standards during the 2010s, indicating again the influences of other nationalities of experts besides NASA debris experts and indeed reminding of the transnational nature of the DEB community efforts. The study therefore highlighted that debris governance was consensually built thanks to epistemic groups, circulating ideas and norms across national and international levels, in several directions and led to international policy coordination.

2.6 An enduring influence

This research found an enduring epistemic influence over the decades of the space age, which benefitted space governance in general plus debris governance and space sustainability progresses. Policy instruments for debris mitigation were typically building upon a pre-existing body of agreed provisions and instruments, thus reinforcing the agreed ideas and norms, and once codified, these norms became enduring. Debris governance is found as a result of an incremental process building each new instrument “by reference” to the preexisting body of instruments, thus consolidating the basis of the debris regime.

A chronology of ideas and their respective epistemic communities’ influences over debris governance is shown in Figure 6-1. This figure is a timeline illustrating with arrows this ongoing input of the epistemic groups, with AC starting to influence space governance from the 1950s with ideas diffused into the main space regime instruments, and DEB together with continued AC group influences from the 1980s with ideas codified in debris instruments and lastly with the LTS group emerging from the early 2010s and whose ideas also impacted debris policies. The enduring influence of the AC shared ideas beyond space governance and diffusing into debris-specific governance instruments has been confirmed in this debris study.

2.7 Evolutionary nature of epistemic influences

Evidence of an evolutionary aspect of debris governance progress facilitated by epistemic communities' influences has been found thoroughly in this debris study. Working under supporting fora conducive to policy solutions and innovations, the thesis found many examples where the debris DEB community was involved in an iterative process towards updating its shared knowledge to incorporate the latest developments or innovate in designing policy solutions to tackle emerging debris proliferation problems. Many illustrations of this adaptative process are provided in the research, overall, the IADC, ITU, ECoC-ECSS and ISO sections illustrate best this evolutionary feature in the debris governance part occurring in the last phase.[709] The updated versions of the main debris instruments such as the ISO debris standard in 2019, and the IADC Guidelines 2020 revision have adapted some requirements especially for post-mission disposal in LEO showing their consideration of the latest threat of mega constellations, also observable in other revisions examples. In earlier decades, examples include This finding about the evolutionary and adaptative nature of their work involving epistemic experts of the DEB group is found across several of the debris instruments over the consolidation period. The shared knowledge or "worldview" on the problem keeps being updated, sometimes on a regular schedule such as planned for every 5 years for instance[710] or in response to a new identified crisis in the space

[709] In the space and arms control treaties process, the epistemic influences were found to occur a little differently, leading less to revised versions of the same instrument and more to the emergence of new instruments or conventions reinforcing the previous ones.

[710] Youssef, El Gammal, *ECSS - European Cooperation for Space Standardization, Space Programs and Technologies Conference*, (doi:10.2514/6.1996-4305). El Gammal notes a similar planned revision schedule and iterative process under a mixed working group of space agencies and industry delegates group, regarding the ECSS European standardization effort.

system calling for changes in the requirements.[711] This process involving epistemic experts results in multiple iterations of the same debris instrument, in response to new knowledge and problems as they appear over time. This finding for debris governance and its instruments differs with the five main space governance treaties and following conventions under COPUOS, whose provisions have remained intact. Some provisions of OST have been developed further in new conventions, and discussions to modify them sometimes lead to new initiatives and drafts, yet it is not the same as the iteration of an existing instrument such as observed here. Examples of such adaptative process by iteration and revisions to the instrument has been observed in the 2000s for the IADC revised guidelines in 2007 and revised ITU-R.S1003 recommendation in 2002. In previous decades, this evolutionary process was found under the ITU forum in the earlier phase of emerging debris governance as well as in the early space governance decades when ITU mandates were extended to firstly cover space research issues in 1959, then adapting to technological developments with covering beyond research in the early 1960s, and with consecutive WARC conferences and ITU Conventions issuing Radio Regulations constantly adjusting their rules and basic principles.

2.8 A debris regime in progress, not mature yet, however increasingly even more global

This research finds that this pluri-epistemic influence led to the institutionalization of debris mitigation ideas into a debris governance regime. Following first basic provisions in

[711] In the 2000s, trigger evens such as the Chinese ASAT and the *Cosmos*/Iridium collisions generated very large debris populations calling for revisions to debris governance tools. El Gammal regarding the ECSS European standardization platform notes a similar planned revision schedule and iterative process under its space agencies and industry delegates mixed working group process.

space governance and arms control treaties outcomes, pluri-epistemic influences facilitated the emergence and consolidation of a growing number of debris instruments, shown in Table 6-1. Many of the five global governance gaps have been filled over the five decades of the study, as explained in detail under each decade section.

The debris regime is consisting in a mix of basic provisions, partial and comprehensive international debris mitigation instruments. The table shows five main international debris instruments achieved especially in the consolidation phase of debris governance since the 1990s such as the IADC Debris Mitigation Guidelines, the UN COPUOS Debris Mitigation Guidelines, the European Code of Conduct for Debris Mitigation, the main international and industrial debris standard ISO:24113, and the Recommendation ITU-R.S.1003: Environmental protection of the geostationary-satellite orbit for the protection of GEO.
Also, besides the significant body of international instruments summed in Table 6-1, there is also a growing number of national debris policies and regulations found in the UN Compendium of space debris mitigation standards with more than 30 space-faring nations observing and further completing these five main debris instruments, indicative of the growing debris regime progress.

Even though many governance gaps have been filled over the five decades analyzed, the debris case remains a regime “in progress”, mostly due the institutional gaps not being fully filled yet. Indeed, an international overarching debris body with sufficient authority to manage and verify compliance with the debris mitigation instruments and make them binding could strengthen the debris regime. The current organizations of IADC and COPUOS remain advisory bodies issuing voluntary recommendations, however their guidelines ideas and provisions diffused nationally and regionally becoming contractually binding representing progress. Compliance levels observed also across the five decades also indicate that the debris regime represents a solid global governance basis. While efforts still need to be made towards filling some governance gaps for maturing the debris regime rules and organizations especially with an authoritative body, the epistemic influences have helped shape a solid global governance regime enhancing the existing international space regime and allowing for progress also towards greater space sustainability.

While still in progress, the debris regime is an ongoingly consolidating regime especially since the 1990s. Plus a trend of increasing debris governance progress has been highlighted, with an increasing number of debris-covering instruments further codifying debris mitigation ideas, and with a growing involvement of the private sector actors, both commercial and research institutes or associations under non-governmental platforms. This role of commercial space stakeholders under NGO such as the Space Safety Coalition is a recent development observed over the past two years. The Coalition's mixed public-private membership and its best practices agreement being more stringent than even the main debris guidelines help consolidate the debris regime as a truly global case sometimes referred to as a "good" global governance is understood as involving a more global participation in the governance process.

The role of NGO platforms has been important, but not the only supporting fora enabling epistemic ideas influences and diffusion. Diplomatic fora under the UN, bi-lateral and multi-lateral governmental fora such as disarmament negotiations, committees such as the IADC which are space agencies, many civil society NGOs like IAF and also think tanks and research institutes and associations level, plus the private sector and their NGOs organizations have all played important roles as shapers of debris governance over the years. For instance, this research found an increasing role of private actors in debris governance best practices instruments over the last decade, yet the other fora and types of actors have always played an important role in governance shaping affecting the debris issue since the birth of the space age in the 1950s. Beyond the findings of Machon et al. in 2019[712] regarding epistemic influences over the shaping of one of the main debris mitigation instruments, namely the COPUOS Debris Mitigation Guidelines, this research discovered that besides these key fora, especially the IAF and IISL, COSPAR and the IADC, many more epistemic conducive fora were involved in the shaping and promoting of debris mitigation ideas and policy outcomes. These fora entail governmental and non-governmental groups, under the United Nations system, or outside at a multi-lateral or bi-lateral level, as well as under mixed platforms such as public-private consortia all of them serving as supporting platforms for epistemic communities and ideas shaping and diffusion. As recognized by epistemic theory scholars, the borders of epistemic groups are not exact and rather almost "invisible", and they mostly operate across various for a not just one body.[713] This debris research confirmed that the epistemic influence process for the three groups occurred across multiple and diverse international, national, transnational and global fora who all enabled the epistemic influence process from epistemic knowledge construction, social learning and diffusion and reaching

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[712] Miloslav, Machoň, "The Influence of Epistemic Communities on International Political Negotiations about the Space Debris Problem," 2018-2019, http://www.academia.edu/download/62966594/1325-ArticleText-2668-1-10-20151205EN20200415-53781-9lha8b.pdf (accessed, March 19, 2021).

[713] Marianna Y. Smirnova and Sergey. Y. Yachin. "From Expert to Epistemic Communities: on the transformation of institutional frames of power in the modern world". *Journal of Social Sciences Research* 5, no. 1. (2014): 649-57, https://doi.org/10.24297/jssr.v4i2.6647, 654.

policy outcomes. These fora included additional bodies of the United Nations system besides COPUOS, namely also the ITU, the CD, Environmental-themes conferences, several bi-lateral and multi-lateral arms control platforms outside of the UN, some multi-lateral space agencies fora such as the European level under ESA, and many more non-governmental platforms. Among the NGOs, research institutions, think tanks and industry associations were found, like UNIDIR recognized as an NGO forum, the Secure World Fondation, the Stimson Fondation, the ILA, the World Economic Forum, and increasingly also NGOs involving private actors like the SDA and CONFERS.

Many fora have indeed been found in this debris research, with many platforms having been involved as supporting platforms doing more than just holding discussions, having also proposed instruments or facilitated the diffusion of ideas affecting debris. The study also found that the same types of governing fora have been present over many decades with a growing role of private sector associations more evident as governing bodies proposing best practices instrument over the last two decades of 2000s and 2010s.

The research found a diversity and multiplicity of epistemic influences and supporting fora whether they are formal institutions or more lose organizations or networks of individual experts helping to shape the debris rules and system, rendering debris governance more global.

6.1.3 Answer to Question 3: Was international policy coordination possible despite the national security component of the space debris issue?

The study found that some level of international cooperation and policy coordination could be achieved with basic elements in space governance and then debris governance instruments emerging, despite the strong national security implications of the space debris issue. The research uncovered "intentional" provisions being provisions to limit intentional debris creation in all of the main debris mitigation instruments of the UN COPUOS, IADC and ISO, and this has been achieved even in the absence of a consensus reached on the ICoC draft or on an ASAT banning treaty.

Mainly, these national security components of debris mitigation and governance efforts relate to counterspace capabilities including direct ascent and co-orbital anti-satellite weapons testing. Another important debris national security aspect derives from the emerging satellite servicing operations like the On-Orbit Servicing (OOS) and Rendezvous and Proximity Operations (RPO). A misinterpreted hostile act of getting too close to another satellite without earlier warning could trigger a physical response and generate debris as well.

States need to protect their sovereignty and maintain or develop national defense capabilities to keep up with other states, so the observed increase of all types of counterspace capabilities development and testing, especially since the 2007 Chinese ASAT, represents an important challenge for debris governance.

However, this research could highlight some progress achieved regarding this aspect in debris governance especially regarding the destructive ASATs, which are the largest sources of debris to date, as identified by debris experts in Table 1-1, Figure 1-2 and Figure 1-3. The research found that a level of international cooperation was achieved with international policy coordination occurring under several fora such as the IADC and COPUOS leading to debris mitigation guidelines covering some of these national security aspects of the debris issue. Namely, space agency members, then member states of COPUOS could agree on provisions limiting these anti-satellite weapons testing under their respective “intentional debris creation” category as observed in the debris instruments shown in Table 6-2.

Coordination on shaping debris governance instruments also occurred under the non-governmental forum of ISO, and under other standardization platforms such as the ECSS at the European level contributing to the ISO work with a debris working group. Other non-governmental organizations (NGOs) served as supporting platforms conducive to epistemic influences especially of the DEB group for shaping debris governance instruments including intentional provisions such as the IAASS and its Manifesto and the Outer Space Institute (OSI) and its latest Salt Spring Recommendations. Policy coordination also occurred under new types of non-governmental and mixed fora, involving commercial stakeholders sometimes with governmental or academia members and shaping additional best practices recommendations such as those of the Space Safety Coalition and CONFERS. Both issued best practices guidelines for commercial operations contain provisions about collision avoidance and the prevention of physical harm or interferences. Not mentioned in Table 6-2 because these instruments do not directly use the “intentional” debris creation wording, these recommendations nevertheless concern the same aspects including anti-satellite weapons issues such as co-orbital and direct ascent ASATs and can also be seen as a form of restraint achieved in terms of space security. The Stimson Foundation’s Model Code also mentions about harmful interferences against space objects with injurious consequences for international peace, security, and stability. The ICoC draft of 2008 especially contained an “intentional” provision while the latest draft of 2014 removed the “intentional” word while keeping the ideas of refraining from direct damage or destruction and harmful interference causing debris" in its article 4.2.

These "intentional" provisions found across all these debris governance instruments whether in the main or in additional or even proposed instruments illustrate well that policy progress was possible in debris governance even on the security aspect of the debris and represent a significant achievement for overcoming national security preferences as obstacles for international cooperation.

6.1.4 Answer to Question 4: Did the increase in the number of space actors allow debris governance progress?

The research found that the increasing number of space "stakeholders", state and non-state actors, especially emerging spacefaring nations and commercial entities represented both a threat and an opportunity for debris governance progress. At first, these increasing numbers of actors worsened the debris threat from the safety and security points of views, while at the same time allowing for some debris governance progress as observed with debris instruments shown in Table 6-1. The study brought to light that whether states or commercial actors, the greater participation and engagement of these new stakeholders facilitated this progress. This increasing number of stakeholders, their increasing participation in debris governance efforts under the COPUOS forum or new mixed membership non-governmental platforms such as SSC also make debris global governance a tat more "global".

Indeed, the pressure on the space environment due to the development of space traffic and testing of counter-space capabilities such as ASATs especially since 2007 has firstly created a more congested and contested outer space environment. The increasing number of space assets launched in orbit over the past decades has drastically increased the risk of collisions and of debris proliferation. Also, the launch of significantly larger constellations of satellites comes on top of the other general trend of the development of the space domain for economic and governmental uses both civilian and military. Lastly, the contested aspect of outer space activities with increased counter-space capabilities developments and testing for national security motives has also significantly heightened the pressure on the outer space environment especially since 2007 with an increase in ASAT demonstrations.

Nevertheless, the growth of space-faring nations within the main space governing fora under the United Nations' COPUOS and ITU have also allowed debris governance progress. During the 1990s at the ITU level, a recommendation had been adopted for the geostationary orbit with a very large number of member states.[714] The COPUOS Debris Mitigation Guidelines and LTS Guidelines were themselves also adopted despite membership growth from about 18 states in the 1950s to more than 90 members by the end of the 2010s.[715] Indeed, the growing number of space-faring nations still allowed for two high-level political endorsements of debris instruments to emerge under the United Nations forum of COPUOS, such as the COPUOS Debris Mitigation Guidelines in 2007 and more recently a majority of guidelines under the COPUOS LTS Guidelines in 2019. Member States have also been found

[714] ITU membership is the largest of the UN bodies today with 193 member states and over 850 sector members involving non-state actors of associations, academia, and the commercial sector. (https://www.itu.int/en/mediacentre/backgrounders/Pages/itus-evolving-membership.aspx, accessed March 10, 2021). In 1993, ITU member states involved already more member states than COPUOS which had 53 member states, and 9 observing members. (https://www.unoosa.org/oosa/en/ourwork/copuos/members/evolution.html).

[715] "Committee on the Peaceful Uses of Outer Space: Membership Evolution". Since December 2019, COPUOS membership is composed of 95 member States and 42 Observer organizations https://www.unoosa.org/oosa/en/ourwork/copuos/members/evolution.html (accessed July 28, 2020). https://www.unoosa.org/oosa/en/ourwork/copuos/members/copuos-observers.html (accessed March 9, 2021).

to increasingly institutionalize the main international debris instruments in their national regulations and policies, with about thirty nations reporting debris progress as observed under the UN Compendium of Space Debris Mitigation Standards,[716] another aspect of consolidating support of debris governance.

As for the newcomers of the private sector, they have been increasingly joining or even leading best practices initiatives also further consolidating debris governance towards an even "more" global governance regime. This trend has been observed at various levels especially in the last decade especially under non-governmental mixed membership fora, such as the Space Data Association (SDA), the Space Safety Coalition (SSC), CONFERS, the World Economic Forum and its Space Sustainability Rating (SSR). These new types of NGOs showed that the commercial actors can also "learn" or lead initiatives under mixed consortia and further facilitate epistemic community influences as a supporting platform for ideas and norm promotion and codification into debris instruments as best practices in the same way as the more classical NGO fora like IAF, IAA, IISL and COSPAR do in the debris governance system. This serves as complementary efforts to the main debris instruments agreed in governmental fora such as under the United Nations and help to further implement COPUOS Debris Mitigation Guidelines and LTS guidelines, ITU recommendations as well as international standards of the ISO forum such as the main debris standard ISO 24113.

[716] UN Doc. A/AC.105/2014/CRP.13.

6.1.5 Limitations: Additional findings

The findings below are a continuation of the above list and have been separated from the above section due to their limitative nature for regime formation in this debris case study. Some of them are relating to material factors, while others relate to the ideational factors of the epistemic and governance frameworks.

1. Epistemic influences take about one to two decades

The research found a limitation to epistemic ideas and their influences for governance progress relating to the long time it takes for ideas to diffuse until some outcomes can appear. Indeed, the study found in every decade and for every group of shared ideas that epistemic influences enabled regime progress, yet it was occurring at the length of decades. On average for the debris case, it took one to two decades between the time when epistemic ideas are shaped forming knowledge until some policy goal can reach an outcome level such as agreements working as policy instruments as basis for a regime. This can be seen a limitation for regime formation.

However, this study also found that this limitation led to a consolidation process in the debris case. The ideas are shaped for a long time and diffuse as norms and get institutionalized into policy provisions, some of which can be binding or non-binding but upon which others are built, creating a consolidation effect. These policy outcomes reached in the debris case have been observed to endure as they have been built by consensus and incrementally, so that the institutionalization process led to enduring policy solutions not just policy innovations to solve an immediate crisis, this contributing to regime development.

Also, many of the debris policy instruments were built by reference to earlier achieved outcomes, enhancing each other in the end, such as mentioned above in findings 2.6 and 2.4.

For the DEB group, the shaping of the debris mitigation ideas as shared ideas is deemed to date from the seminal work of Donald Kessler in 1978.[717] The core of the DEB consensually agreed ideas are deemed to be crystallized in reports in 1988 and 1989 such as the IG space report 1989 and the ESA report of 1988, and the IADC and the debris becoming an agenda item of COPUOS occurred in the early 1990s a little over a decade later, while the first international policy outcome dedicated to debris mitigation comprehensively is the IADC Guidelines issued in 2002 taking two decades.

For the LTS group, the origin of the sharing of ideas is found around 2007,[718] and the first institutionalization of the ideas are found in the first set of LTS Guidelines agreed by 2016 and recently completed by more guidelines in 2019. The process took thus also about a decade between the initiative and the policy outcomes.

For the influences of the AC group studied in Adler for the early period preceding debris governance, the ideas started to take shape as “arms control ideas” around the mid-1950s and after circulating under Pugwash conference and following years of discussions and some publications and working groups, led to the PTBT treaty early 1960s, and to some diffusion of the restraint ideas into the main space treaty OST by 1967, thus about a decade later.

[717] Kessler and Cour-Palais, “Collision frequency of artificial satellites: The creation of a debris belt”, *Journal of Geophysical Research* 83 no. A6 (1978):2637–2646.
[718] Brachet,‘ The origins of the “Long-term Sustainability of Outer Space Activities” initiative at UN COPUOS’ *Space Policy*, 3 (August 2012): 161-165.

As regards the AC group influence over ASAT testing limits, which diffused into the "intentional" destruction provisions in debris instruments calling for restraint on ASAT testing to avoid intentional debris creation, early ideas circulated around the ASAT ban treaty attempts in the late 1970s, slowly took shape in the 1980s, and will be found in the first debris outcomes in the late 1980s, as the ones gathering the core debris mitigation ideas, and the ensuing debris instruments especially developed as space agencies standards from the 1990s. The process thus also spanned over a period of a decade to the first outcomes, and of two decades to diffuse into the main comprehensive debris instruments such as the IADC guidelines in 2002.

2. Threshold level for the knowledge gap

The research found that there is a threshold level to be attained in the knowledge gap for the epistemic process to really start. In the case of the International Code of Conduct proposed by the European Commission for instance, the research found that due to a lack of share understanding and building of a shared knowledge about what kind of code it should be and what it should entail, the ICoC initiative was not able to allow for epistemic influences to help it become institutionalized.

3. Cost

Several levels of cost limitations were found in the debris case. One level relates to the cost of implementing debris mitigation guidelines, rules, standards. The other level relates to the cost of developing and testing the new technologies required for remediation of space debris known as Active Debris Removal (ADR) technologies. Another level relates to legal aspects also dependent on cost concerns.

The cost of debris mitigation was a factor limiting the emergence of a debris regime at COPUOS since the early days of the debate and led to space debris being labelled "premature" and preventing it to enter as an agenda item back in the late 1980s as mentioned in Perek 2002.[719] The concerns of many nations remain about the burden of paying for the implementation or for the removal. Space launching nations worry about cost to their current missions, while emerging space-faring nations worry about the cost being a barrier for them to be competitive and at a disadvantage to bear the cost of debris procedures or damages induced by space powers for many decades. The major sources of orbital debris have indeed resulted from mainly the activities of space powers, and for new entrants it is regarded as an unfair cost disadvantage. Yet, the study found that there is a large increase in the number of nations supporting the debris instruments, referring to them and incorporating them nationally.

Even some of the founding nations of IADC display a limitation to compliance progress with the debris instruments is illustrated by Brian Weeden in 2020.[720] Weeden explains how in the United States, despite debris policies and standards in place, NASA and the DOD are still waiving on some debris mitigation provisions in order to avoid the cost when the technology of the assets to be launched predates the guidelines.

Another aspect limiting the progress in debris efforts relates to the remediation efforts namely paying for removing assets in space or to develop technologies known as active debris removal (ADR), which are just emerging and costly to develop and test as well.

[719] Perek, "Space Debris at the United Nations," 127.
[720] Weeden, "The United States is losing its leadership role in the fight against orbital debris."

However, there is progress lately with the European governmental approval of a removal mission at ESA-level and in Japan with the private involvement of Astroscale in removal technologies.

Lastly, liability limitations are also present in the debris case not just because it is hard to identify debris pieces and establish fault for legal definitional reasons, but also because there is the inequality question of why some nations should pay the price of debris removal when it was created by another nation. The study then notes that besides the legal aspect of the definition problem, there is also a cost aspect preventing regime progress.

4. National security preferences

As nations increasingly rely on space technologies to support their military operations and more begin to be able to conduct such activities as ASATs and other counter-space capabilities testing, the national security preference represents a limiting factor for debris governance and the debris regime. Mostly the continued used of space technology as a demonstration of national power which was occurring during the Cold War and resumed since 2007 represents an ongoing threat for debris proliferation, especially destructive kinetic-kill ASATs. The Chinese test from 2007 was the largest debris-creating event with around 3000 pieces and due to its target being located around the 800 km LEO orbit, many of these debris are long-lived, as explained in Table 1-2. The ensuing tests have been conducted at much lower altitudes like the 2008 American test and the latest Indian ASAT test in 2019. Still some long-lived space debris were created from these lower-altitude tests because of the laws of space physics. and related unpredictability. Indeed, in both cases some pieces were projected into higher orbits as it is hard to predict how many orbital pieces will go up, yet it was much smaller numbers and the rest fell down. The research found therefore that this national security imperative limitation such as ASATs as demonstrations of power did still allow for some level of debris governance progress.

Firstly, since the mid-1980s and as noted also in Moltz, Kessler, Portree and Loftus, learning about debris proliferation brought by debris experts led to progress in the United States with ASAT DOD guidelines, congressional bans and the first space debris presidential directive and policy by 1989, and to similar restraint forms in the Soviet side with an additional unilateral moratorium on direct-ascent ASATs around a similar period.[721]

Secondly, even after the Chinese kinetic-kill ASAT of 2007 and following resuming of counterspace capabilities developments across more nations, this national security policy limitation still allowed for the codification of DEB ideas from the 1980s into internationally agreed voluntary guidelines. The research observed that this 1980s policy progress on the ASAT issue in the US and USSR gradually expanded into all of the main debris instruments emerging from the 1990s. As mentioned in Table 6-2, all of the main instruments and also additional following ones include an "intentional provision" specifically calling for restraints of intentional debris creation behaviors, covering ASATs. Some provisions specify that if unavoidable, intentional activities ought to be conducted at lower altitudes. This study found that progress was also achieved regarding compliance with this requirement of conducting ASATs at least in lower orbits producing less long-lived debris since the end of 2007. Thus, debris knowledge, normative, policy and compliance steps enabled progress and even

[721] Details are provided in the 1980s sections under chapter 4.2. Kessler "A Partial History of Orbital Debris: A Personal View," 10-11; Moltz, *The Politics of Space Security: Strategic Restraint and the Pursuit of National Interests*, 177, 339-341, and Moltz, *Crowded Orbits: Conflict and Cooperation in Space*, 153.

international cooperation in debris governance, in spite of the ongoing national power demonstrations.

6.2 Policy Implications

This doctoral study has policy implications for national and international policies relating to space and to other global issues under stress needing management policies besides outer space issues.

A first policy implication of this research relates to the originality and innovations proposed, which serve as basis to enrich space policy literature and international relations literature, especially for the evaluation of global governance emergence and evolution. Indeed, going back to first decade of the space age and covering seven decades, this research provides a deeper analysis of the transnational "knowledge" epistemic experts within the debris governance process. It expands emerging space epistemic community literature covering a debris community, going further in its study of that influence than regarding the United Nations level of COPUOS. For instance, this study explores the influences of additional epistemic groups than the debris group DEB and their shared ideas. Namely it also considers the influences of the Arms Control communities of Adler and proposes the Long-Term Sustainability communities as additional influential groups. It also looks into additional decades and especially more recently since 2007, identifies more supporting fora than IAF, IAA, IISL, IADC and COSPAR, looks into additional instruments than the COPUOS Debris Mitigation Guidelines, and details the debris policy process and progress achieved as a form of global governance. This empirical exploration of the debris case considers three epistemic groups, five levels of global governance progress achieved, a body of about twenty debris-related instruments and basic provisions, and a variety of fora such as governmental and non-governmental ones involved as supporting platforms for enhancing epistemic communities' governing influences. This research also offers an original contribution to space policy literature with its proposed detailed evaluation of space sustainability progress as a global governance progress and declined under the five global governance gaps of knowledge, normative, policy, institutional and compliance.

Another important policy implication of this debris research concerns the progress achieved on the security aspect of space debris governance and sustainability progress. Indeed, the study found such progress within the instruments and also in the overall compliance with the intentional creation of long-lived debris, such as especially resulting from anti-satellite tests. This global governance progress step holds lessons for evaluating other global issues with national security dimensions. Indeed, in the absence of a treaty banning Anti-Satellite Weapons testing, the epistemic communities aggregated influences still succeeded in shaping governing instruments with a specific provision calling on restraint of such "intentional" activities. This renders the debris case more complex than a simple functional cooperation aside from the political aspects and national rivalries typically limiting international cooperation. In fact, the study noted that all of the main adopted debris governance instruments indicated in Table 6-2 do contain such "intentional" provision. Also, the thesis noted that all ASAT tests following the Chinese one in 2007 were conducted at lower altitudes and created less long-lived debris thanks to the observance of these voluntary guidelines provisions, making the debris governance a meaningful security policy achievement towards ensuring space sustainability progress.

A last policy implication concerns further research. Indeed, as a case study showing the possibility to overcome some aspect of national rivalries and to shape a global governance regime, this debris governance research holds lessons for assessing global governance in additional space sustainability issues. International cooperation issues for the governance of the cislunar environment, understood as the Moon orbital environment could be an interesting topic for further research and complement this space debris policy study and the literature on space sustainability governance. Indeed, the latest Artemis accords include only a few space powers while excluding others major ones with demonstrated scientific and technological capabilities to reach the Moon. Combined with rising interest of the private sector, there is clearly a need for improved international cooperation to ensure Cislunar sustainable increasing uncertainties calling for policy analysis.

The proposed framework with its many and diverse findings has provided a rich evaluation tool for identifying epistemic influences and distinguishing levels of achievements in global governance progress. Indeed, numerous epistemic influences have been found to allow international policy coordination around the debris issue and to enable the emergence of debris governance instruments and supporting institutions. It was able to map out progress steps towards a more sustainable space environment via global governance gap filling efforts over seven decades and to highlight epistemic communities group dynamics steps and new trends in debris governance, resulting in a comprehensive assessment of debris governance efforts as enablers of space sustainability progress.

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TABLES

Table 1-1 Main Sources of Space Debris

Main Categories	Causes	Debris Sources
Mission- related objects **(Parts Released during Mission Operation)**	**objects re-leased by design**	**operational debris** (fasteners, covers, wires, etc.)
		objects released for experiments (needles, balls, etc.)
		tethers designed to be cut after experiments
		others (released before retrieval)
	unintentional-ly released objects	**fragments caused by ageing** (flakes of paints and blankets resulting from degradation)
		tether systems cut by debris or meteoroids
		objects released before retrieval to ensure safety
		liquids (leaked from nuclear power systems, etc.)
		particles ejected from solid motors
On-orbit break-ups	**intentional destruction**	**destruction for scientific or military experiments** (including self-destruction, intentional collision, etc.)
		destruction prior to re-entry in order to minimise ground casualty
		destruction to ensure security of on-board devices and contained data
	accidental break-ups	**explosion caused by failure during mission operation**
		explosion caused by command destruct systems, residual propellants, batteries, etc., after mission termination
	on-orbit collisions	**fragments caused by collision with catalogued objects**
		fragments caused by collision with un-catalogued objects
Mission-terminated space systems		**systems left in near-GEO, GTO, LEO, and HEO**

Source: "Support Document to the IADC Space Debris Mitigation Guidelines," 8 (IADC-04-06, Rev 5.5 May 2014)

Table 1-2 Average Lifetime of Objects in Circular Orbits

Orbit altitude (km)	Lifetime
200	1 – 4 days
600	25 – 30 yrs
1000	2000 yrs
2000	20000 yrs

Source: Darren, McKnight, Walter Flury and Hartmut Sax (eds), "IAA Position Paper on Orbital Debris," *Acta Astronautica*, Vol. 31 (Oct. 1993), 177.

Table 1-3 Top Ten Satellite Breakups 1965-2009

Common Name	Year of Breakup	Altitude of Breakup	Cataloged Debris*	Debris in Orbit*	Cause of Breakup
Fengyun-1C	2007	850 km	2841	2756	Intentional Collision
Cosmos 2251	2009	790 km	1267	1215	Accidental Collision
STEP 2 Rocket Body	1996	625 km	713	63	Accidental Explosion
Iridium 33	2009	790 km	521	498	Accidental Collision
Cosmos 2421	2008	410 km	509	18	Unknown
SPOT 1 Rocket Body	1986	805 km	492	33	Accidental Explosion
OV 2-1 / LCS 2 Rocket Body	1965	740 km	473	36	Accidental Explosion
Nimbus 4 Rocket Body	1970	1075 km	374	248	Accidental Explosion
TES Rocket Body	2001	670 km	370	116	Accidental Explosion
CBERS 1 Rocket Body	2000	740 km	343	189	Accidental Explosion
			Total: 7903	Total: 5172	

* As of May 2010

Source: NASA Orbital Debris Quarterly News, Vol. 14, Issue 3, July 2010, 2.

Table 1-4 History of Chinese DA-ASAT from 2005-2018

Date	ASAT System	Site	Target	Apogee	Notes
July 7, 2005	SC-19	Xichang	None known	??	Likely rocket test
Feb. 6, 2006	SC-19	Xichang	Unknown satellite	??	Likely near-miss of orbital target
Jan. 11, 2007	SC-19	Xichang	FY-1C satellite	865 km	Destruction of orbital target
Jan. 11, 2010	SC-19	Korla	CSS-X-11 ballistic missile launched from Jiuquan	250 km	Destruction of target
Jan. 20, 2013	Possibly SC-19	Korla	Unknown ballistic missile launched from Jiuquan	Suborbital	Destruction of target
May 13, 2013	Possibly DN-2	Xichang	None known	~30,000 km	Likely rocket test
July 23, 2014	Possibly DN-2, (possibly SC-19)	Korla? (Jiuquan?)	Likely ballistic missile launched from Jiuquan	Suborbital	Likely intercept test
Oct. 30, 2015	Possibly DN-3	Korla	None known, possible ballistic missile	Suborbital	Likely rocket test
July 23, 2017	DN-3	Jiuquan?	Likely ballistic missile	Suborbital, malfunctioned	Likely intercept test
Feb. 5, 2018	DN-3	Korla	CSS-5 ballistic missile	Suborbital	Likely intercept test

Source: Weeden and Samson, *Global Counterspace Capabilities: An Open Source Assessment*, April 2019, 1-14.

Table 1-5 Recent Chinese RPO activities 2010-2019

Date(s)	System(s)	Orbital Parameters	Notes
June – Aug. 2010	SJ-O6F, SJ-12	570-600 km; 97.6°	SJ-12 maneuvered to rendezvous with SJ-06F. Satellites may have bumped into each other.
July 2013 – May 2016	SY-7, CX-3, SJ-15	Approx. 670 km; 98°	SY-7 released an additional object that it performed maneuvers with and may have had a telerobotic arm. CX-3 performed optical surveillance of other in-space objects. SJ-15 Demonstrated altitude and inclination changes to approach other satellites.
Nov. 2016 – Feb. 2018	SJ-17, YZ-2 upper stage	35,600 km; 0°	YZ-2 upper stage failed to burn to the graveyard orbit and stayed near GEO. SJ-17 demonstrated maneuverability around the GEO belt and circumnavigated Chinasat 5A.
Jan. 2019	TKS-3, TKS-3 AGM	35,600 km; 0°	TkS-3 AKM separated from the TKS-3 in the GEO belt and both performed small maneuvers to maintain relatively close orbital slots.

Source: Weeden and Samson, *Global Counterspace Capabilities: An Open Source Assessment*, April 2019, 1-7.

Table 1-6 Recent Russian RPO potential Co-orbital tests: 2014-2020

Date(s)	System(s)	Orbital Parameters	Notes
Jun. 2014 – Mar. 2016	Cosmos 2499, Briz-KM R/B	1501 x 1480 km; 82.4°	Cosmos 2499 did series of maneuvers to bring it close to, and then away from, the Briz-KM upper stage.
Apr. 2015 – Apr. 2017	Cosmos 2504, Briz-KM R/B,	1507 x 1172 km; 82.5°	Cosmos 2504 maneuvers to approach the Briz-KM upper stage and may have had a slight impact before separating again.
Mar. – Apr. 2017	Cosmos 2504, FY-1C Debris	1507 x 848 km; 82.6°	After a year of dormancy, Cosmos 2504 did a close approach with a piece of Chinese space debris from the 2007 ASAT test
Oct. 2014 – Feb. 2020	Luch, Multiple	35,600 km, 0°	Luch parked near several satellites over nearly five years, including the Russian Express AM-6; American Intelsat 7,Intelsat 401, Intelsat 17, Intelsat 20, and Intelsat 36; and French-Italian Athena-Fidus satellites.
Aug. – Oct. 2017	Cosmos 2521, Cosmos 2519	670 x 650 km; 97.9°	Cosmos 2521 separated from Cosmos 2519 and performed a series of small maneuvers to do inspections before redocking with Cosmos 2519.
Aug. – Dec. 2019	Cosmos 2535, Cosmos 2536	623 x 621 km; 97.88°	Cosmos 2535 and Cosmos 2536 conducted at least 25 individual RPO operations to within 2 km and as far apart as 380 km.
Dec. 2019 – Feb. 2020	Cosmos 2543, USA 245	859 x 590 km; 97.9°	Cosmos 2543 raised its orbit to come within 30 km of USA 245 and establish repeated close approaches within 150 km, likely for the purpose of surveillance.

Source: Weeden and Samson, *Global Counterspace Capabilities: An Open Source Assessment*, April 2020, 2-9.

Table 1-7 Recent US Co-orbital tests: 2003-2019

Date(s)	System(s)	Orbital Parameters	Notes
Jan. 2003	XSS-10, Delta R/B	800 x 800 km; 39.6°	XSS-10 did a series of maneuvers to bring it within 50 meters of the Delta upper stage that placed it in orbit.
Apr. 2005 – Oct. 2006	XSS-11, multiple objects	LEO	XSS-11 did a series of maneuvers to bring it close to the Minotaur upper stage that placed it in orbit. it then performed additional close approaches to other U.S. space objects in nearby LEO orbits over the next 12-18 months.
Apr. 2005	DART, MUBLCOM	LEO	DART did a series of autonomous maneuvers to bring it close to the MUBLCOM satellite and ended up bumping into it.
Mar. – Jul. 2007	ASTRO, NEXTSat	LEO	ASTRO and NEXTSat were launched together and performed a series of separations, close approaches, and dockings with each other.
Jul. 2014 – present	GSSAP, multiple objects	GEO	Two pairs of GSSAP satellites have been performing RPO with various other objects in the GEO region
Jul. 2014 – Nov. 2017	ANGELS, Delta 4 R/B	GSO	ANGELS separated from the Delta 4 upper stage that placed the first GSSAP pair into orbit and then performed a series of RPO in the GSO disposal region.
May 2018	Mycroft, EAGLE	GEO	EAGLE separated from the Delta V upper stage, and Mycroft subsequently separated from EAGLE. Mycroft conducted RPO of EAGLE in the GEO region.
Oct. 2019	Mycroft, S5	GEO	Mycroft maneuvered to rendezvous with S5 after the latter ceased communications.

Source: Weeden and Samson, *Global Counterspace Capabilities: An Open Source Assessment*, April 2020, 3-7.

Table 5-1 Comparative Table ISO Standards, UNCOPUOS Debris Guidelines and IADC Guidelines

		Measures	ISO Standards (or Technical Reports)	UN Guidelines	IADC Guidelines
Limiting debris generation	Released objects	General measures for avoiding the release of objects	**ISO 24113, 6.1.1**	Recommendation 1	5.1
		Slag from solid motors	**ISO 24113, 6.1.2.2, 6.1.2.3**	--	--
		Combustion products from pyrotechnics	**ISO 24113, 6.1.2.1** (Combustion Products < 1 mm)	--	--
	On-orbital break-ups	Intentional destruction	**ISO 24113, 6.2.1**	Recommendation 4	5.2.3
		Accidental break-ups during operation	**ISO 24113, 6.2.2** (Probability < 10^{-3})	Recommendation 2	5.2.2 (Monitoring)
		Post-mission break-up (Passivation, etc.)	**ISO 24113, 6.2.2.3** (Detailed in ISO 20893, 23312)	Recommendation 5	5.2.1
Disposal at end-of-operations	GEO	Re-orbit at end of operation	**ISO 24113, 6.3.2** (Detailed in ISO 20893, 23312) 6.3.2.1: General Requirement 6.3.2.2: 235 km+ + (1 000•Cr•A/m), e < 0,003 6.3.1: Success Probability > 0,9	Recommendation 7 (No quantitative requirements) Note: ITU-R S.1003-1 recommends:235 km + 1,000 *Cr*A/M* Here, A[m^2], M[kg], Cr[-]	5.3.1 235 km+ (1 000•Cr•A/m), e < 0,003
	LEO	Reduction of orbital lifetime	**ISO 24113, 6.3.3** (Detailed in ISO 20893, 23312) 6.3.3.1: Orbital lifetime after end of operation < 25 years 6.3.1: Success Probability > 0,9	Recommendation 6 (No quantitative requirements)	5.3.2 (Recommend 25 years)

SPACE DEBRIS MITIGATION STANDARDS

	Measures	ISO Standards (or Technical Reports)	UN Guidelines	IADC Guidelines
	Options for removal from the protected region	**ISO 24113, 6.3.3.2 (a) ~ (f)** (Detailed in ISO 20893, 23312)	Mentioned in Recommendation 6	5.3.2
Re-entry	Avoidance of ground casualties	**ISO 24113, 6.3.4** (Detailed in ISO 27875)	Included in Recommendation 6	5.3.2
Collision avoidance for large debris		**ISO/TR-16158** (for assessment only) ISO/19389	Recommendation 3	5.4
Protection from the impact of micro-debris		**ISO 16126** (for assessment only)	--	5.4
Exchange or pooling of space data for the purpose of safety-of-flight and mitigation of Radio Frequency Interference		**ISO 13541, Attitude** **ISO 26900, Orbit** **ISO 13526, Tracking** **ISO 19389, Conjunction**	Consensus LTS Guideline 11 (Share space object and orbital event information), Guideline 12 (Orbital information sharing), Guideline 13 (sharing of space debris information), Guideline 14 (Conjunction Assessment), Guideline 31 (Reentry)	5.4 "Reliable orbital information"

Source: UNOOSA Compendium of space debris mitigation standards, "ISO Space Debris Mitigation Standards" https://www.unoosa.org/documents/pdf/spacelaw/sd/ISO20180921.pdf (accessed February 21, 2020).

Table 6-1 Summary of Main International Space Debris Mitigation Instruments and Space Governance Basic rules

	Comprehensive Debris Mitigation Instruments*	Partial Debris Mitigation Instruments**	Space Governance Basic Elements ***
1950s			UNGA Resolution 1148 UNGA Resolution 1348 UNGA Resolution 1472
1960s			UNGA Resolution 1962[722] PTBT Treaty Outer Space Treaty[723] Rescue Agreement ARRA
1970s			ABM Treaty[724] Liability Convention Registration Convention ENMOD Convention
1980s			ASAT Testing Bans (U.S. and U.S.S.R.) Soviet Unilateral ASAT testing Moratorium
1990s		ITU-R. S. 1003	UN NPS Principles
2000s	IADC Debris Guidelines ECoC UN COPUOS Debris Guidelines IAASS Manifesto	ISO ODM	
2010s	ISO 24113 Standard UN COPUOS LTS Guidelines SSC Best Practices	UN GGE on TCBM ISO CDM CONFERS Best Practices and Guiding Principles	

* International instruments designed to manage the debris issue and with a comprehensive approach
** International instruments designed to manage partial aspects of the space debris issue such as specific orbits (GEO) or activities (RPO and OOS)
*** International space and arms control agreements not specifically designed to address debris mitigation yet covering partial aspects of debris mitigation and serving as basic provisions for a space debris regime

[722] Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space
[723] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Outer Space Treaty)
[724] Following the ABM treaty, ensuing arms control treaties have been agreed almost in every decade between mostly the United Stated and Soviet Union/Russia and kept the ABM NTM protection provision, thus also found in the INF, CFE, START I, SORT/Moscow and New START treaties all contributing as basic element of restraint in space governance. United States Department of State, Bureau of Arms Control, Verification and Compliance, Treaties, https://2009-2017.state.gov/t/avc/trty/102360.htm (accessed May 14, 2020).

Table 6-2 Summary of Space Debris Instruments with "Intentional" Provisions

	Main Space Debris Mitigation Instruments				Additional Debris Mitigation Instruments*					Proposed[725] Instruments
International Debris Governance Instruments	IADC Debris Guidelines 2002	ECoC Code of Conduct for Debris 2004	UN COPUOS Debris Guidelines 2007	ISO Standard 24113 2010	GGE TCBM Recom. 2013	Stimson Model Code of Conduct 2007	IAASS Manifesto 2008	CONFERS Guiding Principles 2018 CONFERS Recommended Practices for Design and Operations 2019	OSI Decl. 2020	ICoC Draft 2008
Provisions Limiting Intentional Debris creation "Intentional Provision"	5.2.3 Should be avoided	4.1.2 Prohibited	4. Should be avoided	6.2.1 Prohibited	§45 Avoid, but if necessary notify	preamble §7. Refrain from harmful interferences against space objects	4. Ban ASAT	Guiding Principles Provision III, b) avoiding Recommended Practices 1.4.2. Avoid physical interference; provide notice of intention	Article II, para 1 avoid debris creating ASATs, ASAT-Ban Treaty"[726]	Article 4.2 and 5.1 Refrain

[725] Arguably another instrument could be included, the ILA Space Debris Instrument 1994 with its provision on the "obligation to prevent debris creation and harm to the space environment" and on the "obligation to avoid situation generating disputes and settle disputes peacefully".
[726] OSI Salt Spring Recommendations on Space Debris, Section II. 1. Recommends "The avoidance of anti-satellite (ASAT) weapon tests, especially those that generate debris, and the negotiation of an international treaty prohibiting such tests," 1.

Table 6-3 Space Debris Governance Epistemic Communities

Epistemic community	Early Members[727]	Meeting Fora[728]
DEB	Kessler Loftus Perek McKnight Johnson Flury Rex Klinkrad Alby Bonnal Böckstiegel Toda	IAF/IAC/IAA/IISL IADC COPUOS COSPAR ESA/ESOC Debris Conferences ISTS
LTS[729]	Brachet Martinez Schrögl Jakhu	IAF/IAC/IAA/IISL COPUOS
AC[730]	Garwin Velikhov Sagdeev	UCS National Academy of Sciences U.S./U.S.S.R

[727] This table only gives an idea about who were some early members who initiated the interest for the issue, pushed for the emergence of related initiatives or became leading promoters of the shared ideas of the group, and is non-exhaustive. Typically, these epistemic groups have gained numerous members who also kept promoting the shared ideas by publishing, chairing working group or discussion fora over the ensuing years.

[728] These are the main fora where most epistemic members met and also a non-exhaustive list as numerous debris and sustainability specialized conferences or workshops have emerged over more than 30 years since the 1980s: NASA workshops, ESA/ESOC Debris Conference, IAASS Symposium, UNIDIR Space Security Conference, Japan Space Forum Symposia on Space Sustainability, AMOS Conference, CNES workshops, ESTEC Clean Days, JAXA workshops.

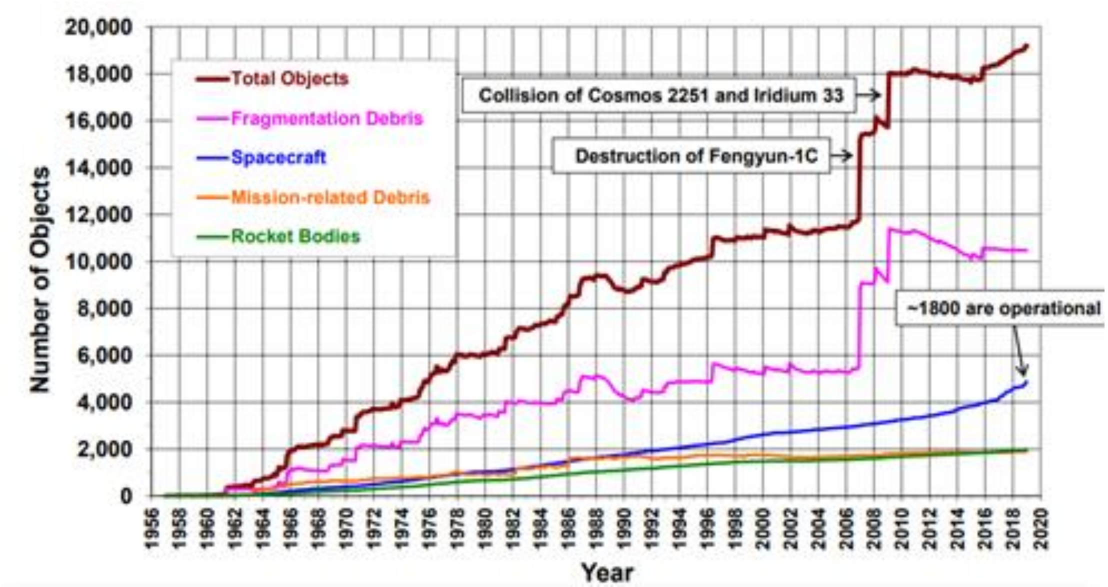
[729] These early members of the LTS group belonged firstly also to the DEB group. They promoted a wider approach under the LTS initiative helping to create a distinct epistemic group, whose shared ideas encompass a larger scope more comprehensive than the DEB set of ideas.

[730] The arms control epistemic group is external to the space community, emerging under arms control discussions platforms, and explored by Emmanuel Adler, "The Emergence of Cooperation: National Epistemic Communities and the International Evolution of the Idea of Nuclear Arms Control" ; and also by Kristina Bekenova, "The Epistemic Communities as a Key to International Cooperation" Journal Of Humanities And Social Science 19, no.8, I (Aug. 2014): 68-75. Some ideas diffused into space governance treaties, serving as restraint ideational basis for many space governance instruments, and by the 1980s the ASAT limited test bans provided support for debris governance specifically. The individuals mentioned here are those who were active from the 1980s for debris efforts.

Earlier key figures are especially detailed in Adler's work, including James Killian, Paul Doty, and others who founded the AC as an epistemic group at the end of the 1950s, and met especially at the Pugwash conferences from late 1950s early 1960s onward.

FIGURES

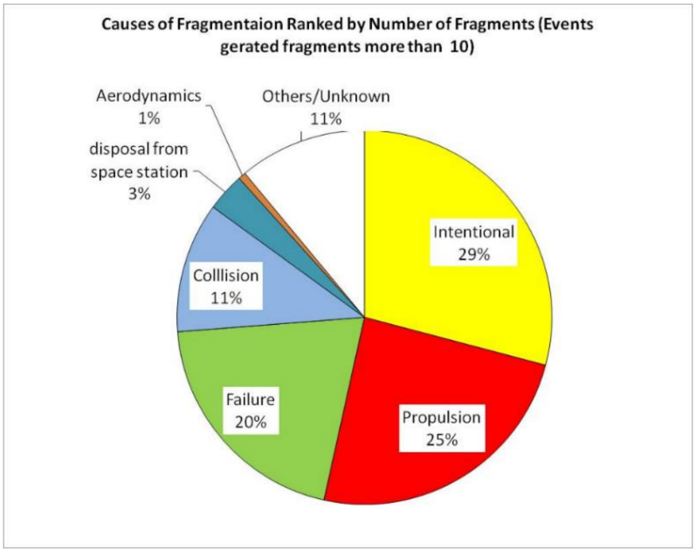
Figure 1-1 Growth of orbital debris 1957-February 2019: 23,000 Large Objects



Source: NASA Study by Anz-Meador, P., et al. "History of On-orbit Satellite Fragmentations (15th Edition)," NASA/TM-2018-2220037, (2018).[731]

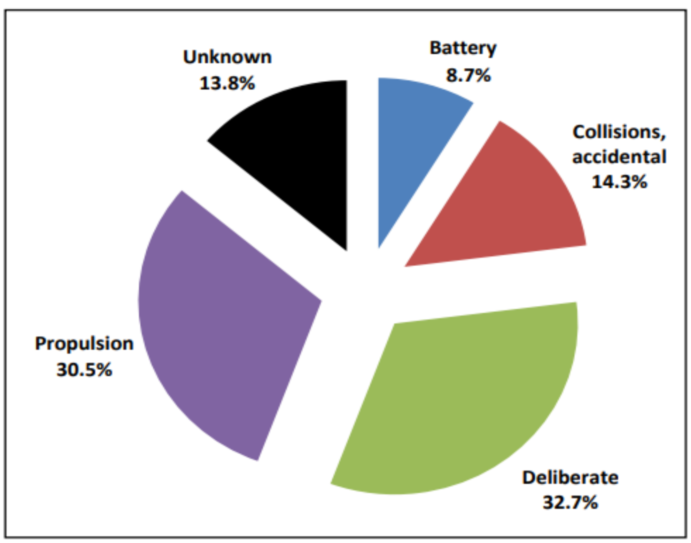
[731] The latest Indian ASAT of March 2019 is not included.

Figure 1-2 Largest sources of orbital debris in the 2000s and 2010s as intentional



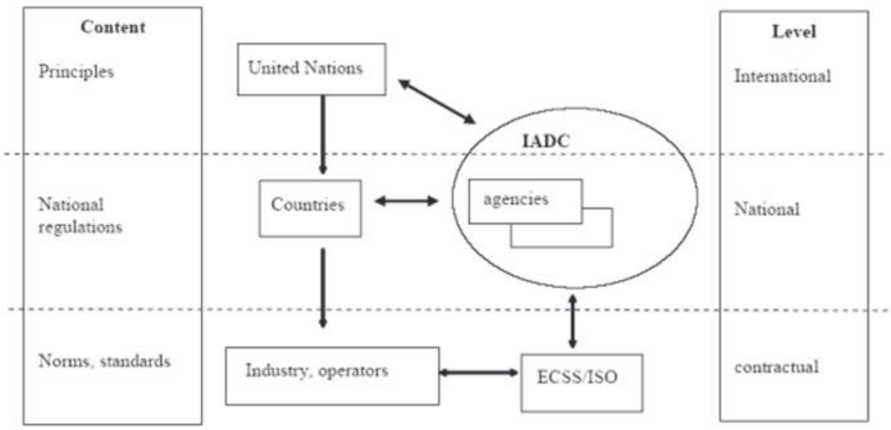
Source: Akira, Kato, "Debris Mitigation Guidelines," APRSAF-21, 15.

Figure 1-3 Largest sources of orbital debris in the 2000s and 2010s as intentional



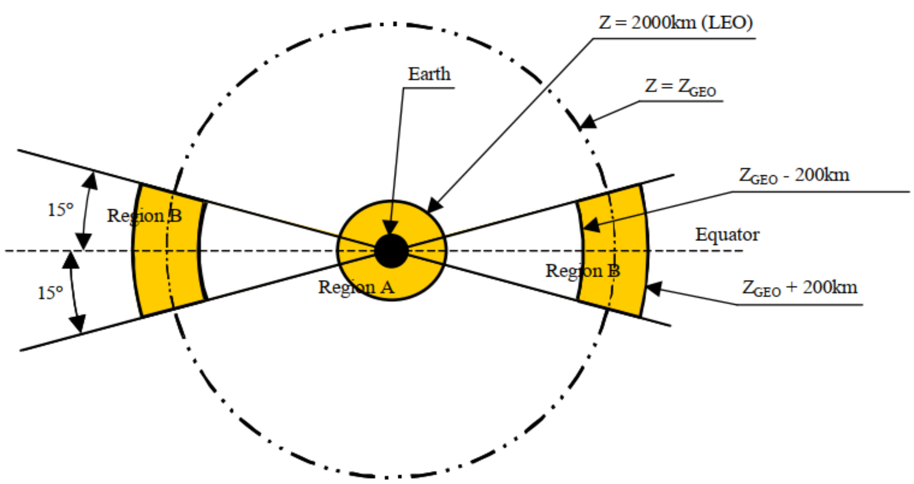
Source : Anz-Meador, P., et al. "History of On-Orbit Satellite Fragmentations (15th Edition)," NASA/TM-2018-2220037, (2018).

Figure 1-4 Space Debris Mitigation Rules levels



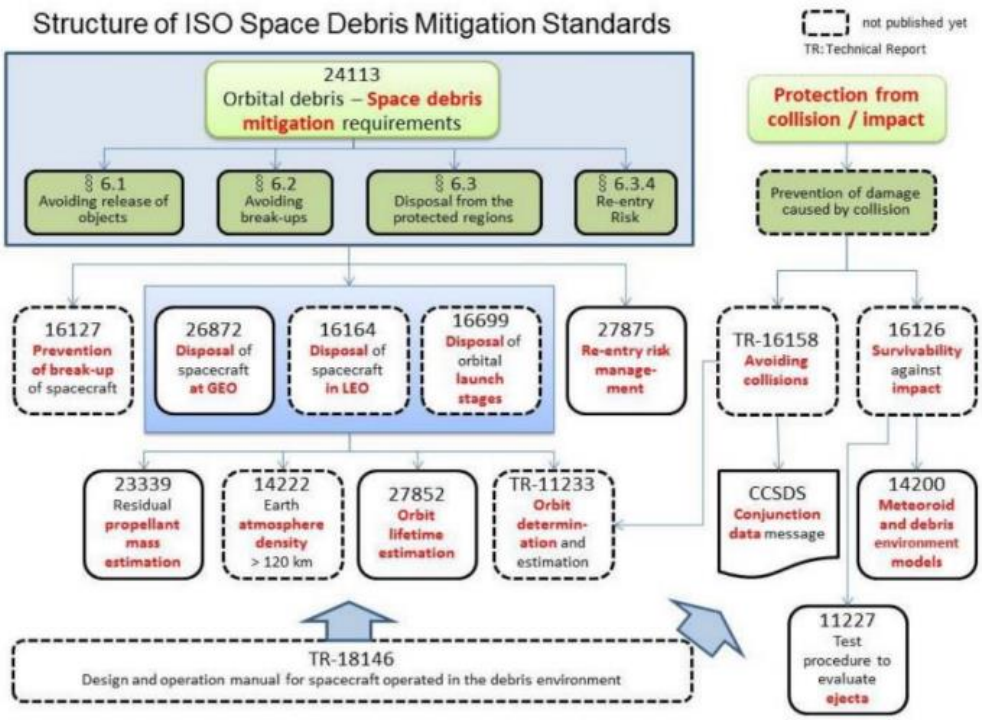
Source: IAA Position Paper on Space Debris Mitigation, *Implementing Zero Debris Creation Zones*,11.

Figure 1-5 IADC Protected orbits in LEO and GEO



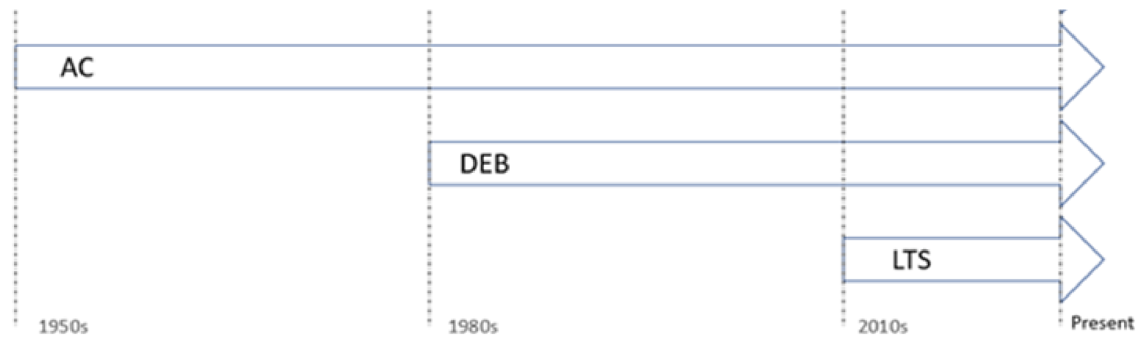
Source: IADC Guidelines

Figure 5-1 ISO Space Debris Standards: ISO 24113 and CCSDS CDM



Source: International Organization for Standardization (ISO) webpage

Figure 6-1 Chronology of Epistemic Influences over Space and Debris Governance



APPENDIX

Appendix to Chapter 2

Appendix A.2 Research Interviews

	Name SURNAME	Affiliation	Research Input Details
1	Ilknur AKDEVELIOGLU	COPUOS Turkish delegation, Counsellor, Permanent Mission to the United Nations	Interview 2015 COPUOS plenary session - Vienna, Austria
2	Fernand ALBY	CNES Former Debris Working Group Member	Emails 2017 and 2020
3	Cécil AMEIL	SES, SDA - Industry Professional	Interview 2015
4	Setsuko AOKI	Keio University - Space Law Professor	Interview 2015 Keio Space Law Workshop - Tokyo, Japan
5	Frank ASBECK	EEAS (European Commission External Service) ICoC Team	Interview 2014 EU-Japan space policy Forum - Tokyo, Japan
6	Christophe BONNAL	CNES Senior Expert - CNES Launcher Directorate	Interview 2015 IAC Jerusalem, Israel - and emails 2020
7	Gérard BRACHET	Former COPUOS Chair, Former CNES Director, Space Debris Expert, LTS Initiative	Interview 2015 IAC Jerusalem, Israel - and emails 2020
8	Christian CAZAUX	CNES, IADC delegation, LTS working group	Interview 2015 COPUOS plenary session - Vienna, Austria
9	David FINKLEMAN	CSSI/AGI, Space Debris Expert	Interview 2015 IAC Jerusalem, Israel - and emails 2019
10	Walter FLURY	ESA, Space Debris Expert	Interview 2018 IAC Bremen, Germany
11	Henry HERTZFELD	GWU Space Policy Institute, Professor	Interview 2015 IAC Jerusalem, Israel
12	Yasushi HORIKAWA	Former Chair of COPUOS, JAXA	Interview 2015 JAXA Tokyo, Japan
13	Moriba JAH	Texas University, Debris Expert	Skype Interview 2018
14	Ram JAKHU	McGill University, Space Law Professor and Debris Expert, IAASS	Emails 2012 to 2020
15	Akira KATO	JAXA Debris Expert	Interview 2014 APRSAF Tokyo, Japan
16	David KENDALL	Former Canadian Space Agency, COPUOS Chair and IADC Chair	Interview COPUOS Vienna, 2015
17	Armel KERREST	Brest University, Space Law Professor	Interview 2015 Keio University Space Law Workshop Tokyo, Japan
18	Heiner KLINKRAD	ESA Former Head of Space Debris Office, European Space Operations Centre	Interview 2015 IAC Jerusalem, Israel
19	Holger KRAG	ESA ESOC Head of Space Safety, Head IADC delegation	Interview 2018 IAC Bremen, Germany
20	Bruno LAZARE	CNES Space Debris Expert	Emails 2020

21	Charlotte MAHIEU	ESA International Relations Practitioner and Scholar, IAA debris Committee, former ESPI	Skype Interview 2014
22	Sergio MARCHISIO	Sapienza University, Space Law Professor	Interview and Emails 2014
23	Peter MARTINEZ	Former LTS Working Group Chair	Interview 2014 IS3DUTokyo, Japan
24	Tanja MASSON - ZWAAN	Former IISL President, Space Law Professor	Interview 2015 Tokyo, Japan
25	Philippe MOREELS	*Astroscale,* SDA, Industry Professional	Interview 2015 Tokyo, Japan
26	Daniel OLTROGGE	Director, Center for Space Standards and Innovation, Analytical Graphics, (AGI); SSC, CONFERS, UNCOPUOS, ISO	Emails 2020
27	Daniel PORRAS	UNIDIR Former Fellow	Emails 2020
28	Jana ROBINSON	Prague Security Studies Institute Managing Director, Space Policy Scholar	Skype Interview 2020
29	Kai-Uwe SCHRÖGL	ESA/DLR, Space Policy and IR Professor, IISL President, Former Chair of UNCOPUOS Legal Subcommittee former ESPI Director	Emails 2015
30	Tommaso SGOBBA	IAASS President, former ESA Debris expert	Skype Interview 2020
31	Teruhisa TSUJINO	NISTEP MEXT Researcher Space Technology	Interview 2015 Tokyo, Japan
32	Brian WEEDEN	SWF Director of Program Planning, Space Debris Expert	Emails 2014 to 2020
33	Ray A. WILLIAMSON	SWF Former Executive Director, Space Sustainability Expert	Emails 2015