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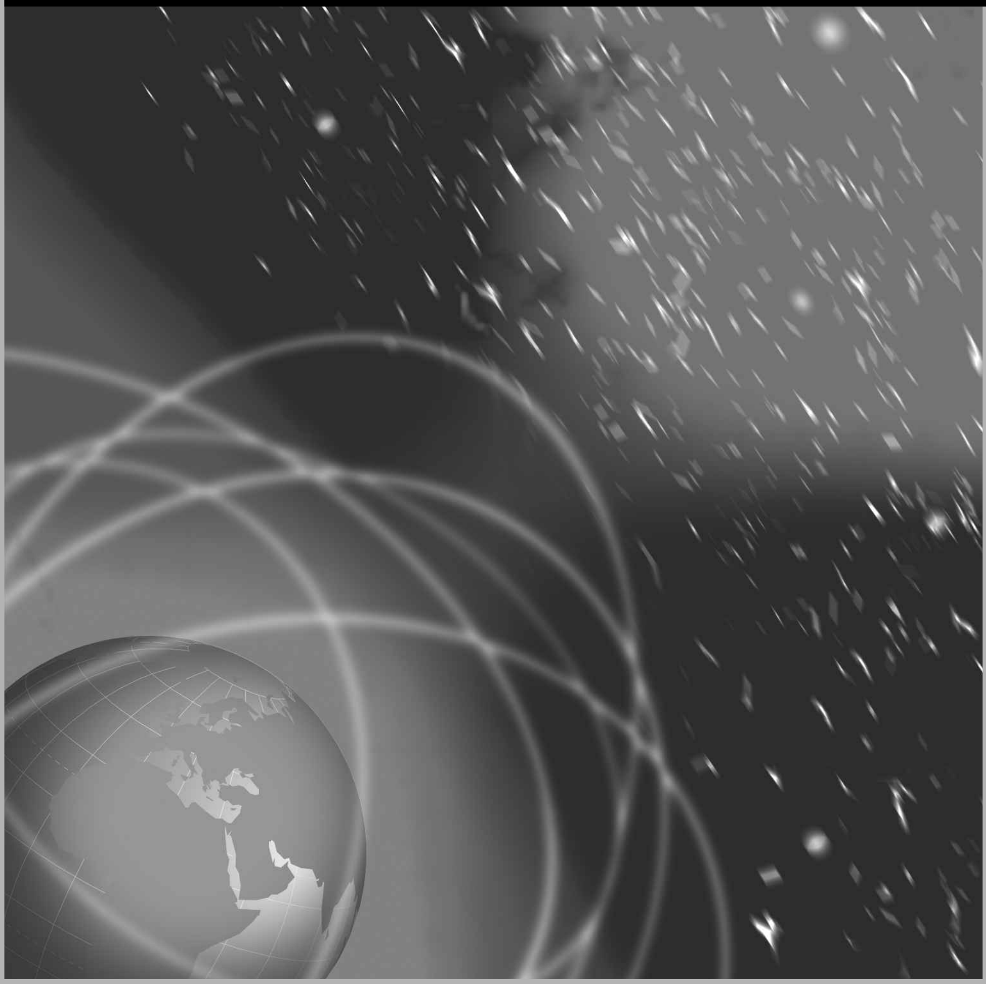

A SAFER SPACE ENVIRONMENT?

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EDITOR'S NOTE

The space environment—and space technologies—have evolved enormously since the adoption of the Outer Space Treaty in 1967, and this rate of development shows no sign of slowing. As technologies continue to advance, our dependence on space assets will only increase. This reliance generates vulnerabilities and there is growing awareness that space security is a critical issue for all states—not just the established space powers. For many, the Outer Space Treaty and subsequent agreements, indeed international law as a whole, are no longer sufficient to address the potential threats to space security of today and tomorrow.

This issue of *Disarmament Forum* explores the possible components of a strengthened space security regime and potential ways forward for the international community. Contributors discuss a range of options, from efforts already being undertaken within the private sector to ensure safe satellite manoeuvres to the new draft European Code of Conduct on Outer Space Activities. There are suggestions on approaches states could be taking to establish a more secure space environment and on possible steps toward a treaty on space security.

The first issue of *Disarmament Forum* in 2010 will look ahead to the implementation phase of the Convention on Cluster Munitions, which opened for signature in December 2008. Over 100 states have already signed this humanitarian disarmament treaty, and it could enter into force as early as next year.

The new convention comprehensively bans the use, production, stockpiling and transfer of cluster munitions. In addition, the treaty obliges its member states to assist victims of cluster munitions, clear cluster munition affected areas, destroy their stockpiles of the weapon, and cooperate and assist each other toward these ends. Nevertheless, these are formidable tasks. How can states party to the convention, in partnership with international organizations and civil society, ensure the treaty's practical goals are achieved? Issue 1, 2010 will examine what will be required to implement some of these humanitarian and development commitments.

Information Security. Cyber warfare. Cyber terrorism. Cyber Security. The lack of a clear, commonly shared vocabulary—let alone agreement on the nature of the threat—will be one of the challenges faced by the Group of Governmental Experts established via General Assembly resolution 63/37, and which started its work in November. In order to promote awareness of this issue, UNIDIR has produced a short bibliography of relevant articles, from national doctrines to analysis by independent experts. Download the bibliography from <www.unidir.ch/pdf/activites/pdf3-act483.pdf>.

UNIDIR held two events on the margins of the First Committee of the UN General Assembly this year. On 20 October, "Promoting Discussion on an Arms Trade Treaty" provided an update on the project that UNIDIR is implementing for the European Union. Over 120 representatives of government, international organizations, industry and civil society listened to presentations on the key messages resulting from the regional seminars organized by the Arms Trade Treaty (ATT) project so far, and on specific thematic concerns for a future ATT. Just over a week later, the First Committee approved a draft resolution to establish a United Nations conference to negotiate an Arms Trade Treaty in 2012.

The following day, UNIDIR and the Secure World Foundation held a conference entitled "Latest Developments on Space Security and Disarmament". Speakers considered proposed approaches to space security from legal and technical perspectives. The presentations are available on our web site.

In partnership with the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization, on 2 September 2009 UNIDIR held a conference on "The CTBT: The Nexus between Politics and Science". Speakers discussed how scientific and technical aspects regarding the verification system could affect entry into force. Summaries of the presentations from these meetings—with audio files from the CTBT conference—can be found on UNIDIR's web site.

Did you know that UNIDIR is on Facebook? Join the group and keep posted on UNIDIR activities, as well as find news and views about disarmament and security. In addition to becoming a group member, we hope that you will actively participate by posting comments and topics for discussion, thereby helping us to create a space for dynamic disarmament dialogue.

Kerstin Vignard

SPECIAL COMMENT

We have not yet reached a consensus on where outer space begins and where it ends. But, it is clear that there is no end to how important it is to our everyday lives. Since 1957, almost 7,000 satellites have been launched. Today, some 900 space satellites are in orbit, operated by more than 40 countries.

The preservation of the peaceful use of space is in the interest of all countries—whether they are space-capable or spacefaring, or not. Space exploration generates technological innovation that is essential in accelerating development. Satellite communications provide access in remote and isolated communities to bridge the so-called digital divide. Space technologies enable monitoring of the pace and extent of global warming, which is critical in informing and directing our mitigation efforts. Telecommunications, television, navigation, enhanced warning systems for natural disasters, support for recovery activities, weather forecasting, agricultural planning and natural resource protection make a considerable contribution to the world economy—and they all increasingly depend on the use of outer space.

We may not have our heads in the clouds, but our collective terrestrial well-being is certainly closely linked with our celestial progress. Any interruption of the use of outer space would disrupt our daily lives. With benefits comes responsibility, and with dependence comes vulnerability. It is the combination of these four factors that makes the need to take action for greater space security so urgent.

Many space systems and their applications are of dual use. As technology advances in space, the likelihood of space becoming a conflict arena increases. Preventing a weaponization of outer space is fundamental to our collective security and to ensuring strategic stability.

The International Space Station is a compelling example of the benefits of a collaborative approach to space research. As one of the most complex scientific endeavours ever undertaken, it involves support from five space agencies, representing 16 nations. Even if space may be the final frontier, there should not be any borders in our cooperation there.

For its part, the United Nations has played a leading role in establishing principles to ensure that outer space and space activities continue to enhance the well-being of humankind. This Organization has brokered international treaties stipulating that outer space, including the Moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means. Moreover, treaties provide for freedom of exploration, liability for damage caused by space objects, space safety and rescue, notification and registration of space activities, dispute settlement and the scientific investigation and exploitation of natural resources in outer space.

The 1967 Outer Space Treaty has so far provided the basic framework of international space law. The 1963 Treaty banning Nuclear Weapon Tests in the Atmosphere, the 1972 Convention on International Liability for Damage Caused by Space Objects and the 1975 Convention on Registration of Objects Launched into Outer Space are milestones. Likewise, the 1979 Agreement Governing the Activities of States on the Moon and Other Celestial Bodies and the 1976 Convention on the Prohibition of Military or any Other Hostile Use of Environmental Modification Techniques represent considerable achievements in the ongoing efforts to reserve the use of outer space for peaceful and scientific purposes.

All of these legal instruments were agreed and adopted during the Cold War. The record of implementation, coupled with technological developments and capabilities, have demonstrated that they do not offer a comprehensive solution to current and future challenges to space security. There is a clear need to update the legal regime.

I firmly believe that all areas of disarmament are connected and that progress in one area will have a positive impact on developments in other fields. We need to build on the current trend toward better relations among states to advance all areas of disarmament and arms control, including in outer space. Legally binding instruments, transparency and confidence-building measures must be combined to achieve security in outer space.

Initiatives such as the Chinese–Russian draft treaty on the "Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force Against Outer Space Objects (PPWT)", the European Union draft Code of Conduct for Outer Space Activities and a Canadian proposal all help to facilitate the process toward greater global security.

As the United Nations General Assembly has reiterated, the Conference on Disarmament has the primary role in the negotiation of a multilateral agreement, or agreements, on the prevention of an arms race in outer space in all its aspects. The adoption of a Programme of Work in the Conference in May 2009 opened new perspectives in these discussions and could pave the way for practical steps to strengthen the norms, institutions and legal regimes concerning space security.

A shared sense of urgency and political will are indispensable if we are to capitalize on the renewed momentum. This can best be nurtured and carried forward through partnerships among governments, international organizations, academia, industry and civil society. When we pool our resolve and our resourcefulness we can formulate strong solutions to the challenges before—and above—us.

As the human family, it is our obligation to preserve the benign nature of outer space and to put in place mechanisms to realize this goal. The longer we wait, the more difficult it will be to elaborate effective arms control measures. This is true for all fields of disarmament, but even more so for outer space where technology advances so quickly. And if we cannot make progress on outer space security, I doubt that we will be able to do so significantly in other areas. At the same time, success in the preservation of outer space for peaceful purposes could have a positive effect on other fields.

Space is our common heritage. And it is not a foregone conclusion that it will stay that way.

Sergei A. Ordzhonikidze

United Nations Under-Secretary-General

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Secretary-General of the Conference on Disarmament and

Personal Representative of the United Nations Secretary-General to the Conference

Promising confidence- and security-building measures for space security

Philip J. Baines and Adam Côté

In the last 50 years, outer space has become a domain of critical national infrastructure and of vital strategic and tactical importance. Outer space provides communication, navigation, remote sensing and a myriad of other services to both civil and military clients. Due to the emergence of space as an essential part of modern life, there has been growing discourse concerning the subject of space as a "contested environment", in which states compete for control of space, rather than allowing space to be used "for the benefit and interest of all countries."[1] This discourse has led to such initiatives as the Prevention of an Arms Race in Outer Space (PAROS) at the Conference on Disarmament (CD). Given this increasing interest in space both from countries such as China, which are beginning to exploit and benefit from outer space, and veteran spacefaring nations such as the United States and the Russian Federation, which are becoming increasingly dependant on outer space, it is surprising that there is not yet an arrangement or treaty designed to protect the space environment and ensure its continued use for future generations, given the very real potential for armed conflict in this newly contested domain.

This paper seeks to address the issue of space security by laying out the foundations of a space security treaty aimed at preventing physical conflict in outer space in order to preserve its continued use today and well into the future. The paper will address the reasons why a treaty is necessary, the threats currently facing humanity's collective use of outer space, and postulate suggested confidence- and security-building measures (CSBMs) for space security. Although the idea of a space security treaty is new, the concepts being presented here are not. Many are taken from other disciplines or issues and applied to outer space. We hope that by building onto these older concepts and ideas, it will become easier for countries to both adopt and comply with a space security treaty for the benefit and interest of all countries.

The scourge of space debris

Outer space offers a unique challenge to the concept of conventional conflict among states. Namely, by destroying the satellite of another state, and creating debris, aggressors are also destroying their ability to further use space. Space debris can travel at excessively high speeds (upwards of 7.8km/s in low Earth orbit), turning pieces of damaged or destroyed satellites, as small as 10cm in diameter, into destructive forces capable of delivering the same amount of energy to an object as a 35,000kg truck travelling at 190km/hour.[2]

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Furthermore, once space debris is created, it will remain in orbit—sometimes indefinitely.[3] Outer space cannot cleanse itself of debris as quickly as mankind is able to make it. This leads to a cascade effect, where old debris hits new satellites, creating more debris.[4] Without efforts to curb this problem, entire areas of space could become unusable for hundreds, or thousands, of years. Since there is no way to effectively remove large amounts of debris from orbit, it is essential that states preserve the orbit's utility through efforts to control the amount of debris that is created. This is especially true with respect to the potential for armed conflict in outer space. For this reason, it is crucial to have in place a set of agreements, coupled with a verification and governance system, to ensure the security of outer space.

Security challenges for outer space

The security challenges facing outer space can be broken down into two distinct types of threat: irreversible and reversible. Irreversible refers to the permanent damage of a satellite, or the destruction of that satellite. Reversible refers to temporarily disrupting signals to or from a satellite, or the denial of such signals to or from that satellite.

Irreversible

Lt Col. Bruce M. DeBlois of the US Air Force contends that space weaponization is not an "'all-or-nothing' affair."[5] DeBlois argues that space threats lie on a continuum, ranging from relatively low to relatively high. On this continuum, DeBlois argues that space-based weapons (whether able to engage other space objects or targets on or above Earth) pose the greatest threat to space security.[6] This is because space-based weapons have the greatest potential to create space debris. It is estimated that the destruction of a 5–10 ton satellite could double the amount of debris in low Earth orbit.[7] As such, any full-scale conflict in space would render parts of outer space unusable. Earth-to-space weapons pose a similar, if lesser, threat, though they are still able to cause the same catastrophic effects as space-based weapons. Most important is the need not to purposefully create space debris or even derelicts in outer space that can subsequently collide with space debris to produce yet more debris.

Certain dual-use satellites that could damage or destroy objects also present a space security threat. Dual-use satellites refer to satellites that serve a legitimate civil purpose in space, but can gain the effects of a weapon when used for a military objective, for example, by intentionally colliding with another satellite. This threat can arise where such satellites possess the necessary pursuit sensors and the fine-control rocket engines to enable close proximity operations with a non-cooperative satellite or, alternatively, can illuminate an object with sufficient electromagnetic energy to cause damage, due to the susceptibility of sensitive electronics or optics. The vast majority of satellites do not possess such capabilities and therefore make poor suicide bombers and rather ineffective ray guns.

Finally, the threat of accidental collision is ever present in space and steps should be taken to attempt to reduce the probability and consequence of accidental collisions in space.

To summarize, humanity's use of outer space is plagued by four major irreversible threats. They consist of:

- the threat of space-based weapons that are specially designed or modified to damage or destroy;
- the threat of weapons that reach into outer space from Earth to damage or destroy;
- the residual threat of certain dual-use satellites that could also damage or destroy; and
- the residual threat of accidental collisions in outer space or on the surface of Earth.

Any space security regime worth pursuing should address these four threats in a comprehensive manner—not only preventing states from creating excess amounts of debris, but also determining compliance with the regime's provisions. Here an obligatory governance structure using verification methods based on a collection of space situational awareness (SSA) systems is highly recommended.

Reversible

In addition to the irreversible or destructive threats for space systems are threats of a reversible or disruptive nature. Reversible threats can include jamming or spoofing uplink or downlink communications channels of satellites.[8] For example, states use outer space for military purposes such as intelligence, surveillance, reconnaissance, navigation and timing, and communications, among other activities.[9] Powerful states rely upon the use of these satellites to ensure strategic stability, as was the case during the Cold War,[10] or to gain tactical military advantage for Earth-based military missions.[11] These military uses of space can pose security threats for other states, which may require negation under conditions for which the self-defence provision of Article 51 of the UN Charter could be expected to apply.[12]

It is argued that strategic stability is crucial to the maintenance of international peace and security (and indeed life) on Earth. The world need not be reminded of the frightful days of the Cuban missile crisis. Early warning detection, strategic communication and reconnaissance systems are vital to the maintenance of strategic stability. Purposeful interference with these satellite systems risks triggering an escalatory response. In the case of nuclear war, it is difficult for a state to credibly threaten a large-scale nuclear attack, due to the concept of mutually assured destruction.[13] However, states may engage in limited wars, in which they seek to substantially raise the risk of escalation to nuclear war.[14] Given the inherent difficulties of defending satellites in outer space, a state is more likely to engage in retaliatory or escalatory behaviour should its space assets be interfered with or attacked with weapons.[15] Any escalatory behaviour would be a significant threat to both space and Earth security. For this reason, purposeful interference with satellites that ensure strategic stability is an important security threat that should be addressed, especially by states in possession of nuclear weapons. Here, the security of space is best maintained through "stability more than superiority",[16] if states are to avoid missteps during crises that could lead to an actual nuclear war.

A state is more likely to engage in retaliatory or escalatory behaviour should its space assets be interfered with or attacked.

Outer space is also becoming essential to conducting tactical military operations on land, sea and in the air. Satellites such as communications and navigation satellites provide invaluable information to troops on the ground in real time. In times of peace, satellites provide reconnaissance information that can help avert crises. By keeping a continuous watchful eye on rival states, it becomes more difficult to misinterpret their actions. Interference with these satellites during peacetime has the potential to be interpreted as an "act of aggression" under the UN Charter. Should a state be attacked in this fashion, Article 51 of the UN Charter would permit it to engage in self-defence. This poses a space security threat since interference with tactical military satellites during peacetime has the potential to trigger a crisis or a conventional war. Should a state already be engaged in hostilities on the surface of Earth or elsewhere, Article 51 of the UN Charter would enable the defending state to purposefully interfere with the satellites, sensors and signals that are taking part in that aggression. The need to assure humanity's continued use of outer space, including a state's own use, should prevent any state from physically destroying satellites. A space security treaty should codify this common understanding. A space security treaty should not, however, prevent states from temporarily or reversibly interfering with satellites, sensors or signals for reasons of self-defence, as is allowable under the UN Charter and the Outer Space Treaty (OST).

Finally, inadvertent interference with satellites from radio frequency or electro-optic frequencies remains a growing problem in space and measures should be taken to ensure that this residual threat is also minimized. Here a collection of SSA systems are important for crisis stability, as they will help discern inadvertent accidents and prevent them from being misconstrued as deliberate attacks.

To summarize, outer space is subject to two kinds of reversible threat. They are:

- the threat of purposeful interference with respect to reliance upon the use of satellites to ensure strategic stability, and the use of satellites to gain a tactical military advantage on Earth; and
- the residual threat of inadvertent interference from radio frequency and electro-optic frequencies.

Confidence- and security-building measures for space security

Having established the threats that need to be addressed for space security, this paper will now focus on proposing possible CSBMs aimed at laying the foundation for a comprehensive space security treaty.

Irreversible

The first and most significant irreversible threat to space security is the threat of space-based weapons that are specially designed or modified to damage or destroy targets in outer space, on a trajectory above the surface of Earth, or on the surface of Earth. We can address the threat of space-based weapons by building upon the existing Outer Space Treaty, specifically Article IV.[17]

> **CSBM (1)** States shall not place in orbit around Earth any weapons or objects carrying weapons, install weapons on the Moon or any other celestial body, or station weapons in outer space in any other manner.[18]

This proposal raises a couple of questions: one concerning the definition of the word "weapon", and another concerning what such a prohibition would encompass. For the purposes of a space security treaty, a "weapon" is defined using a combination of the ordinary meaning of the word "weapon" and select parts of the Anti-Ballistic Missile (ABM) Treaty and the Missile Technology Control Regime as "a device based on any physical principle, specially designed or modified, to injure or a kill a person, irreparably damage or destroy an object, or render any place unusable."[19]

To assist with discerning a space-based weapon from an ordinary satellite, the concept of "form follows function" may be employed. Coined by Louis H. Sullivan in 1896, form follows function is the idea that the design or look of an object directly relates to the purpose it serves.[20] Sullivan writes: "All things in nature have a shape, that is to say, a form, an outward semblance that tells us what they are, that distinguishes them from ourselves and each other."[21] In essence, objects of the same class tend to look alike. Further, "where function does not change, form does not change."[22] As such, there is no need to change the design of an object if the function of that object does not change.

Nam P. Suh further developed this idea: he establishes a direct mathematical relationship between the functional requirement of an object and the design parameters of that object.[23] Suh argues that the best designs are ones that fit one functional requirement with one design parameter. Anything beyond this represents improper design.

Using these design theories we can discern space-based weapons from satellites, as they imply that a satellite that is designed to be a weapon will also look like a weapon, and a satellite that is designed to be benign will look benign.[24] One recognizable example of these design principles drawn from our ordinary experience is revealed in the comparison of a butter knife with a bayonet. A butter knife is short and it is dull-edged. Clearly this utensil has been designed for the purpose of benign kitchen tasks and the use of human safety factors are in ample evidence. A bayonet, on the other hand, is sharp, pointed, very long, double-edged and possesses the structural rigidity necessary to repeatedly harm human beings.

A similar type of analysis can be performed by experts, aerospace engineers and other intelligence analysts to distinguish the functions of objects in outer space. Indeed, even in the absence of a space security treaty, states must keep a vigilant watch on activities in outer space in order to maintain an ordered targeting list for the negation of space objects that could project harm in outer space or onto Earth.

These ideas were employed in the Strategic Arms Limitations Talks (SALT) II Treaty between the Soviet Union and the United States. In this treaty, these design principles were referred to as functionally-related observable differences (FRODs).[25] FRODs suggest that certain aeroplanes could be distinguished from others as being able to perform functions that fell into the domain of the SALT II Treaty. As such, FRODs became a standard method of verification. If it looked like it might be able to violate the SALT II Treaty, then it fell to the two countries to discuss and consult with each other to find a resolution to the compliance issue.

Observations by national technical means can ascertain, based on FRODs, whether a space object is "specially designed or modified" to serve as a weapon. Should situations arise in which the observable difference is too close to call by national technical means alone, the use of the treaty's executive council structure as a means to consider these compliance issues would be far more beneficial for international peace and security than the alternative reliance on a deterrence strategy based on threats, retaliation, reprisals and other uses of force among nuclear-armed powers.

In addition to form, satellites are deployed in highly specialized orbits. The relation of a satellite to others or to the surface of Earth tells a great deal about the function the satellite is to perform. For example, satellites are deployed in the geostationary orbit in order to gain a view of one-third of the surface of Earth. This location makes it ideal for strategic communication and early warning missions. Likewise, satellites deployed in low Earth orbit gain proximity to Earth's surface that can be exploited by remote sensing satellites to gain sharp resolution images of Earth. The behaviour of satellites within these orbits can also indicate their purpose. For example, most satellites have no need to approach other satellites. Future in-orbit repair or refuelling missions, requiring rendezvous or docking functions, would exhibit behaviours (and forms) that are different from most satellites. Like form, behaviour in space and in time can be used to distinguish a belligerent satellite from a benign satellite.

Referring to DeBlois's oft-cited article, the above CSBM addresses the highest level of threat,[26] as it would prohibit orbital bombardment systems, orbital anti-satellite (ASAT) weapon systems, and space-based missile defence interceptors or directed energy weapons. This prohibition on weapons in outer space also enables further prohibitions to be considered for weapons on Earth that may reach into outer space, for without this first prohibition, states could not be expected to agree to the prohibition of terrestrially-based anti-satellite weapons for the fear of creating a sanctuary for space-based weapons.

Moving along DeBlois's continuum then, to the threat of weapons that reach into outer space from Earth to damage or destroy.

CSBM (2) States shall not test or use a weapon on any satellite so as to damage or destroy it.

Once again, clarification is needed on a certain aspect of this CSBM. As was the case in the first CSBM, the definition of weapon remains the same. The word test, however, should be restricted to a validation activity conducted in the open. That is, "test" means to field or flight test in a manner observable by the national or multinational technical means of observation available to a state. This helps to ensure that the prohibition, as worded, can be verified by national technical means of observation.

In terms of prohibitions, this CSBM would prohibit inflicting damage or destruction on a satellite, *regardless of the weapon's location*, but would still allow ballistic missile defence (BMD) systems located on the surface of Earth to pass through outer space and engage ballistic missiles also passing through outer space. This CSBM would prohibit dedicated land-, sea- or air-based ASATs and modified BMD interceptors that are tested or used in an anti-satellite weapon role. CSBM 2 also prohibits the test or use of directed energy weapons on satellites that can harm satellites at a distance. This ensures that satellites placed into outer space may serve their natural lives and, at the end of their useful lives, execute their pre-arranged disposal plans to protect against the further production of space debris. This CSBM therefore would prohibit all activities that could deliberately create a derelict in orbit that may subsequently collide with space debris, as well as the direct production of space debris from a deliberate collision with an interceptor. It would not impede the development or test or use of ballistic missile defence systems against sub-orbital ballistic missiles.

Certain dual-use satellites, as articulated above, pose a more interesting and unique threat to space security than the two previous threats. This is due to the nature of certain satellites and their intended uses.

> **CSBM (3)** States shall not test or use a satellite, itself, to gain the effects of a weapon through any direct action.

Such an undertaking would prevent satellites from inflicting damage or destruction themselves, but would still permit the use of outer space for the aid of military forces on Earth. The main challenge for this CSBM is maintaining sufficient awareness to provide accountability for activities in outer space. If, for example, a state uses a satellite that is capable of executing a pursuit to purposefully collide with another satellite in an attempt to damage or destroy that satellite, how will the world know who caused the resulting collision? For the most part, awareness of an attack in space currently only comes when people on Earth notice its effects.[27] That is to say, in space, it is very hard to see an attack coming if you are not looking. By the time one satellite has collided with the other, it may be difficult to properly attribute the attack, assuming it was an attack at all and not just an accident. It is for these reasons that robust SSA systems are fundamental to determining compliance with this and other CSBMs. SSA is crucial to attributing attacks and distinguishing attacks from accidents.[28] Moreover, SSA is essential to deterring such attacks. If a state is aware that it will get caught by engaging in such action, it will be less likely to do so.

Accidental collisions in outer space or on the surface of Earth pose the least significant threat for the security of space. However, they pose a great threat to the continued use of space. Space debris is created from accidental collisions just as it is from intentional ones and efforts must be made to reduce these occurrences. Likewise, to obtain crisis stability, it is important to be able to distinguish between an accident and a deliberate attack. The following series of CSBMs address this residual threat.

> **CSBM (4)** A State should undertake to provide at least 72 hours prior notice of all space launch attempts from the territory, vessels, aircraft or satellites under its jurisdiction and control.

> **CSBM (5)** When a State has reason to believe that a satellite maintained on its registry may re-enter the atmosphere of Earth sooner than within the next thirty (30) days, such a

State should provide notice without delay to all States that it has reason to believe may be affected.

CSBM (6) A State should not test or use a satellite maintained on its registry to purposefully approach, rendezvous, or otherwise operate in close proximity of another satellite, without providing sufficient prior notice to the State of registry of that other satellite. A State should also not dock or make purposeful physical contact with another satellite, without the prior approval of the State of registry of that other satellite.

CSBM (7) When a State has reason to believe that an active satellite maintained on its registry has a significant risk of collision with another satellite that it also believes is active, the State shall provide notice, without delay, to all other States that it has reason to believe may be affected.

CSBM (8) In the isolated event that a single satellite maintained on the registry of one State collides with another satellite maintained on the registry of another State, or one satellite purposefully approaches or makes physical contact with another satellite without giving the prior notice or gaining the appropriate approval required under CSBM 6, each affected State should consult with one another without delay.

Adhering to these CSBMs will significantly reduce accidental collisions in outer space and on the surface of Earth, as well as misunderstandings that could arise from such accidents. These proposed CSBMs have their roots in Article IX of the OST, which calls on states to mutually assist and cooperate with each other.[29] In effect, these CSBMs provide timelines and best practices to follow when operating in the outer space environment. Under these CSBMs, a state commits to provide notice to other states that may be affected by its activities in outer space. These notices enable the affected states to make better use of the consultation mechanisms that are available to them under Article IX of the OST. Increased communication opportunities, coupled with multiple robust SSA systems, will go a long way in reducing both the number of instances, and possibly the severity, of accidental collisions in outer space.

Reversible

In order to deal with reversible threats to outer space, it is important to ensure the continuity of communication, observation and early warning signals. When discussing satellites that provide strategic stability, it is important for all states, nuclear or not, to ensure that these crucial systems remain free from purposeful interference. Strategic stability comprises two main facets: observation and communication. The loss of one or both of these abilities can threaten the strategic stability among states that possess nuclear weapons.

CSBM (9) All States that possess nuclear weapons should use redundant and independent early warning systems that are based on more than one type of sensor.

CSBM (10) No State should purposefully interfere simultaneously with two or more early warning systems of any State that possesses nuclear weapons.

CSBM (11) No State should purposefully interfere with national or multinational technical means of observation operating in accordance with the generally recognized principles of international law.

These CSBMs address the observation facet of strategic stability and ensure that states in possession of nuclear weapons maintain at least two early warning systems based on separate indicators in order to ensure that any nuclear launch can be verified. If only one indicator were to be used, a malfunction in that system could be misinterpreted as a hostile launch. In order for this fail-safe to function properly, it is important that no state interfere with two or more of these systems at once. If a state is able to deceive both systems simultaneously, it may force the defending state to launch its nuclear weapons. The idea of redundant early warning systems as a necessary fail-safe measure has been in place since the early days of the Cold War.[30]

CSBM (12) States that possess nuclear weapons should establish redundant and independent communication channels among their respective national command authorities consistent with their national security and foreign policy interests.

CSBM (13) No State should purposefully interfere with the signals of any such communication channels.

CSBM (14) No State should purposefully interfere with the command and control signals between the national command authorities of States that possess nuclear weapons and their military forces in possession of such weapons.

In terms of communication, it is important for states in possession of nuclear weapons to establish communication links among themselves in an effort to avert possible misinformation or misinterpretation of activities, especially during crises or conventional hostilities. During the Cold War, the United States and the Soviet Union established the Hot Line Agreement to facilitate such communication.[31] Extending this to other states in possession of nuclear weapons is recommended. Furthermore, interference with these lines of communication should be avoided at all times, as should interference between those with the authority to launch nuclear weapons and those military commands in possession of them.

The CSBMs described above were self-evident to the United States and the Soviet Union during the Cold War as both superpowers defined “red lines” of international behaviour, which were designed to signal that certain activities were threatening vital interests.[32] In fact, it is argued that the maintenance of peace during the Cold War was due in part to this series of conditions (communications, rational decision making, informed strategic planning, and a mutual sense that nuclear war was not in the interest of either country).[33] It is evident that the measures outlined in CSBMs 9–14 are simply restating already recognized international norms. As such, they would not necessarily need to be included in a space security treaty. The states that possess nuclear weapons may also want to retain the communication of red lines within their normal conduct of international relations in order to control the escalation ladder during situations that they might face in the future. A benefit of this reservation is that a space security treaty can address reversible threats more simply, as outlined below.

The use of satellites for tactical military objectives, as discussed earlier, should be approached differently during peacetime and during hostilities, including the outbreak of hostilities. Actions taken by states against satellites performing these roles can differ both in terms of legality, as well as consequence, depending on this divide, established by the UN Charter. As such, proposed CSBMs must reflect this divide.

CSBM (15) No State should purposefully interfere with any satellite sensor or signal that is operating in accordance with the generally recognized principles of international law, except when it considers that such purposeful interference is both necessary and allowable by the UN Charter.

CSBM (16) No State should use a satellite to originate, from itself, any purposeful interference, except when it considers that such interference is both necessary and allowable by the UN Charter.

These two measures would help reduce the risk of the initiation of a crisis by one state interfering with another state's satellite's sensors or signals, but they can each engage in this behaviour should they need to respond to an "act of aggression" pursuant to Article 51 of the UN Charter. In such instances, it would normally fall to the UN Security Council to seek a resolution to the outbreak of hostilities. CSBM 15 is recognizable as a variant of similar provisions within the ABM Treaty and in the Treaty on Conventional Armed Forces in Europe.[34]

Further discussion of CSBM 16 is warranted by its clarification of CSBM 15. There is the possibility that purposeful interference originating from a satellite will act as an accelerant for the development of dedicated anti-satellite weapons or the modification of ballistic missile defence interceptors to negate the source of the interference in outer space with means that could produce space debris. After all, radio frequency or electro-optic jammers on the surface of Earth are often engaged with bombs or other explosive devices during hostilities. To prevent physical conflict in outer space, such interference should only originate from the surface of Earth, where terrestrially-based weapons may ultimately deal with the source of the interference. In a similar way to the current protective measures employed for the defence of aircraft, satellites in the future could become equipped with on-board jamming pods or flares to address the residual threat of terrestrially-based ballistic missile defence interceptors being modified to serve as anti-satellite weapons. By using electronic warfare measures against these residual threats, states would be adhering to both the UN Charter and a space security treaty.

The final threat to address is that of inadvertent interference between states. This paper suggests building upon the consultation mechanism of Article IX of the OST with a series of best practices for dealing with inadvertent interference.

CSBM (17) A State should cooperate, without delay, in the resolution of radio frequency or electro-optic frequency interference with another State upon the receipt of a notice of such interference.

CSBM (18) A State should give at least 72 hours prior notice of any high-power laser or microwave illumination of any point in outer space originating from the territory, vessels, aircraft or satellites under its jurisdiction and control, where it has reason to believe that there would be a significant risk of disrupting or denying the observation or communication signals of an active satellite maintained on the registry of another State.

The promise of CSBMs

The international community can go a long way toward ensuring the security of space for this generation and for generations to come by implementing a space security treaty that encompasses the CSBMs postulated above. These CSBMs reflect a grand bargain that is necessary in order to attain the security of a state's continued use of assets in the especially fragile domain that is outer space, without sacrificing its own national security interests with respect to threats originating from that domain. However, simply signing and ratifying a treaty based on these principles would not be enough. To be complete and effective, a treaty would need prohibitions and obligations, a verification process to ensure its adherence and a governance system to ensure its viability.

Verification and governance

Verification and governance are crucial to the success of any space security treaty. A violation of its provisions could undermine the purposes of the agreement. In the context of outer space, there are two types of verification: adequate and effective. Although the differences between the two are not spelled out, it is generally understood that effective verification entails stricter requirements and more rigorous inspections.[35] Adequate, however, is a verification standard consistent with the standard needed to wage war in outer space.[36] Essentially, in order to conduct physical conflict in space, one would need to be able to discern between military and civilian targets (as required by the Geneva Conventions).[37] Moreover, in the absence of a ban on space weapons, militaries would be required to have robust space situational awareness in order to maintain a targeting list of possible threats. This ability to discriminate between military and civilian targets, or to establish an order of priority for targets based on their ability to harm other objects, can also be used as a verification standard for ensuring that space-based weapons are never deployed.

Verification and governance are crucial to the success of any space security treaty.

The first step toward a robust verification and governance system is a collection of robust SSA systems. As discussed above, it is important to know what functions objects perform in outer space, who is in control of them, what orbits they occupy and how they behave in these orbits. This knowledge will not only act as a deterrent to the weaponization of space, but also reduce the risk of accidental collisions or interference.[38]

The independent SSA systems of China, the Russian Federation and the United States could become the basis for Regional Space Operation Centres (RSpOCs) that would each maintain extensive knowledge of what activities are taking place in outer space on a real-time basis. These RSpOCs could serve as a form of clearing house, in which sufficient space information would be made available to other states in a format that is consistent with the national security and foreign policy interests of these three major space powers. As every state will have a significant relationship with at least one of these powers, every spacefaring state could gain access to the necessary and sufficient information for its safe and sustainable use of outer space. This would be particularly true were both China and the Russian Federation to make similar data available to third parties as the United States currently does under its Commercial and Foreign Entities project.[39] Looking forward, these RSpOCs, enhanced by Joint Data Exchange Centres established among them, could serve as the foundation for the multilateral verification of a space security treaty.[40]

The second step toward a robust verification and governance system for space security is an executive council established under a space security treaty designed to report to the UN Security Council on compliance matters relating to the treaty. This executive council could serve as a basis for consultations concerning both compliance and whether or not a given satellite qualifies as a weapon based on its design and behaviour. This sort of governance system would be much more mutually beneficial and adhere to the spirit of Article IX of the OST, in contrast to a system of deterrence and tit-for-tat reprisals which may, in turn, lead to an arms race in outer space.

Conclusion

The production of space debris is a serious threat to humanity's continued use of outer space. Only through control of this debris can the world ensure the use of space for future generations. It is important to achieve the security of space as a means of controlling debris. States must not fight the first war in outer space, since humanity could lose its use of this domain for centuries or millennia to come. In addition, the use of space is only made possible through international cooperation in the coordinated use of the radio frequency spectrum. Interference with this aspect of space should be made only in conformance with international law and pursuant to the UN Charter. When necessary, any interference should be temporary, localized and reversible.

This paper has proposed that a grand bargain be struck in order to preserve our continued use of outer space for all humankind. Physical violence in outer space must be prohibited and purposeful interference should be restricted to reasons of self-defence as permitted by the UN Charter. A space security treaty has been proposed with prohibitions and obligations to codify this balance of interests. While the principles have been presented in the form of a legally binding treaty, the principles could be first codified in a code of conduct in order to begin state practice and attain space security for the benefit of all humankind.

Notes

1. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (Outer Space Treaty), signed at London, Moscow and Washington, DC, 27 January 1967.
2. Jessica West et al., 2007, *Space Security 2007,* Waterloo, Project Ploughshares, p. 21.
3. David Wright et al., 2005, *The Physics of Space Security: A Reference Manual,* Cambridge, MA, American Academy of Arts and Sciences, p. 22.
4. Ibid.
5. Lt Col. Bruce M. DeBlois, 1998, “Space Sanctuary: A Viable National Strategy”, *Airpower Journal,* vol. 12, no. 4, Winter, p. 41.
6. Ibid., p. 42.
7. David Wright, 2007, “Orbital Debris Produced by Kinetic Energy Anti-Satellite Weapons”, in *Celebrating the Space Age: 50 Years of Space Technology, 40 Years of the Outer Space Treaty, Conference Report, 2–3 April 2006,* Geneva, UNIDIR, p. 160.
8. Wright et al., op. cit., p. 118.
9. DeBlois, op. cit., p. 42.
10. “DSP (Defence Support Program)”, Mission and Spacecraft Library, NASA, at <msl.jpl.nasa.gov/Programs/dsp.html> (archived site).
11. “Global Positioning System (GPS)”, Mission and Spacecraft Library, NASA, at <msl.jpl.nasa.gov/Programs/gps.html> (archived site).
12. “Nothing in the present Charter shall impair the inherent right of individual or collective self-defence if an armed attack occurs against a Member of the United Nations, until the Security Council has taken measures necessary to maintain international peace and security. Measures taken by Members in the exercise of this right of self-defence shall be immediately reported to the Security Council and shall not in any way affect the authority and responsibility of the Security Council under the present Charter to take at any time such action as it deems necessary in order to maintain or restore international peace and security.” Charter of the United Nations, Article 51.
13. Robert Powell, 2003, “Nuclear Deterrence Theory, Nuclear Proliferation, and National Missile Defense”, *International Security,* vol. 27, no. 4, Spring, p. 89.
14. Ibid., p. 90.
15. Ibid., p. 89 and Harrison et al., 2009, *Space Deterrence: The Delicate Balance of Risk,* Eisenhower Center for Space and Defense Studies, p. 12.
16. James Clay Moltz, 2008, *The Politics of Space Security: Strategic Restraint and the Pursuit of National Interests,* Palo Alto, CA, Stanford University Press, p. 56.
17. “States Parties to the Treaty undertake not to place in orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner. The moon and other celestial bodies shall be used by all States Parties to the Treaty exclusively for peaceful purposes. The establishment of military bases, installations and fortifications, the testing of any type of weapons and the conduct of military manoeuvres on celestial bodies shall be forbidden. The use of military personnel for scientific research or for any other peaceful purposes shall not be prohibited. The use of any equipment or facility necessary for peaceful exploration of the moon and other celestial bodies shall also not be prohibited.” Outer Space Treaty, Article IV.
18. Note that this prohibition has been written using legally binding language through the use of the words “shall not”. A non-legally binding CSBM could express the vision as “should not”, as is demonstrated in later CSBMs.

19. "…based on any physical principle…", see Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems, signed 26 May 1972; "…specially designed or modified…", see Missile Technology Control Regime Guidelines and Equipment and Technology Annex.
20. Louis H. Sullivan, 1896, "The Tall Office Building Artistically Considered," *Lippincott's Magazine,* March.
21. Ibid.
22. Ibid.
23. Nam P. Suh, 1995, "Designing-in Quality through Axiomatic Design", *IEEE Transactions on Reliability,* vol. 44, no. 2, June.
24. For an example of this, one needs to look no further than the Multiple Kill Vehicle (MKV) versus the GFZ-1 research satellite.
25. Treaty between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Strategic Offensive Arms, signed at Vienna, 19 June 1979. For FRODs, see Article II(3), First Common Understanding.
26. DeBlois, op. cit., p. 42.
27. Harrison et al., op. cit., p. 15.
28. Harrison et al., op. cit., p. 16.
29. "In the exploration and use of outer space, including the moon and other celestial bodies, States Parties to the Treaty shall be guided by the principle of co-operation and mutual assistance and shall conduct all their activities in outer space, including the moon and other celestial bodies, with due regard to the corresponding interests of all other States Parties to the Treaty. States Parties to the Treaty shall pursue studies of outer space, including the moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose. If a State Party to the Treaty has reason to believe that an activity or experiment planned by it or its nationals in outer space, including the moon and other celestial bodies, would cause potentially harmful interference with activities of other States Parties in the peaceful exploration and use of outer space, including the moon and other celestial bodies, it shall undertake appropriate international consultations before proceeding with any such activity or experiment. A State Party to the Treaty which has reason to believe that an activity or experiment planned by another State Party in outer space, including the moon and other celestial bodies, would cause potentially harmful interference with activities in the peaceful exploration and use of outer space, including the moon and other celestial bodies, may request consultation concerning the activity or experiment", Outer Space Treaty, Article IX.
30. Michael D. Wallace et al., 1986, "Accidental Nuclear War: A Risk Assessment", *Journal of Peace Research,* vol. 23, no. 1, March, p. 25.
31. Dianne DeMille, 1988, *Accidental Nuclear War: Reducing the Risks,* Canadian Center for International Peace and Security, p. 7.
32. Giandomenico Picco, 1994, "The UN and the Use of Force", *Foreign Affairs,* vol. 73, no. 5, September/October, p. 18.
33. Ilan Berman, "The Iranian Nuclear Crisis: Latest Developments and Next Steps, Testimony before the US House of Representatives", reproduced in Joint Hearing before the Subcommittee on Terrorism, Nonproliferation and Trade and the Subcommittee on the Middle East and South Asia of the Committee on Foreign Affairs, House of Representatives, 110th Congress, First session, 15 March 2007.
34. Treaty between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems, Article XII; Treaty on Conventional Armed Forces in Europe, signed at Paris, 19 November 1990, Article XV.
35. Michael Krepon, 1986, "The Politics of Treaty Verification and Compliance", in Kosta Tsipis, David W. Hafemeister and Penny Janeway (eds), *Arms Control Verification: The Technologies that Make It Possible,* Elmsford, NY, Pergamon-Brassey's International Defense Publishers, p. 21.
36. Phillip J. Baines, 2006, "Adequate Verification: The Keystone of a Space-based Weapon Ban", in *Safeguarding Space Security: Prevention of an Arms Race in Outer Space, Conference Report, 21–22 March 2005,* Geneva, UNIDIR, p. 92.
37. Geneva Convention (IV) Relative to the Protection of Civilian Persons in Time of War, 12 August 1949, Common Article 3.
38. Harrison et al., op. cit., p. 16.
39. National Defense Authorization Act for Fiscal Year 2004, public law 108–136, section 913, 24 November 2003, available at <celestrak.com/NORAD/elements/Section913.pdf>.
40. See Office of the Press Secretary, The White House, Memorandum of Agreement between the United States of America and the Russian Federation on the Establishment of a Joint Center for the Exchange of Data from Early Warning Systems and Notifications of Missile launches, 4 June 2000, at <clinton5.nara.gov/WH/New/Europe-0005/factsheets/memo--joint-warning-center.html>.

Steps to strategic security and stability in space: a view from the United States

Bruce W. MacDonald

Although the United States has been a spacefaring nation for over 50 years, the essential and growing role that space plays as a fundamental enabling feature of conventional and strategic military posture and the strength of advanced civilian economies around the world is too little understood. The rivers of information and other services that space assets provide allow economies to function more efficiently and provide ever increasing benefits to people around the world, as satellite navigation systems and international cellphones, to name but a few applications, attest. These space information services are also key to the verification of arms control agreements, and they permit military systems, and military decision-making, to be far more effective than in the past—vital advantages across the spectrum of national security concerns. It is no wonder that current US space policy for the first time calls US space assets "vital" to its national interests.

More serious than this lack of public understanding about space is the serious shortfall in understanding the larger implications of the importance of space. Threats to the world's space assets, and hence to the world's vital national interests, come in many forms—some hostile, some not. One of the biggest threats is what we just do not know: about objects in space, the intentions of those who put the objects there, and the strategic landscape of space itself—how it operates, where it poses strategic dangers, and what needs to be monitored and managed. We need to understand how China, the Russian Federation, the United States and others see space stability. How will this shape their space doctrine, acquisition, strategies and diplomacy? There is much we should know and understand, but do not, about this new space-enabled military era the world has recently entered.

The strategic problem

Given the vital and growing role that space plays in modern life, the world has an overriding interest in maintaining the safety, survival and function of space assets so that the profound civilian, commercial, and military benefits they enable can continue to be available.

These vital space assets face three forms of threat, all of them worrisome and growing. First, the proliferation of space and other technologies, and specifically the anti-satellite (ASAT) capabilities demonstrated within the past three years, call attention to the risk that an advanced country could exploit this fast-growing world dependence on space in a war.[1] Second, space "traffic" is heavier than it has ever been and getting heavier still, in terms of both vehicles and communications, but there is no space traffic control authority. The current level of simply monitoring space objects is widely regarded

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as far below what is needed: there is a substantial and growing need for space traffic management capabilities, including enforceable rules of the road and codes of conduct, and space situational awareness to inform a space traffic management capability. Third, space debris poses an insidious and growing threat to all space assets. Debris in space does not quickly fall to the ground: at all but the lowest orbits, debris can stay aloft for centuries and more. In addition to the 19,000 orbiting objects the United States Air Force is tracking, there are hundreds of thousands of potentially lethal objects in orbit, and millions of smaller objects that pose at least some risk.[2] If current space debris trends continue, there will be almost 1000% more debris than today within 25 years.[3] This would greatly increase the risk of satellite collisions and force satellite operators into making frequent, costly and satellite-lifetime shortening manoeuvres. The collision earlier this year between a US Iridium satellite and an older Russian Cosmos dramatically illustrates the problem.[4]

The core of the space security problem is that the substantial economic and national security benefits that space assets provide is accompanied by their substantial vulnerability to both natural and man-made threats. In addition to the increasingly worrisome threats of orbital debris, as well as physical and electromagnetic traffic in space, military writings in several countries make clear that developing offensive capabilities against space assets has significant appeal to some military planners.[5]

Global space policy needs to address key space stability issues

In 2006, the Bush Administration issued a revised space policy that declared for the first time that US space assets are "vital to its national interests", in recognition of the extraordinary and growing US military and economic dependence on them.[6] This phrase carries much heavier national security implications than have ever before been attributed to space.

The 2006 US policy also reserves the right to deny adversaries "the use of space capabilities hostile to US national interests." But attacking others' space capabilities invites attacks on one's own space capabilities. Since evolving technology guarantees that more nations will depend even more on space assets in the future and that these vital assets are also likely to face greater threats, current US space policy faces an inherent contradiction and instability. Failure to address this contradiction will allow instabilities to grow over time, as technology and growing space dependence will make space assets ever more desirable military targets.

There is an inherent risk of strategic instability when relatively modest defence efforts can create disproportionate danger to a potential adversary, as with space offence. The technical challenge and cost for nations that already have advanced space capabilities to develop credible anti-satellite and other offensive counter-space capabilities are not unreasonable for the potential military benefits such capabilities would provide. And if a country perceived that space conflict was inevitable, a disabling first strike against an adversary's space assets would be far preferable to, and easier to execute than, retaliating against the space assets of the side that struck first. This is the essence of crisis instability, when pre-empting pays far greater benefits than retaliating. We don't know what would happen in a crisis, but the potential for space instability seems high and likely to grow. Sadly, this growing instability problem is largely overlooked in discussions of space security policy. This must change, and wise space policy, and diplomatic initiatives, must take these new strategic space realities into account.

A new perspective on space is needed to understand and more fully appreciate the strategic landscape that space presents. With this strategic understanding, it should be possible to craft approaches that would make space a safer and more stable environment, with the ever-increasing bounty of its benefits available to all states that abide by a common compact of responsible space behaviour. Fortunately, the Obama Administration is conducting a review of US space policy, which provides the United States with an opportunity to address space stability issues more fully.

The mirage of space dominance

It would be unwise for any country to seek space dominance, for quite practical and strategic reasons. There are many ways to attack space assets, and it is easier and cheaper to attack than to defend them, which would likely frustrate any sustained attempt at dominance and leave every country worse off. In trying to maintain dominance, any country would be at the mercy of unpredictably advancing space technologies that could favour another country. In the face of likely resistance to such a provocative and hegemonic posture, any country seeking to dominate in space would constantly be trying to stay ahead technologically to maintain this dominance, demanding large expenditures that would be a growing burden on other national security and economic needs. Such a situation would also be very unstable, especially if another country achieved a technological breakthrough that threatened to upset the previously dominant country's hegemony. A crisis occurring in this context could provide a compelling incentive to the about-to-be-dethroned country to pre-empt before its space dominance slipped away.

In the years ahead, the United States will remain a pre-eminent space power, though other countries, most especially China, will very possibly diminish the margin. US space policy of the recent past has exhibited an incomplete appreciation of this new strategic environment and has been incautious in some policy dimensions. This is because of the absence of both a clearly thought-out space doctrine and a coherent national space security strategy. Other countries, though in different ways, have also exhibited an incomplete appreciation of the new strategic landscape of space.

To avoid the dangers inherent to seeking dominance, the United States could aim instead for a posture of space excellence: the most capable in space, a space leader. The United States could seek a non-hegemonic "best-in-class" posture: a state with more advanced space capabilities than other countries, deriving substantially more benefits from space than others, but which would not dominate in space. This space excellence would provide leverage in commercial, civilian and military applications, but would not make space a new battleground.

A national stabilizing space protection strategy

The Congressional Commission on the Strategic Posture of the United States, led by two former US Secretaries of Defense, recognized the importance of space stability when it recommended in its final report that the United States should "develop and pursue options for advancing U.S. interests in stability in outer space … includ[ing] the possibility of negotiated measures."[7]

This recommendation is relevant to other countries as well. It would allow everyone to continue to reap the civilian, commercial and military advantages of space and safeguard the continuing commercial development and utilization of space. It would give space and non-space powers alike a vested interest in avoiding space conflict.

A stabilizing space protection strategy for a country would:

- focus on stability, avoidance of conflict in space, and transparency;
- incentivize nations to avoid destabilizing, irreversible actions in space;
- provide back-ups to assure availability of key space services in the event of satellite outages from whatever causes, benign or hostile;
- discourage all nations from initiating space attacks;
- encourage agreements that constrain the most destabilizing dimensions of space competition and provide ground rules for normal space operations; and

- expand dialogue among nations to promote better understanding and reduce chances for misunderstanding and miscalculation, always dangerous in a crisis.

Creating a stable space domain requires countries to respond to space threats in a responsible manner, one that ideally does not provoke other nations to greater counter-space efforts than they would otherwise pursue. All nations should be careful to avoid creating a self-fulfilling prophecy and should refrain from activities and public communications that invite the build-up of the counter-space capabilities of others.

Diplomacy and arms control

Diplomacy and arms control have major roles to play in providing for a safe and stable space environment. Such initiatives on space need to take into account the strategic realities of space in order to enhance space stability in ways that allow all countries to benefit.

While diplomacy and arms control cannot by themselves solve space security problems, they can help mitigate the risks. Space diplomacy and arms control should play a stronger role in the future, a view that the Congressional Commission on the Strategic Posture of the United States stated earlier this year. While noting that the specific promise of space arms control was not clear—it is, after all, in its infancy in many ways—the Commission recommended that:

> The United States should seriously study these issues and prepare to lead an international debate about how to craft a control regime in space that serves its national security interests and the broader interests of the international community.[8]

Diplomatic activity on space should seek to strengthen stability in space, encourage the prevention of space conflict, and be verifiable. Diplomacy should promote behaviour that maximizes the world's ability to utilize space and minimize operational and other problems associated with space operations. US space policy in the recent past has explicitly rejected space arms control, eroding US international leadership in this area and allowing some to credibly mischaracterize the US stance as provocative and hostile. The Bush Administration was interested in voluntary steps such as a code of conduct and rules of the road, especially regarding space debris, which was commendable but should have been given more emphasis. The Obama Administration has expressed greater willingness to consider arms control as an important tool in addressing space security issues: inter-agency review of space diplomacy and arms control is apparently taking place within the ongoing space policy review. In a welcome and encouraging signal of a shift in US policy, at the First Committee of the Sixty-fourth Session of the UN General Assembly in 2009, the US representative noted that:

Diplomatic activity on space should seek to strengthen stability in space, encourage the prevention of space conflict, and be verifiable.

> In consultation with allies, the Obama Administration is currently in the process of assessing US space policy, programs, and options for international cooperation in space as a part of a comprehensive review of space policy. This review of space cooperation options includes a "blank slate" analysis of the feasibility and desirability of options for effectively verifiable arms control measures that enhance the national security interests of the United States and its allies.[9]

There are several classes of agreement that can be considered for space, one of which includes codes of conduct and rules of the road. These kinds of agreement have been proposed in various forms for several years and are designed to ensure that those who operate in space do so responsibly, with due regard for the rights of others in space, and with an appreciation that space should be available for the benefit of future generations as well as the present one. Michael Krepon of the Stimson Center has done valuable work in this area, and the European Union has issued a commendable draft Code of Conduct for Outer Space Activities.[10] One value of this kind of approach is that the agreements need not be in treaty form, which takes longer to negotiate. There have been relevant ongoing discussions and meetings on the subject of space debris, a growing problem that cannot be entirely resolved by the voluntary guidelines recently approved by COPUOS.[11] Other issues that could be covered by this category of agreement include space situational awareness, space traffic management, and further debris mitigation measures.

A ban on KE-ASAT weapons

One option deserving special attention, which could be in treaty form or not, is a ban on any testing in space that creates significant debris, explicitly including kinetic energy ASAT (KE-ASAT) weapons. KE-ASAT weapons are designed to destroy a satellite by high-speed impact, either through direct ascent from Earth to the satellite (as China and the United States have demonstrated) or by hitting it with shrapnel from a nearby planned explosion (as with the older Soviet ASAT system).

The continued testing of KE-ASAT weapons could seriously interfere with space operations and space traffic management. Space debris is growing by about 10% per year, even without space conflict. Already satellites must occasionally be moved because of debris near-misses: one satellite operator has said that one of its fleet of satellites must be moved every three months because of debris. At this rate, in 25 years there will be ten times as much debris in orbit as we have today. Cascading effects, where debris collides with other debris in space to create still more, known as the Kessler Syndrome, is also a matter of growing concern.

Even a modest space war, involving the destruction of 30 satellites, could increase the level of space debris by almost a factor of four, if each destroyed satellite produced the same level of debris as the Chinese satellite event of 2007.[12] A larger conflict, involving the destruction of 100 satellites, would quickly increase space debris by over 1250%, and that does not include Kessler Syndrome effects, which would increase the debris level still further. We could make the most useful orbits in space useless to future generations. The inability to use space-based assets could threaten international security in other ways, as states would be unable to use their satellites to verify arms control agreements (for example the Russian Federation and the United States' verification of Strategic Arms Reduction agreements).

A logical extension of concerns over space debris, the option proposed here would seek to discourage the development of KE-ASAT weapons by banning testing against orbiting objects. (With carefully crafted language, missile defence testing could be allowed to continue.) By banning such ASAT tests, states could never have the level of confidence in such weapons that they would probably need in order to rely upon them in a major conflict. The ban could potentially be expanded to cover all major debris-producing events in space.

Some point out possible problems with this approach. A ban on debris-creating KE-ASAT weapon tests would not prevent planned near-miss testing, which could still allow improved confidence in such ASAT weapons. The ban could bring to a halt promising new areas of space operations technology—for example, replenishment and repair missions to satellites, and orbital docking. These challenges, however, could be overcome. Keep-out zones could be defined that would ban approaches within a certain distance of a satellite, perhaps with a closing velocity restriction to permit peaceful purpose approaches. These and other negotiating obstacles could be overcome in good faith discussions.

A ban on testing KE-ASAT weapons would bring many benefits. One of the most important is to put states on record as recognizing the major threat that orbital debris poses to all spacefaring nations and agreeing that, whatever one thinks of offensive space weapons, kinetic energy-based weapons are unacceptable. Without an explicit ban on such weapons, there is no official sanction against the deliberate creation of debris for military purposes. This would be a serious mistake.

Such a ban would be verifiable by national technical means. While a ban on the weapons themselves would be difficult to verify without exceptionally intrusive inspections, destructive KE-ASAT weapon tests, even those involving near misses, can be observed. It is difficult to hide satellite intercepts in space.

A KE-ASAT agreement would be no panacea: it would address only a modest sliver of the much larger space security issue, and would not even guarantee that KE-ASAT weapon capabilities would be completely stopped. The United States' shoot-down of an errant satellite in 2008 with a sea-based missile defence interceptor demonstrated the truism that ballistic missile defences have inherent anti-satellite capabilities. But such an agreement would make much more difficult a country's attempt to develop a force of such weapons in which it could have high confidence during conflict, which would be a significant step toward space stability. A country would be running very serious risks with an untested system if it sought to use a large number of missile defence interceptors in a role for which they were neither developed nor tested. (The alternative to a ban on testing and use of KE-ASAT weapons would be to allow such testing, which would pose a serious threat to space security.)

Acceptability

The United States has no plans to develop a KE-ASAT weapon, meaning such a testing ban would have minimal programmatic impact. Conversations the author has had with Russian and Chinese specialists indicate that while they prefer the proposal their governments have presented, they see merit in a partial approach that might be feasible if their broad-ranging proposal is not possible.[13]

It should be noted that a special task force sponsored by US think-tank the Council on Foreign Relations specifically endorsed a KE-ASAT weapon ban:

> The Task Force believes that the United States has a clear interest in beginning discussions with China on space weapons, including proposals to ban tests of kinetic antisatellite weapons. The United States and China, along with Russia, should take the lead in implementing a trilateral test ban, which could form the basis for expansion to a global ban.[14]

Indeed, this approach has been proposed before by the author and others.[15]

Some countries have called for a ban on space weapons without providing credible or convincing ways to verify such a ban. Such far-reaching proposals are troubling because they seem to demonstrate a disregard for the profound risks these proposals, if enacted, would pose, based in part on their major verification challenges. When the stakes involved are low, where violation of an agreement by one party would pose no serious threat to another party to the agreement, such a verification problem may not be a major obstacle. If Country A violated a fishing agreement, it would be a matter of concern, but it would not pose a major threat to the security of Country B. Yet space is so interwoven into the economic and military fabric of some spacefaring states that sudden major damage to its space infrastructure could result in economic and military devastation. A ban on space weapons understandably must demand a much higher and more reliable standard of verification before such an agreement could be seriously considered. Failure to provide such credible approaches to verification demonstrates a misunderstanding of the new strategic landscape of space. It also suggests a diminished level of seriousness of the proposal that is not commensurate with the security stakes involved. Some suggest that the opposition of the Bush Administration to all space arms control is behind the US objections to this approach, yet the verification problems of such a ban were raised many years before, for example, by the Congressional Office of Technology's 1985 assessment *Anti-satellite Weapons, Countermeasures, and Arms Control*.[16]

A graduated approach

There is a larger point at work here as well. Space arms control is an important new subject area on the international agenda, and with which the world has little experience—the Outer Space Treaty is now 42 years old, and there have been no such new agreements since that time. Accordingly, smaller steps that have less risk associated with them and can build confidence should be preferable to grand far-reaching ones about which serious concerns exist. Precisely because a ban on all space weapons, or ability to interfere with weapons in space, is a broad approach, characterized by important verification shortcomings, and has profound implications for the security interests of potential signatories, it represents a limiting and perhaps indigestible approach to some countries. In getting from the first floor to the second floor of a building, one climbs a staircase with multiple steps. Trying to do so in one big step is a formula for making no progress at all. Accordingly, a more modest step in space arms control could help pave the way to greater progress, and give all participants the opportunity to accustom themselves to options for progress in this area.

A more modest step in space arms control could help pave the way to greater progress.

Achieving greater security in space will take time, given the stakes involved, and should be achieved incrementally. Neither strategic arms reductions, nor controls on nuclear testing, achieved progress all at once, but rather have made progress through a graduated series of steps. Given the security stakes involved, progress on space diplomacy is unlikely to be achieved any differently. This does not mean that important progress cannot be made, just that it should not be sought all at once.

Clearly, more thoughtful review of space arms control options is needed, but there is ample room to move forward, with broad civilian and commercial backing, in the areas of space traffic management and space debris. Such steps would be an affirmative US response to China's and Russia's space arms control proposals at the United Nations and would position the United States to play a major leadership role in shaping a more responsible space regime.

In addition to diplomatic steps, countries can help reduce the vulnerability of their space assets by reducing incentives to attack them. For example, having more distributed capabilities spread across larger numbers of smaller satellites, and maintaining non-space back-up capabilities, although this could aggravate the problem of space traffic. Enhanced space situational awareness and incident attribution techniques could also help.

Beyond negotiations toward specific agreements, the dialogue that has begun on space issues should be expanded. Again, the Congressional Commission on the Strategic Posture of the United States offers advice, recommending "a strategic dialogue with Russia broader than nuclear treaties, to include … space systems" and that "there are other serious civilian issues such as space situational awareness, space debris, and space traffic management that could be used to develop international discussion and working relationships".[17]

A "no first use" policy should also be considered, as it could be a useful adjunct to other space agreements. Countries that derive major benefits from space should generally be loath to initiate space conflict, as they would only put at great risk their own space assets, at least when their adversaries are themselves major space powers. While such declarations could always be reversed, they could provide a stabilizing context in which mutually beneficial agreements could be sought.

It appears that there will be an opportunity to make important progress on making space more stable and secure in the coming year, given that "the United States looks forward to discussing insights gained from this Presidential [space] review next year at the Conference on Disarmament during substantive discussions on the Prevention of an Arms Race in Outer Space agenda item as a part of a consensus program of work."[18] It seems likely that steps can be taken that would improve security in space, if countries are willing to set aside overly ambitious grand proposals and begin building a step-by-step staircase of practical agreements to greater security and stability in space.

Conclusions and recommendations

Countries need to take important policy, programmatic and diplomatic steps to protect and strengthen their own and global security interests in space. Steps they should seriously consider taking include:

- developing a space security strategy that emphasizes space stability;
- opening up national space policies to allow and encourage negotiated agreements on the basis of national interest and verifiability;
- enhancing their space situational awareness capabilities;
- diversifying how space information services are provided to reduce vulnerability;
- building upon current military-to-military dialogues to see what can be accomplished in the space arena, and according high foreign policy priority to this;
- giving arms control an appropriate role in addressing space security;
- strengthening space dialogue on codes of conduct and "rules of the road" on a multilateral basis; and
- seeking a KE-ASAT weapon testing moratorium or ban.

Notes

1. In 2007 China tested a direct ascent kinetic energy anti-satellite weapon on one of its weather satellites, and in February 2008 the United States shot down one of its own satellites using a modified Aegis missile defence system ("China Claims Peaceful Missile Test", *Reuters,* 23 January 2007; "US Missile Hits 'Toxic Satellite'", *BBC News*, 21 February 2008).
2. "How much orbital debris is currently in Earth orbit?", Orbital Debris Frequently Asked Questions, NASA Orbital Debris Program Office web site, last updated 7 July 2009.
3. For figures on current trends in space debris, see Paul Marks, "Space Debris Threat to Future Launches", *New Scientist*, 27 October 2009.
4. For further details of this collision, see CelesTrak's account, "Iridium 33/Cosmos 2251 Collision", 5 March 2009, updated 15 July 2009, at <celestrak.com/events/collision.asp>.
5. See, for example, United States Department of Defense, 2009, *Annual Report to Congress: Military Power of the People's Republic of China 2009*, "Space Warfare", pp. 13–14; "China Declares Space War Inevitable", *DoD Buzz*, 4 November 2009, which reports on an interview with People's Liberation Army Air Force Commander Xu Qiliang conducted by the *People's Liberation Army Daily;* Brigadier General Kevin T. Campbell, Director of Plans, United States Space Command, "Warfighter Perspective on Space Capabilities", briefing presented to the Council on Foreign Relations, 23 May 2002; and US Joint Chiefs of Staff, *Space Operations,* Joint Publication 3-14, 9 August 2002.
6. Excerpts from the US National Space Policy of 2006, released by the White House 6 October 2006, are available at <www.globalsecurity.org/space/library/policy/national/us-space-policy_060831.pdf>.
7. Congressional Commission on the Strategic Posture of the United States, 2009, *America's Strategic Posture: The Final Report of the Congressional Commission on the Strategic Posture of the United States,* Washington, DC, United States Institute of Peace, p. 71. The author is Senior Director of the Commission.
8. Ibid., p. 69.
9. Garold N. Larson, Alternate Representative to the First Committee, Statement to the First Committee of the Sixty-fourth Session of the United Nations General Assembly, 19 October 2009, at <usun.state.gov/briefing/statements/2009/130701.htm>.
10. For more on the Stimson Center's model code of conduct, go to <www.stimson.org/space/programhome.cfm>; for more on the European Code of Conduct on Outer Space Activities, see the article by Wolfgang Rathgeber, Nina-Louisa Remuss and Kai-Uwe Schrogl in this issue of *Disarmament Forum*.

11. Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space, in UN document A/62/20, New York, 2007.
12. CelesTrak's account of China's ASAT test states that 2,377 items of debris have been catalogued from the event, see <celestrak.com/events/asat.asp>, updated 10 June 2009.
13. In February 2008, China and the Russian Federation introduced a draft Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force against Outer Space Objects to the Conference on Disarmament (see document CD/1839, 29 February 2008).
14. William J. Perry and Brent Scowcroft (chairs), *U.S. Nuclear Weapons Policy,* Independent Task Force Report no. 62, New York, Council on Foreign Relations, p. 45.
15. Bruce W. MacDonald, 2008, *China, Space Weapons, and U.S. Security,* Council Special Report no. 38, New York, Council on Foreign Relations, September, p. 30; T. Bolz, 2009, *In the Eyes of the Experts: Selected Contributions by the Experts of the Congressional Committee on the Strategic Posture of the United States,* United States Institute of Peace, October, p. 326; William J. Perry and Brent Scowcroft, op. cit.; Michael Krepon, 2008, *Space: A Code of Conduct*, Washington, DC, Henry L. Stimson Center.
16. The report states that a ban on space weapons "would have the disadvantage of being the most difficult [approach] to verify" (US Congress, Office of Technology Assessment, 1985, *Anti-satellite Weapons, Countermeasures, and Arms Control,* Washington, DC, US Government Printing Office, p. 132).
17. Congressional Commission on the Strategic Posture of the United States, op. cit., pp. xii and 69.
18. Garold N. Larson, op. cit.

Commercial efforts to manage the space environment

Richard DalBello

The commercial satellite industry has billions of dollars of assets in space and relies on this unique environment for the development and growth of its business. As a result, safety and the sustainment of the space environment are two of the satellite industry's highest priorities. This paper provides an overview of industry efforts to coordinate space traffic control practices and to manage the growing problem of satellite radio frequency interference.

Background

The commercial satellite industry has been providing essential space services for almost as long as humans have been exploring space. Over the decades, this industry has played an active role in developing technology, worked collaboratively to set standards, and partnered with government to develop successful international regulatory regimes. Success in both commercial and government space programmes has meant that new demands are being placed on the space environment. This has resulted in orbital crowding, an increase in space debris, and greater demand for limited frequency resources. The successful management of these issues will require a strong partnership between government and industry and the careful, experience-based expansion of international law and diplomacy.

The satellite industry has never taken for granted the remarkable environment in which it works. Industry has invested heavily in technology and sought out the best and brightest minds to allow the full but sustainable exploitation of the space environment. Where problems have arisen, such as space debris or electronic interference, industry has taken the initiative to deploy new technologies and adopt new practices to minimize negative consequences.

Space traffic control

Since January 2007, Intelsat has relied on an in-house close-approach monitoring system to ensure the safety of its fleet of over 50 satellites. This system relies on information from the United States Joint Space Operations Center (JSpOC) to analyse potential close approaches between satellites. The basic information (the so-called two-line element or TLE data) used in this process is available through the US government's Space-Track.org web site. Space Track obtains satellite orbital data from the US Department of Defense and posts TLEs in near real time. It provides this data upon request to registered users. Intelsat routinely screens its satellites using the TLE data and, during special activities such as satellite relocations and transfer orbit missions, we also exchange data with other commercial

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and government operators whose satellites are near or adjacent to our satellites. The information exchanged usually consists of the latest location information, near-term manoeuvre plans, and frequency and contact information for further discussion.

There are drawbacks to the current close-approach monitoring process. In addition to a lack of agreed standards for TLE modelling, TLE data do not have the required accuracy for credible collision detection. An operator that is forced to rely on TLE data must increase the calculated collision margin to avoid potential close approaches. This wastes fuel and shortens the life of satellites and, in some cases, can introduce uncertainties that make space operations less safe. In most cases, threats identified using the basic TLE data are downgraded after coordination with other operators or further evaluation with more precise orbital data.

In addition to the inaccuracies of TLE data, they also lack reliable information on future satellite manoeuvres. This limits the usefulness of the TLE for longer-term predictions, since manoeuvre information is necessary to predict properly the orbital location of active satellites. Today, operators relying on chemical propulsion systems will manoeuvre about once every two weeks to maintain their orbital position. Accurately predicting the orbital location of a satellite will become more difficult as more satellites employ ionic propulsion systems and are, essentially, constantly manoeuvring.

The problem is rendered more complex by the fact that there is no single standard for representing the position of an object in space. Operators characterize the orbital position of their satellites differently depending on the software they use for flight operations. In addition, there is no one agreed protocol for sharing information, and coordinating operators must be prepared to accommodate the practices of other operators. To do this, separate tools are necessary to exchange data with each operator: operators must maintain redundant file transfer protocols and tools to convert and reformat information so that it is consistent with other owners' or operators' software systems for computing close approaches. Some operators write their own software tools for monitoring and predicting the close approach of other spacecraft, while others contract with third parties for this service. The magnitude of the effort to maintain space situational awareness grows quickly as the number of coordinating operators increases. However, operators are not in fact under any obligation to be able to track their satellites beyond the requirements of the relevant national or regional licensing authority, and many are not able or willing to participate in close-approach monitoring at all, due to lack of resources or capabilities.

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Because of the relatively imprecise nature of the TLE data, the US Air Force established the "Interim CFE Data/Analysis Redistribution Approval Process" (commonly referred to as the Form 1 Process) for granting operators access to information that goes beyond the basic TLEs. Through the Form 1 Process, operators can request additional information (the special perturbation, or SP, data) on specific close-approach situations (although this is less useful for low Earth orbit satellites since the assessment of miss probability changes rapidly). Although helpful, it is cumbersome to rely on the Form 1 Process as an operational tool because it requires advance notice, which is often impossible in emergency situations.

Data Center proposal

In response to the shortcomings of the current TLE-based CFE programme and the recognition that better inter-operator communication is desirable in and of itself, a number of commercial satellite operators have recently begun a broad dialogue on how best to ensure information-sharing within the satellite communication industry. One proposal currently being discussed in the international operators' community is the Data Center. As conceptualized, the Data Center would be an interactive repository for commercial satellite orbit, manoeuvre and frequency information. Satellite operators would routinely deposit their fleet information with the Data Center and retrieve information from other member operators when necessary. The Data Center would allow operators to augment existing TLE data with precision orbit data and manoeuvre plans from the operator's fleets. The Data Center would also:

- perform data conversion and reformatting tasks allowing operators to share orbital element and/or ephemeris data in different formats;
- adopt common usage and definition of terminologies;
- develop common operational protocols for handling routine and emergency situations; and
- exchange operator personnel contact information and protocols in advance of need.

As the Data Center gains acceptance, it could perform additional functions, such as the close-approach monitoring tasks currently being conducted by the operators. In this phase, US government-provided TLE data could be augmented by the more precise data available from operators. This would improve the accuracy of the Center's conjunction monitoring and could provide a standardized way for operators to share information with governments. In the early stages, information on non-operational space objects would still need to be supplemented by TLE data from the Air Force CFE programme or other government programmes. US or other government support would still be required when precise information is needed to conduct avoidance manoeuvre planning.

A prototype active Data Center was established to study the feasibility of such an approach following workshops of the major commercial owners/operators held in February 2008 in Washington, DC and December 2008 in Ottawa. A majority of the operators present agreed on the need to simplify the data exchange process to minimize risk for safety of flight and on the importance of creating a common Data Center. The operators agreed to work on the prototype Data Center as a proof-of-concept to improve coordination for conjunction monitoring. This prototype is a virtual centre, currently funded by the Center for Space Standards and Innovation (a research arm of Analytical Graphics, Inc.).

The prototype Data Center expanded quickly and today seven operators are participating and regularly contributing data from over 120 satellites in geostationary orbit. The participating operators receive daily close-approach alerts when the miss distances and conjunction probabilities fall below certain thresholds and a daily neighbourhood watch report showing the projected separations of satellites that are flying in an adjacent control box (geostationary satellites are generally required to remain in a "box" in space). The participating operators provide their ephemeris data in the reference frames and time systems generated in their flight software and the Data Center performs the transformation and reformatting to a common frame for close-approach analysis. This greatly simplifies efforts and reduces the burden on individual operators, thus encouraging participation. Given that the Data Center supports the exchange of satellite information, much of which is proprietary, a strict policy has been put in place to ensure privacy of the data. The Data Center is not allowed to redistribute the data received from the owners/operators to non-members without the approval of the owners of the data. While there is significant work remaining to refine the process, the initial results from the Data Center prototype are very promising.

The principal goal of the Data Center is to promote safety in space operations by encouraging coordination and communication among commercial operators. The Data Center could also serve as a means to facilitate communication between operators and governments. Details on the implementation of the Data Center, services to be provided, usage policies, structure of the organization and by-laws have yet to be determined and would ultimately require agreement among the member operators.

The development of a Data Center could provide new visibility and awareness of the geostationary orbit, allow all satellites to be flown in a safer manner and reduce the likelihood of an accidental international incident in space.

The Satellite Operators' Radio Frequency Interference Initiative

In addition to the Data Center, a number of satellite operators, including Arabsat, Asiasat, Eutelsat, Hispasat, Inmarsat, Intelsat, JSAT, SatMex, SES and Telesat, are already working together on a project called The Satellite Operators' Radio Frequency Interference (RFI) Initiative. This initiative is intended to respond to the concerns expressed by satellite customers regarding the increase in incidents of satellite radio frequency interference and the impact that these incidents have had on the quality of commercial satellite services.

Radio frequency interference is an electromagnetic disturbance that interrupts, obstructs or degrades the performance of electronic equipment. Each year, there are thousands of reported incidents of satellite radio frequency interference, which can originate with the satellite or with the Earth-based terminal, and be caused by faults in equipment, the proximity of equipment (both in space and on Earth), and problems with the transfer mechanism of the signal. Over the years, satellite operators have developed informal agreements and deployed new technologies to attempt to address interference. However, these informal agreements have not kept pace with the growth of the problem: the combination of more satellites in the sky and more terminals on the ground is raising new operational challenges.

As a result of the growth of the commercial industry, and the corresponding increase in demand for new orbital locations, global regulators have had to decrease the physical separation between satellites. This has increased the problem of adjacent satellite interference. As the number of satellites has increased, there has been a corresponding proliferation of ground terminals. And as the terminal industry has grown, new suppliers have entered the market, and it has been difficult to monitor the quality of some products. Furthermore, in today's marketplace there is a demand for smaller and mobile terminals. These classes of terminal require increased uplink power, which in turn increases the likelihood of interference. Finally, rapid industry growth has made access to training more difficult for some new operators. Industry records clearly indicate that "operator error" remains one of the most significant causes of satellite interference, but there are no regulated, internationally consistent education requirements for operators.

Concern over these issues motivated a number of satellite operators to launch the Satellite Interference Initiative (SII). This initiative is focused on accomplishing three major objectives.

- Support standardized training/certification: training is an essential element of good satellite operations. With the expansion of the industry and the increase in competition, the industry's commitment to training its antenna installers and uplinkers has wavered. The initiative is in its early stages, and currently dialogue is limited to the like-minded operators that are working together on SII. Participating operators seek to gain support for standardized training and, where appropriate, certification programmes to ensure compliance with industry best practices.
- Endorse "carrier identification" technology for terminals: carrier identification (ID) technology would help to identify malfunctioning or poorly maintained equipment by embedding information such as location, contact details and equipment data within the satellite signal. For the carrier ID initiative to be successful, antenna manufacturers would have to include the technology as a standard feature in their equipment. As part of the

Satellite Interference Initiative, satellite operators will be contacting major manufacturers to try to build a consensus on the inclusion of this technology.

- Building data sharing among satellite operators: as with the Data Center initiative for position location, the Satellite Interference Initiative seeks to formalize, standardize and, where possible, automate the process of sharing information about interference events. To identify the source of an interference event, operators need to know a number of elements such as precise satellite location and configuration information and known uplink sources (often referred to as reference emitters). These data could be included in a radio frequency interference database and routinely shared as part of an interference alert network.

Within the next decade, many more countries will gain the ability to exploit space for commercial, scientific and governmental purposes. Commercial satellite operators have taken the lead on building tools for space management, while it has been more difficult for governments to take concerted action. In the future, perhaps there will be commercial and governmental space management systems, both sharing information to ensure a safe and sustainable space environment. Programmes such as the space traffic Data Center and the Satellite Interference Initiative will become essential tools for managing our increasingly complex world. It is essential that industry and government work together to provide leadership on space management issues today in order to protect the space activities of tomorrow. Bad decisions and short-term thinking will create problems that will persist for generations. Wise decisions and the careful nurturing of our precious space resource will ensure that the tremendous benefits from the peaceful use and exploration of outer space are enjoyed by those who follow in our footsteps in the decades to come.

Space security and the European Code of Conduct for Outer Space Activities

Wolfgang Rathgeber, Nina-Louisa Remuss and Kai-Uwe Schrogl

Space security, generally understood as being concerned with the absence of unjustifiable man-made or natural threats to space assets, has become critical to the well-being of humanity, given the heavy reliance of modern societies on space vehicles and their applications. The concept of space security is supported by governments as well as by those sectors of industry and business that are investing heavily in space. Accordingly, a number of initiatives to ensure space security have been put forward over the years, in particular with a view to prevent the weaponization of space or an arms race in space.

The existing multilateral laws and regulations applicable to space can be subdivided into treaties, bilateral agreements and United Nations General Assembly resolutions. The fundamental framework is provided by the Charter of the United Nations, which aims at international peace and security by obliging Member States, among other things, to refrain from forceful measures against the integrity or independence of states, while at the same time respecting their right to self-defence.

Chronologically, the Partial Test-Ban Treaty (PTBT) of 1963 is the first international treaty on arms limitation in outer space. This is an activity-specific instrument that bans nuclear tests and explosions, but does not prohibit placing weapons in outer space per se. The basic document devoted to regulating outer space is the 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Outer Space Treaty), along with the Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space,[1] on which the Outer Space Treaty (OST) is largely based. The OST forbids placing nuclear weapons or other weapons of mass destruction (WMD) in Earth orbit, and it prohibits testing and deploying any weapon on the Moon or other celestial bodies, reserving them exclusively for peaceful purposes.[2] The 1972 Liability Convention specifies that launching states are responsible for damage inflicted upon other states by their space objects and sets up a compensation procedure. The 1979 Moon Agreement reiterates the principle of peaceful purposes and in a more general sense aims at preventing the Moon and other celestial bodies from becoming areas of international conflict.[3]

Other international treaties also cover areas relevant to space security. The Constitution of the International Telecommunication Union addresses the usage of the radio frequency spectrum for satellites. While affirming the right of member states to military radio installations, it also calls on member states to abide by the principle of no harmful interference, which is defined in the annex to the constitution. The Comprehensive Nuclear-Test-Ban Treaty (CTBT) foresees the ban of nuclear explosions in all environments, but it has not yet entered into force.

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Bilateral negotiations and agreements between the Soviet Union and the United States also relate to outer space. Article XII of the Anti-Ballistic Missile (ABM) Treaty covers interference with national technical means, such as spy satellites. SALT II, the Strategic Arms Limitation Treaty, extended these provisions. However, following the United States' withdrawal in 2002, the ABM Treaty is today deemed void, and SALT II never became legally binding. The Strategic Arms Reduction Treaty (START I), signed by the Soviet Union and United States in 1991, introduced transparency and confidence-building measures (TCBMs). The START I provision banning interference with national and multilateral technical means of verification was made multilateral by the Conventional Armed Forces in Europe (CFE) Treaty (Article XV).[4]

United Nations General Assembly resolution 1721 (XVI) of 1961 established the application of general international law, in particular the UN Charter, to outer space. It can be seen as a first step toward a legal regime for space with liability obligations. Several other General Assembly resolutions followed over the years, such as the Principles Declaration, which formed the basis for the OST.

In 1981, Italy introduced a draft resolution to the United Nations entitled "Prevention of an Arms Race in Outer Space" (PAROS) on behalf of the Western European and Other States group.[5] This resolution called on the Committee on Disarmament (today the Conference on Disarmament, or CD) to negotiate agreements preventing an arms race in outer space and explicitly stated that military uses of space were in contradiction to the OST. However, CD discussions about PAROS came to a standstill in 1995, when China insisted on linking PAROS to the Fissile Material Cut-off Treaty (FMCT), which was considered unacceptable by the United States. Since then, China and the Russian Federation have been trying to advance negotiations on a treaty preventing the weaponization of outer space with a number of alternative proposals,[6] and PAROS resolutions have been passed by the General Assembly every year since it adopted the first one. More recently, and taking a slightly different approach again, UN General Assembly resolution 61/75 of 2006, introduced by the Russian Federation, invited Member States to inform the Secretary-General of their views on transparency and confidence-building measures in the interest of PAROS.[7] Resolution 62/43 also called for TCBMs and referred to the Secretary-General's report on Member States' concrete proposals for TCBMs following resolution 61/75.[8]

The United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) was set up in 1959 to explore international cooperation in outer space activities, to encourage research and the dissemination of information on outer space matters, and to study legal problems arising from the exploration of outer space. The Committee meets annually. COPUOS has achieved the most recent agreement related to outer space activities: in 2007 it adopted debris mitigation guidelines.[9]

The recent attempts to introduce additional measures to counter a possible weaponization of space demonstrate that the existing legal framework is largely regarded as insufficient. However, diverging opinions on how to move forward persist.

The case for a code of conduct

Given the deadlock in relevant CD discussions, the US National Space Policy of 2006 (opposing the development of new legal regimes infringing its right to use and access space), and the renewed focus on TCBMs, the idea of a code of conduct for outer space activities has been gaining ground. A code of conduct is a non-legally binding instrument, where adhering states voluntarily commit themselves to rules of the road. It can be seen as an ultimate goal in itself, or as a stepping stone toward a legally binding treaty. On the one hand, because it constitutes soft law, a code of conduct is easier to agree to and potentially avoids lengthy discussions about definitions, but can still give significant impetus to both national and international political processes. In fact, proponents argue that provisions contained in a code of conduct are likely to eventually become customary international law. On the other hand, there is a danger that such codes detract attention from ongoing promising efforts toward a stronger instrument.

Proponents argue that provisions contained in a code of conduct are likely to eventually become customary international law.

Proponents of a code of conduct for space activities often refer to The Hague Code of Conduct against Ballistic Missile Proliferation (HCOC), brought into effect in November 2002, as a successful example of how soft law can be respected. The HCOC foresees pre-launch notifications and other TCBMs for ballistic missiles with WMD capabilities. Voluntary in nature, it does not feature formal consequences for non-compliance. The HCOC has been signed by more states than the OST, and although it is not legally binding, with 130 signatories, its political force is widely considered as instrumental to preventing missile proliferation.

In 2002, the Henry L. Stimson Center issued a study listing the advantages of a code of conduct for outer space activities. It then introduced three draft codes in 2004, 2006 and 2007.[10] While the first version included definitions for relevant terms like debris, anti-satellite (ASAT) and space weapons, subsequent versions refrained from such attempts in order to facilitate consensus. The codes also mention rights and obligations of spacefaring nations without spelling out verification provisions. The underlying idea was to establish rules that would then develop into norms and potentially into treaties.

While Chairman of COPUOS, Gérard Brachet took a different approach. He presented a working paper for future COPUOS activities with a view to ensuring long-term space security,[11] on which basis he gathered a group of experts from different backgrounds, including industry and operators, to draft the so-called Brachet Code of Conduct. The Brachet Code of Conduct, in contrast to the EU Code of Conduct, addresses specific technical issues and is likely to include threats ranging from natural sources to space weather. The Brachet Code of Conduct also involves national technical experts for the related topics, and in taking such a bottom-up approach, it is not meant to compete with or replace the EU Draft Code of Conduct. It is still in the drafting process and shall be formally presented to COPUOS's Scientific and Technical Subcommittee in February 2010.

The European Draft Code of Conduct

Genesis

Aiming at putting arms control in space on the EU agenda, Germany, holding the Presidency of the Council of the European Union, organized a workshop on "Security and Arms Control in Space and the Role of the EU" in June 2007 in Berlin. The Deputy Commissioner for Arms Control and Disarmament of Germany, Ambassador Rüdiger Lüdeking, supported the idea of a code of conduct, acknowledging at the same time the importance of an incremental approach and not precluding parallel or subsequent measures.[12] Italian Ambassador Carlo Trezza reiterated the objective of a legally binding agreement regarding security in outer space, but also stated that there was a tendency within the EU to prefer "less ambitious schemes" and that a potential code of conduct could embody corresponding measures. Ambassador Trezza referred to a food-for-thought paper by Italy presented to CODUN, the EU working group on disarmament, in March 2007, comprising several principles, including adhering to and implementing existing commitments, both binding and non-binding; preventing space from becoming an area of conflict; respecting the role of space for general security; and refraining from utilizing space objects harmfully against other space objects.[13]

In September 2007, the European Union called on COPUOS to consider a more specific space code of conduct rather than the general analysis of potential rules of the road that had been previously suggested.[14] Later on, at the United Nations, Portugal (on behalf of the EU) stated that the broad support for UN General Assembly resolutions on TCBMs for outer space and PAROS, which the EU had voted for unanimously, showed the European dedication to set up TCBMs and to draw up a "code of conduct" and "rules of behaviour" in space.[15]

Building upon discussions around the Italian food-for-thought paper, the Portuguese EU Council Presidency drafted a first version of a European Union Code of Conduct in the second half of 2007. An updated version, entitled "Best Practice Guidelines for / Code of Conduct on Outer Space Activities", was circulated in the beginning of 2008, under the Slovenian Presidency. After accounting for several comments, the document was agreed upon in June 2008. In parallel, the Netherlands issued a plan for discussing the code with key partners and for modalities to promote it in relevant international forums.[16] The EU and the United States exchanged views. Talks were also held with China and the Russian Federation. France took over the EU Council Presidency in July 2008 and made the proposal a priority. It sought to make the code acceptable to as many states as possible. In December 2008 the Council of the European Union officially released its Draft Code of Conduct for Outer Space Activities.[17]

Content

The main purpose of the Code of Conduct is twofold. On the one hand it aims to strengthen existing United Nations treaties, principles and other arrangements, as subscribing states commit to make progress toward adhering to them, implementing them and promoting their universality. On the other hand, it aims to complement the United Nations treaties, principles and other arrangements by codifying new best practices in space operations, including notification and consultation. This should strengthen confidence and transparency among space actors and contribute to developing good faith solutions that allow access to space and the carrying out of space activities for all.[18]

The Draft Code of Conduct comprises a preamble and 12 articles, subdivided into four sections: Core Principles and Objectives, General Measures, Cooperation Mechanisms and Organisational Aspects. In the preamble, the EU recognizes the "need for the widest possible adherence to relevant existing international instruments". It also clarifies the underlying principles of the code, which clearly show the mediating position of the EU as they take into account the main concerns of the key spacefaring nations. The preamble states that a comprehensive approach to safety and security in space should be based on freedom of access to space for all for peaceful purposes (accounting for US claims), preservation of the security and integrity of space objects in orbit, and due consideration for the legitimate defence interests of states.

Additional general principles to be followed by the subscribing states are laid down in Article 2, such as "the freedom of access to, exploration and use of outer space and exploitation of space objects for peaceful purposes without interference, fully respecting the security, safety and integrity of space objects in orbit". The other principles address the right of self-defence as well as states' responsibility to prevent harmful interference and to promote peaceful exploration, preventing space from becoming an area of conflict.

Sections II and III introduce the rules of the road, augmented by relevant provisions covering space debris and notification of manoeuvring. Article 4 deals with space operations, Article 5 with space debris control and mitigation, and Articles 6–10 cover notification, registration, information, and consultation and investigation. Article 7 aims at complementing the Registration Convention by calling upon subscribing states to register space objects and to provide the UN Secretary-General with relevant data, referring to UN General Assembly resolution 62/101 on registering space objects. Additionally, "Subscribing States resolve to share, on an annual basis, and, where available, information on: national space policies and strategies, including basic objectives", rules of the road, space debris strategies and environmental conditions and forecasts (Article 8). Compliance and verification are ensured through a consultation mechanism and an investigation mechanism. The first allows subscribing states "with reason to believe that certain outer space activities conducted by one or more Subscribing State(s) are, or may be, contrary to the purposes of the Code" to request consultations (Article 9.1). The investigation mechanism may be agreed at a later point in time. It "could be based on national information and/or national means of investigation provided on a voluntary basis by the Subscribing States and on a roster of internationally recognised experts to undertake an investigation" (Article 9.2). The Draft Code of Conduct foresees biennial meetings "or as otherwise agreed" to review the implementation of the code and its evolution (Article 10.1). A "central point of contact" is to be nominated to deal with new subscriptions, to maintain the information-sharing system, to serve as a secretariat at the biennial meetings and to carry out other tasks as agreed (Article 11).

Comparing the first draft with the released version, one can identify a shift in language. Formulations like "shall" and "agree" have been replaced by "will" and "decide" in all relevant provisions. The whole proposal has become stronger in its wording. Moreover, its title changed from "Best Practice Guidelines" to "Code of Conduct" (most probably due to the fact that the proposal had become known as such outside the EU). Greater emphasis is placed on national doctrines as, for example, some of the direct references to the UN Charter or UN General Assembly resolutions have been removed from the preamble as well as from Article 3.1, which now no longer refers to the UN Charter explicitly but to the existing legal framework only. An explicit reference to Article 51 of the UN Charter, which the United Kingdom and the United States would have liked to include, was not approved by several EU member states, including Germany, Italy and the Scandinavian countries and was thus replaced by a more general formulation referring to the UN Charter only but not to Article 51. Along the same lines, while Article 4.2 sets up concrete space debris mitigation guidelines, Article 4.3 softens these guidelines by permitting manoeuvres with the objective of repairing space objects, mitigating debris, avoiding collisions or managing space traffic, provided that "all reasonable measures to minimise the risks of collision" have been taken. Thus, the draft represents a compromise, enhancing the chance of successful third-party talks. It is important to remember that the EU is eventually aiming at a legally binding treaty: while the Draft Code of Conduct is not legally binding, it could become customary law, but this depends on how many states agree to abide by it.

The draft represents a compromise, enhancing the chance of successful third-party talks.

There are issue areas that the Draft Code of Conduct does not address at all: for example, it does not refer to temporary interference with space objects. Neither does it give indications on the preferred negotiation forum for space security issues. Contrary to the objective put forward in Italy's food-for-thought paper, the draft code does not address potential overlap between future activities at the CD and at COPUOS. The Draft Code of Conduct also lacks provisions tackling "keep-out zones" or "long-lived space debris".[19] The code focuses instead on behavioural recommendations, which allows the EU to circumvent negotiations on definitions, in contrast to the proposals from China and the Russian Federation (which employ negative definitions, i.e. prohibitions). However, this approach also precludes the EU from "specifying actions, situations, timeframes and spatial conditions" in detail.[20]

Development since release

The French EU Council Presidency had already introduced the Draft Code of Conduct to the US administration in the last quarter of 2008, before it was officially released in December 2008. The United States compiled a list of comments and changes. After its release, the Czech Presidency of the

EU held a series of bilateral talks and discussions with other spacefaring nations with the intention of reaching a consensus text that would be acceptable for as many states as possible. During this first round Brazil, Canada, India, Indonesia, Israel, Japan, Republic of Korea, South Africa and Ukraine were consulted. The Swedish Presidency will now proceed with the second round of consultations with, inter alia, China, the Russian Federation and the new US administration.

Information on the progress of these bilateral talks has been kept to a minimum. The main reason for this confidentiality is that the CODUN group does not want to complicate future negotiations by making unauthorized information available. It has so far not been made public how the EU member states will deal with the comments, criticism and amendments brought forward in these bilateral consultations.

Obstacles and issues

The content of the final Code of Conduct, its forum of negotiation, as well as the mode of adoption all need further clarification. Obstacles to the code's final adoption can be subdivided into inter-European difficulties and sets of problems with third countries.

In a statement by the Czech Presidency at COPUOS in 2009, it was made clear that the code is a basis for informal discussion in international forums but it is not meant to be officially introduced and discussed in any existing international forum such as COPUOS or the CD.[21] The EU Presidency will, however, continue to inform multilateral bodies on the progress of the Code of Conduct initiative. It is envisaged that at the end of the consultation process an ad hoc conference will be organized in order for states to subscribe to the Code of Conduct.[22]

This is the official common EU position, but there seems to be some debate among EU member states regarding whether the Code of Conduct should remain outside of the traditional negotiating forums. The initial idea had been to conduct independent negotiations outside CD and COPUOS, taking the Ottawa process (which led to the Mine Ban Treaty) as an example, and to circumvent the deadlock in the CD. There are fears, however, that the ad hoc conference may have unintended consequences, such as the questioning of existing principles of space law, particularly those of the OST. While the Draft Code of Conduct will not be affected by such debates immediately, implementation of and adherence to the code could be harmed eventually: space security efforts could be sidetracked and the existing space law regime could itself be damaged.

The recent change in the US administration may result in a greater openness to discussions and a stronger Draft Code of Conduct.

Regarding third countries, the United States' strong opposition to initial drafts of the code has led to the weakening of its wording.[23] It is possible that the recent change in the US administration may result in a greater openness to discussions and a stronger Draft Code of Conduct. In contrast, while the EU is following its schedule on bilateral consultations, China and the Russian Federation continue to promote their proposal for a legally binding treaty. The two states recently announced the finalization of an information document for the CD entitled *Basic issues and comments on the draft agreement to prevent the placement of weapons in space, or the use of force or threat of force against objects in space*. At the beginning of the General Assembly this year, both countries urged CD members to submit proposals on the issue of confidence-building measures in outer space.[24] Russia and China's continued focus on the treaty approach leads one to assume that their approval of the EU's Code of Conduct would be tied to some kind of support by the EU for the Chinese–Russian draft treaty.

The way ahead

While the Draft Code of Conduct stresses that it does not intend to replace other initiatives and that it complements and contributes to those initiatives by underlining the importance of taking all measures to prevent space from becoming an area of conflict, it has to be acknowledged and accepted that it has already developed into a singular project.

First of all, it does not only provide mid-term operative mechanisms but also contains the perspective for a future comprehensive regulation of space activities: space traffic management (STM). The term has been around for a number of years, but only a study by the International Academy of Astronautics (IAA), prepared between 2001 and 2006, looked into STM in an interdisciplinary and fundamental way.[25] The International Space University (ISU) and the International Association for the Advancement of Space Safety (IAASS), among others, have also undertaken work on space traffic management since this initial study.

STM is defined as "a set of technical and regulatory provisions for guaranteeing safe access to outer space, operation in outer space and return from outer space to Earth free from physical or radio-frequency interference".[26] STM is not about tackling single issues, but regards the regulation of space activities as a comprehensive concept, based on the idea of regarding space activities "as a traffic system and not as disconnected activities of States".[27] It is a permanent solution to the issues of safety and security in space.

As we have seen, the existing treaties and regulations on space are neither complete nor harmonized, with some provisions being more advanced than others and many provisions entirely absent (i.e. on the avoidance of polluting the atmosphere/troposphere or any obligation regarding pre-launch notifications). Nonetheless, they do provide the basic elements for a space traffic management regime. Thus, the idea at this point is to counter the lacunae and ambiguous provisions within the existing framework in the form of a new international intergovernmental agreement, which is complementary to the existing legal structure and will establish a comprehensive STM regime. The Code of Conduct can be seen as an element of the proposal to establish a comprehensive space traffic management regime.

STM requires data, i.e. a space situational awareness system. This in turn requires the creation of a database through a notification system that includes pre-launch notification (with more, and improved, data than that which is currently supplied to the Registration Convention), pre-notification of orbital manoeuvres and active de-orbiting, and provision of information on the end of the active and operational lifetime of space objects. From this database the comprehensive STM regime could then draw up rules in the following areas:

- safety provisions for launches;
- safety provisions for human spaceflight;
- zoning (selection of orbits);
- right of way rules for in-orbit phases;
- prioritization with regard to manoeuvre;
- specific provisions for geostationary and low Earth orbit, respectively;
- debris mitigation mechanisms;
- safety provisions for re-entry; and
- environmental provisions.

STM would also clarify the concept of the "launching State" as well as the definition of "space objects". Moreover, STM would provide answers to questions of liability, setting forth an enforcement mechanism as well as a provision covering dispute settlement.[28] Clearly, STM requires strong oversight,[29] but it can be considered the appropriate means for guaranteeing the conduct of space activities in accordance with the principle of "no harmful interference" contained in the OST.[30]

The Draft Code of Conduct is also of special interest as it the most visible and substantive diplomatic effort of Europe in space policy and regulation so far,[31] and exemplifies the EU's current evolution into a more active international player in space matters. The code's reception demonstrates the influence Europe has assembled today: the EU is in the process of becoming a normative power advocating the prevention of an arms race in space. The Code of Conduct project is thus part of a larger EU space policy. The EU needs to develop its formative role and display its principled identity more strongly,[32] so that it has a firm base from which to take a position when other space-related issues arise. Such issues include the set-up of a European SSA system (possibly involving trans-Atlantic cooperation), the increased role of space assets in internal security, or a European approach to responsive space (i.e. more flexible space assets that can be developed and launched more rapidly).[33] For all of these issues, international cooperation remains of utmost importance. Through the Draft Code of Conduct, Europe is presenting both a substantive mechanism for dealing with problems of security in space and a promising diplomatic approach to reach a broadly acceptable result.[34]

Notes

1. UN General Assembly resolution 1962 (XVIII), 13 December 1963.
2. The OST touches upon other issues as well, which subsequent agreements address in more detail. For an in-depth account of the OST see Stephan Hobe, Bernhard Schmidt-Tedd and Kai-Uwe Schrogl (eds), 2009, *Cologne Commentary on Space Law, Volume 1: Outer Space Treaty,* Cologne, Heymanns.
3. Pericles Gasparini Alves, 1991, *Prevention of an Arms Race in Outer Space. A Guide to the Discussions in the Conference on Disarmament,* Geneva, UNIDIR.
4. Jonathan Dean, 2002, "Future Security in Space: Treaty Issues", *INESAP Information Bulletin,* no. 20, August.
5. See UN General Assembly resolution 36/97C, 9 December 1981.
6. For a detailed comparison of the different elements of these various proposals refer to Wolfgang Rathgeber and Nina-Louisa Remuss, 2009, *Space Security: A Formative Role and Principled Identity for Europe,* ESPI report 16, Vienna, January. The main documents referred to are Possible Elements for a Future International Legal Agreement on the Prevention of the Deployment of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects, CD/1679, 28 June 2002, which was supplemented by various working papers (CD/1778, CD/1779, CD/1781, CD/1784, CD/1785 and CD/1786 as well as revised versions like CD/1818), and the Draft Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force against Outer Space Objects, in CD/1839, 29 February 2008.
7. UN General Assembly resolution 61/75 of 6 December 2006, UN document A/RES/61/75, 18 December 2006.
8. UN General Assembly resolution 62/43 of 5 December 2007, UN document A/RES/62/43, 8 January 2008.
9. More information on COPUOS can be found on the UN Office for Outer Space Affairs web site, at <www.oosa.unvienna.org/oosa/en/COPUOS/copuos.html>.
10. Henry L. Stimson Center, 2007, Model Code of Conduct for Responsible Space-Faring Nations, at <www.stimson.org/pub.cfm?ID=575>.
11. COPUOS, *Future Role and Activities of the Committee on the Peaceful Uses of Outer Space,* UN document A/AC.105/L.268, 10 May 2007.
12. Quoted in Marcel Dickow, 2009, "The European Union Proposal for a Code of Conduct for Outer Space Activities", in Kai-Uwe Schrogl, Charlotte Mathieu and Nicolas Peter (eds), *Yearbook on Space Policy 2007/2008: From Policies to Programmes,* Vienna, SpringerWienNewYork, pp. 153–154.
13. Ambassador Carlo Trezza, "A Possible Comprehensive Code of Conduct for Space Objects in an EU Perspective", presentation made to the EU workshop on "Security and Arms Control in Space and the Role of the EU" held in Berlin, 21–22 June 2007, at <sedi.esteri.it/rapparm/2007.06.21.22-trezza-InterventoConferenzaUEBerlinospazio.rtf>.
14. Theresa Hitchens, "COPUOS Wades into the Next Great Space Debate", *Bulletin of the Atomic Scientists,* 26 June 2008.
15. Statement by Portuguese Ambassador José Júlio Pereira Gomes on behalf of the European Union to the First Committee Thematic Discussion on Other Weapons of Mass Destruction, Sixty-Second Session of the United Nations General

Assembly, 19 October 2007, at <www.delegfrance-cd-geneve.org/declarations/unioneuropeenne/unga_owmd_eu_statement.doc>.
16. Marcel Dickow, op. cit.
17. Draft Code of Conduct for Outer Space Activities, EU Council, document 17175/08, PESC 1697, CODUN 61, Brussels, 17 December 2008, Annex II, at <register.consilium.europa.eu/pdf/en/08/st17/st17175.en08.pdf>.
18. A summary of the EU report to COPUOS can be found in *Report of the Committee on the Peaceful Uses of Outer Space,* UN document A/64/20, New York, 2009, paragraph 45.
19. Marcel Dickow, op. cit., p. 160.
20. Marcel Dickow, op. cit. For a more detailed comparison of the Code of Conduct with other proposals refer to Rathgeber and Remuss, op. cit.
21. "Draft EU Code of Conduct for Outer Space Policies", information note delivered by Petr Lála informing COPUOS about CODUN activities, Vienna, June 2009.
22. "Statement by the Czech EU Council Presidency under Item 4: General exchange of views", United Nations Committee on the Peaceful Uses of Outer Space, Fifty-second session, Vienna, 3–12 June 2009.
23. Rathgeber and Remuss, op. cit.
24. Ray Acheson, "Collective Security as National Security", *CD Report,* Reaching Critical Will, 25 August 2009.
25. Corinne Contant-Jorgensen, Petr Lála and Kai-Uwe Schrogl (eds), 2006, *Cosmic Study on Space Traffic Management,* Paris, International Academy of Astronautics, at <iaaweb.org/iaa/Studies/spacetraffic.pdf>.
26. Ibid.
27. Kai-Uwe Schrogl, 2008, "Space Traffic Management: The New Comprehensive Approach for Regulating the Use of Outer Space", *Acta Astronautica,* vol. 62, nos 2–3, January–February, pp. 272–276, October, Vienna.
28. Contant-Jorgenson et al., op. cit., pp. 14–15.
29. Schrogl, op. cit., pp. 3–4.
30. Contant-Jorgenson et al., op. cit., p. 10.
31. Before this, Europe has only made one joint initiative of such weight: in 1998 it called on COPUOS for an improvement of the Registration Convention, out of which the two recent UN General Assembly resolutions on the legal concept of the "launching State" and on registration practice emerged (resolution 59/115 of 10 December 2004, UN document A/RES/59/115, 25 January 2005; resolution 62/101 of 17 December 2007, UN document A/RES/62/101, 10 January 2008).
32. Rathgeber and Remuss, op. cit.
33. For a detailed discussion on the various concepts for responsive space refer to Nina-Louisa Remuss, forthcoming 2010, *Responsive Space: Elements of a Roadmap for Europe,* ESPI Report 22, Vienna.
34. For the relevance of this initiative as a major diplomatic step for Europe, see Laurence Nardon, 2009, "UE/Espace. Une puissance spatiale de plus en plus compétente", *Rapport annuel de l'Institut français des relations internationales (RAMSES) 2010,* Paris, IFRI, September.

The missile regime: verification, test bans and free zones

Over sixty years after the introduction of nuclear weapons and ballistic missiles in the Second World War, the international strategic environment is becoming increasingly complex and competitive. The Revolution in Military Affairs penetrates multiple dimensions of national and international security. The arms race extends from nanospace to outer space, transcending national borders.

Nuclear weapons and missiles, which played a central role during the Cold War, have not lost their prominence: strong political forces maintain that nuclear deterrence remains a cornerstone of national security for the foreseeable future, despite a growing movement to eliminate nuclear arsenals. In 2002, the United States asserted that its nuclear weapons would continue to play a "critical role" because they possess "unique properties".[1]

However, without an appropriate delivery capability, the military utility of nuclear weapons is limited. Missiles appear attractive as they are much easier to operate than manned bomber aircraft and do not expose an attacker's personnel to direct risk.[2] The lack of legal structures or taboos against the development, testing and maintenance of missiles creates a conducive environment for their testing. Thus, these complex systems are tested with increasing frequency and are increasingly threatening international stability.

To deal with this threat, the ultimate goal for the authors of this paper is the Zero Ballistic Missile (ZBM) regime proposed by the Federation of American Scientists in the early 1990s.[3] However, as a starting point we propose that states notify each other in advance of missile flight tests in order to reduce tensions and potential for conflicts. This would be a first step toward a gradual missile flight test ban as a part of a zone free of weapons of mass destruction (WMD).

In theory, an advance notification of a missile flight test is realizable and its verification is both technically feasible and financially affordable. Missile testing can be easily monitored from remote sites on the ground, in the air or from space. The non-deployment of missiles can be verified with airborne visual inspection or from space.[4] Moreover, the verification process would be a valuable confidence-building measure, and could be particularly beneficial to regions where tensions run high, such as South Asia and the Middle East. The Peace Research Institute Frankfurt has set up a Multilateral Study Group on the Establishment of a Missile-Free Zone in the Middle East (MSG). The MSG, academic and theoretical in nature, brings together experts from the Middle East, China, Europe, the Russian Federation and the United States. It is an attempt to explore a regional effort to control delivery systems as well as to examine the possibility of banning their testing as part of the overall effort to establish a WMD-free zone in the Middle East.

Moving toward a flight test ban: evolution of an idea

To avoid a new arms race on a regional, or even global, scale, there have been a number of suggestions for more comprehensive arms control approaches with regard to missiles. While the concept has some political appeal, it is yet to prove realizable.

The idea isn't new: one can date it back to the 1950s, when the concept of a flight test ban was explored in order to get international disarmament negotiations under way. France, the United Kingdom, and later the United States perceived this as an ideal opportunity to curb the nascent Soviet missile programme. However, the discussions fell through for reasons beyond the scope of this paper. The idea was revisited in 1986, when Ronald Reagan and Mikhail Gorbachev met at the Reykjavik Summit to discuss perhaps the most far-reaching proposal to eliminate ballistic missiles. Unfortunately, these negotiations collapsed due to differences about President Reagan's Strategic Defense Initiative (SDI, also known as Star Wars).[5]

In 1987, the Missile Technology Control Regime (MTCR) was initiated by the Group of Seven (Canada, France, West Germany, Italy, Japan, United Kingdom and United States). The MTCR is a voluntary and informal agreement that aims to prohibit the transfer and spread of ballistic and cruise missile technologies to non-member states.[6] The regime's membership expanded to 29 in 1997 and by the end of 2004 it had 34 member states. Under the MTCR, states defined a nuclear-capable missile as one able to deliver a 500kg or greater payload to a distance of 300km or more. These parameters corresponded to the perceived minimum weight of a nuclear warhead, and to the strategic distances in the most compact theatres where nuclear-armed missiles might be used. In 1992 the scope of the MTCR was expanded to include unmanned aerial vehicles for the delivery of WMD, making the payload and range thresholds less rigid.

The MTCR has played a significant role in constraining horizontal proliferation of long-range ballistic missiles, especially in the developing world. This could be attributed to the regime having increased the financial costs of proliferation.[7] Complete ballistic missile systems as well as key components, subsystems and manufacturing technology have become less available, as has the technical expertise vital to the development and manufacture of ballistic missiles. The regime's expansion has also been instrumental in promoting the concept of a missile non-proliferation "norm". This norm has helped drive up the political costs of proliferating for those countries determined to acquire a ballistic missile capability or enhance existing systems. In 2002, the MTCR was supplemented by The Hague Code of Conduct against Ballistic Missile Proliferation (HCOC), which calls for restraint in the proliferation of unmanned delivery systems, and has 130 members to date.[8]

Despite some success in delaying missile programmes and building a basis of support, the MTCR has some fundamental drawbacks that limit its effectiveness.[9] For example, the MTCR's approach of technology denial is a long-term solution to proliferation concerns. It does not restrain existing arsenals or programmes. A new alternative would be to follow a path toward missile disarmament following the proposals of the 1986 Reykjavik summit.[10] Curbing missile development by a flight test ban—including development by the nuclear-weapon states and others with advanced missile programmes—would be an important step.

Flight testing is an integral part of the missile development process. Most countries that have or seek to develop missiles with accurate inertial guidance, solid fuel and multi-staging, undertake numerous flight tests to ensure confidence. While the need to test can be reduced with advances in computer simulations, improvements in static firings of rocket motors, and the transfer of knowledge from space launches, the history of missile development demonstrates that new missiles and new technologies that have performed well in computer simulation and ground testing can reveal unpredicted fatal defects in flight testing. For example, there were reports that the United States'

MX missile inertial guidance system performed brilliantly in early development tests, but its accuracy fell off when the production team took over.[11] Even states with existing ballistic missile arsenals would probably argue that flight testing of existing systems is essential to preserve their reliability. Thus, if missile flight testing were banned, the loss would be similar to the loss of confidence in the reliability of nuclear weapons that is expected from the Comprehensive Nuclear-Test-Ban Treaty (CTBT), and should reduce the likelihood of a pre-emptive first strike.[12] By notifying each other in advance of a flight test and subsequently verifying the test, states could build the requisite confidence to negotiate a test freeze, and could lay the foundation for negotiating a missile flight test ban.

Affordable and verifiable

Compliance with missile test notification would be relatively easy to verify technically, provided that the remote sensing of missile launches is supplemented by provisions to minimize the risk of the conversion of space launchers into ballistic missiles. As the then CIA Director William Webster acknowledged in May 1989, "The status of missile development programs is less difficult to track than nuclear weapons development. New missile systems must be tested thoroughly and in the open...".[13] The existing national technical means of the most technologically capable states are already able to detect and track, for example, ballistic missile launches, trajectory and telemetry. US early warning satellites can track missile launches around the world. Detecting test preparations of mobile missile systems may pose a problem, but the actual flight tests would still be detectable. In addition, an array of ground-based radar systems would provide reliable launch detection, target acquisition and tracking. Over-the-horizon and sea-based radar could extend coverage into areas difficult to reach for ground-based radar.

The role of technology should not be underestimated in verification.[14] Technology helps in systematically collecting, analysing, storing and rapidly disseminating information. Technology can operate continuously and at a constant level compared to human inspectors. Technology can also be designed to detect treaty-relevant information only. For example, in the 1987 Intermediate-Range Nuclear Forces (INF) treaty between the Soviet Union and the United States, it was permitted to X-ray the missile canister to determine the type of missile; however, the resolution of the X-ray was constrained so that other sensitive information was not revealed.[15] Space-based and aerial technologies are common methods of verification. However, both these technologies suffer from significant disadvantages.[16]

The infrasound sensor component of the International Monitoring System (IMS) of the Comprehensive Nuclear-Test-Ban Treaty Organization Preparatory Commission could aid in detecting and confirming a missile launch.[17] The IMS is a network of monitoring sensors set up to detect and provide evidence of nuclear explosions to CTBT states parties for the purposes of treaty verification. Infrasound, part of the acoustic spectrum lying below the range of human hearing (i.e. approximately 20–0.001Hz), is of particular interest for the monitoring of a number of man-made and natural phenomena. This is primarily due to the lack of significant attenuation at these frequencies in Earth's atmosphere, allowing acoustic waves to be observed even after travelling thousands of kilometres.[18]

As a typical rocket infrasound signal is in the 0.1–1Hz frequency range it will be possible to detect missile flight launches in the acoustic far field, far from the launch site.[19] The detection of infrasound from rockets primarily depends on three different factors:

- the local noise conditions at the site of the receiver;
- the propagation conditions between the source and the receiver; and
- source characterization.

We can investigate the potential of the IMS infrasound's network to detect rocket launches using an instance of a detection at Aktyubinsk (shown in Figure 1). The detection observed is that of the Zenith rocket, which was launched on 29 June 2007 from Baikonur Cosmodrome at 1000 UTC (Universal Coordinated Time). The sound waves arrive at the sensor at approximately 1032 UTC.

Using a minimum of three microphones, the spacing of which depends upon the frequency characteristics of the waves of interest, the individual channels of the array are cross-correlated and spatially transformed over a finite window time in order to provide a direction from which the wave energy in the window arrives at the receiving array. On performing this procedure repeatedly over the length of a time series that contains a signal, the back azimuth as well as the wave velocity can be computed.

Based on openly available data of detections at Aktyubinsk and other stations, an empirical relation of the maximum distance at which a rocket can be detected versus the class of the rocket has been derived by P. Brown et al.[20] This relation is given as follows:

$$1.3\log(R) = 2.759 + \log(NP),$$

where R is the maximum range in kilometres, and NP is the noise power of rockets (the total amount of acoustical energy radiated per unit of time).

This relation is used to determine the maximum horizontal detection range of rockets. Table 1 lists the maximum detection range of certain rockets currently in military arsenals.

Table 1. Detection ranges for an infrasound station for select missiles

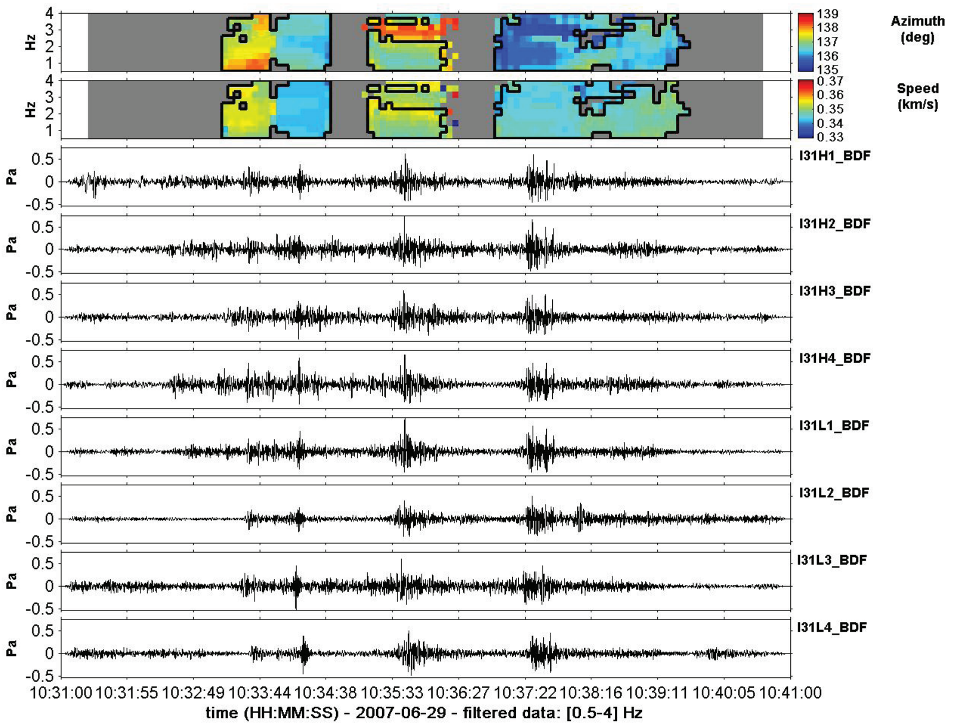
Rocket name	*Liftoff thrust (kN)*	*Maximum horizontal distance at which the rocket launch can be detected (km)*
Proton	10,470	6,300
Ariane 5	6,470	4,500
Agni II	503	675
Scud-B	93	130

As monetary aspects play a crucial role in any verification agreement, having a verification system already established might help reduce costs. In this instance, it may very well reduce capital outlay. A design criterion of less than 0.1Hz is typical for all IMS infrasound stations, and this would be more than adequate for missile launch detection: rocket signals are prominent at 0.1–1Hz. The mean spacing between IMS stations is 2,500km on land and 4,500km in the oceans, which, referring to Table 1, would be sufficient to detect long-range missiles.

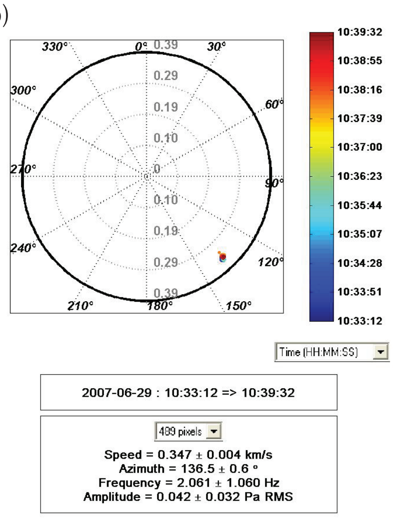
Were an independent verification system to be established to detect missile flight tests, the arrays could be smaller (baseline of 500m between sensors) than a typical IMS infrasound array as it would not need to detect signals at such low frequencies. A typical IMS infrasound array costs approximately US$ 200,000. This is primarily due to larger baselines and the inclusion of equipment to ensure that the data is not tampered with. The cost of an array purely for missile flight test detection would be approximately US$ 100,000, as shown in Table 2. The sum does not include basic infrastructure such as buildings, communications, and the empty and isolated land required to site the equipment, which could easily add up to another 50% of the overall cost. Operating costs should also be taken into account, and so must personnel.[21]

Figure 1. Infrasound signal from Zenith rocket launch recorded at Aktyubinsk array (I31KZ).

(a)



(b)



(c)

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Note: (a) The observed back azimuths (from the source to the receiver) seem to be arriving from between 135 and 139 degrees. The arrival velocities of the waves are between 0.33 and 0.37km/s. This is characteristic of infrasound velocities; (b) Radar plot showing the directions from which the signal originates; (c) Trajectory of the rocket, plotted using freely available software, and indicating the I31KZ sensor at Aktyubinsk as well as the launch pad at Baikonur Cosmodrome.

Table 2. Itemized cost for a 500m baseline infrasound array

Item	*Unit cost (US$)*	*Quantity*	*Total cost*
Chaparral 2.5 MB vault	3,900	4	15,600
Soaker hose	15	48	720
Nanometric digitizer	10,000	4	40,000
GPS antenna	150	4	600
MB vault	3,000	4	12,000
Teck cable	13.5	2,500	33,750
DC power supply	300	1	300
UPS battery backup	2,500	1	2,500
Terminal server	3,000	1	3,000
Communication modem	1,000	4	4,000
Computer system	3,000	1	3,000
Software	15,000	1	15,000
		Net total	130,470

Building confidence

Finally, verification of flight tests using sensors such as the ones suggested here may also contribute positively to confidence building, thus constituting a preliminary step toward a possible flight test freeze, then ban. For example, India and Pakistan signed an agreement on 3 October 2005 to notify each other at least 72 hours in advance of a ballistic missile flight test. The two states also agreed not to allow trajectories of tested missiles to approach or land close either to their accepted borders or the Line of Control, the ceasefire line running through the disputed region of Kashmir. They pledged not to allow missiles being tested to fly closer than 40km from these boundaries or land less than 70km away. Verifying such missile tests with infrasonic sensors located on either side of the border will provide both countries with an opportunity to work together, to improve their knowledge of the technology, and to enhance mutual cooperation.

Missile test freeze in the Middle East

There is considerable literature on creating a nuclear-weapon-free zone (NWFZ) or WMD-free zone in the Middle East. Egyptian President Hosni Mubarak initiated the call for establishment of a WMD-free zone in April 1990. His proposal had three main components.

- The prohibition of all weapons of mass destruction—nuclear, chemical and biological—in all states of the Middle East.
- All states in the region should provide assurances toward the full implementation of this goal, in an equal and reciprocal manner to fulfil this end.
- Establishment of proper verification measures and modalities to ensure the compliance of all states of the region without exception.[22]

This was soon followed by a report of the UN Secretary-General on the "Establishment of a Nuclear-Weapon-Free Zone in the Region of the Middle East".[23] This proposal also suggested that a freeze on additional deployments of ballistic missiles could ease tensions in the region. The authors of the report said, "As a starting point for discussions, it would be desirable to consider a complete suspension by all States in the region of domestic production and of imports of missiles beyond a certain range."[24] The authors of the UN report admitted that small-scale violations of the production and import freeze may occur, but argued that even a relatively simple verification scheme would be enough to detect substantial violations that could be considered militarily significant.

In May 1991 US President George Bush announced a Middle East arms control initiative that included a "freeze on the acquisition, production, and testing of surface-to surface missiles by states in the region".[25] However, the proposal failed to gain traction, and the international arms industry continued to manufacture and sell arms to states in the region, including surface-to-surface missiles.[26]

In 1995, the Non-Proliferation Treaty Review and Extension Conference agreed a special resolution on the Middle East, to which the 2000 Non-Proliferation Treaty Review Conference re-confirmed its commitment. The resolution focuses on achieving the following objectives.

- The establishment of a nuclear weapon-weapon-free zone in the Middle East.
- The accession to the NPT by states in the region that have not yet done so.
- The placement of all nuclear facilities in the Middle East under full-scope IAEA safeguards.[27]

The establishment of an NWFZ in the Middle East would be a first step toward establishing an effectively verifiable NWFZ, and then a zone free of all WMD and their delivery systems.[28] These, however, focus on banning the ordnance to be carried by missile delivery systems, not the delivery systems themselves.

Although there exists a range of literature on a WMD-free zone or a NWFZ in the Middle East, including studies recently published in the region,[29] there is currently no specific literature on a missile-free zone in the Middle East. It is clear, however, from the proposals relating to a WMD- or nuclear-weapon-free zone, that many see a link between missile control and the creation of such a zone in the Middle East. One analyst has suggested that it might be possible to draw precedents from the INF Treaty for the Middle East in terms of verifying a missile ban or freeze as a step toward a WMD-free zone.[30] The INF Treaty eliminated all intermediate-range missiles, defined as those having ranges between 1,000 and 5,500km, and shorter-range systems, defined as having ranges between 500 and 1,000km. Only ballistic and cruise missiles fired from ground launchers were included. A revised, tailored regional INF agreement would have the advantage of already having been adhered to in practice.

The road ahead

If we are to successfully achieve a missile flight test ban, it is important to recognize the centrality of the issue of trust. Mutual trust is key in international relations and a vital ingredient in preventing the stalling of disarmament efforts. Here we define trust as the ability to form a basis for constructive dialogue, to form a medium for cross-cultural and cross-regional exchange, reaching out beyond comfort zones, building bridges and increasing intercultural tolerance. The definition of trust could also be extended to issues such as building mutual interests and respect for differences.[31]

There must be candid conversation and constructive dialogue on nuclear disarmament: conversations should be held more frequently and all relevant opportunities for such conversations must be tapped. Members of civil society must be invited: in raising awareness on small arms, cluster munitions and on the need for a comprehensive nuclear test ban, non-governmental organizations (NGOs) have forged an action partnership with governments to achieve change that we are only beginning to see the consequences of.[32] NGOs can also help in breaking the barriers between governments, they can lay the foundation for formal talks by enabling, organizing, sponsoring and conducting informal means of exchange.[33] Gender perspectives can affect the way society views nuclear weapons and pave the way for them to be devalued and abolished—and the same applies to missile freeze and eventual destruction. As international efforts toward total nuclear disarmament gather momentum with initiatives such as missile-free zones, the work of NGOs, and of men and women around the world, must be acknowledged and given its due importance: everyone has a role to play.

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The turnover of diplomats in Geneva since the original agreement on the Shannon mandate, and the multitude of issues that personnel in smaller delegations often have to deal with make it difficult for the CD to retain its institutional memory. There is a real risk that the lack of historic knowledge and technical know-how among delegations may cause inertia and affect the prospects for progress toward a new treaty.

This project aims at raising awareness among diplomats within the CD, and those responsible for disarmament in the capitals, on the history of the FMCT discussions in the CD, the events and changes since these discussions, the critical issues to be dealt with by the negotiators, and the potential obstacles that will need to be overcome in order to achieve a treaty. The ultimate goal is to help speed the start of FMCT negotiations as well as deepen the level of discussion.

The project will produce a short reference bibliography of resources related to an FMCT and a briefing book covering the historical development of a mandate to negotiate, essential treaty elements such as scope and verification, and possible negotiating strategies. Three briefings for disarmament diplomats will be held in order to introduce the papers and encourage dialogue on critical issues.

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