TOWARDS A CODE OF CONDUCT

SPACE SITUATIONAL AWARENESS AS A PATH FORWARD

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Contents

Acronyms

AFSPC – United States Air Force Space Command
CFE – Commercial and Foreign Entities
COLA – Collision Avoidance
COPUOS – Committee on the Peaceful Uses of Outer Space
CSM – Conjunction Support Message
CSSI – Center for Space Standards and Innovation
DoD – United States Department of Defense
ESA – European Space Agency
GEO – Geo-synchronous Orbit, 22,240 miles above Earth
IOC – Initial Operation Capability
ISON – International Scientific Optical Network
JFCC SPACE – Joint Functional Component Command for Space
JAXA – Japanese Aerospace eXploration Agency
JPL – Jet Propulsion Laboratory
JSpOC – Joint Space Operations Center
LEO – Low Earth Orbit, 124-1,240 miles above Earth
MEO – Medium Earth Orbit, 1,240-22,240 miles above Earth
NASA – National Aeronautics and Space Administration
ODR – Orbital Data Request
OIG – Orbital Information Group
OST – Outer Space Treaty
Polar Orbit – near-polar inclination and an altitude of 435 to 500 miles
RDTE – Research, Development, Testing, and Evaluation
SBSS – Space-Based Space Surveillance Satellite
SCC – Space Control Center
SDA – Space Data Association
SOCRATES – Satellite Orbital Conjunction Reports Assessing Threatening Encounters in Space
SSA – Space Situational Awareness
SSN – Space Surveillance Network
STRATCOM – United States Strategic Command
UNCLOS – United Nations Convention on the Law of the Sea
UNOOSA – United Nations Office for Outer Space Affairs
USAF – United States Air Force

Introduction

The Final Frontier has long captured the imaginations of humankind. Our ancestors saw the heroes of their legends outlined in the stars, and believed that in the movements of the stars and the planets lay great secrets and hidden knowledge. Galileo, Copernicus, Kepler, and so many other pioneers sought the more tangible knowledge of the cosmos, and saw the blueprints of the universe written there. The science fiction of Jules Verne and Isaac Asimov saw a future of humanity inextricably linked to the wider cosmos, while Gene Roddenberry dreamed of a united humanity that would "Boldly go where no man has gone before"[1], and George Lucas delighted millions with very human tales from "A galaxy far, far away…"[2]. The astronomer Carl Sagan famously wrote "The Earth is a very small stage in a vast cosmic arena"[3], and though humanity did not slip the surly bonds of Earth until well into the 20th Century, our cultural heritage suggests we are not so much venturing out as coming home.

The early years of space were dominated by the superpower competition of the Cold War, with the "Space Race" between the Soviet Union and the United States capturing not only the imagination of millions around the world for the technological advances and human daring, but because it represented the principle efforts at space exploration and exploitation. Though other nations launched satellites, the United States and the Soviet Union were the principle actors. Indeed, the cost of doing business in the final frontier was so high that only superpowers could afford it.

Space was big, so the conventional wisdom went, and did not need careful regimes beyond those that governed but the most limited of human behavior. Yet a mere 59 years after Sputnik-1, the first manmade object was launched into space atop an R-7 (8K71) rocket, the space surrounding Earth, "…a domain that no nation owns but on which all rely, is becoming increasingly congested, contested, and competitive."[4] Where Sputnik blazed through the skies alone, its steady beeping signal a reminder that humans had indeed dipped the first toe into the vast cosmic

[1] *Star Trek*.
[2] Lucas, *Star Wars*.
[3] Sagan, *Pale Blue Dot*.
[4] "National Security Space Strategy (Unclassified Summary)."

arena, today satellites, spacecraft, and space stations dance their way through the skies around Earth.

The popular conception is that, after the sprint of the space race, culminating with the Apollo landings on the moon, space activities – exploration and exploitation – have slowed. Certainly human spaceflight has not gone beyond low earth orbit, though that is not to discount the advances in science and technology that have come from the Space Shuttles or the International Space Station. Despite beautiful images from the Hubble Space Telescope, groundbreaking research by robotic explorers on the Moon, Mars, and comets, the retirement of the Space Shuttle in 2011 served as a very visible, public sign that the days of government-dominated human spaceflight were drawing to a close.

Yet beyond the popular consciousness, space activities have grown to underpin the workings of modern society. Communications, weather forecasting, earth imaging and mapping, navigation, and all manner of security applications find ready homes in the harsh, unforgiving environment of outer space. Advances in technology have made activities previously in the realm of science fiction, such as space tourism, hotels[5][6], and asteroid mining[7][8][9], the rapidly approaching next step in human space activity. This progress, however, has not been without cost, nor are future endeavors without risk.

Scientists currently estimate that more than 5,000 launches since 1957 have placed more than 30,000 large (10-20cm)[10] space objects in low-Earth orbit (124-1,240 miles above Earth's surface)[11]. Of these, 23,000 of the largest are regularly tracked[12], with 22,000 of them by the US Department of Defense Department of the Air Force Strategic Command's (STRATCOM) Joint Space Operations Center (JSpOC)[13]. Only 1,400 of these are active payloads, while an estimated

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[5] Fecht, "5 Questions About Space Hotels."
[6] "Bigelow Aerospace - BEAM."
[7] "Company | Planetary Resources."
[8] Amos, "Luxembourg to Support Space Mining."
[9] Stockton, "Congress Says Yes to Space Mining, No to Rocket Regulations."
[10] Adushkin et al., "Orbital Missions Safety – A Survey of Kinetic Hazards."
[11] "Orbits of the Earth | Space Foundation."
[12] Adushkin et al., "Orbital Missions Safety – A Survey of Kinetic Hazards."
[13] Bird, "Sharing Space Situational Awareness Data."

500,000 other pieces of orbital debris are too small to be tracked.[14] To put this in perspective, the first 10,000 pieces of space debris accumulated over the first 40 years of human space activity; the remainder were created in the next ten years, both due to high-profile accidents and deliberate activity.[15]

Of the active payloads currently in orbit, another stark contrast to the beginnings of the space age can be seen in who owns them: over 60 nations and government consortia, to say nothing of the numerous other commercial, academic, and nonprofit actors, own and operate satellites.[16] In addition to the risk of damage from physical congestion, the radiofrequency spectrum – on which all operations depend upon, to a greater or lesser extent – is also growing more congested. The Space Data Association, formed by the four largest commercial satellite operators after a 2009 collision between the commercial Iridium-33 and a Russian communications satellite Kosmos-2251[17] lists the integrity not only of the space environment, but the RF spectrum, as a key component of its operations.[18]

Suffice it to say, not only has space become more congested, contested, and competitive, but the number and variety of actors, and their concerns, have made it far more complicated. The growing number of uses of the space domain parallels the heavy reliance modern society places on each of these uses. Communications and navigation are two areas that touch people's lives most directly, whether it be the television signals bringing live sports coverage from the other side of the country (or the world), or the ubiquitous GPS signals that have moved from the realm of advanced military hardware to dedicated vehicle-based devices to one of many features present on the billions of smart phones worldwide. Not to be outdone, however, weather forecasting and earth imaging aid everyone from local news weather forecasters to zoning boards to archaeologists looking for the remains of ancient civilizations.[19] Though they may not be in the public consciousness, the heavy reliance placed on space-based assets by the United States

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[14] Duff-Brown, "FSI | CISAC - The Final Frontier Has Become Congested and Contested."
[15] Zenko, "A Code of Conduct for Outer Space."
[16] "National Security Space Strategy (Unclassified Summary)."
[17] Smith, "Space Data Association and USSTRATCOM Reach Data Sharing Agreement."
[18] "Http."
[19] Roach and 2010, "'Lost' Amazon Complex Found; Shapes Seen by Satellite."

Armed Forces cannot be overstated,[20] and is well noted not only by American defense planners but also those of potential peer competitors. In short, the outer space domain is not only more heavily populated, by a wider number of actors doing a greater number of things, but the reliance on these assets means that if anything were to "go wrong", the impact would be correspondingly greater than in the past. Moreover, this reliance on space based assets incentives efforts not only to protect them, but for nations to pursue the means of denying them to an enemy should the need arise.[21]

Purpose

This paper is an attempt to begin addressing the problems that come with the new normal outlined above, a new normal of "congested and contested". It proposes the first steps by which one can arrive at an International Code of Conduct for outer space activities, and demonstrate the feasibility of such a code in laying the groundwork where a pair of treaties, handful of agreements, but mostly benign neglect have failed to do so. That such an International Code of Conduct is needed is widely accepted;[22][23][24] both the European Union and United States Department of State have circulated draft proposals of just such a code.[25] Unfortunately, there has been little action on this front since the 1979 Moon Treaty, due in part to two particular concerns: first mover advantage and developing nations being "locked out" of the space domain, and the contentious questions surrounding national ballistic missile defense and security.[26]

An international code of conduct for outer space activities does not rise to the same level as a binding legal agreement. It is unlikely there will be comprehensive legally binding language in the near or even intermediate future, a consequence of the geopolitical tensions at the moment. Major space powers find themselves on the opposite sides of crises around the world, with

[20] "National Security Space Strategy (Unclassified Summary)."
[21] Grego, "An Updated History of Anti-Satellite Weapons - All Things Nuclear," -.
[22] United Nations General Assembly, *Transparency and Confidence Building Measures in Outer Space Activities*, 2006.
[23] United Nations General Assembly, *Transparency and Confidence Building Measures in Outer Space Activities*, 2007.
[24] Rajagopalan, "Op-Ed | Keep Space Code of Conduct Moving Forward."
[25] Embassy, "State Department on Code of Conduct for Outer Space Activities."
[26] Zenko, "A Code of Conduct for Outer Space."

significant questions as to the shaping of the future world order now being raised by the People's Republic of China, and the Russian Federation.

This tension between the established space powers comes in addition to the rise of nascent space programs in emerging countries from South Asia to Africa to South America[27], all of which hope to gain access to and exploit the unique opportunities offered by the outer space domain for their own national interest. The rise of emerging nations' space programs also gives rise to certain fundamental disagreements and distrust between established space powers and those hoping to establish themselves within the outer space arena.[28] In short, there are many challenges to a comprehensive Treaty on par with the UN Convention on the Law of the Sea, which regulates all manner of ocean-going activities.

Therefore, what this paper proposes is to use all actors' common interest in maintaining safe space operations as the starting point. It will not address the questions of missile defense or the broader militarization or weaponization of space, nor will it attempt to delineate who has what right to operate in what manner or where. Instead, it recognizes that all of the actors in the space domain have a common interest in space remaining accessible. To do this – indeed, to operate in space at all – each actor must maintain a certain degree of Space Situational Awareness, or SSA, and in gathering and sharing that information with other actors, the security of every actor's space based assets are enhanced. Such sharing already occurs on a limited, bilateral basis; this paper proposes to broaden and formalize such activity, and in doing so create norms of communication and behavior, among spacefaring actors.

Furthermore, this paper will demonstrate how the outer space domain is unique among domains of conflict in its fundamental qualities that provide inherent limiting factors to escalation. Because of these factors, there is a window of opportunity to pursue the sharing of SSA with enough insurance against bad behavior to provide spacefaring actors the ability to buy in without the fear of losing their space-based assets to a competitor. This insurance, baked into the physical nature of space, is offered as evidence an SSA-oriented approach can succeed.

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[27] Rajagopalan, "Op-Ed | Keep Space Code of Conduct Moving Forward."
[28] Zenko, "A Code of Conduct for Outer Space."

A Brief History of Space Activities and Regulations

The launch and orbit of Sputnik-1, commonly referred to as "Sputnik" and the first human-made object to orbit the Earth, sent shockwaves around the world. Now, when humanity looked into the heavens, they saw not only the Moon, stars, and other celestial bodies, but the work of their own hand, soaring through the heavens, sending back to Earth a steady, beeping reminder of humanity's first brave step. That such a feat was managed by a single nation, one of two opposing super powers locked in a quest for influence around the world on land, sea, the air, and now in space, served to put humanity on notice that there was a new domain of activity, and competition.

Yuriy Karash, writing in *The Spacepower Odyssey: A Russian Perspective on Space Cooperation* posits that the international relations theory of Realism – which holds that states will seek to maximize their own power – "explains the political significance attached to the space programs by the Soviet Union and the United States."[29] Indeed, both nations sought to pursue space activity as much for purposes of pride – who had the best scientists, engineers, and technicians – as for any scientific value. In *Astropolitik: Classical Geopolitics in the Space Age*, Everett Dolman holds that "…the reality of confrontation in space politics pervades the reality of the ideal of true cooperation and political unity in space which has never been genuine, and in the near term seems unlikely."[30]

Certainly the history of space activities does lend support to the idea of competition, not cooperation. Arising as it did from the depths of the Cold War the space age has, as previously noted, seen more superpower competition than not. However, this competition did not preclude the establishment of international bodies, agreements, and even two treaties – the effectiveness of the latter treaty in no way detracting from the foundational nature of the first. This section will first outline a timeline of treaties, agreements, and associations that comprise the bulk of the bodies and regimes regulating space conduct today. Then, it will examine several historical

[29] Karash, *The Superpower Odyssey*.
[30] Dolman, *Astropolitik*.

examples of accidents and incidents that are tangible reminders of a failure to adapt to the increasingly congested, contested, and complex domain.

Treaties and Agreements

The United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS; COPUOS) was established as an ad hoc committee by the General Assembly on 13 December 1958, with the United Nations Office for Outer Space Affairs (UNOOSA) created as a "small expert unit" to service the committee.[31] Based on the importance of space for human activity, and the recognition of Article 2, paragraph 1, of the Charter of the United Nations which holds for sovereign equality of all Members, the General Assembly "Wishing to avoid the extension of the present national rivalries into this new field" established COPUOS and UNOOSA as a way to coordinate activities and fulfill the potential of international cooperation.[32]

Even as the Space Race heated up between the rival super powers, the international community followed up this act with the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies. More commonly known as the Outer Space Treaty (OST), it was ratified in 1966, entering into force in 1967.[33] Currently, there are 98 state parties to the Treaty, and it has been signed by an additional 27 states.[34]

The Outer Space Treaty is notable in that it establishes the basic legal framework for international space law. Several provisions are notable from the perspective of governing conduct or behavior. First, the Treaty prohibits placing weapons of mass destruction in orbit, on the moon or other bodies, or otherwise stationing them in space.[35] It is important to note that this applies to basing or stationing such weapons; weapons of mass destruction that travel *through* outer space (such as Intercontinental Ballistic Missiles or ICBMs) are not covered by the

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[31] "UNOOSA - COPUOS History."
[32] United Nations General Assembly, *Question of the Peaceful Use of Outer Space*.
[33] United Nations General Assembly, *Treaty on the Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies*.
[34] Diederiks-Verschoor and Kopal, *An Introduction to Space Law*.
[35] United Nations General Assembly, *Treaty on the Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies*.

language of the Treaty.[36] Neither are conventional weapons in orbit prohibited, which gives rise to a host of disagreements we will examine later.[37]

Second, the Treaty explicitly limits the use of the Moon and other bodies for peaceful purposes only, prohibiting the testing of weapons, military bases, maneuvers, or other military installations or fortifications. There is a carve out allowing military personnel to conduct scientific research or "for any other peaceful purposes", along with any equipment or facility needed for such peaceful exploration.[38] Historically, that has taken the form of both astronauts and cosmonauts being military personnel, most often test pilots, though Valentina Tereshkova, the first woman in space, also held the distinction of being the first civilian in space, as the Soviet Air Force did not have female pilots at the time.[39] At NASA, geologist Harrison Schmidt became the first astronaut with a non-military background when he took part in Apollo 17.[40]

Last, the Treaty forbids any nation from claiming all or part of the Moon or other celestial body, stating they are "…not subject to national appropriation by claim of sovereignty, by means or use of occupation, or by any other means."[41] Indeed, "The exploration and use of outer space, including the Moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind."[42] Drawing heavily on established maritime law, parallels can be seen in the later United Nations Convention on the Law of the Sea (UNCLOS), which itself draws on the older concepts of freedom of the seas.[43]

The Outer Space Treaty was followed by the Agreement on the Rescue of Astronauts, the Return of Astronauts, and the Return of Objects Launched into Outer Space, or the Rescue Agreement,

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[36] Diederiks-Verschoor and Kopal, *An Introduction to Space Law*.
[37] Ibid.
[38] United Nations General Assembly, *Treaty on the Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies*.
[39] Ghosh and News, "Valentina Tereshkova."
[40] "Astronaut Bio: Harrison Schmitt."
[41] United Nations General Assembly, *Treaty on the Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies*.
[42] Ibid.
[43] United Nations General Assembly, *Third United Nations Conference on the Law of the Sea*.

in 1967.[44] The Rescue Agreement draws heavily on established maritime and search and rescue agreements and law, with requirements for nations to render all possible assistance to the "personnel of a spacecraft", with the distinct provision that should accident or distress force astronauts to land in another nation's territory, "they shall be safely and promptly returned to representatives of the launching authority."[45]

The Rescue Agreement was followed by the Convention on International Liability for Damage Caused by Space Objects, or the Liability Convention, in 1972[46] and the Convention on Registration of Objects Launched into Outer Space, or the Registration convention, in 1975.[47] Both sought to clarify both responsibility for objects in outer space, as well as organize the system of registration. In both cases, numerous parallels were drawn to existing bodies of law that covered more terrestrial matters: The Liability Convention mimics established liability laws[48] here on Earth, while the Registration convention has its origins in civil aviation aircraft registration regimes.

There have been several agreements and conventions that have occurred to address specific goals, such as expanded satellite accessibility or a particular technical challenge. Though one cannot deny the importance of such actions, it is important to note their limited scope – in some cases, extremely limited. All are voluntary, though many are managed through the United

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[44] United Nations General Assembly, *Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space*.

[45] Ibid.

[46] United Nations General Assembly, *Convention on International Liability for Damage Caused by Space Objects*. The Liability Convention spells out the definitions of damage – loss of life, personal injury, or other impairment of health; or loss of or damage to property to States or of persons, natural or juridicial, or property of intergovernmental organizations. Of particular note is that the "launching state" is considered both 1) "A State which launches or procures the launching of a space object", and 2) "A State from whose territory or facility a space object is launched." In this sense, each state is responsible for any activity originating from its soil – thus covering private launches with whatever regulations the state has. In the United States, this falls to the Federal Aviation Administration.

[47] United Nations General Assembly, *Convention on Registration of Objects Launched into Outer Space*. The Registration Convention has the same definitions of launching state as the Liability Convention, perhaps unsurprising as they were adopted within three years of each other. the registration convention spells out who shall keep the registry (Art.II; the Secretary General of the United Nations) and the information required (Art. IV), which includes date and territory of launch, basic orbital parameters, and general function (e.g. "Earth sensing" or "communications").

[48] The United States fell afoul of this with the de-orbiting and break-up of Skylab in 1979. Large pieces of Skylab fell southeast of Perth, Australia; a fine for littering was assessed and eventually paid by public donations. O'Neil, "Celebrating July 13, 'Skylab-Esperance Day.'"

Nations, and offer not so much codes of conduct to abide by as technical best practices to follow – and even then, only if they concern themselves with strictly technical matters.

On the technical note, the Brussels Convention Relating to the Distribution of Programme-Carrying Signals Transmitted by Satellite of 1974 falls under the purview of the World Intellectual Property Organization[49], and covers the distribution of radio signals by satellite; specifically, to ensure they are not redistributed in such a way as to cause interference of other signals, and to prevent intellectual property infringement via unauthorized re-broadcasting.

The International Telecommunications Satellite Organization (ITSO) was established in 1964 to establish a global communications satellite system; it has grown from an initial membership of 13 nations to the current total of 149. In 2001, ITSO spun off its global satellite system – Intelsat – to form Intelsat, Ltd., a private entity. ITSO retains oversight of Intelsat, Ltd.,[50] which now manages 53 satellites. Lastly, and of certain interest to this work, the International Telecommunications Union (ITU), formed in 1865 as the International Telegraph Union and is considered a specialized agency of the United Nations Development Group,[51] underwent significant restructuring in 1992 to form the ITU-R (Radio) as one of three organizational sectors.[52] In this capacity, the ITU-R is responsible for radio frequency spectrum allocations for transmitting satellites, as well as the orbital positions of the satellites. This helps to prevent both harmful interference caused by multiple active transponders in the same location, as well as physical collisions.

Several other agreements and treaties intersect with the domain of space activity, though do not deal exclusively with space activities. Most notable among them is the Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water – more commonly known as the Partial Test Ban Treaty – which went into effect in 1963.[53] Though this treaty explicitly prohibits nuclear detonations in outer space, it is administered by the UN Office for

[49] "WIPO-Administered Treaties: Brussels Convention Relating to the Distribution of Programme-Carrying Signals Transmitted by Satellite."
[50] "ABOUT ITSO."
[51] "Overview of ITU's History (5)."
[52] Ibid.
[53] Department Of State. The Office of Website Management, "Limited Test Ban Treaty."

Disarmament Affairs, and is most often considered an arms control treaty due to its scope, which includes many non-space activities.[54]

Impetus to Act

Along with the various treaties and agreements, there are several historical points relevant to spacefaring actors' conduct in the final frontier. Where Sputnik and the Moon landings may be seen as high points of technological achievement, and the Apollo-Soyuz Handshake and International Space Station as pinnacles of international cooperation and amity, there have been incidents which demonstrate the very real challenges faced, whether they be deliberate action or the result of accidents.

In July of 1962 the United States Air Force detonated a 1.44 megaton nuclear warhead 248 miles above the Pacific Ocean, which produced a flash of light visible over much of the Pacific and Aurora – normally seen at the Poles – as far away as Hawaii, Tonga, and Samoa.[55] The test – codenamed Starfish Prime – also created an electromagnetic pulse (EMP) that caused blackouts on the island of Oahu, 800 miles distant. The radiation it created was intended to augment the naturally occurring Van Allen belts that surround the Earth for the purpose of knocking out Soviet ICBMs, should they ever be launched in anger.[56] There did seem to be an effect on electronics; some credit the failure of the Telstar 1 – the world's first telecommunications satellite – four months later with the impacts of Starfish Prime; Britain's first satellite, Ariel-1, was on the opposite side of the planet and also suffered fatal damage.[57] A year later, the Partial Test Ban Treaty, which as noted prohibited nuclear detonations in the atmosphere and outer space, went into effect.[58]

During the intervening period between 1963 and 1997, some 10,000 objects were placed in orbit around the Earth, most of them deliberately: spent rocket stages, functioning satellites, and reactor cores, just to name a few. Since that time, however, the number has grown to over 30,000

[54] Ibid.
[55] Portree, "Starfish and Apollo (1962)."
[56] Ibid.
[57] Smallwood, "That Time the US Accidentally Nuked Britain's First Satellite."
[58] Department Of State. The Office of Website Management, "Limited Test Ban Treaty."

large pieces (as noted earlier).[59] Though many human-made objects put in space are now done in a manner that allows them to de-orbit and burn up in the atmosphere, this practice did not become widespread until the late 1990s;[60] the problem is still immense.

2007 Chinese Anti-Satellite Test

Part of this problem is a result of deliberate choices. In 2007 China drew widespread condemnation from around the world for an Anti-satellite missile test that destroyed a defunct weather satellite using a modified ballistic missile.[61] Targeting a defunct weather satellite, Fengyun-1C, on 11 January 2007, China used a modified ICBM designated "SC-19"[62] using a "hit-to-kill" targeting method that successfully impacted the satellite at an altitude of 537 miles above the surface of the Earth.[63]

The test was successful: the satellite was destroyed, creating a cloud of more than 3,000 pieces of orbital debris larger than 5-10cm.[64] This one test caused China to move from being responsible for a very small fraction of space debris in Low Earth Orbit to being responsible for a comparable amount as the United States and Russia.[65] This test caused the size of the US Space Surveillance Network catalogue to increase by 25% in a single incident.[66] More worrisome, the debris cloud extended from less than 125 miles to greater than 2,292 miles above Earth; the majority of the debris "have mean altitudes of 528 miles (850 kilometers) or greater, which means most will be very long lived"[67] according to NASA's Nicholas Johnson.

The size, altitude, and velocity of space debris all play an important role in the impact of space debris; those located at higher altitudes are far more likely to linger for much longer – decades and centuries longer – than that at lower altitudes, where they are subject to atmospheric drag that causes them to deorbit in days, weeks, or months.[68] 1985's ASAT test by the United States

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[59] Adushkin et al., "Orbital Missions Safety – A Survey of Kinetic Hazards."
[60] Federal Aviation Administration, "Launch Quarter 2002 Quarterly Launch Report."
[61] Mastalir, "The US Response to China's ASAT Test: An International Space Security Alliance for the Future."
[62] "Hillary Rodham Clinton, Senator for New York."
[63] Nicholson, "World Fury at Satellite Destruction - National - Theage.com.au."
[64] Wright, "Who Owns the Most Space Debris?"
[65] Ibid.
[66] esa, "FAQ."
[67] David, "China's Anti-Satellite Test."
[68] "Debris in Brief."

Air Force demonstrated this fact. The target, P-78-1 Solwind, was the until the Chinese test the last satellite deliberately destroyed. Located in low earth orbit, the majority of the debris quickly de-orbited and burned up in the atmosphere. NASA's space debris catalog notes that by 2007, there were no debris left from the test.[69]

In addition to the problem illustrated by the *results* of the 2007 Chinese ASAT test, the test itself represented the first time since the 1985 that any nation had targeted a satellite for destruction in outer space. This not only represents a new capability of the Chinese People's Liberation Army for other nations to be concerned about, but also a breach of the unofficial moratorium that had existed since 1985, largely due to the recognition of the dangers inherent in anti-satellite weapons.

USA-193 ASAT

Not to be outdone, on February 21, 2008, ostensibly to prevent environmental and health damages should it re-enter with a propulsion tank full of toxic fuel, the United States destroyed the malfunctioning intelligence satellite USA-193.[70] USA-193 developed faults early in its mission, which caused it to begin de-orbiting with a propulsion tank still mostly full with hydrazine; then-Deputy National Security Advisor James Jeffrey reported that there was a "small but real risk that the hydrazine tank could rupture, releasing a 'toxic gas' over a 'populated area', causing a 'risk to human life.'"[71] Many experts considered this story a cover for an ASAT test[72], with strong condemnations coming from Russia and China.

USA-193 was destroyed by a modified RIM-161 SM-3 "Standard" missile launched from the AEGIS-equipped *Ticonderoga*-class cruiser USS Lake Erie, with the intercept occurring at an altitude of 153 miles.[73] Due to the low altitude – with the corresponding increase in atmospheric

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[69] Johnson et al., "History of On-Orbit Satellite Fragmentations, 14th Edition.". Though the last debris had de-orbited by 2007, over 80% had done so within several weeks of the test. While a large number of fragments from the Chinese test have also already deorbited, a large number still orbit the Earth, and may remain in orbit for hundreds of years.
[70] Shachtman, "Experts Scoff at Sat Shoot-Down Rationale (Updated)."
[71] Ibid.
[72] "US Spy Satellite Plan 'a Cover.'"
[73] "MDA - One-Time Mission: Operation Burnt Frost."

drag – coupled with the method of intercept, the vast majority of the debris created de-orbited and burned up in the atmosphere within hours; none were left by the end of 2008.[74]

Regardless of the true reasoning for the intercept, the worrying factors here have less to do with the results of the action as the reasoning behind the action, and the willingness to use anti-satellite weaponry. As previously noted, nothing in international law prohibited the actions; indeed, if the dangers of the hydrazine fuel were not over-exaggerated as a cover, the destruction of the satellite was the responsible course of action! But in conjunction with the Chinese ASAT test not even a year earlier, the overall implications are more troubling, and do not signal a trend towards greater peaceful use of space. The unofficial moratorium appears to have given way to the ready use of space as one more arena in which a rising China could compete with the United States, and the United States demonstrate its ability to respond in kind. Moreover, both tests indicated that space, far from being the sanctuary some early theorists thought it could be, was in fact an environment in which assets were open to attack. When coupled with the aforementioned reliance of the United States in particular on space based assets for military operations, to say nothing of commercial uses, the message would seem to cause concern.[75]

Iridium-33 and Kosmos-2251

At the other end of the spectrum of intent lies the accidental collision between two objects in Earth orbit. Iridium-33 was a commercial communications satellite owned and operated by Iridium Communications Inc.[76] At 11:56 EST on February 10, 2009 , Iridium lost contact with Iridium-33, and request assistance from JSpOC[77], the United States Strategic Command's Joint Space Operations Center, which serves as a command and control focused on planning and executing Strategic Command's Joint Functional Component Command for Space (JFCC SPACE).[78] JSpOC noted two "break ups", one where the orbit of Iridium-33 should have been and the other later determined to be Kosmos-2251; Russian government sources confirmed that Kosmos-2251 was destroyed.[79]

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74 esa, "FAQ."
75 Weeden, "The End of Sanctuary in Space."
76 "Russian and US Satellites Collide."
77 Weeden, "The Space Review: Billiards in Space (page 1)."
78 "Factsheets : Joint Functional Component Command for Space."
79 "Russian and US Satellites Collide."

It was later determined that the two satellites intersected at "almost a 90^o angle close to the North Pole"[80], approximately over the northern coast of Siberia, traveling at a combined velocity of 10km per second (22,000 miles per hour).[81] On impact, the two satellites were completely destroyed, created over 2,200 trackable fragments.[82] Despite early claims in some quarters, neither satellite was out of control, nor had either made any appreciable changes in orbit prior to the collision.[83] Where there have been collisions previously between objects in space – indeed, the space shuttles routinely returned to Earth with damage from tiny impacts – this is, as David Wright from the Union of Concerned Scientists writes, the first known collision of two intact satellites.[84]

The total destruction and loss of Iridium-33 represents a serious loss for Iridium Communications; not only was their investment of millions of dollars destroyed, but the signals it was supposed to relay – and Iridium Communications profit from – were also interrupted. Though Iridium Communications was able to shift the burden of the signals to other satellites, and eventually replace the destroyed satellite, the implications are clear for not only the satellite industry, but the investors and insurers who are involved with it.

Galaxy 15

Yet just as not all hazards are intentional, neither are they all kinetic. The spectacular destruction of Kosmos-2251 and Iridium-33 represents only one part of the dangers space based assets face from unintentional actions. On early April 5, 2010 Galaxy 15, a telecommunications satellite, suffered a failure that caused in Intelsat Ltd., the operator, to lose control of it.[85] The satellite drifted from its assigned orbital slot and, though physical collisions with other satellites were avoided, in the process of its drift Galaxy 15 passed through the orbital slots of 15 satellites owned by SES of Luxembourg, Telsat of Canada, and Satmex of Mexico.[86]

[80] Weeden, "The Space Review: Billiards in Space (page 1)."
[81] Ibid.
[82] esa, "FAQ."
[83] Weeden, "The Space Review: Billiards in Space (page 1)."
[84] Wright, "Colliding Satellites."
[85] Ferster, "Intelsat Loses Contact with Galaxy 15 Satellite."
[86] de Selding, "Intelsat Moving Recovered Galaxy 15 to Test Location."

What makes the Galaxy 15 incident of particular interest is it demonstrates that potential threats to the use of space are not found only in physical destruction – intentional or accidental – but in electromagnetic interference and other forms of "soft" disruption. The transponders on Galaxy 15 remained stuck in the "on" position, despite damages that caused it to lose contact with ground controllers. As such, any signals the satellite crossed as it drifted were received by the satellite and rebounded to Earth, causing interference with other communications.[87] This both caused the signals to be relayed to the wrong recipients, and the correct recipients receiving no signal, but also impacted the ability of other satellite operators to communicate with their assets.[88]

This can be contrasted with the earlier example of the Iridium-33/Kosmos-2251 collision, in which both vehicles were completely destroyed, to demonstrate the multi-threat environment even peacetime operations face in outer space. In that first case, complete destruction of the satellites not only resulted in a large number of debris being generated, but also the complete loss of revenue generated by the Iridium satellite (which would have been doubled had Kosmos-2251 been functioning at the time).[89] In this second example, Galaxy 15 did not cause any physical destruction; instead, it had the potential to disrupt up to 15 other communications satellites owned by a variety of operators.[90] As Jonty Kasku-Jackson writes, "Intelsat would not only have lost revenue from its satellite but could also have been liable for interference with other satellites."[91]

[87] Ibid.
[88] Ibid.
[89] Kasku-Jackson, "International Commercial Avenues to Complement Deterrence Actions."
[90] Ibid.
[91] Ibid.

Why an International Code of Conduct?

The status quo in outer space activity is unsustainable. As the history shows us, far more actors are now undertaking space activities than in the early years of space exploration. Moreover, a far greater variety of actors is active in this domain, meaning that in the 59 years since Sputnik first orbited the Earth, the actors have gone from two super powers to dozens of nations, satellite owner-operators, intergovernmental and non-governmental organizations, ranging from scientific and academic uses to communications and disaster response activities. We know the hazards space operations face, with historic examples ranging from deliberate interference and destruction by a competitor, to the accidental interference and destruction caused by malfunctions and miscommunications. This all occurring in an environment so harsh and unforgiving that if 999 actions and parts perform perfectly, the 1,000th can fail and cause the total loss of an asset.

The aforementioned treaties, conventions, and agreements were not created in such an environment, with the exception of the revisions to the ITU. Even here, anecdotal evidence suggests that the current system for interacting with the ITU and managing assigned orbital slots may be under strain due to the sheer volume of launches, operators, and the ever-hastening speed of technological advance.

Yet reaching a formal, legally binding treaty is unlikely, not only for geopolitical reasons but for the sheer number of actors present and activities undertaken in the domain. Space-based systems are responsible for everything from ballistic missile early warning to arms control and verification to communications, navigation, scientific experiments aimed at both terrestrial and stellar subjects; they are operated by governments, commercial entities, non-governmental and intergovernmental organizations. From national security and commercial competitiveness there are valid reasons for secrecy concerning capabilities and payloads. To craft legally-binding language that would adequately govern all areas of activity would be difficult in its own right, let alone in a time of geopolitical tension.

In an attempt to address these concerns, and to "enhance the safety, security and sustainability of activities in outer space,"[92] the European Union proposed a draft International Code of Conduct (ICoC) for Outer Space Activities as a "transparency and confidence-building measure."[93] Citing the advances in space activity and the positive impact they have on modern society, as noted earlier, the draft ICoC sought to provide a sort of "gentleman's agreement" regarding outer space activities and behavior, as the Code is not governed by international law.[94]

Unfortunately, this draft Code of Conduct failed to gain much traction, largely due to the underlying geopolitical currents mentioned previously. This can be seen in the two types of objections to the European Union's draft Code of Conduct: objections based on incumbency, and objections based on militarization. Unsurprisingly, this second category of objections come from those who both fear an increasing militarization of space, and from those who fear restrictions introduced in space may prevent their own defense.[95]

The first objection is part of broader concerns among developing countries that those who are established – economically and industrially – will seek to use mechanisms such as the Intergovernmental Panel on Climate Chance and accompanying treaties to restrict their development, so as to retain competitive advantages. There are historical examples of this: the best-known is the Nuclear Non-Proliferation Treaty which restricted their access to nuclear technologies and enshrined certain nuclear-armed states as legitimate holders of nuclear weapons.[96] That those states were supposed to, in good faith, disarm over time and yet failed to do so only further reinforces this fear. Should a new treaty, agreement, or code of conduct fail to consider the reticence of states, in light of the NPT, to sign on, it does not have much chance of success.

From the security and defense standpoint, that the United States is heavily reliant on space-based resources and technology ranging from communications to navigation to imagining is common

[92] "European Union - EEAS (European External Action Service) | Code of Conduct for Outer Space Activities."
[93] Ibid.
[94] Lister, "The International Code of Conduct: Comments on Changes in the Latest Draft and Post-Mortem Thoughts."
[95] Rajagopalan, "Op-Ed | Keep Space Code of Conduct Moving Forward."
[96] Mutschler, *Arms Control in Space*.

knowledge; this leads American decision makers to fear the efforts of other nations to attack this reliance as part of an asymmetric war fighting strategy.[97] As will be explored later, space is an offense-dominated environment, in that it is incredibly difficult to protect one's own space-based assets from destruction while correspondingly easier to attack those assets.[98] Developing the tools to either defend against attack, or to deter an attack from happening, is therefore an important national priority that does have its basis in the UN Charter, as Rajeswari Pillai Rajagopalan, a senior fellow at the Observer Research Foundation in New Delhi, and others have noted.[99]

Furthermore, as the truism that "Any object can be an anti-satellite weapon – once" demonstrates – best illustrated by the Iridium-33/Kosmos-2251 collision – it is difficult to dismiss security concerns of those operating within the domain. The counter to this is that developing space powers do not necessarily have the capability – technologically or financially – to develop counter-space technologies and methods needed to defend their space operations; therefore, they are as uniquely vulnerable to attack as the heavily reliant United States is.[100][101]

Critically, despite geopolitical tensions – or perhaps even because of them – the time for such a Code of Conduct is ripe. As Adushkin et. al. write, the proliferation of actors, coupled with the proliferation of space debris, could easily be mated to geopolitical tension to unintentionally escalate a crisis. They note that in the past decades, there have repeatedly been sudden failures of satellites and spacecraft used for defense purposes, which leaves two possible explanations: a collision with unregistered debris, or the actions of a space adversary.[102] This has troubling implications: imagine the effect if, during a time of China/US brinksmanship over the South China Sea, a Navy communications satellite suddenly goes off-line. Was this the act of space debris, or an intentional act by China to escalate and/or gain an advantage? Recent efforts have

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[97] Nelson and Sessions, "Defense Space Activities."
[98] "National Security Space Strategy (Unclassified Summary)."
[99] Rajagopalan, "Op-Ed | Keep Space Code of Conduct Moving Forward."
[100] Ibid.
[101] Zenko, "A Code of Conduct for Outer Space."
[102] Adushkin et al., "Orbital Missions Safety – A Survey of Kinetic Hazards."
Vitaly Adushkin and Stanislav Kozlov are scientists at the Institute of Geosphere Dynamics, RAS, Moscow; Stanislav Veniaminov is a scientist at the Scientific Research Center "Kosmos", part of the Russian Ministry of Defense, while Mikhail Silnikov is a scientist at Scientific and Production Corporation for Special Materials, Saint Petersburg.

focused around improving our Space Situational Awareness, such as placing space weather monitors on defense satellites (so as to determine if disruptions are caused by space weather or another factor),[103] but they will take years to fully implement; this also assumes it will provide definitive answers when called upon.

We are at a unique point in time in space activities. Even as the domain becomes more congested, contested, and complex, there are more actors – constituents – with a vested interest in preserving the maximum of freedom of use than ever before. What was once the domain of only the wealthiest and most powerful nation states now finds support from large, established private sector operators, university-based academic researchers, and a staggering array of start-up companies. There are now multiple competitors for launch contracts, breaking the duopoly of Arianespace and United Launch Alliance, while ever greater numbers of satellite operators compete to offer services ranging from navigation to telecommunication to on-demand imaging. All have a vested interest in an outer space that is free from conflict, predictable in its regulatory structure, and open for business.

Furthermore, the relentless march of technology places us in a rare position: the future path of exploration, exploitation, and activity can be easily seen (even if details remain to be addressed). Science fiction is, more rapidly than ever, becoming science fact. Space tourism, whether in the private spaceships of Virgin Galactic or in the inflatable "hotels" of Bigelow Aerospace, is gaining steam as a viable enterprise. Asteroid mining, once the realm of pulp sci-fi, now boasts well-resourced ventures[104] backed by serious investors who are seeking to capitalize on the uncounted trillions of dollars of resources available for recovery.[105] Serious efforts are being undertaken by both government and private entities to not only return to the Moon, but to land human beings on asteroids and comets, and eventually travel to Mars. Whether the timeframe is the next ten, twenty, or thirty years, technological developments and unprecedented levels of public and private will draw these ever closer from the realm of possibility to the realm of inevitability.

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[103] Gruss, "Air Force Seeks Info on Space Weather Sensor."
[104] "Company | Planetary Resources."
[105] Amos, "Luxembourg to Support Space Mining."

To wit, we can see where technology and economics are driving us. We know the benefits of networked military operations enabled by space infrastructure; what the United States Department of Defense has created, other nations now seek to emulate or exceed. We cannot overstate the reliance on space-based assets of the modern global economy. We can see as ideas formerly only found in fiction find the sweet spot of technology and economics, for those with the will to capitalize on them.

Yet with all of this stated, there is still time – before the next conflict, before the next disaster, before the robotic probes begin mining and the tourists begin flying – to begin establishing the ground rules and prevent bigger problems. Creating such a Code of Conduct not only benefits established actors, but those contemplating entry to the arena by providing predictability. But how to reach it?

Why Space Situational Awareness

Transparency and trust are critical, and both are sorely lacking in the current outer space domain. For reasons mentioned previously, while complete transparency may not always be possible due to the sensitivity of technologies and payloads found in orbit, it *is* possible to increase transparency with regards to the locations and actions of objects in space. There are already ample precedents to doing so; the United States has Space Situational Awareness sharing agreements signed many different nations, and recently signed an agreement to cooperate with the commercial Space Data Association, which coordinates SSA sharing among its private sector members.[106]

The typical form of such an agreement is as follows. The United States has signed nearly 50 unclassified data-sharing agreements with governments and private-sector entities,[107] with classified data sharing agreements made with close allies such as France.[108] These take the form of General Perturbation (GP) Two-Line Elements (TLEs) which allow operators to perform Conjunction Assessments (CA) – that is, to determine how close objects will come to each other while in orbit.[109] Currently, JSpOC performs these operations, screening active satellites in orbit; where necessary, satellite operators – regardless of whether a formal SSA sharing agreement is signed – are alerted should the Conjunction Assessment reveal a high enough chance of collision, at which point operators can decide whether or not to take avoidance measures – in certain circumstances, a near miss may be preferable to an avoidance maneuver that creates other collision risks.[110]

These are, however, piecemeal and bilateral agreements. While they have undeniable utility for the parties involved, they do not by their very nature involve a standardized means of communication among all parties; instead, US Strategic Command (USSTRATCOM) acts as a single entity which tracks objects, and notifications are sent to relevant entities as needed.[111] A step further is required: to create an international Space Situational Awareness Sharing Program

[106] Smith, "Space Data Association and USSTRATCOM Reach Data Sharing Agreement."
[107] Gruss, "US, France Expand Space Situational Awareness Data-Sharing Agreement."
[108] Ibid.
[109] Bird, "Sharing Space Situational Awareness Data."
[110] Ibid.
[111] Gruss, "U.S. Air Force Seeks New Space Situational Awareness Data To Track Threats."

capable of coordinating efforts of both nation states and private associations that currently operate in space so as to create a fuller picture of space based assets, and further reduce the risk of accidental interference or destruction.

An organized regime for sharing SSA will not only enhance the picture of the space domain, through the collection and integration of information from a wide variety of radars, telescopes, and the telemetry of individual satellites and vehicles, but it will also force the standardization of the data that is shared, and when it is shared.[112] Best practices can be developed, not only for the sharing of information but the operation of space based assets. Ideally, the process of doing so will also create opportunities for relevant actors – nations, private and public sector actors, and the growing number of non-profits – to work together and establish the working relationships so important for navigating complex environments.

Air Force Lieutenant Colonel Michael P. Gleason, writing in *The Space Policy Primer*, defines Space Situational Awareness (SSA) as "understanding what your own satellite is doing; understanding what other objects are in space, and understanding what those objects are doing."[113] The outer space environment being as harsh as it is, even the first task – understanding what your own satellite is doing – can be a difficult task, as there are many, many ways things can go wrong. Knowing where one's satellite is in relation to other satellites and vehicles is the second task, both to reduce the risk of collision (as seen in the Iridium Satellite Collision), and to electromagnetic spectrum interference when two transmitting satellites venture too close to each other (the Galaxy 15 incident).

As to the purpose of this paper, however, one question must be answered: why start with SSA? SSA is something all actors have a vested interest in – be they state or non-state/commercial, civilian or military. Knowing where your satellite is, where it is in relation to other satellites around it, and where other satellites are, is critical not only for physical self-preservation but also to ensure the electromagnetic spectrum is kept clear of interference. This applies to both

[112] Chow, *Space Situational Awareness Sharing Program*.
[113] Gleason, "Space Policy Primer."

communications and navigation satellites but also to anything else that requires contact with a ground control station (so reconnaissance satellites, remote sensing/research, etc.). Currently numerous countries are engaged in monitoring outer space activity to promote their own SSA, the most famous of which being the US Air Force and NASA tracking space debris.

Sharing data related to Space Situational Awareness – particularly on space debris but also on the orbits and movements of satellites and space vessels (stations or otherwise) – can be an important first step in building the trust necessary for formulating Space Codes of Conduct. Currently the United States Air Force tracks thousands of objects in orbit to help preserve our own satellites (and shares this information with non-US Government entities), and other nations do the same through early warning radars (Russia). Codifying how this information is shared and creating a center or central organization to coordinate sharing amongst those working in outer space would be a powerful first step in creating transparency and confidence among all players in the outer space realm. A practical solution that can receive buy-in not only from state actors, but from private sector commercial and non-profit operators while simultaneously promoting best practices and transparency is the antithesis of the failed attempts at the grand bargain: to craft an overarching, all-in-one code which is objected to by all actors and inevitably runs afoul of the old adage "Perfection is the enemy of Good Enough."

A starting point for this can be found in the Space Data Association (comprised of the 'top four' commercial satellite companies: Inmarsat, Intelsat, SES, and Eutelsat), which was formed in reaction to the Galaxy 15 Incident.[114] The Incident (previously examined in greater detail) in which a communications satellite with active transponders drifted away from its assigned orbital slot in 2010, highlighted the potential for severe harm to commercial satellite providers. In this case, the orbital slot was assigned not only to prevent collisions, but also electromagnetic interference with the signals of other satellites. The "framework protects each company's data, thus facilitating sharing of that data"[115], and is an example of a successful code of conduct for commercial operators. Creating a similar structure for nation states would not only inject an

[114] "Http."
[115] Kasku-Jackson, "International Commercial Avenues to Complement Deterrence Actions."

additional degree of safety into current and near-future operations, but also provide a common ground through which future codes of conduct can be examined.

This is an activity in which all spacefaring actors have a vested interest in. Currently orbital slots are assigned for both avoiding physical collisions and electromagnetic interference by the International Telecommunications Union, or ITU. Building on this by creating a dedicated cooperative regime of SSA monitoring would be an easy first step towards greater cooperation, confidence, and trust in the outer space arena.

Technology

To begin with, the technology required to do this is not overly sensitive. The crown jewels, so to speak, of a nation's high technology are not given away. The implementation and creation of such an organization, furthermore, can address the sensitivity of the radars and imaging equipment used, drawing either from existing technology or (if necessary) contracting for new, uniform technology standards. The creation of such an organization does not preclude nations from having similar capabilities of greater sensitivity and precision, just as GPS sensitivity for military applications was long well ahead of that for commercial usage. Furthermore, as the example of GPS illustrates, if a technology provides such a military advantage for one nation, other near-peer competitor nations will seek to copy it for their own ends (e.g., GLONASS, Galileo, and BeiDou Navigation Satellite System). A terrestrial example is the dissemination of phased-array radar technology into tornado watch and weather monitoring activities within the United States.

The United States has been sharing SSA since the 1950s, though only in recent years has it disseminated this information more broadly[116], through numerous bilateral sharing agreements. From an organizational perspective, this has fallen under the purview of STRATCOM, under which the Joint Functional Component Command for Space (JFCC-SPACE) performs the actual SSA mission. Within the JFCC-SPACE, the Joint Space Operations Center (JSpOC) uses the Space Surveillance Network (SSN) to "gather, catalog, and analyze the SSA data."[117] JSpOC

[116] Chow, *Space Situational Awareness Sharing Program*.
[117] Bird, "Sharing Space Situational Awareness Data."

also conducts daily Close Approach (CA) screenings of all operational satellites; when a CA is discovered, the satellite owner/operators are notified within 72 hours and can decide whether to execute a Collision Avoidance Maneuver (COLA)[118] to preserve their spacecraft. Currently JSpOC notifies all parties directly, with the exception of China and Russia, which are contacted via embassy channels.[119] In 2010, JSpOC performed 7,000 CAs, which resulted in 126 COLAs; each day, between 20-30 pieces of CA information are shared, and based on this information five instances per day were deemed serious enough to warrant owner/operator notification.[120]

Currently, this data is available widely – nearly anyone can create a Space Track account and access information in the form of Two-Line Element Sets (TLEs) which give a rough position of space objects.[121] For more detailed information, specific SSA Sharing agreements are needed[122] which encompass non-United States government parties. These agreements are made with a variety of nations and organizations, as well as the private Space Data Association.[123][124][125][126][127]

Other nations also perform space surveillance, and expansion of the system would not only allow better coverage by reducing blind spots through real-time monitoring, something the current system is not capable of. Real-time monitoring greatly enhances SSA and, when combined with space weather monitoring equipment of the sort proposed by the Secretary of the Air Force[128], would go a long way in minimizing the risks Adushkin et. al. outline in the way of accidental or ambiguous events inadvertently causing escalation.[129]

Organizational

Secondly, creating this body as a new organization (even if it is under the auspices of the ITU, or other UN body such as UNOOSA or ICAO) gives the chance to bring in emerging space powers

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[118] Chow, *Space Situational Awareness Sharing Program*.
[119] Ibid.
[120] Ibid.
[121] Bird, "Sharing Space Situational Awareness Data."
[122] Ibid.
[123] "USSTRATCOM Signs Space-Data Sharing Agreement with ESA - U.S. Strategic Command."
[124] Smith, "Space Data Association and USSTRATCOM Reach Data Sharing Agreement."
[125] "USSTRATCOM, Spain Sign Memorandum to Share Space Services, Data - U.S. Strategic Command."
[126] "USSTRATCOM, Germany Make Arrangement to Share Space Services, Data."
[127] "U.S. Strategic Command Signs Space Data-Sharing Agreement with Israel - U.S. Strategic Command."
[128] Gruss, "Air Force Seeks Info on Space Weather Sensor."
[129] Adushkin et al., "Orbital Missions Safety – A Survey of Kinetic Hazards."

such as India and China from the beginning, as their contributions will be vital for its success. The oft-cited failure of the European Union's Space Code of Conduct, that it failed to consult with these nations, can be avoided by starting anew on a very specific issue.[130][131] Here we also avoid the danger of tackling too broad a spectrum of activities: this SSA sharing and cooperation does not touch, for example, ballistic missile defense research, nor does it place any limitations on current or future space activities, or the actors that may wish to pursue them. This goes to the question of equity and fairness, which will be addressed shortly.

Creating an SSA Sharing body or organization brings numerous organizational benefits as well. Instead of a patchwork of nations and private associations, a dedicated SSA Sharing organization can coordinate the information received from members and ensure certain minimum standards are met. Ideally, this results in the standardization of several key facets: the types space objects tracked, the type of information shared, the manner in which it is shared, and the circumstances in which operators of satellites are notified.

A logical next step towards a code of conduct would then seek to standardize when COLAs would be attempted. Currently, each owner/operator determines based on their own internal processes what is an acceptable risk of collision when determining whether or not a CA necessitates a COLA. To create guidelines which owner/operators follow in determining whether to execute a COLA would further reduce the chance of accidental collision. A precedent can be seen in current regulations (intended to reduce space debris) that require satellite operators to plan for either de-orbiting of their craft at the end of its useful life, or to boost it into a so-called "graveyard orbit", where it is less likely to interfere with the operations of other satellites and spacecraft; though the measure initially suffered setbacks due to technical failures and constraints, it is now part of the routine operations undertaken by satellite operators.[132]

These are all areas in which the international community can work together without ever touching the questions of defense research or militarization of space. Such an SSA Sharing

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[130] Rajagopalan, "Op-Ed | Keep Space Code of Conduct Moving Forward."
[131] Zenko, "A Code of Conduct for Outer Space."
[132] Federal Aviation Administration, "Launch Quarter 2002 Quarterly Launch Report."

organization would in effect operate as a built-in Transparency and Confidence Building Measure through its establishment and operation, to say nothing of the benefits it would provide. Each party would be free to acquire better or more detailed information should they see fit, just as each party would still be free to keep the payload or technology of each satellite secret; an example of this sort of privacy clause can be seen in the Space Data Association's agreements between members, and with the United States Government.[133][134]

Equity

Lastly, the creation of an SSA Sharing organization does not enshrine the gap between dominant space powers (such as the United States and Russia) and emerging space powers. Many developing countries' (and developing space powers') fears can be traced to the idea that they will be legally locked out of the final frontier; as noted earlier, they see precedent in the mechanisms of the Non-Proliferation Treaty. India, whose ISRO has proven to be one of the more resourceful of the active space agencies, has often complained that the NPT simply enshrines a nuclear "nobility" whose promises of reduction in weapons always prove to be hollow. Ragagopalan notes these concerns are widespread among African and Latin American countries:

> [C]ountries from Africa and Latin America are also suspicious of the code because it is seen as possibly restricting their development. Given that most of these countries are yet to develop their space capabilities, they perceive any instrument developed by the West as an effort to limit the development of their capabilities, much like the nonproliferation regime that restricted their access to nuclear technologies.[135]

Given the importance of the space economy, and the projected importance of the space domain in humanity's future development, this is not an unreasonable concern.

By focusing so narrowly on SSA, this regime does not limit the activities of any nation or entity, it merely ensures that activities in outer space are monitored for the sake of avoiding collisions

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[133] "Http."
[134] de Selding, "Space Data Association Promises To Sue Any Member That Misuses Pooled Data."
[135] Rajagopalan, "Op-Ed | Keep Space Code of Conduct Moving Forward."

and other undesirable interference in operations. It avoids addressing the thorny issues of Ballistic Missile Defense and current or future types of space-based weaponry. Should nations still feel the need to address these – as they undoubtedly would, given Moscow and Beijing's desires for a de-militarization of space[136] – they can do so in appropriate forums. For those that disagree, they are still free to pursue defensive operations and research an anti-ballistic missile defenses. Every actor in the space domain has an interest in maximum freedom of operation – and SSA sharing promotes that specifically.

Ideally, such a formal system of Awareness sharing would not only encourage best practices through the standardization of information shared, but also serve as a groundwork for a future "Space Traffic Control" system. In time, as both manned and unmanned spaceflight grows in volume, this may also serve as the foundations for a such a system, de-conflicting the orbital space around Earth. It could be created from scratch, or arise from the auspices of the ITU-R, which currently regulates orbital slots for satellites. But in either case, it should be an opportunity for collective engagement in outer space, a place where nations can work together towards a tangible, common goal, and establish dialogue, and plot a vision for a cooperative, vice competitive, use of outer space.

Finally, a formal system for Space Situational Awareness Sharing ties nicely with the European Union External Action Service's (EEAS) draft Space Code of Conduct, which notes "that all States, both space-faring and non-spacefaring, should actively contribute to the promotion and strengthening of international cooperation relating to these activities."[137] States entering the space realm for the first time are incentivized – and have an increased ability – to conduct themselves within established norms of physical and electromagnetic spacing. Current spacefaring nations strengthen their ability to safeguard their space-based assets, and through cooperation with new arrivals can impart behavioral norms.

[136] "Outer Space Increasingly 'Congested, Contested and Competitive', First Committee Told, as Speakers Urge Legally Binding Document to Prevent Its Militarization | Meetings Coverage and Press Releases."
[137] European External Action Service *DRAFT International Code of Conduct for Outer Space Activities* 31 March 2014

In conclusion, such activity not only has precedent (as seen in the commercial sector), but further reduces the chances for accidents creating dangerous space debris. It creates buy-in for states new to space exploration and exploitation, by bringing them into a system of equals in sharing this information. Last, it lays the groundwork for formal, systematic nation-to-nation contact regarding outer space activities. By not addressing the uses of outer space, rather merely the actions within the domain, this path avoids the contentious issue of militarization, and thus stands a much greater chance at gaining the support of all nations, be they established or emerging space powers.

The Limits of Escalation and the Opportunities of the Kessler Syndrome

Several times this piece has referred to the idea that every actor in the space environment has a vested interest in maximum freedom of operation in the space domain; that is, restrictions do not serve any of their interests. Such a bold statement requires supporting evidence, which can be found in the unique environment of outer space. Specifically, the question of orbital debris – heretofore examined as problems to be addressed, or dangers worthy of spurring cooperative action – has an important impact on the conduct of all actors in the space arena.

As hinted at in the previous discussion on American space reliance, and the inevitable insistence on "right to defense" language in any treaty or code of conduct, space is an offense-dominated environment. This gives one great incentive to act aggressively for fear of losing the ability to act at all. RAND Corporation's Forrest E. Morgan sums up the problem very succinctly: "Deterring adversaries from attacking some U.S. space systems may be difficult due to these systems' inherent vulnerability and the disproportionate degree to which the United States depends on the services they provide."[138] As more nations enter the arena, the complexity of deterrence becomes ever greater. Technological limitations – primarily discerning the cause of technical problems – also compound the difficulty in attributing damage to any other actor; though solutions are in the pipeline, phasing them in will take time.[139]

However, the creation of space debris from kinetic offensive actions – debris that may limit your own ability to utilize space – creates a built-in limiting function on these actions. Therefore, less than lethal means are likely to be employed – and herein lies a chance for an International Code of Conduct to help regulate ladders of escalation in outer space conflict.

Unique among potential areas of conflict, outer space has a built-in limiting factor that forces a careful management of escalation by default – the Kessler Syndrome, or the fear of an exponential propagation of space debris denying the use of space to anyone. NASA explains the danger as such:

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[138] Morgan, *Deterrence and First-Strike Stability in Space*.
[139] Gruss, "Air Force Seeks Info on Space Weather Sensor."

> The prevalence of space debris increases the likelihood of cascading collisions, creating debris belts that render many orbits effectively unusable. This cascading effect, in which debris generation outstrips debris re-entry, is known as Kessler Syndrome[140]

Depending on the location of the debris, they may deorbit over a span of weeks, months, years, or millennia: Low Earth Orbit objects will de-orbit much quicker than those in High Earth Orbit, which may take tens of thousands of years. This is, needless to say, bad for all parties; if the goal of space activity is to secure it for one's own use, kinetic destruction of enemy satellites will likely be only a very last resort.

Therefore, non-kinetic anti-satellite weapons – ranging from lasers, microwaves, particle beams, and x-rays – are more likely to be employed in all but the direst circumstances. These weapons have inherent properties that allow them to scale up, causing temporary and/or mild damage, to completely disabling their target, causing a mission kill – that is, preventing the target from carrying out its assigned mission – without the physical destruction that would result in debris. Because of these thresholds, it is possible to introduce arms limitations and clearly define escalatory steps in space activities.

Background

Kinetic activities can be grouped into two types: the destruction of a satellite in place (that is, in orbit) or the destruction of launch facilities, telemetry stations, and communications/command and control stations on the ground. The most common perception of warfare in outer space is of kinetic kill Anti-Satellite missiles, launched from the ground, sea, or from an aircraft, such as the United States' Bold Orion and ASM-135 ASAT programs[141]. But any craft in space may be used as an ASAT weapon – once. Dave Webb, writing in *Securing Outer Space*, notes that collision devices – which can be difficult to distinguish from other satellites – can be a potent kinetic weapon. Furthermore, there is evidence that Russia has experimented with the ability to utilize such weapons.[142] An operational example is the Soviet-era Istrebitel Sputnik, which either create

[140] Gregory, Mergen, and Ridley, "Space Debris Elimination (SpaDE) Phase I Final Report."
[141] Grego, "An Updated History of Anti-Satellite Weapons - All Things Nuclear."
[142] Gruss, "Russian Satellite Maneuvers, Silence Worry Intelsat."

a cloud of shrapnel to destroy their target, or collide with it directly.[143] As an example of the debris generated from a satellite collision, 2009's Iridium-33/Kosmos-2251 collision created more than 2,200 trackable fragments.[144] here again, Kessler Syndrome plays a limiting factor: to take action with such weapons creates the risk that in denying space for your adversary, you will have denied it to yourself as well.

However, there are other non-kinetic means available, including directed energy weapons such as microwaves, lasers, particle beams, and x-rays; as well as the use of high-altitude detonations of nuclear weapons.[145] Of these, the latter is least likely to be of use outside of major international conflict, due to its indiscriminate nature: as previously mentioned, the "Starfish Prime" test led to the destruction of seven satellites in orbit at the time.

The remainder can be in theory used to damage a satellite, either through direct effects such as blinding sensors and overloading. Such actions do not necessarily have to be permanent: causing temporary disruption, such as dazzling optical sensors with high energy lasers, overloading electronic gear with directed energy electromagnetic pulse weapons, jamming communications in the RF spectrum, or even cyber attacks aimed at ground control stations or even the satellite itself can cause sufficient disruption.

Forrest Morgan at RAND explains this as a potential area of space deterrence failure:

> Different attacks bear different risks of retribution. Reversible effects attacks, such as dazzling and jamming, that do not damage space system components would credibly justify much lower levels of punishment than attacks that do cause damage. Attacks that physically damage a satellite increase the probability that the victim would attempt to punish the attacker in some costly way, but those that do not generate debris would probably not incur the same level of wrath as kinetic strikes that litter the space environment.[146]

[143] "NASA - NSSDCA - Spacecraft - Details."
[144] esa, "FAQ."
[145] Grego, "An Updated History of Anti-Satellite Weapons - All Things Nuclear."
[146] Morgan, *Deterrence and First-Strike Stability in Space*.

Recommendations

Therefore, non-kinetic weapons– lasers, EMP, microwaves, and cyber – represent the most likely means of attack; as less-than-lethal weapons, they can be "ramped up". This represents a perfect place to introduce limitations, and to define escalatory steps. Rather than just being thresholds of deterrence failure, as Morgan writes, these should be considered the opportunity to create predictability in escalation.

Additionally, due to American concerns regarding limitations on Ballistic Missile Defense research and development, most arms limitations schemes run into serious resistance, despite enjoying wide international support. As can be seen with the AEGIS Ballistic Missile Defense system, currently seen at sea and AEGIS Ashore, as well as Ground Based Interceptors currently deployed to Alaska, any international attempts at arms control cannot count on American support. Both of these – as well as the most technologically mature systems elsewhere – are kinetic kill vehicles. For aforementioned reasons, kinetic weapons are inherently self-limiting: debating their legality is a moot point.

Non-kinetic weapons, in contrast, offer multiple cleavages in capabilities that can be utilized to stabilize escalation and normalize conduct. Identifying and defining situations in which these less than lethal weapons would be used, as well as *what* type of weapon would be used, represents the opportunity to create predictability of escalation. Jamming a communications satellite, for example, would not be met with the same response as destroying it with an EMP weapon; dazzling optical sensors on a reconnaissance satellite would carry a lower level of response than destroying them outright. Cyber attacks that block access, or prevent commands from being executed, as opposed to those that "brick" the system or cause it to deorbit, can also be seen as an option. Here we see the possibilities of a new domain of conflict – cyber – interacting with an established but not well understood or controlled domain in ways that have not yet been fully understood.[147]

By identifying levels of escalation and non-kinetic activity, it may be possible to not only stabilize the escalatory ladder, but provide guidance as to proportionality. Just as Earthbound

[147] Zetter, *Countdown to Zero Day: Stuxnet and the Launch of the World's First Digital Weapon*.

Rules of Engagement are bounded by proportionality, so too would be offensive actions taken in outer space. Once these steps are known and agreed upon, the “use it or lose it” mentality of the offensively dominated environment can be blunted.

Lastly, a corollary may also be desirable that emulates nations’ current publicly-stated nuclear postures. That is, the circumstances a country may seek to disrupt, rather than destroy, an opponent’s space-based infrastructure can be delineated. This allows all actors the ability to clearly spell out lines their adversaries should not cross, and what potential responses to them would be; that a response to interference, damage, or destruction of space based assets would be forthcoming, and the fact that the current majority of those assets are unmanned will not prevent retaliation – either in kind or elsewhere in the world.

There is one danger of relying solely on softkill, however, which underscores the need to work towards a broader-reaching International Code of Conduct. Those nations without reliance on space-based systems have much less incentive to exercise restraint for fear of creating debris; specifically, rogue actors such as North Korea will not be deterred by the possibility of creating more space debris. This represents the limit of the built-in limiting factor of the Kessler Syndrome.

Conclusion

For almost sixty years, it has been possible for humanity to operate in space, allowing an amazing growth of technologies which in turn fed the growth of entire industries built around the exploitation of and operation in space. Despite often intense superpower rivalry, space remained free for the use of all. The actors involved were those nation states with the resources and the political desire to do so, and while not quite the Wild West, space activities could proceed with a minimum of regulation.

This is no longer the case.

It is as oft-said as it is true: space is increasingly congested, contested, and complex. The sheer number of nations alone is enough to call into question some of the fundamental assumptions made when original treaties such as the Outer Space Treaty were drafted. Those agreements that worked best – covering registration, liability, or rescue – had both firm foundations in existing terrestrial law and legal precedent, and were uncontroversial enough or so patently needed on a very basic level as to prevent serious objections not only from spacefaring powers, but the broader international community.

Moreover, technology has allowed the types of behaviors and activities to take place that previously were of questionable value even *after* billions of dollars of R&D funding were spent. Ballistic Missile Defense, which was derided as "Star Wars" during the 1980s[148], is now being pursued by nations around the world, and several successful examples of intercepts have been demonstrated; two of these systems have demonstrated the capability to go after satellites in orbit. As the case of the Chinese ASAT test demonstrates, the technology required for ballistic missile defense is not far from that required for anti-satellite weaponry; and when employed, the consequences reach far beyond the attacker and their target(s) in the form of indiscriminate space debris.[149][150]

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[148] Hoffman, *The Dead Hand*.
[149] Mastalir, "The US Response to China's ASAT Test: An International Space Security Alliance for the Future."
[150] David, "China's Anti-Satellite Test."

At the same time, these same technological advances are being exploited by the commercial sector in ways that used to be the realm of science fiction. Space tourism, in the form of exo-atmospheric travel and space hotels, is poised to take off. The promise of riches locked in asteroids has led to serious attempts to begin asteroid mining, and nations are racing to update their domestic laws to give businesses and investors the certainty they need to proceed with their designs. Scale and price have progressed in such a manner as non-profits and universities are increasingly able to participate in the space domain, and with a growing assortment of capabilities. Such accessibility is unprecedented, and will only grow over time as micro- and nano-satellite technology (commonly referred to as Cubesats)[151] and "piggyback" launch payloads gain greater commercial traction.[152]

Space Situational Awareness Sharing holds promise because it does not attempt to unravel the Gordian Knot of space self-defense and ballistic missile defense. It is narrowly defined in scope, and universal in its application: all actors operating in the space domain have an interest in better SSA, if only to preserve their own property and capabilities. It does not rely on new technological developments or practices, but rather on existing technology – and with the exception of space weather monitoring modules, as noted previously, the use all of this technology follows established practices.

By the very nature of its implementation, SSA Sharing encourages transparency and openness, thus acting as a Transparency and Confidence Building Measure. It necessitates the standardization of what is tracked, what information gathered, what information is shared and when; it also progresses logically to standard practices in the operation of satellites once CA information is shared: under what circumstances do satellite operators execute a COLA maneuver? When combined with the transparency such sharing encourages by default, the end result of such standardization is a currently unheard of level of predictability in outer space operations. Though it will never be possible to control for all variables, those with the greatest human influence can be managed to a far greater extent under such a system.

[151] Wall, "US Spy Satellite Launches Into Space Along with 13 Tiny Cubesats."
[152] Lele and Shrivastav, "Issue Brief: Rocket Launchers for Small Satellites."

That such a narrow approach could have this sort of impact is a result of the unique nature of outer space. Fears of orbital debris, expounded upon at length earlier, and the resulting Kessler Syndrome from too many space debris-creating events, provide built-in limiting factors to escalation in future conflicts. This presents a default fallback position for those concerned about an adversary's anti-satellite and space weapons capabilities while the SSA Sharing takes place. In essence, while more (and better) information is available to all sides, if one side took advantage of that information for destructive purposes, they would also be negatively impacted by those destructive actions by the space debris created; as noted earlier, in denying an adversary access to space, the attacker also denies themselves due to the debris created.

That is to say most importantly, the existence of the Kessler Syndrome buys policy makers time to cooperate and work towards the trust necessary to create international codes of conduct. In conflicts short of existential struggles, it behooves all sides to refrain from using kinetic attacks against their opponent's orbital infrastructure, for fear of in denying space to the adversary, they also deny it to themselves and incur the wrath of the other operators in the domain.

A comprehensive, uniform, overarching Code of Conduct for outer space activities is a notable goal and ideal end state. But in the push to reach such an agreement, with every lose end tied neatly into the package, policy makers run the risk of continuing the impasse that has characterized attempts to reach comprehensive space regimes thus far. Rather than allow perfection to become the enemy of good enough, an SSA Sharing regime makes concrete steps to mitigate the immediate issues all space actors large and small are grappling with, lays the groundwork for future agreements through the nature of its implementation and operation.

The adaptability and flexibility such an sharing agreement provide are important here; as Robert Keohane and David Victor write in their work *The Regime Complex for Climate Change*, "…regime complexes are marked by connections between the specific and relatively narrow regimes but the absence of an overall architecture or hierarchy that structures the whole set."[153] Keohane and Victor identify six evaluative criteria for regime complexes, and a formal SSA Sharing regime performs strongly in all six. A formal SSA Sharing Regime, as understood

[153] Keohane and Victor, "The Regime Complex for Climate Change."

through the lens of a regime complex, would have the coherence, accountability, determinacy, sustainability, epistemic quality, and the fairness that a more comprehensive architecture might not achieve.

Coherence – the idea that various specific regimes of a regime complex be compatible and mutually reinforcing – is found in the pre-existing nature not only of the treaties and agreements examined earlier in this paper, but in current best practices. Maintaining and sharing SSA is in line with current government *and* private practices, as seen in the work of JSpOC and their counterparts in other nations, as well as the private sector's Space Data Association.

Likewise, by its very nature, accountability is baked in. The transparency required for such data sharing means all actors are aware of the others' actions. This in turn enhances the legitimacy of the regime in that all actors can easily judge if their counterparts are acting appropriately. Furthermore, rather than a regime established to keep players out of the space arena, it sets a standard all would seek to rise to meet in a collaborative fashion. Determinacy is found both through the greater transparency SSA Sharing provides, but also through the knowledge that all actors have the vested interest in establishing these norms, and that due in part to orbital dynamics, the same rules apply to all operators when it comes to the creation of space debris, be it accidental or the result of intentional actions. These are readily understandable by all actors, and indeed have largely already been discussed and debated, as shown previously.

Sustainability in particular is enhanced with greater numbers of nations and commercial operators interacting and sharing data; it enables not only better real time coverage[154] but also more information available as to telemetry – rather than track and observe, a satellite operator can provide their own information to greatly quicken the process.[155] Furthermore, with more actors involved, greater redundancy is built into the system. This both protects against a malicious actor, as well as the challenges of operating in an unforgiving environment like space.

[154] Bird, "Sharing Space Situational Awareness Data."
[155] Ibid.

Unique among areas of human activity, the space domain remains a highly technical realm governed first and foremost by scientific laws; epistemic quality as Keohane and Victor describe it, is enhanced here due to the much greater extent to which scientific principles govern activity.[156] This further lends credence to determinacy and sustainability, as SSA Sharing is governed not only by regulatory frameworks established, but by physical laws. This in turn lends greater sustainability to such a sharing regime.

Finally, fairness is baked into the concept of an SSA Sharing regime from the outset, lest we allow intentional blind spots to enter our space surveillance. All information shared is shared with all actors, and as new nations enter the space domain, their information is added to the pool, and they have access to the same information every other actor possesses. While nations would of course be free to pursue greater – enhanced – SSA for their own purposes, the standards established by an SSA Sharing regime would put a hard floor under the level of information shared. Moreover, the deliberate creation of separate standards for established space powers versus emerging space powers would not only be fiercely contested, but also counterproductive and wasteful.

It took humanity four thousand years to take flight; from the time of the Wright Brother's flight at Kitty Hawk to the launch of Sputnik, a mere fifty four years had passed; Yuriy Gagarin orbited the Earth not even four years after that. Eight years later, Neil Armstrong walked on the Moon, and less than sixty years later tens of thousands of objects – along with a few people living on the International Space Station – orbit the Earth, with manned trips planned for asteroids and Mars, while robotic probes are being constructed to main rare earth metals from asteroids. The pace of technology is enabling humanity to once again venture forth into new worlds. Cooperation will be indispensable, cooperation that can be engendered through the creation of frameworks of Space Situational Awareness sharing.

[156] Keohane and Victor, "The Regime Complex for Climate Change."

Timeline of Treaties and Agreements

1957 – The launch of Sputnik, the first artificial object put in orbit, launches the Space Race

1963 – Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space, and Under Water (NTB; Partial Test Ban Treaty"

1967 – Treaty on the Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (OST; Outer Space Treaty)

1968 – Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects into Outer Space (ARRA; Rescue Agreement)

1972 – Convention on International Liability for Damage Caused by Space Objects (Liability Convention)

1974 – Convention Relating to the Distribution of Programme-Carrying Signals Transmitted by Satellite (BRS)

1975 – Convention on Registration of Objects Launched into Outer Space (Registration Convention)

1979 – Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (Moon Treaty; largely considered a failure)

1992 – International Telecommunications Constitution and Convention (ITU-R)

2010 – Space Data Association is formed by Inmarsat, Intelsat, SES, and Eutelsat

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