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EDITOR'S NOTE

The space age has been an era filled with hope, contradiction, competition and promise. In a short period of time the world has become dependent on the space medium for a multitude of civilian and military applications, from meteorology to intelligence gathering. The potential dual-use nature of many space objects and technologies lies at the heart of the debate concerning the peaceful uses of outer space.

Many nations are resistant to the idea of weaponizing outer space. Nearly each year the General Assembly adopts two space-related resolutions, concerning the peaceful uses of outer space and the prevention of an arms race in outer space (PAROS). PAROS is also a decisive issue in the Conference on Disarmament, where many members have called for negotiations to prohibit the weaponization of space. Despite the broad international support for preserving outer space for peaceful uses, little seems to slow the drive towards weaponization—a drive predominantly fuelled by evolutionary defence programmes that might cross the space weaponization threshold. In the face of one nation's declared objective of 'the ability to dominate space', the international community needs to weigh whether to protect the civilian benefits shared by all or acquiesce to the military benefits of a few.

The continuing militarization and moves towards the eventual weaponization of space—whether because it is 'inevitable', necessary to protect vulnerable assets, or to control and dominate the 'high frontier'—must be addressed through new thinking and awareness. Threats, real or imagined, from missiles to space debris, need to be discussed and assessed. In this issue of *Disarmament Forum*, experts examine key aspects of the militarization and weaponization debate. We look at the history of the subject, outline national positions and assets, evaluate threats, explore possibilities for arms control verification in space, and put forward options for how to address many nations' increasing discomfort with the idea of space being the 'fourth medium of warfare—along with land, sea and air', as described by United States Space Command's *Vision for 2020*.

The next issue of *Disarmament Forum* will focus on the topic of nuclear terrorism, examining the actual threat posed by terrorists and the contributions that arms control could make to anti-terrorism initiatives.

UNIDIR (through the work of the Geneva Forum), the Small Arms Survey and the International Action Network on Small Arms (IANSA) are creating a database to record actions taken to implement the Programme of Action agreed at the July 2001 United Nations Conference on the Illicit Trade in Small Arms and Light Weapons in All Its Aspects. The database will offer an easy to interpret yardstick to evaluate progress towards national, regional and global commitments—a useful tool as governments prepare for the July 2003 Biennial Meeting that will review the implementation of the Programme of Action. The database will be accessible via the IANSA website <http://www.iansa.org/>.

In its continuing dialogue on fissile materials, UNIDIR, in cooperation with the governments of Japan and Australia, will hold a meeting entitled 'Promoting Verification in Multilateral Arms Control Treaties' on 28 March 2003. This meeting will focus on extracting lessons from existing multilateral disarmament regimes and will discuss whether and how these lessons can be applied to the creation of new verification regimes, such as a fissile materials agreement.

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Kerstin Vignard

SPECIAL COMMENT

Reclining in the summer's evening light, comfortable in our mismatched beach chairs, my friends and I lean back to watch the darkening sky. Venus sits bright near the horizon, and overhead Sirius, the brightest of all stars, begins to push its sparkle through the fading sunlight. We talk quietly, clutching our beers and glasses of wine, and wait.

Suddenly, someone cries out. 'There, above the oak tree, headed north!'. We all strain our eyes, trying to spot the small speck of light hurtling across the sky. Voices ring out as we each see the satellite, and heads swivel to try and be the first to see another. Bets are made, successes tallied, and laughter rings out into the night.

For millennia, others before us have watched the night sky, staring with wonder at the endless ocean of stars. Imaginations have soared up into the universe, seeing great constellations, learning the patterns, finding meaning in the randomness. Understanding the sky led to development of a calendar, to Stonehenge, to the Pyramids, and eventually to the stunning realization that we are not the centre of it all.

In the past forty-five years we have not only stared and wondered, but have actually begun to travel into that night sky. The small points of light speeding overhead are human creations, satellites of Earth, fledgling probes into the endless unknown. Some have travelled further, exploring the other planets, even venturing beyond Pluto. These robotic extensions of our own senses have allowed us to start to directly experience and understand the rest of the universe.

Yet our probing of the sky has by no means been purely scientific and peaceful. Countless satellites have been launched for military surveillance, and the world's first Space Station was armed with a space-to-space gun.

Efforts and treaties have been made to minimize the weaponization of space, but any success thus far has mostly been due to the very inaccessibility of getting to orbit. The cost and complexity of leaving Earth has limited access to the very few, and thus has kept the more base applications at bay.

In the near future, however, we will invent cheaper ways to launch. While this will allow widespread opportunity for peaceful exploitation and profit, it will also open space to many more nations of the world, regardless of stability and intent. The onus will then be even greater on peaceful nations and international organizations to press for responsible stewardship of what John Magee called 'the high untrespassed sanctity of space'.

We will not be completely successful. Humanity has never been peacefully united on the ground, and there is no reason to think we will behave differently just because we are higher up. But the current advantages of worldwide communication, high-speed travel and the fallen Iron Curtain combine to give us a historic opportunity.

There is more cooperation in space exploration than ever before. Satellite customers can choose from launchers all over the world. The huge Atlas V rocket recently launched from Florida used a Russian-made main engine. The Space Shuttle and Soyuz regularly carry multinational crews, and high overhead the International Space Station shines as a beacon of hope, built by sixteen of the world's leading nations, crewed by citizens of Earth.

There is much romanticism about outer space. The generation of children that saw Sputnik and Apollo have since grown up, carrying with them the youthful optimism and hopes of the era, and I am one of them. We desire a universe better than the world we have developed. Yet I am also a Colonel in the Air Force, and clearly see the benefits of taking advantage of the high ground.

As I sit in my lawn chair and look at the sky, however, I am optimistic. Just twenty months ago I was in space, doing a spacewalk outside the Space Station. There was a quiet moment during the assembly work when I gently eased away from the side of the Station, floating free, barely holding on to a flimsy fabric strap. On my right I stared at the vast, ever-unrolling beauty of Mother Earth, while on my left the darkness and promise of the rest of the universe endlessly beckoned. Joining the two was the massive, powerful form of the Space Station—a human creation that let me see something we've been imagining for thousands of years.

Our job, as the current caretakers of the planet and civilization we have been given, is to use our greatest capabilities to solve our greatest problems. If we can give the opportunity to as many people as possible to float free, to see a world without boundaries and a universe without end, it will benefit us all.

After writing this piece, Columbia and her crew were lost on re-entry over Texas. It leaves me with great sadness, and all of us with an irreplaceable loss. It also clearly shows the danger and complexity of space exploration, and gives us the imperative to work harder, and to learn from this horrific lesson how to avoid such a disaster in the future. As each of the fallen crew would tell you, exploration of the rest of Creation is fraught with complexity, challenge and risk, yet the benefit of understanding is infinitely worth the cost. *Per Ardua ad Astra*.

Colonel Chris A. Hadfield

Canadian Space Agency Astronaut

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‘Peaceful uses’ of outer space has permitted its militarization—does it also mean its weaponization?

Johannes M. Wolff

The urge to transcend the heavens and explore the stars has always been a part of human consciousness, as evidenced by the myths of numerous cultures that describe journeys to celestial bodies. Ways of transforming those myths into reality have been explored for some time. Scientific discoveries of the seventeenth century, such as Johann Kepler’s work on the mathematical laws governing the motion of bodies in orbit or Isaac Newton’s research on gravity, were fundamental to the technical aspects of travelling to space and remain relevant to this day.

Despite the calls for the ‘peaceful use’ of outer space, it has been militarized from the very beginning of the space era. This article will introduce the reader to the history of the outer space debate, explore what is meant by ‘peaceful uses’, outline the key treaties and agreements, and look at both current and planned civilian and military projects and their relation to the militarization and weaponization of outer space.

History

The modern space age began in the early twentieth century with technological developments in rocket and missile science. Building on the work of individuals like Hermann Oberth and Walter Homann, Germany was responsible for major progress in rocket science at the time of the Second World War. Immense government support led to the development of the V-2 rocket. Although the V-2 programme was enormously costly and the rocket had limited military value, it is acknowledged as being the first viable space rocket.

After the Second World War, a small group of German rocket scientists from the V-2 project were brought to the United States in order to continue their research, which became the basis of the first space rocket programme. The Soviet Union also had access to V-2 technology after the war. However, the post-war era was not one of rapid progress in the area of space exploration. The United States was engaged with rebuilding its economy and aiding Europe’s reconstruction. Despite the emerging preoccupation of countering the unfolding Soviet threat, America’s superior airpower was considered sufficient to address this concern. For the Soviets, however, development of long-range missiles was critical to counter American air superiority.[1]

As the United States found itself in the Cold War struggle with the Soviet Union, it recognized that it was heavily dependent on the ability to gather information via technical means, most significant of

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which were aerial photographs. At the time such information was collected largely by high-altitude aircraft. Increased Soviet proficiency at fighter interception and anti-aircraft missile design was making surveillance risky and therefore interest in using satellites for reconnaissance grew. The United States began to formulate its political and diplomatic strategy concerning outer space on protecting the legality of satellite intelligence gathering. This generated interest in the legality of satellite overflights; concerns that became real after the Soviet Union launched Sputnik, the world's first man-made satellite, in 1957.

Sputnik transformed the dream of space exploration into reality. Four years later, Yuri Gagarin was the first human to see Earth from space. The launch of Sputnik marked the beginning of space exploration and with it the start of the debate surrounding the militarization of outer space.

As work on space boosters progressed in the United States and the Soviet Union, more normative aspects of space travel began to be explored. Scholars, politicians and diplomats began to take an interest in the issue of space law—more specifically, what should and should not be permitted in space.

With Gagarin's flight, human beings became space travellers. Less than ten years later, men walked on the Moon. Since then, nine space stations have been built and occupied by astronauts from different countries and the International Space Station—a sixteen-nation joint endeavour—is currently under construction. Manned space vehicles, such as the Space Shuttle and the Russian Soyuz, now fly regularly between Earth and low Earth orbit.

Besides exploration and scientific research, space is mainly used for the perspective it provides. This is done with the help of satellites. The satellite industry is the largest sector of commercial space activities today. Orbiting satellites, for example, facilitate communication between distant points on Earth. However, space has also become an important military tool. Satellites have become the eyes, ears and nerves of today's military forces. This is true to such a degree that if the satellites of a space power were to be destroyed, its military capability would be reduced dramatically.

Much of the difficulty of regulating activities in space is linked to the issue of dual use.

Much of the difficulty of regulating activities in space is linked to the issue of dual use. This applies to the technologies that can be used interchangeably for space launch vehicles and for ballistic missiles intended as delivery vehicles for weapons. Even more so, the civilian or military purposes of satellites can be difficult to differentiate. This pertains especially to communication and observation satellites, as well as systems such as the Global Positioning System (GPS), which is used for the guidance of many precision weapons but also for various civilian consumer applications.

'Peaceful purposes'

Initially, the world community—including the space powers—urged that space should be used for peaceful purposes. In January of 1957, even before Sputnik was launched, Ambassador John Lodge expressed on behalf of the United States the hope that 'future developments in outer space would be devoted exclusively to peaceful and scientific purposes'.[2] In his address to the United Nations General Assembly he even went so far as to suggest that the testing of satellites and missiles be placed under international supervision (much as was the case with nuclear technology and the Baruch Plan a decade earlier).

Further moves to ensure that 'outer space be used exclusively for peaceful and scientific purposes and for the benefit of mankind'[3] included the joint submission by four Western powers (Canada, France, the United Kingdom and the United States) to the United Nations Disarmament Commission, calling for a study on an inspection system that would assure that objects launched into outer space would be used exclusively for peaceful and scientific purposes. Adopted by the General Assembly, this became the first United Nations resolution on outer space, and the first time the phrase 'exclusively for peaceful purposes' would be used in an authoritative United Nations text.[4]

The thirteenth session of the General Assembly, held in 1958, provided a forum for the debate on 'Questions of the Peaceful Use of Outer Space'. During this session the term 'peaceful' was used as an antonym to 'military'. Sweden appealed to fellow Member States to 'safeguard outer space against any military use whatsoever'[5] and the Soviet Union put forward a proposal to ban the use of outer space for military purposes. The General Assembly adopted resolution 1348 (XIII), which recognized the 'common aim' of humankind that outer space 'should be used for peaceful purposes only.'[6]

Resolution 1348 established the Ad Hoc Committee on the Peaceful Uses of Outer Space (COPUOS). Its legal subcommittee issued a report in 1959 stating that the United Nations Charter and the Statute of the International Court of Justice were not limited to the confines of the Earth, and that the countries of the world have established a practice, in principle, that 'outer space is, on conditions of equality, freely available for exploration and use by all in accordance with existing or future international law or agreements'.[7]

The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, (The Outer Space Treaty or OST) was concluded in the first years of space exploration, after Yuri Gagarin's historic flight and before Neil Armstrong's walk on the Moon. The OST, which entered into force in 1967, prohibits the testing of weapons, the stationing of weapons of mass destruction (including nuclear weapons), the holding of military manoeuvres, or the establishment of military bases in space.

However, the OST does not cover the transit of nuclear weapons *through* space or nuclear weapons launched from Earth into space in order to destroy incoming missiles (such as some of the American or Soviet missile defence systems originally permitted under the 1972 Anti-Ballistic Missile Treaty). Nor does the OST address other weapons (such as anti-satellite weapons or ASAT) or the placement of conventional weapons in space.

The existing legal structure concerning outer space has a number of additional elements. The Partial Test-Ban Treaty entered into force in 1963 and prohibits nuclear tests and explosions in the atmosphere or in outer space. The Astronaut Rescue Agreement was reached in 1968. The Convention on Registration of Objects Launched into Outer Space entered into force in 1976, which complemented the 1972 Convention on International Liability for Damage Caused by Space Objects. In December 1979, the Agreement Governing the Activities of States on the Moon and Other Celestial Bodies was signed and entered into force five years later.[8]

A second body dealing with outer space issues, the Ad Hoc Committee on the Prevention of an Arms Race in Outer Space (PAROS), was established by the Conference of Disarmament (CD) in 1985. Today PAROS is one of the main obstacles to consensus on the CD's programme of work.

The ambiguity of 'peaceful uses'

When considering the early agreements and statements on outer space, one might have the impression that there has been accord on the peaceful use of outer space. Yet despite their claims that space should be reserved for peaceful uses, the United States and the Soviet Union were developing (and later launching) satellites that would serve a growing number of military objectives. As early as 1955, the United States Air Force contracted the development of reconnaissance satellites, an indication that early space programmes were more driven by military considerations and requirements than civil or scientific ones.[9]

The seeming contradiction over peaceful use emerges from the fact that the relevant agreements never precisely defined ‘peaceful’ and ‘outer space’. With ambiguous definitions subject to various interpretations, certain activities that one would not normally consider peaceful have been pursued.

For some nations the term ‘peaceful’ has been interpreted as ‘non-aggressive’ rather than ‘non-military’,[10] meaning that all military uses were and are allowed and lawful as long as they remain ‘non-aggressive’ as permitted under Article 2 (4) of the United Nations Charter, which basically prohibits ‘the threat or use of force’.[11] The OST allows for ‘passive military’ use of space, for example through reconnaissance, surveillance, early warning or communication satellites.[12] The OST also permits military personnel to conduct scientific research in space.

Article 51 of the United Nations Charter, which relates to the right of self-defence, can be invoked in outer space. One might argue that using outer space for deterrent and defensive purposes serves the cause of peace and that only when it is used for offensive activities that it goes against the idea of peaceful use.[13] However, the distinctions between ‘offensive and defensive actions, active and passive weapons, and aggression and self-defence becomes more and more blurred.’[14]

The lack of a clear definition was recognized as a potential problem at an early stage. In 1967, after expressing his satisfaction concerning the adoption of the OST, the then United Nations Secretary-General stated that ‘the door is not yet barred against military activities in space. The crux of the difficulty is that space activity is already part of the arms race, a fact which we have to reckon with until humanity reaches the stage of an agreement on full and complete disarmament’.[15]

Other arms control treaties have successfully defined the term peaceful. It appears, for example, in the Treaty for the Prohibition of Nuclear Weapons in Latin America (Treaty of Tlatelolco) and in the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction (Biological Weapons Convention).

The Antarctic Treaty of 1959 is considered as the most authoritative aid in the interpretation of the term ‘peaceful’. It declares, ‘Antarctica shall be used for peaceful purposes only. There shall be prohibited, inter alia, any measures of a military nature, such as the establishment of military bases and fortifications, the carrying out of military manoeuvres, as well as the testing of any type of weapons.’ This document has been key in the non-militarization of Antarctica.

Although we continue to speak about the peaceful uses of outer space, it has become a question of rhetoric rather than reality.

Although we continue to speak about the peaceful uses of outer space, it has become a question of rhetoric rather than reality. The current international space regime cannot be viewed as peaceful in a strict sense, as activities related to defensive weapons and support of military functions are carried out in outer space. The militarization of space, and the military reliance on space-based intelligence, surveillance and navigation assets, is well established and continues to grow. It is impossible to turn back time in order to preserve space for truly peaceful purposes, yet it may not be too late to prohibit space weaponization and regulate space activities to prevent offensive and defensive activities and deployments.[16]

Boundary of space

When attempting to differentiate between permitted and prohibited activities in outer space, it is essential to have an operational definition of the boundary between airspace (where certain activities are allowed) and outer space (where comparable activities are banned, restricted or otherwise regulated). Similar to the question of defining peaceful uses, the demarcation of airspace from outer space has been left to several interpretations.

In practical terms, below an altitude of approximately 69 miles (about 110km), sustained orbit is practically impossible. Above an altitude of approximately 53–62 miles (about 85–100km) aerodynamic lift is largely non-existent. However, there are aircrafts that have flown higher than 62 miles and there are satellites and other spacecrafts that pass through orbits lower than 69 miles.

While stating that outer space should be used exclusively for peaceful purposes, the OST fails to define the boundaries of the area to be kept free from military uses (the boundary between the airspace and outer space). The OST could have made a very useful contribution to the definition question had it been consistent in its use of the term ‘outer space’. The treaty sometimes speaks of outer space without any addition and in other instances of outer space as including the Moon and other celestial bodies.[17] Other fora have not had greater success. Notwithstanding the fact that the definition problem has been on the agenda of COPOUS and its Legal and Scientific and Technical Subcommittees since 1959, there have been no concrete results in regards to the demarcation of outer space. It has also been a subject of considerable debate among experts on international law and on space law, yet no consensus has emerged.

Weapons can be categorized according to deployment mode and with respect to their targets. There are weapons that can be based in space, in the air or on the ground. Similarly, these weapons can be aimed at targets in space, in the air or on the ground. For any future discussions on outer space activities, it will be essential to delimit airspace (where use of certain weapons would still be allowed) from outer space (where use of some weapons would not be). An agreed definition would eliminate the significant ‘grey area’ that has permitted the militarization of space and might one day permit its weaponization.

The utility of outer space

During the first thirty years of the space age, the main military use of space was that of communication and reconnaissance. Many experts agree that this had a stabilizing and beneficial effect on world affairs. However, there have been efforts to acquire techniques for denying enemies the ability to use space in this fashion. The United States developed projects in the late 1950s and both the United States and the Soviet Union worked on ways of dominating space throughout the 1960s and 1970s. It was not until the 1980s however, that serious prospects for more active military uses of outer space began.[18]

Yet at the same time, civil uses of space have exploded. With an estimated US$77 billion in revenues and more than 800,000 people employed worldwide in 1996, the global space industry is one of the world’s vital economic engines. Civilian space activities fuel some of the most important high-tech economic sectors: software and hardware development, sophisticated electronics, telecommunications, and advanced materials research. Furthermore, satellites have become essential to communications, navigation, broadcast, meteorology, and numerous other fields essential to our daily lives. This has therefore become one of the arguments put forward for the weaponization of outer space as these civilian assets are ‘unprotected’ and an attack on them could have very serious consequences on a technology-dependent state.

In theory, outer space could be exploited militarily in the same way that land, sea and air are. It could be utilized as a base for attacking an enemy, as a source of materials, as a vantage point for observation (the 'high ground'), and as a means of rapid movement. Current military uses of space mainly involve the use of three types of satellites: observation, communications and early warning satellites. Observation satellites are capable of generating high-resolution images, monitoring communications, and producing information concerning navigation, weather, targeting adjustments, troop movement, etc. Communications satellites allow military commanders to exercise control over distant forces and to receive real-time information about the progress of a campaign or about possible enemy actions to a degree that was previously unknown. Early warning satellites can monitor enemy territory for military activity, such as missile launches, thereby providing additional crucial minutes of response time.

ASAT and missile defence

Until now, satellites and their various uses have been known as 'force multiplier' applications. This means that their military role is one of amplifying the effect of other, more conventional forces, rather than to take action on their own. Satellites capable of attacking targets on the ground are still fantasy, although eventually they could revolutionize land warfare. However, ASAT weapons, and weapons capable of intercepting ICBMs during the space flight phase of their trajectory (i.e. ballistic missile defence or BMD) are the main weapons of concern when considering the future of outer space, as they are currently under development and will further reduce the chances of avoiding the weaponization of space.

With the development of weapon systems for attacking satellites, the dangers of warfare have been extended into outer space. An ASAT system may be based on Earth or else carried by a satellite. Ground-based ASAT weapons are of two types—missiles or high-energy laser weapons. Space-based ASAT systems concepts involve the use of satellites as weapons, conventional explosives or lasers carried on board satellites, and charged particle beam weapons. The question of ASATs is particularly difficult due to the dual-use factor. '[A]ny country with a ballistic missile capability essentially has both a space-launch and an ASAT capability as well. The technology is basically the same.'[19]

Concern over the militarization of outer space is largely emerging as a response to current American plans for ballistic missile defence.

Concern over the militarization of outer space is largely emerging as a response to current American plans for ballistic missile defence. Precedents for such concerns had arisen—and waned—with the Strategic Defence Initiative (SDI) envisaged by the United States in the 1980s, which was scaled down in the 1990s with such projects as GPALS (Global Protection Against Limited Strikes). In 1997 the United States Space Command published *Vision for 2020*[20] which laid out such concepts as 'the ability to dominate space' and 'the application of precision force from, to, and through space'.

At the time the Clinton Administration and armed forces said that the ideas explored in *Vision for 2020* were only part of a future-looking exercise. However, in 2000 President Bush asked Donald H. Rumsfeld to chair a commission to develop plans for America's activities in space. In January of 2001 the Commission to Assess United States National Security Space Management and Organization (known as the Space Commission) issued a report that went much further than *Vision 2020* in terms of scope and policy relevance.[21] Recommendations from that report are currently being implemented. The United States has committed to building a missile defence system that will protect the United States against limited ballistic missile threats, including accidental or unauthorized launches or rogue threats.

The United States Missile Defense Agency's plans and deployment activities hinge on the notion of an 'evolutionary' missile defence system—no longer dubbed 'national' in order to convey the intention to provide protection for allies or friends rather than just for the United States territory. The overall architecture of this system is not preordained. Instead, following the deployment of initial elements in 2004–2005, it will 'evolve' as the testing and performance of various technologies proceeds. Whether such an evolutionary system involves elements of space weaponization is thus not certain, but neither is it in any way foreclosed.

The United States Missile Defense Agency's plans and deployment activities hinge on the notion of an 'evolutionary' missile defence system—no longer dubbed 'national' in order to convey the intention to provide protection for allies or friends rather than just for the United States territory.

According to these American policy documents and others, military space capabilities are to become the foundation for its national security and military strategies. The declared objective of the United States is complete space superiority.

A BMD system is based on target-detection, recognition, tracking and destruction systems. In the past these tasks have mostly been performed by ground-based radar sensors and by target interceptors armed with nuclear warheads. As such systems have numerous vulnerabilities, the United States perceives the need to further develop its BMD systems, thereby reducing a part of their vulnerability by placing them 'out of reach'. However, it should not be forgotten that space surveillance and spacecraft command and control systems, ground receiving stations and space surveillance networks have sensitive ground-based components and are vulnerable to attack.[22]

Since the withdrawal of the United States from the ABM Treaty in 2002, 'there is no longer a treaty prohibition against testing or deploying weapons in space other than weapons of mass destruction.'[23] However, there are elements of the missile defence plans of the United States, such as space-based interceptors, that would necessitate the withdrawal from or modification of international treaties before their deployment. Its withdrawal from the ABM Treaty in 2002 was a clear signal of America's commitment to moving ahead with space-based weapon options by removing obstacles in its path.

Different conceptions of BMD have different implications for space militarization and weaponization. Existing American, Russian or Israeli systems (the Arrow 2) involve space-based elements for communication and detection, but no actual weapons in space. Some ground- or air-based interceptors (whether kinetic-kill vehicles or lasers, for example), however, have ASAT capabilities, and future interceptors based in space would constitute a clear weaponization of outer space. But existing international law does not prevent the development of two types of space-based weapons: kinetic-energy weapons (KEW) and directed energy weapons (DEW). KEW 'kill' by hitting another object at a very high speed, and to increase their effectiveness, they may also include chemical explosives. DEW focuses energy beams at the speed of light to destroy a target.[24]

The close connection between missile defences and outer space is therefore a complex challenge for arms control in the absence of any international legislation governing non-nuclear weapons in space.

Arms control responses

The development and testing of new technologies is leading the United States towards the space weaponization threshold. The development and proliferation of new technologies applicable to ASAT and BMD systems and of new states with missile capabilities create a temptation to forge an arms control regime based on broad generic definitions and technical demarcation, on the presumption that the broader the terms of restriction, the better it will cope with the variety of technologies and the differing levels of technical capacity among various programmes.

It is probable that those opposed to the weaponization of space will argue for an ASAT ban as the most urgent step.[25] However, 'there is a strong relationship between ASAT and BMD technologies and the technical, political and diplomatic action taken in one sphere will almost certainly affect the other'.[26] The pursuit of missile defence by the United States further complicates the issue of differentiating between the testing and deployment of ASAT and BMD. Because of this linkage and the single-minded pursuit of missile defence by the United States, some fear that an ASAT ban is now out of reach, and the question of weapons in space requires to be addressed in a comprehensive manner,[27] as it is easier to exclude armaments than to eliminate or control them once they have been introduced.[28]

The pursuit of missile defence by the United States further complicates the issue of differentiating between the testing and deployment of ASAT and BMD.

Conclusion

Despite lofty commitments, the world failed to maintain outer space for peaceful purposes. Militarization of outer space has been a *fait accompli* since the beginning of the space exploration age. Until now space objects have only acted as force multipliers, however we are approaching the threshold of space weaponization. We have managed to transcend the heavens, a task long seen as impossible, yet we have done little to prevent the militarization of space. We have the opportunity and responsibility to prevent its weaponization.

Notes

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Monsters and shadows: left unchecked, American fears regarding threats to space assets will drive weaponization

Theresa Hitchens

It is clear that the United States Department of Defense, and the administration of President George W. Bush, is increasingly concerned by the perception of growing threats to American space assets. This threat perception is driving a concerted effort to develop a more aggressive American military posture regarding space, including the consideration of space-based weapons.

Indeed, Condoleezza Rice, Bush's national security adviser, in May 2002 launched a review of American space policies—the first since 1996—because 'space activities are indispensable' to American 'national security and economic vitality'.[1] It is quite possible that this review will result in overturning the traditional American restraint regarding deployment of space-based weaponry. This is especially true given the Bush Administration's current plans for missile defence, which envision space-based missile interceptors (both kinetic kill and laser) within the next decade or two.

While the 'space gap' between the United States and other countries is narrowing, there is some reason to ask whether the current American threat assessment is overly pessimistic. It also is clear that other space-faring countries, including the Russian Federation and America's European allies, are far less concerned about threats to their own assets—although perhaps this is because the United States remains more dependent on use of space for both commercial purposes and global military power projection.

According to the Stockholm International Peace Research Institute, the United States at the end of 2001 had nearly 110 operational military-related satellites, compared to 40 for the Russian Federation and 20 for the rest of the world combined.[2] The United States is also a global leader in the commercial uses of space, with the American military being a prime consumer of commercial satellite communications capabilities. Indeed, according to the French space agency, the United States devotes six times more government funds to space than Europe.[3]

Even if a reasonable case can be made that the current and potential future threats to American space assets require stronger military response measures, it is unclear whether space-based weapons are the right answer for either American or global security. Not only are there a number of direct protective measures available for American space assets short of the development of new weaponry, there are also arms control options that could be considered. Indeed, most members of the United Nations are interested in negotiating a treaty to ban the deployment of weapons in space.

In the light of the emerging policy direction in Washington, however, it is imperative that the international community seriously begin to consider the issues surrounding the weaponization of space. At a minimum, it would behove the space-faring nations of the world to actively start discussions with the United States regarding threat perceptions and risk management approaches, as well as future

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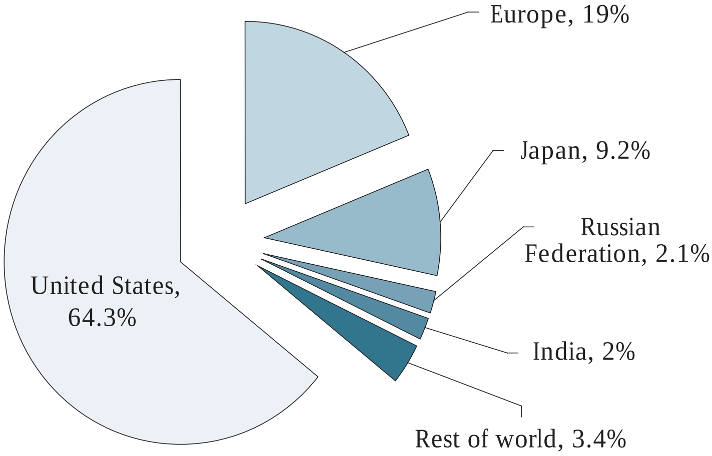
'rules of the road' for the use of space that take into account the growing importance of space-based assets for global prosperity and security. Waiting for Washington to decide a policy path regarding space-based weapons before beginning such discussions will be too late.

World government civil space budgets in 1999



Source: CNES, *2001–2005 Strategic Plan*

American threat perception—driven by vulnerabilities

American intelligence officials are convinced, and have said publicly, that the threat to American military dominance in space is growing. Navy Vice Admiral Thomas Wilson, director of the Defense Intelligence Agency, testified during a 19 March 2002 hearing of the Senate Armed Services Committee that potential adversaries would have significant means to disrupt American space systems by 2010—citing efforts abroad to explore directed energy weapons (lasers), methods of attacking satellite ground stations, jamming and computer attacks.[4]

During the same hearing, CIA Director George Tenet said the development of increasingly sophisticated reconnaissance satellites by countries such as China and India—as well as the growing commercial market in communications, navigation and imagery—is eroding the American military edge in use of space.[5]

In fact, concerns about threats to American space assets were highlighted very early in the current administration's tenure, with the January 2001 release of the report of the Commission to Assess United States National Security Space Management and Organization, better known as the Space Commission. The study, originally chaired by Donald Rumsfeld, the current American defence secretary, warned that the United States could face a 'Space Pearl Harbor' if a myriad actions were not taken to improve the security of space assets. Noting that the United States is more dependent on the use of space than any other nation, the Space Commission report stated:

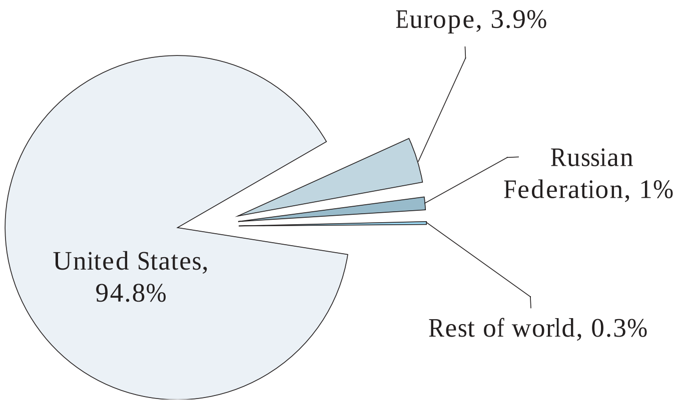
> Assuring the security of space capabilities becomes more challenging as technology proliferates and access to it by potentially hostile entities becomes easier. The loss of space systems that support military operations or collect intelligence would dramatically affect the way American forces could fight, likely raising the cost in lives and property and making the outcome less secure. American space systems, including the ground, communication and space segments, need to be defended in order to ensure their viability.[6]

Dependence

The simple fact is that the American military could not operate the way it does today, on a worldwide basis, without the use of space. In particular, intelligence gathered via imaging and electronic eavesdropping satellites, instantaneous communications, and the use of satellite navigation tools to guide precision-weapons have totally reshaped the American way of war over the last decade. Indeed, Rumsfeld has recently asked senior Pentagon officials to assess whether the military is *overly dependent* on space systems.[7]

The United States outspends the rest of the world by vast amounts in the military space arena, accounting for 94.8% of global military space budgets in 1999.[8]

World military space budgets in 1999



Source: CNES, *2001–2005 Strategic Plan*

And there is a nearly insatiable demand among the American military services for more bandwidth as networking the battlefield, from mobile forces in the field to strategic bombers at home, has become a key goal of the Pentagon effort to transform American military operations to better meet the challenges of global engagement in the post-Cold War world. For example, the demand for access to the radio spectrum in Afghanistan for use in such tasks as guiding unmanned aerial vehicles exceeded the bandwidth available. According to the House Government Reform Committee, 'Satellite bandwidth used in Operation Allied Force in Kosovo was 2.5 times that used in Desert Storm, while forces used were only one-tenth the size'—and the Pentagon's spectrum requirements for mobile communications are expected to grow by 90% by 2005.[9]

'Today, information gathered from and transmitted through space is an integral component of American military strategy and operations. Space-based capabilities enable military forces to be warned of missile attacks, to communicate instantaneously, to obtain near real-time information that can be transmitted rapidly from satellite to attack platform, to navigate to conflict area while avoiding hostile defenses along the way, and to identify and strike targets from air, land or sea with precise and devastating effect', states the Space Commission report.[10]

While many military satellites have built in certain types of protection, such as hardening against electro-magnetic radiation that would be emitted from a nuclear weapon burst, commercial satellites have little protection. In fact, a key concern for the American military is the vulnerability of communications satellites providing such services as television broadcasting, mobile telecommunications and Internet access. This is because the American military relies on commercial providers for about 60% of its communications needs.[11]

Furthermore, Tenet has just directed American intelligence agencies to use more commercial imagery for mapping, and other purposes.[12] This is in part because so-called national technical means, the nation's spy satellites, are being overtasked by the 'war on terrorism'.

More global access

Another simple reason for American military concerns is that there are a growing number of countries with space-based capabilities, numbering today at over fifty. There are about 600 functional satellites in Earth orbit, the vast quantity of them for commercial uses. The technologies involved, from telecommunications to satellite tracking to imaging, are becoming more sophisticated and more widely available.

According to a senior Air Force official, there are eight or ten countries seriously involved in using space assets for military purposes. These include the Russian Federation, China, France, the United

Kingdom, India, Japan, Israel and Brazil, among others, he said. Pentagon officials also assert that a number of these countries are also pursuing new types of space technology, such as microsatellites, that could be used as space-based weapons.

In addition, new commercial technology that could be put to military uses, especially high-resolution commercial imagery and satellite navigation/positioning equipment, is becoming widely available on the open market.

For example, in an unprecedented move, the Pentagon in late 2001 entered into an exclusive contract with American firm Space Imaging to buy up all the imagery of Afghanistan taken by the firm's Ikonos satellite to prevent global media firms from obtaining pictures of American bombing during Operation Enduring Freedom.[13] This move prompted discomfiture in some other parts of the world. Because the United Arab Emirates, a Space Imaging customer, was directly affected by the Pentagon buy, the six countries of the Gulf Cooperation Council are now considering buying their own imaging satellite rather than rely on American commercial providers.[14] Besides the United States, France, Israel and the Russian Federation already are in the imagery satellite business.

American military officials also are worried about the future availability of data from the European Union's planned Galileo navigation satellite network—and have been in discussions about the issue with European officials.[15] American officials have been trying to reach an agreement with the European Union that navigation and positioning data will be denied to certain parties if requested by the United States.

Many American military and political leaders are convinced that, given the dissemination of technology, warfare in space is unavoidable, and that it is thus necessary for the United States to be prepared to conduct and win wars in space.

'I believe that weapons will go into space. It's a question of time. And we need to be at the forefront of that', Pete Teets, undersecretary of the Air Force and director of the National Reconnaissance Office, told a 6 March 2002 conference in Washington.[16]

The prevailing wisdom in all branches of the services is that 'conflict in space is inevitable'.

While Teets, who is now the Pentagon's lead official for procurement of space programmes, was careful to say that no policy decision to put weapons in space has yet been made, his views reflect a consensus among top Air Force leaders—and indeed, among military officials across the board. Again, the prevailing wisdom in all branches of the services is that 'conflict in space is inevitable'.[17]

Vulnerabilities

The vulnerabilities of American military space assets and capabilities, and thus the *potential* threats, can be catalogued in several ways.

First of all, there are numerous types of military satellites in varying orbits—thus with varying vulnerabilities. Perhaps most vulnerable, simply because of their position in orbit, are those satellites in Low Earth Orbit (LEO), usually characterized as those below 1,000 miles (1,667km) above the Earth. There are at least twenty-four American military reconnaissance, electronic intelligence and meteorological satellites in LEO, according to Al Saperstein, a visiting scientist at the Union of Concerned Scientists and a physicist at Wayne State University.[18] Such satellites would be relatively easily reached by a ground-based anti-satellite weapon (ASAT) deployed on even an intermediate range ballistic missile. American military officials have also publicly worried about the possibility that a rogue state or sub-national actor could detonate a nuclear weapon in LEO, wreaking global havoc.

The American satellite navigation network known as the Global Positioning System (GPS), used for everything from setting atomic clocks to guiding precision weapons to targets, has its satellites parked in what is known as Medium Earth Orbit (MEO) at 12,865 miles (21,000km).[19] These have semi-synchronous orbits, passing over the same spot on Earth once a day. The Russian Glonass system also is in this orbital zone, as will be Galileo.

While higher up and thus harder to reach, the Pentagon (and Congress) is highly concerned about inherent vulnerabilities in the twenty-four satellite GPS network. For example, a September 2001 report by the United States Department of Transportation, *Vulnerability Assessment of the Transportation Infrastructure Relying on the Global Positioning System*, highlights the fact that the GPS network is easily disrupted in part due to its low power signals and because its characteristics are well known due to its civil uses.[20] The Space Commission noted that Russian-made, handheld jamming devices are already available that can block GPS receivers for up to 120 miles (193km). And, of course, the orbits of the individual satellites are stable and predictable. The GPS network is being improved to better protect it against jamming, and a newer model network is in the works, known as GPS III and expected to be fully deployed in the 2018 timeframe, that will have more satellites to improve redundancy.[21]

There are twenty-nine or more American military satellites in geosynchronous, or geostationary, orbit (GEO) around the Earth's equator at 22,300 miles (35,888km) in altitude. These pass over the same spot on Earth every twenty-four hours.[22] These include the hardened early warning satellites originally designed to watch for Russian nuclear missile launches. There are also numerous communications satellites used worldwide in this orbit. This orbit is harder to reach, but nonetheless China, France, India, Japan and the Russian Federation have launch vehicles that can place satellites in this orbit (and have done so), and thus could conceivably be used to launch ASATs.

The Space Commission report also includes extensive analysis (in an annex) of the possible vulnerabilities of American space assets, especially commercial satellites and communications grids. 'The reality is that there are many extant capabilities to deny, disrupt or physically destroy space systems and the ground facilities that use and control them'.[23]

Threatening technologies

The Space Commission annex, 'Threats to United States Space Capabilities', looks at threats based on types of technology available to potential adversaries. These are categorized as space object tracking and identification capabilities, and offensive counterspace operations.

Space object tracking and identification

'Foreign knowledge of U.S. space operations is a necessary precursor to the successful conduct of counterspace operations or camouflage, concealment, and deception activities', states the Space Commission annex.[24]

The annex cites a number of ways an adversary could track, and thus potentially target, an American satellite. These include the availability of tracking data by amateur satellite observers posting their findings on the Internet; the proliferation of air and theatre missile defence radar which can track satellites in LEO; and the increasing sophistication of sensor technology (radar, optical telescopes, passive radio frequency and even satellite signals intelligence receivers) and its wide commercial availability.

Offensive counterspace operations

The Space Commission threat annex defines offensive counterspace operations as 'the use of lethal or non-lethal means to neutralize an adversary's space systems or the information they provide.'[25] Using United States Department of Defense terms, it lists five major goals of such operations:

- deception—manipulate, distort or falsify information;
- disruption—temporary impairment of utility;
- denial—temporary elimination of utility;
- degradation—permanent impairment of utility; and
- destruction—permanent elimination of utility.[26]

There are basic types of attacks against satellites and satellite operations, according to the threat annex: 'denial and deception; attack or sabotage of ground segments; direct anti-satellite (ASAT) attack; and electronic attack on the communications, data, and command links of [either] the satellites or ground stations'.

Ground station attack

Currently, the simplest way to attack satellites and satellite-based systems involves ground-based operations against ground facilities. Many of these facilities are not heavily protected: a truck bomb would suffice, or an attacker could use computer network intrusion.

Hacking and jamming

The other relatively simply method is disruption of computerized downlinks between satellites and ground stations. Hacking and jamming also are the least expensive options for anyone interested in disrupting space-based networks, because they do not require putting anything into orbit. The high cost of space launch (ranging between US$5,000 and $10,000 per pound) is not a trivial matter, even for space-faring nations such as the Russian Federation and China, much less for 'rogue' states such as North Korea or non-state actors.

Incidences of computer hacking against American military, financial and industrial networks continue to rise and several countries, including China, are known to be exploring information warfare capabilities. Many countries already have developed military electronic jamming systems (including the Russian Federation, China, Iran, Cuba, Iraq and North Korea) and that technology is becoming widely available even on the commercial market.

Nuclear burst

With regard to the direct ASAT threat, there is broad agreement in the American expert community that the detonation of a low-yield nuclear weapon in LEO will kill nearby satellites through the electro-magnetic pulse (EMP). Perhaps more troubling is that such an explosion would also degrade most others in LEO orbit over a few months time by seeding the Earth's Van Allen belts with highly charged electrons that increase the ambient radiation exposure of satellites passing through the belts to such a degree that their electronic components ultimately fail. Further, this excess radiation could linger in the Earth's magnetic field for years, so satellite replacement would be futile for some time.[27] Such an attack would be available to any country with intermediate range ballistic missiles and nuclear weapons, including India and Pakistan and possibly Iran.

Microsatellites

Pentagon officials also often cite the emergence of microsatellites and nanosatellites, using light-weight composites and high-speed computer chips, as a key potential threat. Microsatellites are usually defined as those weighing less than 100kg, nanosatellites as those weighing less than 10kg. 'These micro/nanosatellites, when employed as unacknowledged secondary payloads, can covertly rendezvous with other space assets to perform satellite inspection and other missions to disrupt, degrade or destroy space assets. Small, low-powered, ground-based lasers can be used to blind optical satellites in orbits out to GEO. With advances and proliferation in standoff weapons technologies, laser, radio frequency and particle beam weapons will likely be available to adversaries in the coming decades', the Space Commission threat annex states.[28]

According to the Space Commission report, companies in the United States, the United Kingdom, the Russian Federation, Israel, Canada and Sweden are involved in maturing microsatellite technology.[29]

The United Kingdom is a leader in microsatellite technology, and technology developed by the University of Surrey has been shared with a number of countries including China, Pakistan, Chile, Thailand and Malaysia, according to the Space Commission threat annex.[30] Indeed, Pentagon officials routinely cite Chinese press reports that Beijing is working on a nanosatellite ASAT system, although the Chinese government's official position is that ASAT weapons should be barred. There obviously is discussion of the issue in China. For example, a 5 July 2000 article in China's official news service in Hong Kong stated, 'For countries that can never win a war with the United States by using the method of tanks and planes, attacking the American space system may be an irresistible and most tempting choice. Part of the reason is that the Pentagon is greatly dependent on space for its military action'.[31]

ASAT interceptors

Besides emerging microsatellite technology, the Space Commission threat annex lists the following types of ASAT interceptors as possible and potentially available to those wishing to target American space assets directly: low-altitude direct-ascent interceptors, low-altitude short-duration orbital interceptors, high-altitude short-duration orbital interceptors, and long-duration orbital interceptors. 'These weapons are typically ground- or air-launched into intercept trajectories or orbits that are nearly the same as the intended target satellite'.[32] Obviously, low-altitude direct-ascent interceptors ground-launched or air-launched against LEO satellites would be the simplest, and cheapest, type of ASAT to develop.

The latter category of long-duration orbital ASATs, those that are launched into a 'storage' orbit for months or years (either on their own, or carried on a 'mothership' satellite), is further broken down to include the following concepts:

- Farsats—parked in a storage orbit some distance from their targets and manoeuvrable to engage on demand;
- Nearsats—deployed close to their targets to inspect and attack on demand;
- Space mines—deployed in orbits that intersect targets' orbits and detonated during a close encounter;
- Fragmentation or pellet rings—vast quantities of small, non-manoeuvring objects dispersed from one or more satellites to create a ring, so that any satellites moving through the ring would be damaged or destroyed; and
- Space-to-space missiles—rocket-propelled ASAT interceptors launched from an orbiting carrier platform to intercept their targets.[33]

Exotic ASATs

Finally, on the high-end of the scale for complexity and difficulty, the threat annex lists laser ASATs, radio frequency ASATs (both high power microwave and ultrawideband, also known as video pulse), and particle beam ASATs as potential future weapons. However, the threat annex is careful to categorize these technologies, for the most part, as difficult, expensive and far away from maturity.[34]

Threat assessment: more than capabilities

It is obvious that American space systems do have inherent vulnerabilities. It is also obvious that technologies for exploiting those vulnerabilities exist, or are likely to become available over the next several decades. However, neither vulnerabilities in American systems nor the potential capabilities of others necessarily translate into *threats*. In order to threaten American space assets, a potential adversary must have not only the technological *ability* to develop weapons and the *means* to develop and use them, but also the *political will* and *intent* to use them in a hostile manner. There is little evidence to date that any other country or hostile non-state actor possesses both the mature technology and the intention to seriously threaten American military or commercial operations in space—and even less evidence of serious pursuit of actual space-based weapons by potentially hostile actors. There are severe technical barriers and high costs to overcome for all but the most rudimentary ASAT capabilities, especially for development of on-orbit weapons. It further remains unclear what political drivers—outside of American development of space-based weaponry—would force American competitors, in the near- to medium-term to seriously pursue such technology.

***Neither vulnerabilities in American systems nor the potential capabilities of others necessarily translate into* threats.**

Moreover, there is little public concern voiced by other space-faring nations, including American friend and allies, about potential threats to their space-based assets—although China and the Russian Federation are uncomfortable with the possibility that the United States might deploy ASAT capabilities. This may be explained by the fact that no other nation's military and commercial operations are so space-dependent, but it also may be that these nations simply do not see the emergence anytime soon of a credible threat.

Indeed, most other countries are more concerned about the threats to global space systems from the possible *weaponization* of space, thus the widespread international interest in a space weapons ban. Key concerns include the creation of debris from testing or actual warfare, and space traffic control as orbital positions become more crowded. Debris is considered perhaps the most critical near-term issue, according to many space scientists. Even tiny pieces of debris can damage or kill satellites, and there are several ongoing efforts to find ways to mitigate creation of space debris—in fact, the United States is a leader in this arena, having developed national guidelines for debris mitigation applicable to both commercial and military space activities.

As noted, there are scattered reports of Chinese interest in ASAT technologies, but evidence of actual progress is scant. The Russian Federation, like the United States, has explored ASAT technology since the beginning of the Cold War, but there is little reason to believe that Moscow has changed its policy against deploying such weapons (the Russian Federation has had a unilateral ban on ASAT testing for some time), especially given the current cash-starved state of the Russian space programme. No other country has shown visible signs of interest (although obviously any space-faring nation, such as India or Pakistan, has latent capability).

'[C]laims of adversarial space weapons are simply unfounded. Military futures studies often cite predictions of foreign space-based particle beams and other such technologies, but in reality they merely provide paranoid justification for U.S. space programs. … The overwhelming evidence suggest that, unprovoked, the rest of the world is simply *not* interested in space weaponization at this time', states former Air Force Lt. Col. Bruce M. DeBlois in a 1998 study.[35]

Similarly, a 1998 RAND study found that no 'nation possesses an operational ASAT capability that poses a significant threat to U.S. national security space systems'.[36] This has not changed in the past four years, despite rapid improvements in enabling technologies—especially for ground-based ASATs and computer-based disruption. Again, while these sorts of technologies are increasingly available, development of working ground-based ASAT systems would not be all that simple or all that cheap. Ballistic missiles are hard to operate and maintain, and they are easy for potential adversaries to keep an eye on. Hacking is more of a worry, but satellite networks (especially American military networks) are equipped with computer protections (and those are upgraded on a regular basis).

The barriers to development and deployment of actual space-based weapons are much, much higher, even for the American military. There are fundamental technical obstacles to the development of kinetic kill weapons and lasers both for use against targets in space and terrestrial targets, and the costs associated with launch and maintaining systems on-orbit are staggering.

There are fundamental technical obstacles to the development of kinetic kill weapons and lasers both for use against targets in space and terrestrial targets, and the costs associated with launch and maintaining systems on-orbit are staggering.

For example, problems with lasers include power generation requirements adding to size, the need for large quantities of chemical fuel and refuelling requirements, and the physics of propagating and stabilizing beams across long distances or through the atmosphere. Space-based kinetic energy weapons have major challenges, too, including achieving proper orbital trajectories and velocities, the need to carry massive amounts of propellant, and concern about damage to one's own forces from debris resulting from killing an enemy satellite. Space-based weapons also have the problem of vulnerability, for example, predictable orbits and the difficulty of regeneration.

A detailed discussion of the technology challenges is beyond the scope of this paper, but a good primer on the innumerable problems with developing space-based weapons is a September 1999 paper by Maj. William L. Spacy II, 'Does the United States Need Space-Based Weapons?' written for the College of Aerospace Doctrine, Research and Education at Air University, Maxwell Air Force Base, Alabama.

A new study by RAND's Project Air Force, *Space Weapons/Earth Wars*, also details technological challenges to various types of space-based weapons that might be used against terrestrial targets. The study further lists several general limitations of space-based weapons and defences, explaining that space weapons face exactly the same vulnerability problems that satellite networks do.[37] The truth of the matter is that technology (not to mention cost) is a crucial limiting factor for the development of satellite networks, ASATs and space weapons—and explains why only a limited number of countries are now so capable.

Intent

As noted, in undertaking a threat assessment, there is also the question of intent of potential adversaries. It is not obvious, from unclassified sources at least, that any nation has any intention, or even incentive, to launch a war in space or attack American space systems. As noted, most countries, including China and the Russian Federation, have been urging a global ban on weapons in space. Many experts, including a number of Air Force strategists, persuasively argue that an American move to put offensive weapons in space could have the perverse effect of creating a new threat to American space assets because other countries would feel compelled to follow suit.[38]

Many experts, including a number of Air Force strategists, persuasively argue that an American move to put offensive weapons in space could have the perverse effect of creating a new threat to American space assets because other countries would feel compelled to follow suit.

China

As noted above, there have been sporadic reports regarding China's interest in disruption of American space-based capabilities. At least in the open literature, there seems to be some argument among Chinese military officials and experts about the best course to chart regarding space. China has many fewer space assets than the United States, despite ambitious plans for the future of its space programme. China is the third nation to develop a manned civil space programme, albeit many decades after the United States and the Russian Federation. Many observers, however, believe China will emerge as a major space power. 'China is set to become a major space power pursuing regional and intercontinental objectives. It could be the world number two in space by 2020', according to the year *2001–2005 Strategic Plan* of France's space agency, the Centre National d'Etudes Spatiales (CNES).[39]

That said, China's official position regarding space weapons is that ASATs and space-based weapons should be banned under a multinational treaty. Indeed, China has been pushing for a treaty on the non-weaponization of outer space since the late 1980s, driven in part by the United States Strategic Defense Initiative and its follow-ons. Chinese military officials also expressed concerns following the Persian Gulf War about the American military's ability to use satellites to amplify American military superiority on the ground in a way not seen before. According to Li Bin, director of CDI-Tsinghua Program on Cooperative Security in Beijing, Chinese arms control officials say they believe space weapons would be detrimental to world security, not just Chinese security.[40]

In recent years, China has been a key proponent of negotiating such a ban within the United Nations Conference on Disarmament (CD), in talks known as PAROS (Prevention of an Arms Race in Outer Space). At the 7 June 2001 meeting of the CD in Geneva, Chinese Ambassador Hu Xiaodi said such negotiations are urgently needed because of American missile defence and space-control plans, and presented a working paper describing potential elements of such a treaty.[41]

That working paper, 'Possible Elements of the Future International Legal Instrument on the Prevention of the Weaponization of Outer Space', includes concepts such as: 'the prohibition of testing, deployment, and use of weapons and weapon systems and their parts and components in outer space; and the prohibition of testing, deployment and use of weapons, weapon systems and their parts and components from outer space against targets on land, sea and air', according to Cheng Jingye, deputy director of the Arms Control Department at the Chinese Ministry of Foreign Affairs.[42]

In 2002, China followed up with a joint paper with the Russian Federation, presented to the CD at the 28 June meeting.[43] According to Cheng, China strongly believes negotiations on such a treaty are urgently needed within the body. 'China is of the view that introducing weapons into space will not contribute to the goals of ensuring space security or reducing space vulnerabilities. Rather it will lead to an arms race in space, which will then be turned into another battleground, thus endangering our dependence on space'.[44]

At the same time, however, some influential thinkers in China have argued that the revolution in military affairs requires China to now consider its options in space. Some maintain that space warfare with a superpower should be a Chinese concern, and that China needs anti-ASAT technology, smaller satellites to reduce vulnerability and first strike capabilities in space.[45]

According to the Pentagon, China already has jamming technology and may be developing ASAT capabilities, including a ground-based high-energy laser and other lasers to blind optical satellites.[46]

However, as indicated, much of China's interest in space seems to stem directly from concerns about American military activities in space. According to the Nuclear Threat Initiative, China's worries about protecting its space-based assets are due to concern about American development of missile defences and future American global dominance as a result of American space power.[47] Indeed, at the 7 February 2002 meeting of the CD, Hu specifically mentioned American actions as a key reason that negotiations on the weaponization of space should commence quickly. 'Now that the ABM [Anti-Ballistic Missile] Treaty has been scrapped and efforts are being stepped up to develop missile defence and outer space weapon systems, there is an increasing risk of outer space being weaponized', he said.[48]

The Russian Federation

As a long-time space power, the Russian Federation is highly concerned about maintaining the integrity of both its military and commercial space capabilities. However, that concern emanates less from worries about external threats to its assets, and more from the fact that the Russian space programme has deteriorated due to lack of funding. In June 2001, Yuri Koptev, head of Russian space agency Rosaviakosmos, told the parliament that age and lack of funds were serious issues, with sixty-eight of the Russian Federation's ninety orbiting satellites near or at the end of their operational lives.[49] He further stated that many of the country's forty-three military satellites were simply too old to be considered reliable, and criticized the Russian Federation's meagre space budget of US$193 million as only half of what the agency needs.

Indeed, in May 2001, the Russian Federation for a short time lost its photo-reconnaissance capabilities, taking its last two satellites out of orbit (although a replacement 'Kobalt' satellite was launched in June 2001).[50] the Russian Federation's Glonass satellite navigation system (similar to the American GPS network) also is deteriorating; in March 2001, Koptev told parliament that only thirteen of the twenty-four satellites required for the network to fully function were working.[51]

Attempting to reverse the decline, the Russian Federation's Security Council moved in May 2001 to re-establish an independent military space force combining all its military space programmes as well as coordinating commercial ventures.[52] Still, the Russian Federation's space programme continues to be dogged by underfunding and decrepit equipment. This, rather dangerously, includes is missile warning satellite networks.

Russian Defence Minister Sergei Ivanov, in February 2002, said that the Russian Federation has 'been short of space assets and to build normal modern armed forces when you are blind and deaf is futile. … We plan to replenish the group of our satellites, notably for the purpose of information, communications and intelligence'.[53]

At the same time, since the dawn of the Cold War the Russian military has been interested in ASAT capabilities. The Soviet Union began work in the early 1960s on a non-nuclear co-orbital ASAT, and ran a number of tests on the system between 1968–1971. After a four-year hiatus, the Soviets restarted ASAT testing in 1976 and continued up until 1981, despite the launching of ASAT talks by the administration of American President Jimmy Carter in 1978.[54]

In addition, the Russian Federation (again, like the United States), has researched ground-based laser ASAT capabilities since the 1980s. According to the 2001–2002 *Jane's Space Directory*, 'For years, Western observers have held that the Sary Shagan and Dushanbe lasers may be capable of damaging passing satellites' sensitive components. Although weather and atmospheric beam dispersion may limit such ground-based lasers, they have the advantage of being able to refire and thus disable several satellites'.[55] An American congressional delegation toured Sary Shagan in 1989, however, and was told by the Soviets that the facility was used only for tracking, Jane's continues.

Despite the work on laser ASATs in the mid-1980s (and possible testing of the Dushanbe laser in 1986), the Soviets in 1983 declared a unilateral moratorium on deploying ASATs, provided no other country deployed. Post-Soviet Russia has reiterated this policy. The 2001–2002 *Jane's Space Directory* notes the status of the Russian ASAT programme as 'inactive'. Indeed, as noted above, the Russian Federation is a key supporter of the PAROS talks and a ban on both ASATs and weapons in space.

Russian military officials, however, have expressed concerns similar to those expressed by their Chinese counterparts about future plans of the American military. Col.-Gen. Anatoliy Perminov, appointed in 2001 as the commander of the new Russian Space Forces, said that the international community 'should be on guard regarding the American policy of the military utilization of outer space. The military-political leadership of the United States continues to have plans to … create a missile defense system using space-based elements, and launch a chemical laser into space'.[56] He also cites American military doctrine and space policy as 'reserving the right to employ force to conduct military operations in space, through space and from space', as of concern.

And certainly, the Russian space establishment is technically accomplished enough that, given sufficient funding—which is a very large if in the near- and medium-term—new research programmes could be brought up to par with American efforts. According to CNES, 'Russia has succeeded in maintaining most of its space systems skills base by entering the commercial marketplace. However, it is also continuing with the cutbacks in government programmes already well underway in the 1990s as it is forced to confront its enduring economic problems. We can nevertheless expect to see a renewed willingness to sponsor military space programmes in the decade ahead, particularly in response to U.S. ballistic missile defense initiatives'.[57]

Perminov, however, denied that the creation of the Russian Space Forces signalled the intent by the Russian military to mimic American space weapons aspirations. 'Russia has never had and does not have any plans to create and place in orbit any space systems with weapons on board'. Instead, he said, Russian Space Forces were 'dictated by the real rise in the role of national space complexes and systems in providing information support for the activity of the armed forces of Russia, and is a highly important element for the further reinforcement of the country's defense and security'.[58]

Europe, Israel and other nations

Unfortunately, there seems to be little open research on other nation's threat assessments regarding space. One European defence official noted that while there has been some discussion at least in British military circles about concerns regarding hacking and jamming of space assets, there simply has not been much attention to the problem. A British official echoed that not only his nation but also the other European countries have much more pressing military needs and have simply not seriously addressed the issue of threats in space. Likewise, according to Yiftah Shapir of the Jaffee Center for Strategic Studies at Tel Aviv University, no one in Israel is addressing the question in open literature.[59]

Indeed, Europe's two major space powers, the United Kingdom and France, are primarily focused on civil space—indeed, the military in both nations is a secondary partner within the two nations' space agencies. As for the 'lesser' or 'emerging' space powers, it is interesting to note that while Israel has focused on satellite surveillance for military purposes, India has taken a strictly civil approach focusing on using space assets for support of national economic and social development, and mitigating natural disasters.

France

France is arguably Europe's major space power, and indeed, the driving force behind Europe's collective space endeavours under the European Space Agency and the European Community. France's CNES was formed forty years ago and serves both as a space agency and a technical centre. While primarily a civil agency, it is overseen by both France's Ministry of Research and the Ministry of Defence. Military space efforts are coordinated by the Space Coordination Group, chaired by the French chief of staff and with participation by the defence procurement agency, the DGA. France is active in a wide variety of space efforts, from launch (Ariane) to Earth observation (SPOT and the civil/military Helios) to telecommunications and space exploration, and is a major player in the European effort to build Galileo.

According to the *2001–2005 Strategic Plan*, France sees the military roles of satellites as:

> Gathering strategic and operational intelligence anywhere, in all weathers and at frequent revisit intervals, to provide information about current or nascent conflict situations. Such information is acquired by military and commercial optical and radar satellites serving a spectrum of applications spanning intelligence, imagery and awareness of the air, land and sea environment. Lastly, electro-magnetic intelligence, space surveillance and early-warning systems now offer the ability to prevent attacks on national territory and to identify forces projected to remote theaters of operation.
>
> Distributing information via geostationary satellites and constellations of low-Earth (LEO) and medium-Earth (MEO) satellites, to complement or back up terrestrial networks and undersea cables.
>
> Delivering continuous information services such as navigational and location aids, and providing a reference for timing and synchronization.[60]

Nowhere does the CNES strategy document discuss threats to space assets, although France and the European Space Agency are active on the issue of space debris. Indeed, the strategy seems primarily aimed at commercial aspects, especially the viability of the French and European space industry. This is similar to publicly available European Space Agency strategy documents—CNES states that while the American space strategy 'is geared towards military uses of space and human spaceflight', the European strategy is 'tailored more to supporting sustainable development, managing the environment, and social and economic spinoffs'.[61] Interestingly, while the strategy discusses the Chinese, Russian, Indian and Japanese space programmes, it is with an eye to both commercial competition and future cooperation—for example, noting the likelihood of growing international interdependence with regard to space launch because of the difficult market and the growing influence of international industry consortia.

While the American space strategy 'is geared towards military uses of space and human spaceflight', the European strategy is 'tailored more to supporting sustainable development, managing the environment, and social and economic spinoffs'.

Furthermore, in reviewing the American space programme, the document reflects little concern about vulnerabilities to American assets either, rather just the opposite, stating: 'The United States is indisputably the world's leading space power. … The United States possesses a panoply of space-based defense and national security assets that give it the ability to deploy forces with maximum security anywhere in the world. U.S. space systems are regularly renewed and capable of surviving most threats'.[62]

The United Kingdom

The United Kingdom is the second largest OECD user of space after the United States, with a very strong space science research programme, according to the British space agency, the British National Space Centre (BNSC). BNSC is a part of the Department of Trade and Industry, which 'is a good indication of how London views space—i.e., it's seen very much in commercial terms', said Mark Smith of the Mountbatten Centre for International Studies at the University of Southampton in the United Kingdom.[63]

The Ministry of Defence is, however, one of eleven government agencies partnering in BNSC, and the Ministry of Defence's research organization, DERA, plays a major role. According to BNSC, 'the United Kingdom's priorities in space are new initiatives in space science, Earth observation, satellite navigation and telecommunications, especially those that have an impact on the information-led economy'.[64]

In its most recent space strategy, *United Kingdom Space Strategy 1999–2002*, BNSC notes the following objectives for military space:

> To have sufficient assured access and capability to exploit space, in order to sustain optimum military effectiveness, cost efficiency and interoperability across defence programmes and in direct support of operations.
>
> To capitalize on the increasing synergy between military and civil developments in all sectors of the space market.[65]

By and large, the British military is seeking to use commercial capabilities whenever possible, for communications, imagery and weather surveillance, and even navigation and targeting requirements where possible. In the communications arena, however, the military does intend to continue to own its own assets managed through public-private partnerships. And the Ministry of Defence currently relies on the American GPS network for navigation and timing, although it is also partnering in the Galileo effort.

Much like its French counterpart, the British space strategy does not make much mention of threats to space assets, with the exception of debris. The document notes that one of the objectives of the strategy is 'to coordinate with other agencies work on the threat to the Earth from space debris and near-Earth objects'. It goes on to note:

> Space debris is a particular concern for users of the popular Geosynchronous Earth Orbit (GEO), the Sun-Synchronous Earth Orbit (SSO) and the Low Earth Orbit (LEO). Designers of launchers and payloads must plan to produce little or no debris during normal launch and operational procedures and aim safely to de-orbit all elements as soon as possible after the end of their operational life. In addition, new space transportation devices and payloads must be designed to improve their survivability.[66]

The Ministry of Defence's most recent defence strategy paper, however, mentions the increasing importance of space-based assets to future military operations, and the risk from the wider availability of such technologies. The document, *The Future Strategic Context for Defence*, notes that the information technology revolution is changing how the military operates, adding: 'and the development of space-based systems, originally driven by the [United States] and others (notably Russia and China) for defense purposes, is now becoming a commercial activity, potentially bringing significant capability to a wider range of nations and organizations'.[67]

The document later notes that while the most potent threats in the next couple of decades will come from conventional capabilities such as attack helicopters and long-range indirect fire, that 'the future battlespace will be inherently joint and multidimensional, encompassing space, cyberspace and the electro-magnetic spectrum' and that 'the use of directed energy weapons' is seems likely to increase. Concern is also raised as to the possibility of asymmetric warfare: 'Adversaries may seek to exploit growing reliance on information systems through offensive information operations. Weaknesses or delays in decision-making processes and command and control structures will be exploited to the full'. In addition, '[c]ivilian infrastructure and information systems may be targeted and such attacks may not always be traceable'.[68]

While not directly referring to possible targeting of space-based assets, as noted above, British defence officials have been expressing some concern as to the potential threat from hacking and jamming satellite networks.

Still, there appears to be little discussion in the United Kingdom of a space threat, nor the possible need for space-based weapons.

Smith noted that because no European nation has the force projection responsibilities of the United States, the pressing need to protect space assets just has not arisen. In addition, Europe continues to rely on the United States as the leader in any coalition action and thus would be primarily dependent on American space-based command, control and communications. Smith explained that, in his view, the British position remains 'wait and see', with few strategic drivers for, and little enthusiasm for spending money on, space weaponization.

'The upshot is: we can't afford it, we may not need it, and, if we do need it, it will be in the context of a U.S. operation rather than because of any independent European intervention', Smith said.

Conclusion

American policy-makers and military officials are becoming increasingly agitated about potential threats to American space assets and are determined to address those potential threats. Although it is obvious that there remain questions as to the scope of those potential threats, their imminence and how best to address them, it is also obvious that the United States currently is on a pathway that—if not arrested—eventually will lead it to become the first nation to weaponize space. It should be clear that there is little to be gained from what seems to be the current *modus operandi* in the international debate: with others remaining content to simply denounce American disinterest in discussing the weaponization issue. If the international community is serious about preventing space from becoming a future battlefield, other space-faring nations must immediately begin serious efforts to understand the American position, undertake their own threat assessments, and find ways to work with Washington to achieve mutually agreeable solutions that both protect space-based assets and avoid creating future threats to the further development of space as a global commons. Risk management approaches, 'rules of the road' and transparency measures are all ideas that could be useful despite current American reluctance to sign up to a weapons ban. Creative thinking will be required; the sooner, the better.

> ***There is little to be gained from what seems to be the current* modus operandi *in the international debate: with others remaining content to simply denounce American disinterest in discussing the weaponization issue.***

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The world's space systems

Laurence NARDON

It is difficult to find a single country in the world today that does not depend, in one way or another, on services provided by space systems. In our daily lives we rely increasingly on satellites for such matters as television and radio reception, telephone communications and the Internet, military and civilian security, weather forecasting, air traffic control and ensuring the security of bank transactions.

Hence even if there are still only a small number of space powers—understood as countries capable of building and launching a spacecraft—the entire international community has a stake in the smooth operation of space systems. This is a practical reflection of the 1967 Outer Space Treaty, Article 1 of which provides that the exploitation and use of outer space shall be the province of all mankind.

This article describes the various craft currently deployed in space, as well as the countries that have a significant space programme and industrial base.

Types of space systems

Many spacecraft are launched into orbit each year. They are all carried by rockets, with the exception of the United States Space Shuttle, which takes off and lands like an aircraft.

In 1945 the United States and the USSR took on the members of the German teams which had been working on the V-2 rocket at the Peenemunde site. As the technologies needed to manufacture a space launcher are broadly similar to those used for ballistic missiles, they pursued their initial ballistic missile and satellite launcher programmes in parallel. In both cases vertical thrust is followed by a curved trajectory; the payload is released by remote control at a precise moment. But the trajectory followed by the payload is different. In the case of ballistic missiles, the payload is guided to a target on the ground. For launchers, positioning engines are used to put the satellites into their final orbit.

Launchers come in various sizes, suited to carrying one or several satellites of different weights. The most common type of launcher is still a rocket launched from the ground that breaks up in orbit after launch. Research programmes are underway to develop reusable launcher systems (such as the manned United States Space Shuttle which has been operational since the 1980s) and systems involving rockets launched from aircraft.

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Currently, possession of launcher technologies is a sign of a credible and advanced space programme. It offers the only possibility of independent access to space and is of major political significance. While the development of such rockets is generally undertaken by national armed forces or space agencies, commercial firms often take over and offer launch programmes on a commercial basis.

Probes are generally sent on space exploration missions, while the United States Space Shuttle, certain versions of Russian rockets and the International Space Station transport or accommodate teams in orbit for both short and long periods, for purposes normally involving scientific research.

Since 1976, the Convention on Registration of Objects Launched into Outer Space has required states or organizations responsible for launches to place them on a 'register of objects launched into outer space'.[1] The purpose of this register is to facilitate efforts to hold launching states liable in the event of problems. States declaring launches are not required to reveal the precise nature of the payload carried by the rocket. Still, the figures provided in the register remain useful tools for evaluating the level of space activity in the world.

Among space systems, applications satellites are by far the most numerous. At the beginning of 2001, more than 2,600 civilian and military satellites were in orbit.[2] A wide variety of functions are listed for these satellites: navigation, observation, telecommunications, technical or scientific experiments. They have a number of different types of users: the scientific community, intelligence officers and other military officials, but above all the public, which purchases the services they provide on commercial markets.

At the beginning of 2001, more than 2,600 civilian and military satellites were in orbit.

The service life of satellites varies and there is a growing problem caused by the presence of inactive satellites and rocket fragments in space around the Earth. This debris presents a hazard for other satellites, since it can cause damage through collisions. It eventually burns up and disappears when it re-enters the atmosphere, but this does not occur at a sufficiently rapid rate to solve the problem. International discussions are underway in an attempt to curb or reduce the amount of debris circulating in space.

The space powers

Some commercial satellites belong to countries that have no independent capability in space technology. Egypt, for example, has two Nilesat direct television satellites; Thailand has three Thaicom telecommunication satellites; and Indonesia has a fleet of seven satellites covering all areas of telecommunications. Local operators have purchased these satellites from firms in Europe, the United States or elsewhere, and their services cover extensive geographical areas.

In this way, even if they do not possess the technologies required to be regarded as fully fledged space powers, many states have interests in space. Of course, individuals who make use of the services provided by satellites are found in every country.

If a narrower definition is used, the number of space powers diminishes. Some countries are fairly well advanced in satellite manufacture, for example Pakistan, which launched the Badr-B meteorological observation satellite in 2001. But the countries described below are those that have both satellite programmes and relatively advanced launcher programmes. Not surprisingly, there are major differences in the resources they possess and in their achievements to date.

United States

The United States, which together with the USSR, was a pioneer in the conquest of space from the 1950s onwards, remains the world's number one space power. The civilian and military space budget in the United States was estimated at US$27 billion in 2001. Thanks to its experience and resources, it is a clear leader in all space-related areas.

The United States has a powerful industrial base. Following the concentration of companies in this sector during the 1990s, there are two firms with main contractor status for satellite launchers: Boeing, with the Delta family of rockets, and Lockheed Martin, with the Atlas family of rockets. There is also a substantial industrial fabric in the shape of subcontractors. Space industries in the United States have major market shares in sales of launchers and satellites.

For some years, these firms have been facing serious economic difficulties, partially due to the fact that since 1998 American regulations governing the export of sensitive equipment have been tightened, hampering the sale of satellites overseas. The crisis in the telecommunications sector has also cut demand for satellites and launchers at the very time when supply has grown in various countries. Yet these companies receive substantial aid from the public sector. The civilian and scientific programmes supervised by NASA are substantial, for example, the Space Shuttle. The Shuttle services the International Space Station. But NASA's ambitions are turning towards other goals, in particular the proposed Mars exploration programme.

The United States military space programme is certainly the most advanced programme in the world today. Space has been used to obtain strategic intelligence since the 1960s, when observation satellites were used to map Soviet military bases. In the 1990s, tactical support systems for ground forces began to be available for large-scale regional operations such as the Gulf War. Satellites for meteorology, navigation, targeting and, of course, telecommunications provide near real-time services to the troops deployed on the ground.

The arrival of Donald Rumsfeld in the Pentagon has given a boost to research on a third and new category of military space facilities. The official view is that the fleets of satellites in orbit, on which the defence of the United States is now so dependent, must be protected at any cost. This protection is understood in both the 'passive' and the 'active' senses.[3] Teams of researchers are working to upgrade satellites to cope with the threat of jamming, for example, but also on systems to attack enemy satellites.

The various laboratories run by the United States armed forces are engaged in research and development programmes on anti-satellite (ASAT) weapons that make use of a variety of highly innovative technologies. The Department of Defense considers chemical and kinetic interceptors and low-energy lasers to be the easiest to produce. Nuclear weapons and radio-frequency weapons are more complex, while high-energy lasers and particle rays are further from reach. The Air Force is studying a space-based laser system and a ground-based system for jamming satellites (space control technology); the Army is developing a ground-based satellite interceptor (kinetic energy anti-satellite weapon or KE-ASAT); and a ground-based laser known as MIRACL (mid-infrared advanced chemical laser) was tested in 1997.[4] However, the development of ASAT weapons is contentious in the United States.[5]

The various laboratories run by the United States armed forces are engaged in research and development programmes on anti-satellite (ASAT) weapons that make use of a variety of highly innovative technologies.

Lastly, there is rising concern that the space facilities of the major powers are vulnerable to certain attacks. The necessity to protect space assets is sometimes used as the justification for the militarization of outer space. Yet it should be recalled that even with simple conventional terrestrial capabilities it is possible to interfere with the smooth operation of military or civilian space systems. An explosive charge set off in a ground station could temporarily deny access to a satellite application.

Russian Federation

Starting in the 1950s, the USSR vied with the United States for primacy in the conquest of space. The Soviet Union recorded many high-profile ‘firsts’: from the first satellite, Sputnik, launched in 1957, and Yuri Gagarin, the first man in space in 1961, to the first permanent orbiting station, Mir, deployed in 1986. Above and beyond prestige, the USSR was also in pursuit of certain military applications. Following the START disarmament agreements, in 1993 and 1994, the former Soviet SS–12M and SS–25 missiles were converted into commercial rockets (Rokot and Start respectively). Soviet missile technologies retained many similarities with those developed for satellite launches. In the same way, the Proton rocket, initially a missile, has become a launcher in the process of its development. The Kosmos series of satellites carried out all the missions demanded by the Soviet authorities, civilian and military.

The collapse of the USSR in 1991 led to a number of problems for its space programmes. The first stemmed from the fact that the former Soviet launch sites were dispersed among various republics. The Russian Federation retained the Plesetsk launch site and constructed a new site at Svobodny, but the Baikonur site is now in Kazakhstan. Ukraine, which still has a major industrial base in the space field, has no launch site within its borders. It has contributed to the construction of a launch site on the ocean as part of the international joint venture Sea Launch.

The second consequence was that the Russian space budget shrunk from US$6 billion in 1992 to an estimated US$1 billion in 2001. Consequently, the programmes suffered a marked slowdown. The United States devised the International Space Station programme partly in order to prevent ex-Soviet engineers from exporting their missile-related know-how to countries considered to be dangerous. The programme provides work and funding that keep the Russian teams in their present posts.

Russian rocket engine technologies have also caught the interest of Western companies, as they are often cheaper and offer different features than others on the market. Western companies have initiated cooperation with firms in the former Soviet Union. International Launch Services, an American-Russian joint venture, handles the launching of Atlas satellites constructed by Lockheed Martin and Proton rockets built by Khrunichev in the Russian Federation. The other American-Russian joint venture is the previously mentioned Sea Launch, which also has Ukrainian and Anglo-Norwegian partners. The European Arianespace has set up Starsem, a company that sells space on Soyuz rocket launches.

The beginning of this cooperation dates from the mid-1990s, when industrialists expected strong demand for telecommunications satellites and launches. This market has since collapsed, and the fact that Western industries have taken over some functions in respect of ex-Soviet launchers is now adding to the problem of over-capacity on the launcher market.

Europe

The European countries embarked on space programmes at the beginning of the 1960s. In contrast to the United States and the Soviet Union, their main motivation was not the development of military applications, nor space exploration, but the development of commercial civilian systems. Europe’s space budget stood at US$6 billion in 2001.

It is a complex matter to evaluate European influence in the space field because of the large number of stakeholders and programmes. Most states have a national programme. France's budget is usually the most significant, with a notable portion attributed to military space developments. There are also a number of programmes being pursued jointly by two or three states. But most of Europe's achievements in space take place under the auspices of the European Space Agency, made up of fifteen European countries.

Europe now administers large telecommunication and meteorology systems and is involved in many scientific research programmes. The Ariane launcher has the largest share of the world market for the launching of commercial satellites in geostationary orbit.

Europe's space industries have been hard hit by the current crisis in demand for telecommunications satellites. They receive less assistance from public funds than their partners in the United States. Yet a promising recent development is related to the fact that the European Union has been assigned functions in the space field. The proposed Galileo navigation programme and the Earth observation programme known as GMES (Global Monitoring for Environment and Security) reflect new space ambitions for Europe, which have been entrusted to the European Commission.

China

While it is hard to ascertain the scale of China's military programme, the progress made in Chinese technology may be assessed through its commercial programmes. In 2001, China had thirty-one satellites in orbit, including eleven telecommunications satellites. The commercial aspects of its range of Long March launchers have been in the hands of the China Great Wall Industry Corporation since the end of the 1980s.

Chinese rockets were used to launch many American satellites up to 1998, when Lockheed Martin and Hughes were accused of having transferred too much technological information to their Chinese partners. These scandals led to tighter controls in the United States on the export of sensitive equipment, and the American government banned American companies launching their satellites from China.

China's space budget was estimated at US$1 billion in 2001. The Chinese government announced its ambitious new space programme in 2001, which will continue the manned flight programme initiated in 1999. A 'taikonaut'[6] is due to fly on the Chinese shuttle Shenzhou by 2005.[7]

Japan

Japan was relatively late in developing its space capabilities. The total space budget, equivalent to US$2.5 billion, is small in relation to Japan's GDP. The restrictions on the country's military ambitions, together with the lack of large-scale market opportunities for space programmes, have discouraged efforts by Japanese industry. Progress in these programmes cannot be compared with that in the motor vehicle or computer sectors, which have been market leaders since the 1970s.

Yet the importance of the National Space Development Agency and the enthusiasm of political leaders for space programmes seems to be rising. Work is well advanced on the ALOS, ADEOS-II and EOS-Aqua Earth observation satellites, the successors to already operational satellites. Japan is also an active participant in cooperative scientific research and in the International Space Station programme.

Following a series of failures, Japan's H-IIA rocket placed four satellites into orbit on 14 December 2002. The Agency plans to launch a further ten H-IIA rockets between now and 2005, when the launcher is due to be privatized. Mitsubishi Heavy Industries has expressed interest.[8] The entry of this new participant into the market is causing concern among commercial enterprises in other countries, which are already suffering from a drop in orders.

Japan's constitution places strong constraints on acquiring very extensive military capabilities, and consequently the Japanese rocket programme has not led to a parallel programme to produce ballistic missiles.

India

India's space programme enjoys high political priority. Although the national space budget stood at only US$300 million in 2001, it is large in relation to the country's GDP. Moreover, production and labour costs are lower than in the West, and as a result much can be done with this sum.

India's achievements in space matters are fairly substantial. The family of IRS observation satellites may be found on commercial markets, and compete with the European system Spot.

India's position within the Non-Aligned Movement means that the country did not develop strong ties with either the West or the Soviet bloc during the Cold War. This has had repercussions for the national space programme. The heads of the Indian Space Research Organisation, India's space agency, and the military personnel handling space issues have become accustomed to operating independently. India plays only a small role in international space cooperation programmes.

India already possesses a rocket capable of launching satellites into polar orbit—the Polar Satellite Launch Vehicle. In April 2001, India launched its first satellite into geostationary orbit, using the Geostationary Satellite Launch Vehicle (GSLV). This programme, which started in the 1980s, was held up for at least six years during the 1990s for political reasons. As part of its missile non-proliferation policy, the United States imposed sanctions on India in 1992 in order to obstruct a 1988 agreement for the delivery of equipment and technologies from the Russian Federation. Negotiations among the three states were completed only in 1998, with a delivery of Russian equipment on terms acceptable to the United States.[9] With this new launcher, India, which hitherto had been a good customer of the European company Arianespace, has become self-sufficient for its launches.

Given that India has developed short-range and medium-range missile systems—Prithvi (with a range of 150–250km) and Agni (up to 2,500km)—fears that a space launcher may be converted into an intercontinental missile must be taken into account.

Israel

Israel's space budget stands at only about US$50 million a year.[10] In the context of the current crisis there is a risk that it will be cut further.

However, Israel's achievements, the fruit of cooperation with the United States, European, Russian and Ukrainian space agencies, are notable. A score of space enterprises and a few university and military research laboratories are active in the country.

Israel's space agency was set up in 1983. Since then, Israel has developed a number of satellite applications. The fifth Offek military observation satellite was launched in May 2002; a commercial

Earth Resources Observation Satellite has been operational since 2000, with a second scheduled for 2004. The first Amos telecommunication satellite was launched in 1996, and more will be launched from 2003 onwards.

Israel is trying to position itself in certain niches such as satellite miniaturization, electric boosters for satellite trajectory modification, and seismic applications of navigation.

Lastly, Israel has developed a launcher system, Shavit, which was used to launch the first Offek satellite in 1988. The company Israel Aircraft Industries, which is in charge of its development, is counting on a growing demand for the launching of small satellites. The current LK-A model is designed to launch 250kg satellites into low elliptical polar orbit (240–600km); the LK-1 system currently under development will launch 350kg satellites into a circular polar orbit (700km).

Israel has a number of operational missile systems. The currently deployed Jericho 2 missile, which may correspond to the first two stages of the Shavit rocket, achieved ranges of 850–1,300km during tests in 1987 and 1989. According to analysts at the Lawrence Livermore National Laboratory, the Shavit rocket could achieve a range of 5,000km if converted into a ballistic missile.

Brazil

Brazil carried out a launcher development programme during the 1970s and 1980s, but its enthusiasm for the programme has waned since the programme for the development of nuclear weapons and ballistic vectors was officially abandoned in 1990. Two of its small VLS rockets were tested, in 1997 and 1999, and Brazil has two launch sites (Barreira do Inferno and Alcantâra).

The country nevertheless has a relatively well-developed industrial base for space activities. Companies that merit mention are Elebra (data processing, radar and telecommunications), Embraer (participates in manufacturing the SCD-1 satellite and in the VLS launcher project), Avibras (rocket probes), Cenic (composites for the VLS launcher), Mectron (satellite control software and data-gathering systems), Digicon (components for satellites, assembly of solar panels in cooperation with the German company MBB) and Akros (dynamic and static testing for satellites, structural analysis, technical documentation). These companies enjoy solid institutional support, within the framework of a national space agency and several research institutes.

Brazil has placed a number of data-gathering satellites in orbit: SCD-1 in 1993 and SCD-2 in 1998. It is also participating in several international projects: the CBERS observation satellite programme with China, a scientific micro-satellite project with the Centre national d'études spatiales (CNES, the French national space studies centre), and has a small role in the International Space Station.

Conclusion

The interest of states in acquiring space capabilities seems to have changed over the past ten years.

Some countries, such as Brazil and South Africa, have abandoned their ambitions in the nuclear and missile fields and consequently seem to be less committed to the pursuit of a space programme. Others, in contrast, such as Pakistan, Iraq and North Korea, are maintaining their missile programmes and for the time being are not seeking to develop civilian applications for these rockets.

Considerations of international prestige and the expansion of trade underlie many innovative space programmes. The development of advanced space capabilities remains a major element of technological and political credibility for rising regional powers, as it was for the United States and the USSR during the 1960s. More recently, prestige might have been a motivating factor for India embarking on its space programme.

The development of advanced space capabilities remains a major element of technological and political credibility for rising regional powers, as it was for the United States and the USSR during the 1960s.

The development of space systems for commercial purposes was another important aim during the 1990s. The strong demand expected in space-related markets held out the hope of substantial profits in the sector covering launchers as well as telecommunication and observation satellites. The current slowdown in demand is dampening competition among the potential space powers. The economic crisis in Asia has also deterred possible candidates. In this context, Japan's enthusiasm seems to run against the tide.

Where the established space powers are concerned, the present situation is an interesting one. Commercial competition is increasing in an already tight market. The drop in demand is accentuating the downward pressure on launcher and satellite prices, and space-sector companies have reached a critical point. Until now, they have reacted to these difficulties by calling for ever-larger state subsidies. Space powers such as Europe cannot go on responding to these demands. In the medium term it seems inevitable that to some extent, without going as far as to establish cartels, markets will be divided up among companies, to curb the fall in prices and lessen the appetite for public funding.

Notes

1. Text available at <http://www.oosa.unvienna.org/SORegister/registxt.htm>.
2. Unless otherwise stated, all figures are from Isabelle Sourbès-Verger, 2001,L'espace dans le monde, *Géoéconomie*, no. 20 (winter), pp. 49–61.
3. *Report of the Commission to Assess United States National Security Space Management and Organization*, Washington DC (Public Law 106-65), 11 January 2001, available at <http://www.space.gov/docs/fullreport.pdf>, known as the 2001 Space Commission.
4. See article in this issue of *Disarmament Forum* by Theresa Hitchens, page 15.
5. Marcia Smith, U.S. Space Programs: Civilian, Military and Commercial, *CRS Issue Brief IB92011*, 2 May 2001.
6. Each language has coined its own word for the persons sent into space, including astronauts in English, cosmonauts in Russian, spationautes in French and taikonauts in Chinese.
7. Marc Boucher, 2000, Shenzhou 2 Launch Imminent, Chinese Manned Space Program Targets the Moon, 30 October 2000, available at <http://www.spaceref.com/news/viewnews.html?id=239>.
8. Space and Tech, 2002, Japan's H2A launches experimental DRTS and USERS spacecraft, 10 September, available at <http://www.spaceandtech.com/digest/flash2002/flash2002-076.shtml>.
9. Philip Clark, 2001, India's GSLV reaches orbit, but can it be a contender?, *Jane's.com*, 20 April, available at <http:/ /www.janes.com/aerospace/civil/news/misc/jsd010420_1_n.shtml>.
10. *Israel Space Agency Aims High Despite Low Budget*, AFP, 18 July 2002.

Is a space weapons ban feasible? Thoughts on technology and verification of arms control in space

Regina Hagen and Jürgen Scheffran

> The international community has acted jointly, through the United Nations, to ensure that outer space would be developed peacefully. But there is much more to be done. We must not allow this century, so plagued with war and suffering, to pass on its legacy to the next, when the technology at our disposal will be even more awesome. We cannot view the expanse of space as another battleground for our Earthly conflicts.
>
> United Nations Secretary-General Kofi Annan[1]

> In the coming period, the US will conduct operations to, from, in and through space in support of its national interests both on the earth and in space.
>
> The Commission to Assess United States National Security Space Management and Organization[2]

In less than fifty years, outer space technologies, and specifically satellites, have revolutionized many aspects of science and everyday life: communication, navigation, meteorology, astronomy and Earth science are just a few of the fields that can be named in the civilian sector. The military has also seized upon the use of satellites for optical and electronic reconnaissance, early warning, communication, navigation, weather forecast and geodesy. In technologically advanced countries, satellites are now an essential part of military command, control, communication, computer, intelligence, surveillance and reconnaissance (C^4ISR) systems. Today, more than 170 dedicated military systems (United States, 110; the Russian Federation, 40; others, 20) are in Earth orbit, complemented by many dozens of dual-use commercial systems. The fact that many assets have both civilian and military applications is one reason why the question of militarization and weaponization of space is so complicated.

During the Cold War, both the United States and the Soviet Union pursued dedicated space weapons programmes. At that time, however, neither side actually developed, tested and deployed an operational space weapon system that posed a credible military threat to the other country. The programmes came to a halt in 1984 after the Soviet Union announced an anti-satellite (ASAT) test moratorium in 1983.

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However, work on missile defence systems continued in the United States in the 1980s and 1990s. The corresponding development programmes were viewed with scepticism by large parts of the international community for two reasons: it was feared they would increase strategic instability and lead to new arms races on Earth, and it was pointed out that a portion of the projected missile defence technologies would also be suitable for space weapons purposes. Those worries were nourished by a series of documents (above all by the United States Space Command) in which the United States publicly announced its plans for 'space control', 'space dominance' and 'space superiority', making missile defense a 'Trojan Horse' for space war.[3] In this context, the 1972 Anti-Ballistic Missile (ABM) Treaty played a significant role in restricting the development and testing that could have led to ASAT and other space weapons capabilities.

Under the administration of George W. Bush and his team, the military role of space is being pursued with even greater vigour. Secretary of Defense Donald Rumsfeld made it clear that he foresees the military need to conduct not only air, land and sea operations but also 'independent space operations'.[4] As the ABM Treaty stood in the way of such plans, the withdrawal of the United States in June 2002 did not come as a surprise.

In spite of this, deployment of operational missile defence and space weapons systems remains several years ahead. Therefore, there is still time to urge for a broad range of diplomatic efforts, ranging from confidence-building measures to control regimes, as well as negotiations on a comprehensive space weapons ban. In recent years, the international community has renewed its discussion of the issue of Prevention of an Arms Race in Outer Space (PAROS). To bolster dialogue, existing proposals have been updated and new proposals have been brought forward by NGOs as well as by governments.[5]

This article discusses some technical aspects of verification of a space weapons ban with a focus on the prohibition of anti-satellite weapons.[6] Since a ban would be difficult to achieve in the current political environment, some might claim that it is premature to discuss the feasibility of its verification. It might also be argued, however, that acknowledging the challenges and opportunities for verification posed by the medium of space might help us to think more openly, creatively and successfully about how to reverse the alarming inertia towards space weaponization.

Acknowledging the challenges and opportunities for verification posed by the medium of space might help us to think more openly, creatively and successfully about how to reverse the alarming inertia towards space weaponization.

In order to gain acceptance for any prohibition of space weaponization, it is crucial to work out convincing verification concepts. Means for and scope of verification, technical limits to verification, confidence levels in verification, and possible loopholes for cheating are all issues that need to be addressed before a space weapons ban might be considered feasible. As a rule, however, this important aspect is neglected. For example, the joint working paper *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*, introduced at the Conference on Disarmament by China and the Russian Federation in June 2002,[7] omits any mention of verification because the issue 'is rather complicated and the ideas are diversified'.[8]

Space arms control—obstacles and supporting factors

The part of outer space in which relevant activities could take place—and would therefore have to be observed—is vast: it ranges from around 100km above sea level to the geosynchronous orbit at 36,000km. Almost unnoticed by the larger public, space has already become quite cluttered. More than 8,000 man-made objects larger than 10cm are currently mapped in an Earth orbit. These include operational satellites (around 7%), rocket bodies (around 15%) and space debris (fragmentation and defunct satellites, 78%). It is therefore difficult to track all space objects and distinguish between harmless and potentially threatening objects and activities. Taken on their own, these factors might be considered discouraging, but one must remember that although space is large, it is transparent and allows for remote tracking, surveillance and observation with optical, infrared, radar, electronic, electromagnetic and other technologies—thereby facilitating the verification task.

Space objects can fail for a variety of reasons: component failure and degradation; design, development, production, programming or mission errors; interruption of ground communication due to natural reasons, jamming or ground station attacks; collision with space debris; physical attack; blinding of sensors; hacking; deception; hijacking; and other reasons. Verification mechanisms might be confronted with the difficult task of attempting to trace a system failure back to a specific cause.

Verification efforts could be boosted by the fact that all space objects are currently launched from Earth. Accordingly, (expensive) space observation technologies can be complemented by (inexpensive) pre-launch verification measures (such as on-site inspection of payloads or societal verification/whistle-blowing).

Space has become indispensable for commercial, economic and scientific uses. Significantly, this is no longer true just for the most technologically advanced nations but for a steadily increasing number of states. Most space objects, from satellites to space vehicles, are potentially dual-use. Confidence in the verifiability of a space weapons treaty would be limited by the technical capabilities of the verification system to discriminate between permitted satellites and prohibited space weapons systems.

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Lastly are the practical difficulties of starting any talks on this issue. The United States has consistently blocked discussions on PAROS in the Conference on Disarmament, a body that takes decisions by consensus. In addition to this difficult political environment, the lack of generally accepted definitions for terms like ‘space’, ‘space weapon’ and ‘peaceful uses’ complicates any discussion of this topic.

Potential ASAT weapons and their verification

A variety of objects and weapons could be used for an ASAT attack, each requiring different verification measures that offer varying levels of effectiveness. The following sections outline some basic features, risks and potential verification measures for a range of space objects.

Manoeuvrable space objects

Any manoeuvrable spacecraft, whether manned or automated, can be used for ASAT purposes. It could push the target off its orbit, bump into it to break it up, employ electronic jamming or laser blinding devices, or release explosives, chemicals or radioactive materials. In addition to these hostile activities, a manned space vehicle such as the Space Shuttle or the Russian Soyuz could hijack the target object, in the same way they can perform a rendezvous with a space station or a satellite that is due for repair.

Manoeuvrability of any spacecraft, however, is confined by fuel availability. Furthermore, to date rendezvous have only been performed with 'cooperative' low orbit targets, even in the case of the Soviet co-orbital ASAT test series of the 1970s and 1980s. To precisely encounter or come very close to a 'non-cooperative' and fast moving target is difficult and requires precise orbit data and demanding trajectory calculations. A rendezvous is further complicated if early warning is available (which could not only come from the target's on-board sensors, but also from other means, such as Earth-bound tracking systems) or if the target has certain manoeuvring capabilities on its own (e.g. to minimally change its orbit or trajectory). In any case, this precise manoeuvring capability is currently available to only very advanced and experienced space-faring nations.

However, rendezvous manoeuvres will become more common for repair (as has been achieved twice with the Hubble telescope), upgrading or refuelling of space objects. Satellite manoeuvrability is gaining in importance for cluster missions for distributed reconnaissance and environmental observation (i.e. a task is split in several subtasks that are performed by different satellites within a cluster), relocation of reconnaissance satellites over conflict areas, steering space objects out of the way of space debris, etc. As a result, experience with space manoeuvres will proliferate to more countries or satellite operators.

An attempt of another nation's spacecraft to approach its target in an ASAT mission could be detected with existing tracking systems and on-board sensors (optical tracking, interpretation of ground communication data, interception of the payload's telemetry signals) with high probability. As a rendezvous is initiated by co-orbiting and approaching the target object over a certain time period, it allows early warning and leaves some time to inquire into the intentions of the manoeuvring object. Inquiries are made easier as space objects can be traced back to specific launches and therefore to specific operators, owners or at least launching states.

To prevent misinterpretation of a non-aggressive rendezvous manoeuvre as an ASAT attempt, advance notice of any manoeuvres and rendezvous would be helpful.

To prevent misinterpretation of a non-aggressive rendezvous manoeuvre as an ASAT attempt, advance notice of any manoeuvres and rendezvous would be helpful. As any manoeuvrable object could be used for hostile purposes, verification is not possible in the sense of verifying the non-existence of such objects. To make up for this deficit, convincing confidence-building measures should be included in a space weapons ban. These could include transparency regarding the capabilities of spacecraft and/or their fuel reserves, intended orbit, and pre-announcement of dislocation and rendezvous manoeuvres. Thus, only deviations from predicted and intended trajectories would have to be tracked and verified.

Space mines

Space mines are a specific class of manoeuvrable space objects insofar as their sole purpose is to destroy a satellite if instructed to do so. As any other spacecraft, a space mine must change its orbit and trajectory to approach the target satellite for an attack. To do so, the space mine would need support from ground- or space-based tracking systems and on-board homing sensors. Alternatively, immediately after its release from the launching vehicle a space mine could attempt to approach and attach itself to the target satellite unobserved—only to detonate when the destruction mechanism is triggered. Target destruction could be achieved by a nuclear explosion, conventional explosives, emission of projectiles or shrapnel, and direct collision to destroy the satellite with kinetic energy. A space mine could put at risk a single satellite or—if considerable amounts of shrapnel were released—a larger area or complete orbit.

A space mine's approach could be detected with radar systems in low altitudes and with optical systems in higher orbits, allowing time for reaction from the targeted side. This would, however, no longer be possible if the space mines were very small (in the 5–10cm range and therefore undetectable by space surveillance networks). Fast space mine acceleration would also pose a problem, because the target satellite could not manoeuvre away in time, but a mine would require considerable fuel reserves to sustain acceleration.

Concealing a space mine within a satellite with permitted functions would be difficult to detect until the approach manoeuvre is initiated. Only pre-launch inspection of payloads could ensure that no such capability is hidden. In doubtful cases, space objects could be inspected by dedicated inspection satellites.

In order to design reliable space mines and improve approach accuracy, multiple tests would be required. Even if testing were prohibited, though, it could prove difficult to distinguish between prohibited tests and permitted manoeuvre activities.

Once again, verification of space mines would be difficult if it were demanded to confirm non-existence. Verification of non-use would be greatly assisted if information on any object, its purpose and trajectory were given prior to launch. Notification of trajectory changes could be made compulsory for all states parties to an ASAT ban. Nuclear space mines are technically feasible and would be effective over longer distances, but are already prohibited under Article 4 of the Outer Space Treaty.

Ground-based conventional missiles

Space rockets, ballistic missiles and mid-course missile defence systems are all designed to traverse space and release an object (the payload, warhead or interceptor vehicle). Therefore they also have the potential to destroy a satellite. Destruction can be caused by a conventional explosion, by projectile emission (shrapnel) or by the kinetic energy of a direct hit collision of the warhead with the target object.

In order to destroy a satellite, the attacking vehicle must approach the target object with very high accuracy. This means that the following factors must be calculated perfectly: the exact position of the satellite on its orbit at a given time;[9] the exact position of the missile launch pad on Earth; the missile's acceleration, the velocity and range; and its trajectory. This implies also that only satellites on specific orbits can be reached from a given launch pad on Earth. Even then, an ASAT missile could only attack one satellite at a time, unless large amounts of shrapnel were released and a whole orbit polluted over time.

Between the 1960s and the early 1980s, both the United States and the Soviet Union conducted several rendezvous manoeuvres and conventional ASAT tests with little success. The Soviet Union announced an ASAT test moratorium in 1983, and testing stopped the following year.

Technologies for ASAT and for missile defence have much in common. In both cases, interception must either occur in the course of a rendezvous or co-orbital manoeuvre or by crossing the satellite trajectory with high relative velocity at just the right moment. With their current series of missile defence tests, the United States is gaining experience that could also be applied to ASAT weapons. No other country comes close with the technology for such endeavours. At the same time, the American missile defence programme is proof of the difficulty of hitting an object in space.[10]

Technologies for ASAT and for missile defence have much in common.

Any testing of a ground-based conventional missile, for ASAT or missile defence, would be easy to observe with existing systems. Infrared sensors on early warning satellites can detect a launch due to its hot exhaust plume. Tracking radars and telescopes could follow the manoeuvre. Telemetry signals can be collected with simple radio beacon receivers.

As long as ballistic missiles are not prohibited and destroyed, it is not possible to exclude ASAT capabilities by missile-owning nations. The advancement of missile defence programmes aggravates the problem, as experience with missile defence tests would increase the confidence of an attacker in system operation for ASAT purposes. Any negotiation of an ASAT ban would also have to consider the issue of ballistic missiles.[11]

Ground-based nuclear missiles

If a nuclear-tipped missile were used as an ASAT weapon, target accuracy would not need to be as high as in the case of conventional missiles. The explosive power would be effective over several kilometres and destroy any object within that range. The primary effect of interest in this case is the system-generated electromagnetic pulse (EMP). Also of interest for satellite destruction are thermomechanical shock by overheating and ionization burnout of electronic components by absorption of x-rays. A one megaton weapon exploded halfway between Earth and the geosynchronous orbit could generate EMP currents as high as 50–100A/m^2—enough to destroy any unprotected satellite in line of sight and to cause considerable damage to electronic systems on Earth that are not specifically hardened.

Of the countries with longer range ballistic missiles and nuclear weapons arsenals, only the United States has tested nuclear weapons in space. Since entry into force of the Partial Test-Ban Treaty in 1963, nuclear explosions in space are prohibited and would violate international law. Any use of nuclear weapons in space could be detected by early warning satellites observing the missile launch and by space-based radiation sensors, thereby leaving no doubt as to the identity of the attacker. As in the case of conventionally armed ballistic missiles, the capability for an ASAT attack with a nuclear warhead exists as long as nuclear warheads and ballistic missile arsenals are maintained.

Air-launched conventional interceptors

Satellite disruption with a conventional air-launched missile is more challenging from a technical point of view. Interception could occur by co-orbiting or crossing the satellite trajectory; where in the latter case the relative velocity (delta-v) between the interceptor and the target can be fairly high. The limiting factors are range and maximum capacity of the aircraft and consequently the payload characteristics of the rocket, i.e. only light-weight warheads can be launched beyond low Earth orbits (LEO). As in the case of other conventional ASAT systems, high manoeuvring accuracy is required to approach the target close enough.

Airborne ASAT launches have a clear advantage over ground-launched ones: the ability to launch the missile in a specific direction and from the most advantageous point for the mission, including the equator.

The United States conducted a series of twelve tests of air-launched missiles (Bold Orion) in 1958 and 1959, with one test specified a success. In the mid-1980s, tests for the Prototype Miniature Air-Launched System (PMALS) were conducted, consisting of a small two-stage missile with a miniature homing device launched from an F-15.

As air launches have considerable advantages for both commercial and military purposes, several air-launch programmes are under development and corresponding test programmes are being conducted. The only existing air-launch system so far is 'Pegasus', carried aloft by Orbital's L–1011 carrier aircraft to around 13,000m where the Pegasus rocket is released. Since the initial flight in 1990, Pegasus and the updated Pegasus XL version have flown almost thirty missions.

In the Russian Federation, several commercial enterprises are working on similar projects, such as using the Antonov AN–124–100 'Ruslan' as the carrier system. Another project proposes using the An-225 'Mriya' carrier aircraft, the world's largest heavy lifter with a maximum payload capacity of 260 tons. It is planned that the carrier would not launch a rocket but an expandable, re-usable orbiter. A similar design is under development for a United States Air Force project, using a modified Boeing 747–400F as the carrier for the proposed Space Maneuver Vehicle to lift 3,000kg payloads to LEO.

In the case of an air-launched intercept, there is little time for early warning. In an ideal constellation, a missile could hit a satellite just ten minutes after its launch from a plane. The aircraft could take off from any airfield where the runway is long enough. Verification of appropriate launches is difficult, as it is hard to distinguish between an ASAT mission of the carrier aircraft and a permitted one. If an airborne missile attempts to manoeuvre close to a satellite, this may possibly be observed with ground- and space-based tracking systems and telemetry receivers, but in practice may prove infeasible because of short warning times.

Due to the existence of air-launch systems for commercial and other military purposes, it would not be possible to verify the non-existence of such systems. Instead, verification of this technology in the framework of an ASAT ban would have to fall back to confidence-building measures, on-site inspections, and verification of non-test and non-use for ASAT purposes.

Directed energy weapons

Outer space seems to be the ideal medium for directed energy weapons. Because laser weapons programmes are the most advanced in the field of directed energy, they are used as an example in this section. Lasers have numerous advantages. Large distances can be traversed at the speed of light in fractions of a second, and the vacuum creates no attenuation of the beam energy. In theory, any object within line of sight could be 'zapped'. With their predictable orbits, satellites would be 'sitting ducks' vulnerable to laser attack—to blind the sensors, overload the electronics, cause thermal or physical damage, or overheat special satellite components (e.g. sensitive payload optics or attitude control sensors).

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Consequently, laser weapon development programmes have been conducted for many years, although hampered by physical and technical problems. Amongst these differences are the high energy requirements to power the laser, the need for precision targeting mechanisms, and the lack of system serviceability. Currently, the United States is working on ground-, air- and space-based laser systems for missile defence, all with inherent ASAT capability. And the Russian Federation has reportedly worked on a space-based laser weapon programme. The first Energiya mission in 1987 carried Polyus, an 80 ton satellite, which included equipment for laser tests. The mission failed to reach orbit, and no further attempts are known.

Ground-based laser

For ASAT purposes, the laser beam would be focused through the atmosphere, either directly to the target or to a transmission mirror satellite. Atmospherical disturbances, attenuation and beam widening over large distances must be compensated by higher energy beams. The ground-based Mid-Infrared Advanced Chemical Laser system (MIRACL), originally developed for President Reagan's Star Wars programme, was test-fired against a phased-out Air Force satellite in 1997, and the United States Army has continued refining the system since then in the framework of missile defence. Together with Israel, the United States is also working on the ground-based Tactical High Energy Laser (THEL) system. While energy supply is less of a problem for a ground-based laser, it can only attack satellites above the horizon and would be both limited to its deployment site and to attacking satellites on a lower orbit. On the other hand, this capability would be sufficient to blind the sensors of other nations' reconnaissance satellites—either temporarily or permanently—and thus prevent them from surveying the particular area within reach of the laser system.

Airborne laser

Flying at high altitudes, an airborne laser features high mobility and less atmospheric transmission loss. Putting a large laser into an airplane is not an easy task, and vibrations, air manoeuvres and turbulence during flight impair operation. The United States Missile Defense Agency, the United States Air Force and industrial companies are working cooperatively on the Airborne Laser (ABL) project and want to demonstrate its capability in ballistic missile shoot down in 2004. The ABL could potentially also be used in an ASAT mode.

Space-based laser

A space-based laser would be a very powerful weapon, as it could be used at any time against any target in space, in the air or on the ground. Similar to an airborne laser, a space-based laser would destroy an object by focusing and maintaining a high-powered laser beam until it causes destruction of the target. In preparation for a first strike attack, a few laser weapons deployed high enough in space could attempt 'sky sweeping' to destroy another nation's command, control, communication and intelligence (C^3I) to reduce the adversary's second strike capability.

The development of space-based lasers is hindered by significant technical problems, such as power supply. The United States Space-Based Laser project (SBL), originally scheduled for in-flight test in 2012, is troubled with delays and has recently suffered budget cutbacks.

It seems that as yet, no laser weapon has been developed that could actually be used in an ASAT mode. In all likelihood, development of the ABL that could be used against satellites is far ahead of ground-based and space-based lasers. At this stage of development, the most effective means to prevent lasers from being used as ASAT weapons is a ban on testing laser weapons. Any tests under realistic conditions—be it on the ground, in the air or in space—would be detected by existing systems. The heat dissipation can be observed by space-based infrared sensors. In addition, high-energy lasers are huge systems that could be detected by reconnaissance satellites or—if they are deployed in space—by tracking systems.

If ASAT laser weapons were deployed, their use could be verified by infrared sensors, by observation of unexpected illumination or by a signal emission of the target satellite. As in other cases, it would be difficult to verify an ASAT laser ban if they are an accepted component of missile defence systems.

Realistic verification and risk reduction

A multitude of technologies, tools and measures could be employed to verify a ban on ASAT weapons. As a transparent medium, space provides ideal conditions in particular for remote tracking and surveillance of space objects and activities.

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The *prohibition* of interference, deliberate concealment measures and encryption that impede verification minimizes the likelihood that cheating on the treaty provisions goes unnoticed.

On-site verification of Earthbound production, launch and infrastructure facilities could be conducted by inspectors; more permanent verification can be facilitated by observers as well as by on-site monitoring instruments and detectors. In the case of credible cheating allegations, on-site inspections might even be conducted in space by using dedicated remote control or manned verification spacecraft. Human intelligence and societal verification (including whistle-blowing) add to the reliability of the verification results.

For several decades the United States has maintained a global *Space Surveillance Network* (SSN, under control of the United States Space Command) to detect, track, catalogue and identify all objects in Earth orbit larger than 10cm, with a primary interest in operational satellites. The SSN consists of United States Army, Navy and Air Force operated ground-based phased-array and conventional radars and optical sensors (telescopes) at twenty-five sites worldwide. Combined, the network makes up to 80,000 satellite observations each day. The SSN's Ground-Based Electro-Optical Deep Space Surveillance (GEODSS) telescopes are scheduled to be upgraded to identify an object size of 5cm and larger. The Russian Federation operates a similar system, although it is less capable.

The European Space Agency maintains the ESTRACK Network to track its own satellites and those of their industrial customers. Furthermore, the European Union in the framework of the Common Foreign and Security Policy maintains its own satellite centre (the former WEU Satellite Centre at Torrejón, Spain).

The so-called '*national technical means*' that are used for (military) reconnaissance and spying are also suitable tools for verification purposes. These include early infrared warning satellites to detect space launches of missiles and rockets; reconnaissance satellites with optical cameras, infrared or microwave sensors to observe suspected ASAT facilities such as launchers, rockets or laser systems; ground-, air- and space-based electronic and electromagnetic surveillance systems to intercept communication signals of suspicious facilities, which could with some probability also receive telemetry signals of prohibited weapons tests in space.

Similar to other arms control treaties, a space weapons agreement could include provisions to set up an *international monitoring system*. The system would include a variety of verification means globally and make relevant data available to all states parties to the treaty.

On-board sensors on important satellites could collect pressure, acceleration, heat and radiation data and notify ground control of any deviation from the expected status. In case of a satellite failure, the sensor data could help to determine the cause of failure and exclude or confirm the likelihood of an ASAT attack.

Confidence-building measures could further enhance reliability of the treaty regime. Advance notice of any launches, including information on the functions and capabilities of the object to be launched, would be an easy way to prevent mistrust. Multinational space activities, including mission design, development, production and operation, might reduce suspicions and could serve as a hedge against cheating attempts.

Lastly, *reducing risk* through means other than verification can add to one's perception of security. Feasible measures to increase survivability of space objects—and therefore decrease vulnerability to both natural disturbances and ASAT attacks—include:[12]

- physical hardening against nuclear radiation, laser irradiation or collision with small objects;
- manoeuvrability to escape a potential physical threat;
- autonomy from ground control to reduce the risk of communication failure or interruption;
- deception of attacking sensors;
- attack warning sensors on-board important spacecraft;
- 'keep away' safety areas (buffer zones) to increase the warning time;
- redundancy and distribution of important functions to several satellites (clustering); and
- provisions for quick replacement of crucial satellites in case of a failure or attack.

Conclusion—understanding the principles of treaty verification

The question of verification of arms control treaties is often narrowed down to particular verification problems or to technical capabilities of (existing) monitoring systems. In so doing, it is generally ignored that broadly accepted verification principles should also be defined. This is important because treaty verifiability is not a precisely measurable value in itself but should be evaluated in the context of the security risks associated with or prevented by treaty compliance. It is therefore useful to keep in mind a few principles of verification.

- Arms control should enhance international stability and reduce the risk of an unrestrained arms race.
- A proper balance should be maintained between the activities that ought to be verified (acceptance threshold) and the activities that can be verified (monitoring threshold).
- Generally, the expenditures for verification should be proportional to the security gain achieved and the risks that remain.
- Verification encompasses several parallel processes. In addition to technical monitoring systems, political, legal, diplomatic and military processes are important factors when it comes to assessing treaty compliance, predicting the risk of cheating and providing for sufficient time to initiate adequate countermeasures in the case of treaty violations.
- Due to the imperfection of available verification means, there remains a residual risk. This can be further reduced by defensive and cooperative measures that offset any advantage a party might gain by cheating.

In essence, two factors determine the reliability of measures to verify an ASAT ban: the availability of specific technologies (which is rapidly increasing in many fields) and the inherent dual-use capability of relevant technologies and systems.

An ASAT ban would be adequately verifiable if development, testing and deployment of ASAT systems with advanced technologies were completely prohibited. This would include ballistic missiles, missile defences, nuclear weapons, carrier airplanes and high energy lasers—and is very unlikely. More realistically, a space weapons ban could restrict only specific weapon systems. A residual risk inevitably would remain from systems that are not covered by the ban but could be used in weapons mode. For example, long-range missiles, manoeuvring spacecrafts, and air- or ground-based lasers could all be used for satellite attacks. An ASAT ban would therefore have to be bolstered with a range of confidence-building measures and transparency agreements.

For this to be achieved, all claims of 'space dominance' and desires for 'force projection into, through, from, and in space' must be given up. The further the development and testing of relevant systems advances—for either civilian or military programmes—the more costly and less reliable eventual verification will be. An atmosphere of trust and non-military conflict resolution would omit the perceived need for the weaponization of space—and ensure that 'Star Wars' remains science fiction.

Notes

1. Address delivered to the opening meeting of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), Vienna, 19 July 1999, available at <http://www.oosa.unvienna.org/unisp-3/> under 'Statements'.
2. Commission to Assess United States National Security Space Management and Organization, 2001, *Report of the Commission to Assess United States National Security Space Management and Organization*, 11 January. The Commission was chaired by Donald Rumsfeld. Full text available at <http://www.defenselink.mil/pubs/space20010111.html>.
3. Select examples include: United States Air Force Scientific Advisory Board, *New World Vistas. Air and Space Power for the 21st Century*, 1995; United States Space Command, *Vision for 2020*, 1997; US Space Command, *Long Range Plan. Implementing USSPACECOM Vision for 2020*, 1998; United States Secretary of Defense Bill Cohen, *Memorandum: Department of Defense Space Policy* and *Department of Defense Directive, Number 3100.10, July 9, 1999, 'Space Policy'*; and Air Force Space Command, *Strategic Master Plan for FY02 and Beyond*, 9 February 2000.
4. Commission to Assess United States National Security Space Management and Organization, *op. cit*.
5. For a comprehensive discussion of Prevention of an Arms Race in Outer Space and the texts of and comments on several space weapons ban proposals, see *INESAP Information Bulletin*, no. 20, August 2002, which also contains a detailed bibliography on the topic compiled by Jürgen Scheffran. Available at <http://www.inesap.org/bulletin20/bulletin20.htm>.
6. In doing so, the *Proposed Treaty on the Limitation of the Military Use of Outer Space* (Göttingen, 1984) is used as an example. This proposal considers a ban on ASAT weapons, on weapons in space and on space-based systems for direct guidance of nuclear weapons, including a ban on manned military command centres in space. This treaty was drafted by H. Fischer, R. Labusch, E. Maus and J. Scheffran and presented at the Conference of Scientists Against the Militarization of Space, July 1984, in Göttingen, Germany. The full treaty text is available at <http://www.mbmd.org/SpaceWeaponsBan/GoettingenTreaty.pdf> and has been re-printed in *INESAP Information Bulletin*, no. 20, August 2002.
7. CD document CD/1679 of 28 June 2002.
8. Fu Zhigang, First Secretary of the Chinese Mission to the United Nations in Geneva, in his article The Joint Working Paper by China and Russia in *INESAP Information Bulletin*, op. cit.
9. The orbit of a satellite is defined by its inclination relative to the equator, the point in orbit furthest away from Earth (apogee) and the point in orbit closest to the Earth (perigee).
10. See the Union of Concerned Scientists, *Limitations and Artificialities of the Testing Program*, available at <http://www.ucsusa.org/global_security/missile_defense/page.cfm?pageID=1026>.
11. For more details, see Andrew Lichterman, Zia Mian, M.V. Ramana and Jürgen Scheffran, *Beyond Missile Defense*, INESAP Briefing Paper no. 8, April 2002, available at <http://www.inesap.org/pdf/Briefing8_02.pdf>.
12. Extensive information on hardening and self-protection technologies is given in United States, Office of the Secretary of Defense, *Space Technology Guide FY 2000–01*, Department of Defense, available at <http://www.c3i.osd.mil/org/c3is/spacesys/STGMainbody.pdf>.

Security without weapons in space: challenges and options

Rebecca Johnson[1]

From H.G. Wells's futuristic fiction to Arthur C. Clarke's *2001: A Space Odyssey*, and from Solaris to Star Trek, space has captured our imagination as a place of exploration, challenge and mystery. The first Sputnik could have led to a Cold War Battlespace, but grew instead into the International Space Station. In the intervening decades, outer space has become much more than a realm of imaginary quests. It has become a site for commercial development, global communication, conflicting ambitions, and an important military resource and domain for power projection.

Outer space surrounds our planet, the 'heavens' above us, wherever we happen to be on Earth. It is visible to all but, at present, accessible to only a few. We will have to decide early in the twenty-first century whether to cooperate internationally to protect outer space as a sanctuary and shared resource for the benefit of billions, or whether to allow the 'ultimate high ground' of space control to be captured on behalf of the military of one nation.[2] This is not a decision that can be avoided. Already the structures for space weaponization are being embedded by a small, but influential coterie of US military officials, politicians and arms contractors. Delayed international action or a failure to decide will result in the weaponization of space as surely as a deliberate decision to deploy weapons for use in and from space.

The 11 September attacks on the World Trade Center and the Pentagon ratcheted up the perceived threats from terrorism and nuclear, chemical and biological weapons. For many, the idea of dangers and insecurities from the future weaponization of space seem too remote to be considered a priority for political action now. Yet history teaches us that by the time a particular weapon or military doctrine becomes an obvious political priority, it is usually too late to intervene and halt its development. Moreover, proliferation to other states or to non-state actors will follow from the possession by a few, though economic, technical or counter-proliferation hurdles may slow it down for a while.

As it is responsible for some 95% of military satellites and more than two-thirds of the world's expenditure on the commercial uses of space, it is hardly surprising that Washington desires to protect US space assets from being disabled or destroyed. The US military and political leaders need urgently to examine the implications of testing and deploying weapons for use in or from space, and whether they would actually increase or decrease the security of space assets. More fundamentally, would such weapons be likely to diminish or enhance the security of life here on Earth? With these questions in mind, this article considers initiatives for addressing space vulnerabilities and long-term security objectives.

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The politics of space weaponization

At a time when much political and military attention is focused on terrorism, why should the international community be concerned about some future possibility of weapons in space? The 'Desert Storm' Gulf War of 1991, the strikes on Yugoslavia in 1999, and the 2001 war in Afghanistan have demonstrated the enhanced power and precision of weaponry that depends on US military satellites. This space-reliant 'revolution in military affairs' (RMA), funded by a US defence budget that in 2002 exceeded the combined total of the next nineteen largest national defence expenditures, has placed the United States far ahead of any other country in the technology and hardware of warfare. Such levels of dominance are not necessarily good for the United States or its allies. Potentially destabilizing, they may also be self-defeating in security terms, provoking adversaries to direct attacks at the 'soft belly' (i.e. undefended civilians), as happened on 11 September.

The drive towards weapons for use in or from space has two principal justifications: firstly, that space weaponization is essential to protect space assets from a pre-emptive attack, dramatically called a 'Space Pearl Harbor' by the Commission to Assess United States National Security Space Management and Organization (known as the 2001 Space Commission, chaired by Donald H. Rumsfeld);[3] and secondly, that who controls space will control the Earth and obtain an unassailable military and commercial dominance. In addition to the assumptions of vulnerability and space power, some also argue from historical analogy that space weaponization is inevitable, and that whoever gets there first will enjoy an overwhelming advantage. The weaponization of space has to be seen in the context of missile defence, increasingly accepted by US allies in the post 11 September political environment. Advocates of US weapons in space have difficulty comprehending the degree to which their plans are viewed as a security threat by others because they assume that US superiority is beneficial for international stability.

From the mid-1990s on, all three types of argument could be found in US policy documents, most notably: the 1996 *National Space Policy*;[4] the 1999 *Department of Defense Space Policy*;[5] US Space Command's *Vision for 2020* (1997)[6] and *Long Range Plan* (1998);[7] The US Air Force *Strategic Master Plan for FY02 and Beyond*;[8] the January 2001 *Report of the Commission to Assess United States National Security Space Management and Organization*;[9] the Defense Department's 2001 *Transformation Study Report*;[10] and the 2001 *Quadrennial Defense Review*.[11] After *Vision for 2020* declared that 'the medium of space is the fourth medium of warfare—along with land, sea and air',[12] the 2001 Space Commission argued that the US government should pursue the relevant capabilities 'to ensure that the President will have the option to deploy weapons in space to deter threats to and, if necessary, defend against attacks on US interests'.[13] United States Space Command foresaw its role in 'dominating the space dimension of military operations to protect US national interests and investment … [and] integrating space forces into warfighting capabilities across the full spectrum of conflict.'[14] The Space Commission concluded that space interests be regarded as a top national security priority and that the United States must ensure continuing superiority in space capabilities in order 'both to deter and to defend against hostile acts in and from space', including 'uses of space hostile to US interests'.[15]

The United States has persisted in dismissing diplomatic initiatives to address 'prevention of an arms race in outer space' (PAROS), arguing that there is 'no need for new outer space arms control agreements'.

Though this steady stream of US policy documents extolling 'combat theories and concepts related to space warfare'[16] has provoked increasing anxiety among other nations, the United States has persisted in dismissing diplomatic initiatives to address 'prevention of an arms race in outer space' (PAROS), arguing that there is 'no need for new outer space arms control agreements'.[17] While the 'space hawks' and 'inevitable weaponizers' in the United States Department of Defense would endorse the Bush Administration's opposition to arms control, there are 'militarization realists' and 'space doves' in the US armed forces and political arena who believe that some kind of arms control or international legislation to prevent the weaponization of space is an urgent necessity.[18] Although the Democratic Party's opposition to Republican plans for space-based missile defences was largely silenced in the aftermath of the 11 September attacks, the former Democratic Leader in the Senate, Tom Daschle, has called the weaponization of space 'the single dumbest thing I have heard so far from this administration. ... It would be a disaster for us to put weapons in space of any kind under any circumstances. It only invites other countries to do the same thing.'[19]

Addressing the vulnerability of space assets

To garner support for space weaponization, the Space Commission evoked the spectre of a space Pearl Harbor, focusing on the vulnerability of space assets and the increasing dependence of US military forces on satellite-based technology. Emphasis is placed on the risks of a pre-emptive attack from anti-satellite weapons (ASATs) or the detonation of a nuclear device at high altitude. Any international approach to address space security needs to take into account both US concerns about the vulnerability of its military and space assets and also the concerns of other governments regarding their vulnerability to US military superiority.

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One characteristic of asymmetric conflict is that the push for military invulnerability will tend to increase civilian vulnerability. The major driver behind space weaponization may be missile defence, but concepts such as full spectrum dominance and space control are mirrored in the Bush Administration's approach to combating terrorism. Notions of full spectrum dominance, as outlined in United States Space Command documents, are perceived as a security threat by countries that have no political desire or intention to threaten the United States, but which would be expected by their own citizens and militaries to develop countermeasures to deter the United States nevertheless. This is a version of the classical security dilemma, whereby the attempts of some states to look after their security needs by strengthening their military resources lead to rising insecurity for others. Regardless of its intentions, overwhelming military security and the current US mission to police the world feed other nations' threat perceptions. In space, as with other issues, the United States needs to be more aware that its actions could be self-fulfilling, and may well provoke asymmetric security responses in others that create greater international threats and vulnerabilities.

Undoubtedly, one or more nuclear detonations at very high altitude would disable satellites in Low Earth Orbit (LEO)[20] that had not been previously hardened against the effect of a nuclear weapon's electro-magnetic pulse (EMP). Although the United States has hardened many of its key military satellites, many commercial assets and several other countries' satellites would be jeopardized. Though the technology to prevent a high altitude nuclear detonation does not exist, it would be extremely difficult for the perpetrator to evade detection. Such a detonation would indiscriminately damage the space assets and communications and navigational systems of friends as well as foes, and there would be high political costs to crossing the nuclear threshold.

The Space Commission's answer appears to be more weapons, but weaponizing space would be likely to accelerate the threats to US assets rather than deterring or preventing them.[21] A more sensible approach would combine the physical and technical hardening of satellites, which would contribute to deterring such an attack, and arms control—with particular emphasis on nuclear disarmament, strengthening the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), and efforts to restrict missile proliferation, such as the Missile Technology Control Regime (MTCR) and the recently concluded International Code of Conduct Against Ballistic Missile Proliferation (ICoC).

For many technological and political reasons, a high altitude nuclear detonation is unlikely, though in an age of asymmetric warfare, it cannot be completely ruled out. A much more immediate danger to commercial and military assets in space, already arising from careless human actions in the first forty-five years of space activities, comes from space-crowding and orbital debris.

LEO is teeming with human generated debris, defined by NASA as 'any man-made object in orbit about the Earth which no longer serves a useful purpose'. There are some 9,000 objects larger than 10cm and over 100,000 smaller objects. As orbiting debris may be travelling at very high velocities, even tiny fragments can pose a significant risk to satellites or spacecraft, as experienced by US astronaut Sally Ride, when an orbiting fleck of paint gouged the window of the Space Shuttle during her first flight.[22] If instead of paint, the projectile had been harder or larger, it could have put the lives of the crew at risk.

As noted by Joel Primack, one of the premier experts on the problems of space debris, 'the weaponization of space would make the debris problem much worse, and even one war in space could encase the entire planet in a shell of whizzing debris that would thereafter make space near the Earth highly hazardous for peaceful as well as military purposes'.[23] Such a scenario would cause the Earth to be effectively entombed, jeopardizing the possibility of further space exploration and greatly complicating civilian uses. In addition, Primack speculates that even a small number of 'hits' in space could create sufficient debris to cause a cascade of further fragmentation (a kind of chain reaction). This, in turn, could potentially damage the Earth's environment and, as the Sun's rays reflect off the dust, cause permanent light pollution, condemning us to a 'lingering twilight'.[24]

States with the capabilities to launch intercontinental ballistic missiles (ICBMs) or to put satellites in space will also be capable of launching an ASAT attack. A few may develop ASAT laser weapons suitable for an attack against anything in LEO. As such states are likely to have their own space assets in orbit, however, the destruction or fragmentation of satellites would exacerbate the problem of space debris and so be counter-productive for their own security interests. Military and commercial systems in space depend on ground facilities (telemetry, tracking and control, communications, data reception, etc.) and radio links (carrying commands, communications, telemetry and data), both of which provide much more accessible opportunities for interference, disablement or destruction. It is unlikely that adversaries would risk a direct, physical attack when electronic hacking, jamming or 'spoofing' provide a low tech, low cost means of disrupting space assets. The weaponization of space as a proposed response to potential vulnerabilities needs to be placed in a much wider context than United States Space Command literature suggests.

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Furthermore, there are a number of technical approaches that could increase the security of space-based assets without resorting to the deployment of weapons. These include: hardening and shielding power sources and vulnerable equipment both to protect against EMP and certain levels of kinetic impact; building in redundancy, ensuring that there are back-up facilities and replacements to avoid a whole system being crippled if one or a few parts of it are disabled; and increasing situational awareness, manoeuvrability, and stealth/concealment capabilities.

International approaches

Placing weapons in space is not the inevitable outcome of the use of space for commercial purposes. Many of the perceived vulnerabilities of space assets can be addressed in other ways. At present, no one but the United States has the capability, intention and resources to pose a significant risk to space-based assets. In addition, no state with the technological potential to pose a future threat to US (or other) space assets (for example, the Russian Federation, China, France/European Union, India) is prioritizing financial or technical resources to developing weapons capable of threatening space assets, and all of these are more interested in building or maintaining cooperative (if sometimes uneasy) alliances with the hyperpower. If US military developments in space continue their drive towards weaponization, however, other governments may feel under pressure to devote political, financial and technological resources to counter or offset US space-based superiority. Before such expensive and dangerous military responses become necessary, a number of governments and NGOs are exploring legal, political and diplomatic ways to address space security and weapons.

When considering what is desirable and feasible, three considerations are important: the current legal situation and what is already being addressed; realistic political possibilities in the near future; and what would need to be done to create the political conditions for addressing space security more effectively. Possible approaches fall into five broad categories: confidence-building measures; utilizing existing legal instruments; partial measures; national and regional approaches; and comprehensive approaches, including treaty negotiations. In examining these options below, I make the argument for the international community to undertake a comprehensive approach that would incorporate most of these elements. Comprehensively addressing space weaponization and security issues would not preclude partial, interim steps or agreements reached without full multilateral negotiations, but there needs to be the clear, overarching goal of creating a legally binding space security regime and embedding an unequivocal taboo on the deployment or use of weapons in and from space.

Confidence-building measures

Space security has been the subject of United Nations resolutions for more than forty years. General Assembly resolution 1721[25] of 20 December 1961 established many of the foundational principles of space arms control that were later to be enshrined in the 1967 Outer Space Treaty (OST). It stressed that exploration and peaceful uses should be open to all, and that international law should apply to space and celestial bodies. It advocated the registration of space launches and international cooperation on issues such as communication and meteorology.[26] The United Nations Committee on the Peaceful Uses of Outer Space (COPUOS), attached to the General Assembly's Fourth Committee, has long been able to discuss the problems associated with space traffic control and debris, but is hampered by an interpretation of its mandate that precludes any addressing of arms control or disarmament questions. Employing the well-known 'ping-pong' tactic, the United States and others insisted that any disarmament-related issues were the purview of the Conference on Disarmament (CD), where they could then be blocked.

Transparency measures under consideration, in conjunction with wider efforts to control ballistic missile proliferation, include notification of launches, providing pre- and post-launch information, and the licensing of activities. The idea of starting the process of addressing space security by looking at transparency, confidence-building measures and international cooperation to track and mitigate debris and overcrowding in space appears attractive because it is thought possible to bypass the space hawks' objections and draw the United States into such discussions. If the United States were prepared to engage and if (a bigger if, this) the talks could be effectively managed, they would be intrinsically valuable. However, as long as the CD and COPUOS maintain a rigid division of labour, it will be difficult—if not impossible—to move from such confidence-building measures into the kind of cooperative arms control that is urgently required. There would be a danger

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that under such circumstances substantive talks on space debris and traffic control would be time-consuming and could be manipulated to divert attention from measures to prevent the first testing and deployment of space weapons.

Strengthening existing legislation

There are already a number of international instruments with jurisdiction over space activities. The most important is the OST, which provides a basic framework for space activities. Enshrining the principles of peaceful use and exploration, and that outer space should be available for the benefit of all (not subject to national appropriation by sovereignty claims), the OST has 102 parties, including the United States, the Russian Federation, China, France, the United Kingdom, India, Israel and Pakistan.[27] It prohibits the stationing of WMD, including nuclear weapons, in space orbit or on celestial bodies. It does not cover the transit of nuclear weapons (on ballistic missiles) through space or prohibit nuclear weapons launched from Earth into space for the purposes of destroying incoming missiles.[28] It also says nothing about ASATs or the placement of conventionally armed weapons in space. Other relevant treaties include the 1963 Partial Test-Ban Treaty (PTBT), which banned nuclear testing in outer space and the Moon Agreement of 1979, which confirmed many of the provisions of the OST, with specific reference to the Moon. Though prohibiting the threat or use of force on the Moon or the use of the Moon to commit hostile acts in relation to the Earth or space assets, the Moon Agreement does not address placing conventional weapons in orbit around the Moon.[29]

Important prohibitions on deploying and testing anti-ballistic missile (ABM) systems in space and on interfering with national technical means (NTM) operated for verification purposes were enshrined in the 1972 ABM Treaty, deemed void following US withdrawal in June 2002.[30] The principle of non-interference with NTM was also enshrined in the 1987 Intermediate Nuclear Forces (INF) Treaty and the 1991 Strategic Arms Reduction Treaty (START I).[31] START I also prohibited the production, testing and deployment of 'systems, including missiles, for placing nuclear weapons or any other kinds of weapons of mass destruction into Earth orbit or a fraction of an Earth orbit' and contained transparency and confidence-building provisions. It reinforced the provisions of the 1988 Ballistic Missile Launch Notification Agreement, providing for advance launch notification of ballistic missiles used as boosters to put objects into the upper atmosphere or space.[32]

George Bunn and John Rhinelander, legal advisers to earlier US administrations, have argued that the OST created an 'overall rule [that] space shall be preserved for peaceful purposes for all countries'.[33] They argue that OST parties would have the right under the treaty to request consultations if another party planned to test or deploy in space a laser or kinetic kill vehicle capable of being used as an ASAT, a description that would cover the space-based component of the Bush Administration's multi-layered missile defence architecture. Endorsing that OST parties should make use of this provision and request formal consultations with the United States, Jonathan Dean also proposed that nations could pass a resolution in the General Assembly to request the International Court of Justice to give an advisory opinion on whether testing or orbiting space weapons of any kind would be contrary to the core rule and objective of the OST that space be maintained for peaceful purposes. On the grounds that the testing or use of space weapons would jeopardize national technical means of verification, enshrined in several treaties and agreements, and the commercial uses of space, Dean also suggests that legal action could be taken to prevent such threats, utilizing international and US courts, as appropriate.[34]

PARTIAL MEASURES

Assessing that the current situation is equally detrimental to the interests of commercial and military space users, advocates of space weapons for missile defence and arms controllers, and that the alternative to compromising around some middle ground would be no agreement at all (and a victory for the space hawks), some arms controllers are exploring partial measures.

The Eisenhower Institute has suggested that certain space assets like the Global Positioning System (GPS) and other navigation satellites, telecommunication and weather satellites could be declared 'global utilities' and given special legal status.[35] Recalling earlier discussions, particularly during the 1980s debates over Ronald Reagan's Strategic Defence Initiative (SDI), a number of governmental and non-governmental representatives have pushed for reconsideration of a multilateral ban on ASAT weapons, at least as a first step.

Another proposal builds on an earlier Bunn proposal to distinguish between weapons in low and high orbit. With the aim of getting the support of key actors among the inevitable weaponizers and militarization realists, Clay Moltz argued the case for prohibiting the use, testing or deployment of weapons or interceptors of any sort above 500 miles and prohibiting the stationing of weapons in LEO. His proposal would permit the testing (and presumably use) of ground-based, sea-based and air-based interceptors in LEO against ballistic missiles but not against satellites or other space-based objects (while recognizing that implementation of this would have to rely on taboo-building and confidence, since verification techniques would be unable to distinguish between permitted ABM interceptors and banned ASAT purposes).[36] While such a compromise would be unlikely to satisfy the space hawks, it allows key elements of the Bush Administration's missile defence plans, while clear barriers would prevent space-based lasers or kinetic kill weapons, and might therefore head off the escalation to higher levels of space weaponization that many fear as the most threatening and destabilizing facet of the missile defence project.

The Stimson Center's 'space assurance' concept takes another approach, starting from the premise that cooperative international measures are necessary to ensure the continuation of space commerce and exploration and would be highly advantageous to US military operations. Accordingly, the Stimson Center favours licensing and controlling particular kinds of space-related activities through consultation, negotiation, or by means of unilateral national action.[37]

These are interesting initiatives to gain attention from moderates in the Bush Administration, but there is a risk that partial approaches may buy off public concern, making it more difficult to build the necessary political momentum to ensure that negotiations actually go ahead.[38] It is also important to note that though there are indications that some in the Bush Administration might be willing to consider a ban on ASAT weapons and uses, this is no longer a viable option for other key states, notably China. US use of force-support assets in space means that such a ban would be dismissed as a mechanism to protect US military capabilities while denying others the right to defend themselves against space-supported attacks. If pursued on its own, an ASAT ban would be regarded as discriminatory and unenforceable. To be viable, it would need to be coupled with a ban on space weapons testing and deployment.

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NATIONAL AND REGIONAL APPROACHES

Although few parliaments have yet begun to pay attention to space security as an issue, it is beginning to be linked with rising international concern about missile defence. The European Parliament has issued periodic reports on Europe and space. By contrast with the US emphasis on the military uses of space, the most recent European Parliament report emphasized that space activities should be only for peaceful purposes, including scientific knowledge, with ‘benefits for research, industry and society as a whole’, including the European Space Agency (ESA) and a future satellite system for global environment monitoring.[39] The report also identified ‘protection and management of the space environment’ as a major policy goal and warned that the European Union could be taking its first step towards the militarization of space with the GALILEO navigation/location system, intelligence-gathering and the Global Monitoring for Environment and Security (GMES) initiative. The European Union’s emphasis on social and economic benefits and on managing the environment is reinforced by France, Europe’s leading space-faring nation and a prime mover behind the ESA.[40] Among US allies in Europe, France has been more keen than most to challenge Washington over missile defence and space policy, and has in the past advocated greater action on PAROS in the CD than the United States is willing to contemplate.

Britain, like France, has an active space programme, with significant investment in space-based telecommunications, remote sensing, surveillance and intelligence gathering. Reflecting its close military collaboration with the United States, however, the United Kingdom has been reluctant for PAROS to be made a CD priority, although it traditionally votes in favour of the annual United Nations General Assembly resolutions on prevention of an arms race in outer space.[41] The British Ministry of Defence (MoD) has expressed concerns about space debris, and has noted—but without expressing explicit concern—that space could become part of a potential ‘future battlespace’ in which the use of directed energy weapons ‘seems likely to increase’.[42] Britain is more dependent on US military space programmes than other European Union countries. Although officials privately express concern about the implications of the Bush Administration’s ambitious and apparently open-ended plans for missile defence and the weaponization of space, Britain already hosts two US facilities that are crucial for missile defence and the US National Security Agency, at Fylingdales and Menwith Hill in Yorkshire, and the current government would be unlikely to take an independent or critical stance unless the issue became domestically politicized at a much higher level than at present.

Within the United States itself, a Democrat Representative, Dennis Kucinich of Ohio, put forward a Space Preservation Bill in the House of Representatives in January 2002. In essence, the bill calls on the United States to ban all research, development, testing and deployment of space-based weapons. If passed, it would also require the United States to enter into negotiations toward an international treaty to ban weapons in space.[43] This initiative, which has also given rise to an NGO-sponsored Space Preservation Treaty, can be a useful tool to stimulate public and political debate, but it is unlikely to become a viable basis for negotiations or real legislative action. Nevertheless, there may be some political merit in other parliaments introducing similar initiatives to stimulate national debate and public and political mobilization around space security issues.

Comprehensive approaches

The most effective comprehensive approach for addressing both US and international security concerns would require three interrelated components:[44]

- a ban on the testing, deployment and use of all kinds of intentional weapons in space. This is needed to extend and strengthen the 1967 Outer Space Treaty’s prohibitions on weapons of mass destruction in space so that directed energy (laser) and kinetic kill weapons are also banned, as well as any other potential offensive innovations that military researchers or planners might dream up;
- a ban on the testing, deployment and use of terrestrially based anti-satellite weapons, adding land, air and sea-based ASAT to the ban on space-based ASAT covered in the previous point; and

- a code of conduct for the peace-supporting, non-offensive and non-aggressive uses of space. The code of conduct/rules of the road could include regulations relating to space debris and space traffic control, missile launch notification, and other transparency and confidence-building measures, with mechanisms for reviewing and updating provisions as and when appropriate.

An obvious and fundamental problem for treaty negotiations is how a ‘weapon in space’ can be defined or distinguished from the military components in space of terrestrially based weapons. Suggestions for basing the ban on ‘purpose’ rather than ‘technology’ need to be explored further. Verification questions abound. Such objections do not undermine or invalidate the concept of either a space security treaty or a set of interconnecting agreements covering these three essential and inter-related components, but they do point to the need for legal and technical experts to get together with diplomats and government officials to work out the needs and parameters of a space security architecture.

With the advent of America’s most recent push to develop missile defences, there has been renewed pressure from many states for the CD to address issues relating to the potential weaponization of space under its PAROS agenda item. Some states, notably China and the Russian Federation, have intensified their demands for the CD to undertake negotiations to prevent the weaponization of space. In June 2002, the Russian Federation and China, together with Indonesia, Belarus, Viet Nam, Zimbabwe and Syria, co-sponsored a working paper on ‘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’.[45] Consisting of thirteen articles, the working paper was laid out as a draft treaty with the object of stimulating the early start of substantive discussions in the CD on the issue of PAROS.[46]

The preamble stated that ‘only a treaty-based prohibition of the deployment of weapons in outer space and the prevention of the threat or use of force against outer space objects can eliminate the emerging threat of an arms race in outer space and ensure the security for outer space assets of all countries which is an essential condition for the maintenance of world peace’.

The draft treaty’s scope comprises three elements: ‘Not to place in orbit around the Earth any objects carrying any kinds of weapons, not to install such weapons on celestial bodies, or not to station such weapons in outer space in any other manner. Not to resort to the threat or use of force against outer space objects. Not to assist or encourage other States, groups of States, international organizations to participate in activities prohibited by this Treaty.’

The Chinese-Russian initiative is partly a political tactic, and partly a genuine attempt to stimulate discussion about what a space security treaty might look like. Like the Kucinich Bill, it is important to recognize that such drafts are only sketched, intended to provoke discussion rather than be a technical or legal basis for negotiations. They can play a very valuable role, providing their supporters recognize their mobilizing function and do not become stuck on the minutiae of specific language formulations or become narrow-mindedly exclusive about their particular approach.[47]

Conclusion

As the Russian Federation’s permanent representative in Geneva, Leonid Skotnikov, underlined when presenting the Chinese-Russian draft treaty to the CD, ‘urgent measures should be taken today to prevent the deployment of weapons in outer space, so that we are not forced later on to waste a colossal amount of time and effort on its deweaponization.’[48] If we ignore the issue now, it is possible that—as with the 'Star Wars' plans of earlier decades—it might go away or collapse under the weight of its own technological, military or financial contradictions. Or, alternatively, it could be quietly and efficiently embedded and promoted within the bureaucracies and military industries, as appears to be the strategy Rumsfeld has chosen, as he proceeds to implement the recommendations of the Space Commission.

As outer space grows in commercial and military importance, there are current threats and vulnerabilities that need to be addressed now, but coherent international approaches are hampered by weapons-driven approaches on defence and security and short-sighted attitudes towards arms control. Although the conditions have not yet developed for negotiations on a comprehensive treaty to be viable, it could be very useful to consider initial measures on launch notification, space debris and elements of a code of conduct for sustainable space activities. If addressed as confidence-building means related to the wider context of space security and non-weaponization, rather than treated as sufficient ends in themselves, such negotiations would be a way to engage the United States and other space-farers in a dialogue about ways of sharing outer space to enhance international security and reap greater long-term benefits for all.

Although the conditions have not yet developed for negotiations on a comprehensive treaty to be viable, it could be very useful to consider initial measures on launch notification, space debris and elements of a code of conduct for sustainable space activities.

The levels of issue salience and civil-society engagement are still quite low. To raise consciousness there needs to be greater understanding of the foreseeable consequences. It is not sufficient to assert that the weaponization of space would create even more debris with unpredictable consequences for the Earth, human security or future space activities. More research needs to be undertaken on a range of technical, strategic, environmental, economic and security implications and to assess the likely architecture (numbers and types of weapons) if one or more countries were to deploy space-based directed energy or kinetic kill weapons or an ASAT array. The debate risks becoming bogged down, however, if it focuses too much on the arguments for or against certain types of weapons or technologies.

Advocates of a space weapons ban need to frame the issue in terms of future security and focus on the following strategies:

- *Forge alliances* within the military, political and industrial sectors, especially in the United States, using technical expertise and cognitive strategies aimed at diminishing support for space weaponization and shaping interests in the direction of identifying both US security needs and international security as best served through creating a space sanctuary or security regime.
- *Strengthen* the advocates of a space weapons ban both within and outside the United States by encouraging knowledge-sharing and the development of a coherent, objective and multi-layered approach. The objective of space security needs to be promoted in terms of a non-weaponized architecture, with a code of conduct regulating space activities to enhance the security of space assets and current and future non-offensive uses and activities.
- *Unify* as large a group of states as possible behind a coherent concept for a space security treaty, preferably through building a strong partnership of governments and civil society experts, advocates and activists.
- *Maximize* the effective engagement of global civil society around achievable goals and viable strategies.

There is nothing wrong with motivating public action through images that make people afraid, if the threats and risks underlying the fears are well founded. In the case of space weaponization or war, the dangers cannot be predicted and must not be underestimated. Future exploration and the peaceful uses of space could be irrevocably damaged. Life on Earth could be harmed in unpredictable and far reaching ways. It is time to create new partnerships between governments, industry, space users and explorers, and informed, concerned citizens to get this message across to the wider public and their political representatives.

Notes

1. This paper has benefited greatly from my discussions in several countries with scholars, activists and military officials too numerous (or sensitive) to mention, but I would like to express particular appreciation to Theresa Hitchens, Bruce DeBlois, John Pike and Yu Xiaoling for challenging and stimulating my thinking on space security.
2. Paul Wolfowitz, US Deputy Secretary of Defense, in a speech to the Frontiers of Freedom organization, used this term in the following quotation: '... while we have demonstrated that hit-to-kill works, as we look ahead we need to think about areas that would provide higher leverage. Nowhere is that more true than in space. Space offers attractive options not only for missile defense but for a broad range of interrelated civil and military missions. It truly is the ultimate high ground. We are exploring concepts and technologies for space-based intercepts.' *Transcript – Wolfowitz Outlines Missile Defense Successes, Way Ahead*, US State Department (Washington File), 25 October 2002, available at <http://usembassy.state.gov/tokyo/wwwhsec20021028b3.html>.
3. *Report of the Commission to Assess United States National Security Space Management and Organization*, Washington DC (Public Law 106-65), 11 January 2001, available at <http://www.space.gov/docs/fullreport.pdf>, known as the 2001 Space Commission.
4. Available at <http://www.ostp.gov/NSTC/html/fs/fs-5.html>.
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9. Available at <http://www.space.gov/docs/fullreport.pdf>.
10. Available at <http://www.defenselink.mil/news/Jun2001/d20010621transrep.pdf>.
11. Available at <http://www.defenselink.mil/pubs/qdr2001.pdf>. In 2002, US Space Command (SpaceCom) was folded into US Strategic Command (StratCom), following Department of Defense reorganization. This integration of SpaceCom as part of the Pentagon's core military mission was one of the recommendations of the 2001 Space Commission (see note 3), now being implemented.
12. United States Space Command, *Vision for 2020*, February 1997, available at <http://www.fas.org/spp/military/docops/usspac/visbook.pdf>.
13. Report of the 2001 Space Commission, *op. cit.*, p. 12. This echoes US SpaceCom's *Long Range Plan*, which stated: 'At present, the notion of weapons in space is not consistent with US national policy. Planning for this possibility is the purpose of this plan should our civilian leadership later decide that the application of force from space is in our national interest.' United States Space Command, 1998, *Long Range Plan*, March, p. 8, available at <http://www.fas.org/spp/military/docops/usspac/lrp/toc.htm>.
14. *Ibid*., Executive Summary.
15. Report of the 2001 Space Commission, *op. cit*., pp. 7–10.
16. The quotation is from the statement of Hu Xiaodi, ambassador of China to the CD on 27 June 2002. See CD/PV.907 of 27 June 2002.
17. Eric Javits, ambassador of the United States of America to the CD on 27 June 2002. See CD/PV.907 of 27 June 2002.
18. This characterization is based on Lt. Col. Hays's typology of four approaches to space weaponization: 'space hawks', keen to pursue weaponization at all costs; 'inevitable weaponizers', who argue from historical analogy and are sceptical of arms control; 'militarization realists', who interpret history differently and believe that the US has little to gain and much to lose by weaponizing space; and 'space doves', who advocate comprehensive arms control on the grounds that concepts such as space sanctuary and space security are more consistent with US national security than initiating an arms race in outer space. Lt. Col. Peter L. Hays, 2002, *United States Military Space: Into the Twenty-First Century*, Colorado, Institute for National Security Studies, September (INSS Occasional Paper no. 42), especially pp. 116–21. See also Lt. Col. Bruce M. DeBlois, 1998, Space Sanctuary: A Viable National Strategy, *Airpower Journal*, vol. 12, no. 4 (Winter), pp. 41–57, available at <http://www.airpower.maxwell.af.mil/airchronicles/apj/apj98/win98/deblois.pdf>.
19. Quoted in Peter Grier, 2001, The New Nuclear 'Theology', *Christian Science Monitor*, 8 May, available at <http://www.csmonitor.com/durable/2001/05/08/fp1s2-csm.shtml>.

20. Space abounds with disagreements about definitions. For example, LEO is defined by some as 60–500km above the Earth and by others as between 100–1,500km above Earth. Geostationary Earth Orbit (GEO) is around 35,000km above the Earth's equator, where satellites proceed on circular, twenty-four hour orbits. In between is the Medium Earth Orbit (MEO).
21. If an adversary able to carry out a high altitude nuclear detonation were reckless enough to defy such compelling technical and political deterrents and risk crossing the nuclear threshold in pursuit of its objectives, we might also reflect that perhaps it would be better if the demonstration target were commercial and military assets in space rather than a city full of people on Earth.
22. Sally Ride, Drell Lecture, Stanford Center for International Security and Cooperation, 10 April 2002, quoted in Joel Primack, 2002, Pelted by paint, downed by debris, *The Bulletin of the Atomic Scientists*, vol. 58, no. 5 (September/October), p. 25, available at <http://www.thebulletin.org/issues/2002/so02/so02primack.html>.
23. Primack, *ibid.*, pp. 24–25.
24. *Ibid.*, p. 71.
25. Full text available at <http://www.oosa.unvienna.org/SpaceLaw/gares/html/gares_16_1721.html>.
26. In 1963, a further United Nations General Assembly resolution called for a ban on the deployment of nuclear weapons or other weapons of mass destruction in space. See General Assembly resolution 1884 of 17 October 1963. This was followed by a further resolution that paved the way for negotiation of the Outer Space Treaty. See General Assembly resolution 1962 of 13 December 1963, available at <http://www.oosa.unvienna.org/SpaceLaw/gares/html/gares_18_1962.html>.
27. The Outer Space Treaty is formally named the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies. For a list of the states party to this treaty, as of 2002, see *SIPRI Yearbook 2002: Armaments, Disarmament and International Security*, Oxford, Oxford University Press and Stockholm International Peace Research Institute, p. 765–66. A further twenty-seven states have signed but not ratified. Treaty available at <http://www.oosa.unvienna.org/SpaceLaw/outersptxt.html>.
28. Early US missile defence interceptors in North Dakota carried nuclear warheads, permitted under the 1972 Anti-Ballistic Missile (ABM) Treaty. The still-deployed Russian system around Moscow (*Galosh*) is also equipped with nuclear interceptors.
29. The Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (the Moon Agreement) was signed in December 1979 and entered into force in 1984. Before this, there were a couple of agreements facilitating cooperation: The 1968 Astronauts Rescue Agreement; the 1972 Convention on International Liability for Damage Caused by Space Objects; and the 1975 Convention on Registration of Objects Launched into Outer Space (the Registration Convention). All available at <http://www.oosa.unvienna.org/SpaceLaw/treaties.html>.
30. It is important to note that Article V of the ABM Treaty prohibited space-based ABM systems, but has been interpreted as allowing space-based interceptors or lasers for theatre missile defence (TMD). This loophole was closed by the Helsinki agreements of 1997. The Helsinki agreements were not ratified by the Senate, and the demise of the ABM Treaty re-opens this option. See Hays, *op. cit.*, pp. 96–97.
31. This non-interference obligation was made multilateral in the Conventional Forces in Europe (CFE) Treaty, which has thirty NATO and East European participants and is of unlimited duration. These points were made by Jonathan Dean in his presentation to the Conference on Outer Space and Global Security, organized by UNIDIR and the Simons Foundation of Canada at United Nations Office Geneva, 26–27 November 2002.
32. These provisions have been augmented by a US-Russian memorandum of understanding establishing a Pre-and Post-Launch Notification System (PLNS) for most ballistic missile and space vehicle launches, signed 16 December 2000. This would be operated as part of the US-Russian Joint Data Exchange Centre. Text available at <http://www.state.gov/t/ac/trty/4954.htm>.
33. George Bunn and John B. Rhinelander, 2002, Outer Space Treaty May Ban Strike Weapons, *Arms Control Today*, vol. 32, no. 5 (June), p. 24 (Letter to the Editor), available at <http://www.armscontrol.org/act/2002_06/letterjune02.asp>.
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35. As noted by Jonathan Dean in his presentation to the Conference on Outer Space and Global Security, *op. cit.*
36. James Clay Moltz, 2002, Breaking the Deadlock on Space Arms Control, *Arms Control Today*, April, pp. 3–9, available at <http://www.armscontrol.org/act/2002_04/moltzapril02.asp>.
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38. The 1963 PTBT, for example, put nuclear testing out of sight, underground, thereby defusing public concern despite the fact that nuclear testing continued to fuel the nuclear arms race for another three decades.
39. European Parliament, 2001, *Draft Report on Europe and Space: Turning a New Chapter, Committee on Industry, External Trade, Research and Energy*, 2001/2072(COS) (Rapporteur: Konstantinos Alyssandrakis), 3 October.

40. Centre National d'Etudes Spatiales (CNES), *2001–2005 Strategic Plan*, available at <http://www.cnes.fr/enjeux/1frame_index_enjeux.htm>.
41. After making a joint statement that they had voted in favour of the PAROS resolution but did not consider it a very high priority in 1998, Britain and Germany have since ensured a common European Union statement to this effect. In recent years, the PAROS resolution receives a very high vote in favour, with none against and a handful of abstentions, which include the United States and Israel and a satellite of the United States, such as the Marshall Islands or Micronesia. For example, General Assembly resolution 57/57 (22 November 2002) received 159 in favour, none against and 3 abstentions. Available at <http://disarmament.un.org/vote.nsf>.
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43. *Space Preservation Act of 2002*, HR 3616 (January 2002), available at <http://www.pnnd.org/us_space_preservation_bill.htm >.
44. For an early discussion of these concepts, see Rebecca Johnson, 2001, Multilateral Approaches to Preventing the Weaponisation of Space, *Disarmament Diplomacy*, no. 56 (April), available at <http://www.acronym.org.uk/dd/dd56/56rej.htm>.
45. CD/1679 of 28 June 2002. This was a follow-on from China's earlier working papers on PAROS. In order to bring the Russian Federation on board as a co-sponsor, China's position underwent some important shifts. In particular, its 2001 working paper entitled *Possible Elements of the Future International Legal Agreement on the Prevention of the Weaponisation of Outer Space* (CD/1645) had proposed that the scope should cover 'weapons, weapon systems or their components that may be used for warfighting in outer space'. This provision was clearly intended to prohibit orbital attack weapons and anti-satellite weapons, but appeared to rule out some of the existing force-support roles, which could be construed as components of weapons, and was very ambiguous on interference with military space assets by electronic means rather than physical force (for example, hacking or jamming), covered for civilian satellites under the 1932 International Telecommunication Union (ITU) Convention, as amended in 1992 and 1994.
46. Leonid A. Skotnikov, Permanent Representative of the Russian Federation to the CD, 27 June 2002, CD/PV.907.
47. If pushed to the exclusion of other approaches, a premature treaty or legislative initiative risks becoming counter-productive, even serving to focus and strengthen the opposition, thereby 'inoculating' the issue against later, more pragmatically targeted campaigns to develop legislation that would enhance space security and prevent weaponization.
48. Skotnikov, *op. cit*.

Resources on outer space security

compiled by J. Paris, with assistance of M. Mott and R. Williams

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UNIDIR FOCUS

Regional Disarmament Initiatives in Africa and the Middle East

The coming of the nuclear age prompted states to consider ways to control nuclear proliferation. Regional arms control regimes emerged as one response to the proliferation concern, often in the form of nuclear-weapon-free zones (NWFZs). NWFZs are designed to ban nuclear weapons within specific geographical areas on the initiative of the states of the region. NWFZs have been a suggested response to proliferation concerns since the late 1950s when the Polish government proposed the Rapacki Plan to ensure a denuclearized post-Second World War Central Europe. Today NWFZs are an integral part of the global non-proliferation regime. Indeed, Article 7 of the Nuclear Non-Proliferation Treaty (NPT) ensures the right of states to set up NWFZs.

Latin America pioneered the creation of the first NWFZ, the Treaty of Tlatelolco, in 1967. Since then, other regional NWFZs have been successfully created: in 1985 the Pacific states signed the Rarotonga Treaty; in 1995 the South East Asian states adhered to the Bangkok Treaty; and in 1996 the African states signed the Pelindaba Treaty.

However, since 1996 further progress in the nuclear non-proliferation and arms control regime has stalled. The Comprehensive Test-Ban Treaty has not entered into force, the Central Asian NWFZ, under discussion since 1997, has yet to become a reality and the Pelindaba Treaty awaits fifteen more ratifications to enter into force.

UNIDIR's long-standing interest in NWFZs continues through its exploration of the current state of established zones and the prospects for the creation of new ones. In this regard, UNIDIR is publishing a history of the Pelindaba Treaty negotiations. Despite the fact that progress towards the African NWFZ was held up for years by the nuclear ambitions of one state, negotiations and discussions continued until South Africa gave up its nuclear weapons programme. As other regions faced with differing levels of armaments might find the African experience informative, UNIDIR and the League of Arab States are co-sponsoring a conference in Cairo to explore ways to apply the lessons learned in Africa and other regions to the Middle East, in the form of a zone free of weapons of mass destruction (WMD).

In each issue of *Disarmament Forum*, UNIDIR Focus highlights one activity of the Institute, outlining the project's methodology, recent developments in the research or its outcomes. UNIDIR Focus will also present a detailed description of a new UNIDIR publication. You can find summaries and contact information for all of the Institute's present and past activities, as well as sample chapters of publications and ordering information, online at www.unidir.org

The Treaty of Pelindaba: On the African Nuclear-Weapon-Free Zone

Oluyemi Adeniji

In the flurry of measures proposed in the 1960s to control atomic weapons, NWFZs featured prominently as an achievable means towards the elimination of nuclear weapons. Among the first regions to decide on a continental NWFZ was Africa, which in 1964 adopted the Declaration on the Denuclearization of Africa. With the suspicion that a major country in the region, South Africa, was developing a nuclear weapon capability to defend its universally condemned policy of apartheid, Africa was hindered from pursuing the implementation of its Declaration. This situation persisted until 1991 when, taking advantage of the new developments in international relations, African states commenced the process of implementing the 1964 Declaration through a resolution of the United Nations General Assembly.

On 24 March 1993, the South African President, Frederick De Klerk, announced that South Africa had indeed built some nuclear weapons, but had subsequently destroyed them. He added that South Africa was ready to support and cooperate with other African states to negotiate a legal instrument on the denuclearization of Africa and promised his country's cooperation in the peaceful uses of nuclear technology. This statement provided further incentive for the pursuit of the African NWFZ and facilitated the invitation of South Africa to participate in the negotiations of a legally binding instrument, which commenced in Harare in April 1993.

Authored by Ambassador Oluyemi Adeniji, *The Treaty of Pelindaba: On the African Nuclear-Weapon-Free Zone* provides a detailed account of the negotiating history of the Treaty of Pelindaba. Ambassador Adeniji, who was Chairman of the Group of Experts that negotiated the Treaty and who enjoys vast experience in the diplomacy of arms control and disarmament, is particularly well placed to recount the proceedings of the series of discussions that led to the conclusion of the Treaty. The book, which is perhaps the most comprehensive analysis of a NWFZ treaty, should prove very useful to both students of arms control and disarmament as well as to future negotiators of NWFZs.

The Treaty of Pelindaba: On the African Nuclear-Weapon-Free Zone
Oluyemi Adeniji
UNIDIR, 2003, 360p.
Sales number: GV.E.03.0.5
US$28 (plus shipping and handling)
Order online at www.unidir.org or www.un.org/Pub/sales.htm

Building a Weapons of Mass Destruction Free Zone in the Middle East: Global Non-Proliferation Regimes and Regional Experiences

The Middle East, a region mired in political and military tensions, has long struggled with creating regional responses to proliferation concerns. The region first considered a NWFZ in 1974 when a proposal was put forward by Egypt and Iran. The United Nations has supported this idea through a number of General Assembly resolutions that note other regional precedents. At the end of the Gulf War in 1991, the Security Council called for a denuclearized Middle East in resolution 687. The 1995 NPT extension conference also adopted a resolution on a denuclearized Middle East.

In April 1990, Egypt proposed the creation of a WMD-free zone in the Middle East, thus encompassing nuclear, chemical and biological weapons as well as specific delivery systems. A key thrust of the initiative is to incorporate Israel into the nuclear non-proliferation regime, as it is not party to the NPT.

UNIDIR and the League of Arab States are sponsoring an international conference on the prospects for a WMD-free zone in the Middle East. The conference will address global non-proliferation regimes, consider regional experiences with establishing NWFZs, discuss the role of international organizations in verification and safeguards, and explore practical steps for creating a WMD-free zone in the region.

The invitation-only conference will be held in Cairo on 24–25 February.

UNIDIR will publish conference proceedings in Arabic and English.

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