PREVENTING THE WEAPONIZATION OF SPACE

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INTRODUCTION

For centuries mankind has waged war and over time the battlefields have continued to evolve on land, at sea and eventually, in the air. With modern advances in technology, it is quite possible that outer space may become the battlefield of the future. Considered the ultimate high ground, outer space "answers the age-old wish of military commanders to be able to see the other side of the hill."[1] For decades the militarization of outer space has taken shape with an increasing number of national satellites orbiting the earth. In fact, modern conflicts such as the Gulf War have proven the ability of space to be an effective combat multiplier, providing enhanced information technology.[2] While the militarization of space is commonly accepted, the weaponization of space implies a means of aggression and has become quite controversial. Whether or not space will be the battlefield of the future is yet to be seen, especially considering the many technical and political challenges facing space-based weapon designers. Therefore, even though there is an ever-present desire to expand modern warfare into space, there is still ample time to prevent the weaponization of space by the establishment of a global treaty banning space-based weapons.

This study is a critical examination of the weaponization of space. Following a historical perspective of the evolution of space and its contributions to aerospace power, a variety of current space-based weapon concepts are described and assessed in keeping with their intended roles of space control and force application. While it is recognized that much research is being conducted on space-based weapons concepts, the many hurdles discussed indicate that the weaponization of space is a long way off. Finally, a Canadian perspective is provided in light of Canada's relationship to the US under the NORAD Agreement, which may be affected by the recent creation of Northern Command and the US approach to NMD.

BACKGROUND

The origins of space pursuit can be traced back as far as the Second World War with the German development of the V2 Ballistic Missile. The V2 was characterized as having a long range and a high speed that made it extremely difficulty to defend against.[3] The advances in technology that made the V2 possible were quite alluring to research scientists at the time. Although Germany's work on ballistic missiles was not originally intended for space, the V2 programme inspired a tremendous amount of global research on ballistic missiles that would eventually lead to space exploration. In the United States, ballistic missile research resulted in the development of the Atlas, Titan, Thor, and Jupiter rockets that were used in support of Inter-Continental Ballistic Missile (ICBM) programmes.

The Soviet satellite launch of Sputnik I in 1957 instigated a plethora of activity in US civilian and military space programmes, resulting in the launch of Explorer I in 1958 and followed by programmes such as Mercury, Gemini, and Apollo. In 1962, Canada launched Alouette 1 and became the third of many nations to place a satellite into orbit.[4] Strategic defences during this era were oriented towards aircraft; however, space was quite appealing as a means of overhead reconnaissance and early warning.[5] In fact, by the end of the 1960s, the numerous satellites that had been launched into space had civil, military, intelligence and commercial applications.[6]

The capability of launching satellites into space also enhanced the development of ICBMs; however, the concept of launching ICBMs with nuclear warheads into space caused much concern for the weaponization of space. As a result, two significant treaties emerged: the 1963 Partial Test Ban Treaty, which bans nuclear tests and explosions in outer space as well as in the atmosphere and under water;[7] and the 1967 Outer Space Treaty,[8] which has become "…the primary agree-ment placing limits on states' use of space."[9] Although these treaties were successful in ad-dressing some of the issues concerning weapons in space, they were not comprehensive nor did they avert an ever-increasing global proliferation of ICBMs. US Anti-Ballistic Missile (ABM) Defence programmes were in place as early as 1946 when Projects Thumper and Wizard were created to study "…the possibility of developing anti-missile missiles capable of destroying incoming projectiles traveling at 4,000 miles per hour [mph] and at altitudes reaching 500,000 feet."[10] Little materialized as a result of these projects until the Nike-Zeus programme began in 1955 to examine the use of conventional weapons as a means of intercepting missiles.

Nike-Zeus overlapped Project Defender, which started in 1958 and turned out to be a ten-year "…Advanced Technology Demonstrator that explored possible new technologies that could be incorporated into future missile defense programs."[11] One of the first space-based weapons concepts was developed as a result of Project Defender. The concept was called Ballistic Missile Boost Intercept (BAMBI), which "…envisioned satellite-launched, hit-to-kill missiles containing huge wire mesh arrays that would destroy offensive missiles in the first five minutes (the 'boost phase') of flight."[12] Smith states, however, that BAMBI was not pursued at the time because of costs and a questionable Soviet threat.[13] In 1962, the Nike-Zeus programme was replaced by Nike-X, which used newly developed radars and nuclear-tipped missiles such as Sprint for short range and Spartan for long range in support of ballistic missile defence.[14]

All ABM programmes under development during this time struggled with the ability to defend effectively against multiple attacks. Although rocket science was sufficiently mature to support ABM initiatives, there were great difficulties in producing viable radars and guidance systems as well as countering physical vulnerabilities such as chaff and decoys that were effective counter-measures.[15] In recognition of ABM limitations, the Nike-X programme was replaced in 1967 by Sentinel, which focused on protecting major US cities. Sentinel was replaced in 1969 by Safeguard, which further restricted US ABM defence efforts to guard-ing only vital military sites.[16] With an increasing commercial and military dependence on satellites, defence research efforts also fo-cused on Anti-Satellite (ASAT) systems as a means of developing "…'reasonable safeguards' to protect space assets."[17]

In 1969, the US and the Soviet Union initiated the first in a series of Strategic Arms Limitation Talks (SALT) in an effort to strengthen mutual trust, relax international tensions, and create a favourable environment for strategic arms negotiations.[18] SALT I was brought to a close in 1972 when President Nixon and General Secretary Brezhnev signed the Interim Agreement on Strategic Offensive Arms,[19] which limited the number of strategic ballistic missile launchers for each country. In 1972, the US and the Soviet Union also signed the landmark Anti-Ballistic Missile (ABM) Treaty[20] in an effort to curtail the strategic arms race. In addition to limiting the number of ABM sites, the ABM Treaty also prohibits the development, testing, or deployment of space-based components of an ABM system.[21]

The SALT negotiations continued with SALT II beginning in November 1972 in accordance with Article VII of the SALT I Interim Agreement, which committed both sides to continue strategic offensive arms talks. SALT II was to replace the Interim SALT I Agreement, provide broad limits on strategic offensive weapons systems, and pave the way for substantial strategic arms reductions to be discussed in SALT III.[22] President Carter and General Secretary Brezhnev signed the completed SALT II agreement in June 1979; however, the agreement was never ratified because of an increase in global tensions at the time.[23] In the midst of the turmoil, concern for the exploitation of space resulted in the 1980 Environmental Modification Convention, which prohibits all hostile actions that might cause long-lasting, severe or widespread environmental effects to the earth or space.[24]

Increased global instability as well as advances in technology and changes in polit-ical leadership also rejuvenated the interest in Ballistic Missile Defence (BMD).[25] In 1983, the Reagan administration created the Strategic Defense Initiative (SDI), common-ly referred to as "Star Wars," to develop new technologies that would guard against missile attacks. The "Star Wars" programme investigated many new technologies, including space-based weapons. In 1987, it was made public that the Soviet Union also had a simi-lar programme.[26] Criticized as being unreal-istic, however, the SDI programme was eventually terminated because it was expensive, limited by technology, and fraught with controversy.[27] At the centre of the controversy was the fact that the Star Wars programme would contravene the 1972 ABM Treaty.

In the 1990s, the US and Russia continued arms negotiations with a series of Strategic Arms Reduction Treaties: START 1 (1991); START 11 (1993); and the outline for START III (1997).[28] Amidst the arms reduction initiatives, however, there was another resurgence of BMD interests with the creation of the Ballistic Missile Defence Organization (BMDO) in 1993 and the National Missile Defence (NMD) System in 1995. Convinced that the real threat of missile attack would originate from rogue nations and dangerous non-state actors, NMD was based on providing a limited capability of intercepting ballistic missiles using non-explosive projectiles.[29] To make NMD possible, the Clinton administration was also hoping to negotiate amendments to the ABM Treaty. Despite the many research efforts, however, there were still limitations in what could be accomplished with the technology at the time. In fact, President Clinton did not pursue amending the ABM Treaty nor did he authorize Congress to proceed with NMD in 2000 because his administration felt that "…the technology would not be ready for deployment before 2006 or 2007.…"[30] Fueled by the 11 September 2001 terrorist attacks on the Pentagon and the World Trade Center, however, President Bush provided a renewed support for ABM initiatives under the Missile Defense Agency (MDA), allocating significant funding for NMD[31] and calling for the "…accelerated development of the NMD system and replacement of the Anti-Ballistic Missile (ABM) Treaty by an accord that would permit the system's deployment."[32] In fact, the US will be unilaterally with-draw-ing from the ABM Treaty in June

2002.[33] The members of the Bush administration feel that their relationship with Russia would be better based on confidence and cooperation than on the mutual vulnerability associated with the ABM Treaty.[34]

With the tremendous advances in technology over the years, space and space-based assets factor heavily in support of BMD efforts. In fact, the US has become in-creasingly reliant on both military and com-mercial space-based assets, the protection of which has reached an increased priority as space and space-based assets become more easily accessible and more readily available. As Hays states, "…if the United States moves expeditiously to take advantage of its existing leadership in space technology and establish an unassailable dominance of orbital space, its position as the pre-eminent world power will be enhanced and perpetuated; if, on the other hand, it fails to seize the opportunity to establish unassailable superiority in space, its world leadership will be threatened by more visionary rivals."[35] The dominance of space, therefore, is an issue of power. As Spacy suggests, the use of space-based weapons is inevitable because "…every environment ac-cessible to man has eventually become an arena for combat."[36] It is the evolution of aerospace power, therefore, that highlights space as the potential battlefield of the future.

AEROSPACE POWER

The advent of the Wright brothers' aircraft in 1903 represented the beginning of a new era in modern warfare and marked the foundation of aerospace power. As Canadian aerospace doctrine states, "[a]erospace power is derived from the use of platforms that exploit the aerospace environment for military purposes."[37] The employment of aircraft in World War I served well to demonstrate the potential of air power, and shortly after the war air forces were created. Dur-ing World War II, "…aerospace power matured and became recognized as a decisive factor in planning and waging war."[38] Since World War II, aerospace power has emerged as a predominant influence in the successful completion of conflict. The dedicated use of aircraft to sustain the logistic support of Ber-lin during the 1948 Berlin airlift campaign, for example, was a clear demonstration of the ability of aerospace power to independently resolve an international crisis. [39]

Advances in technology have continued to shape the characteristics of aerospace power with the introduction of high-performance and stealth aircraft equipped with precision-guided weapons, extremely sophisticated helicopters, patrol assets capable of a multitude of land-based and sea-based tasks, tactical and strategic airlift with enormous ranges and payload capacities, and an ever-increasing dependency on space-based assets. The exploitation of space has also evolved into a source of unique capabilities that provide tremendous contributions to aerospace power. As pointed out by the Commander of the USAF Air University, Lieutenant-General J.W. Kelley,

> [v]ariously defined in the past as both a place and a mission, space is also a laboratory of the unknown; a potential area for commercial exploitation; a medium in which surveillance, communication, navigation, and transit are now routine; and an arena of increasing co-operation, competition, and potential conflict.[40]

With due recognition of the importance of space and space-based assets, the US established Space Command in 1985 "…to help institutionalize the use of space in deterrence efforts."[41] Fundamentally, the goal of Space Command continues to be focused on ensuring the availability of space information to war-fighters. The significance of this mission is exemplified by the increased reliance on information technology, which can be seen when comparing the 1991 Gulf War to the 1999 Kosovo conflict where the rate of data transfer increased by a factor of 10,000.[42]

The focus of space, however, seems to be evolving. Space is now commonly referred to as the ultimate high ground, which Smith contends must be taken advantage of during "…this period of unchallenged conventional superiority on earth…"[43] In fact, reports have been published, stating that Western dominance in space is being lost "…as more countries including China and India are fielding increasingly sophisticated reconnaissance satellites."[44] As well, satellite imagery is becoming easier to obtain through private companies and "…[f]oreign military, intelligence and terrorist organizations are exploiting advances in capabilities as well as the commercially available navigation and communication services that are currently available."[45] An advocate of using space in support of air warfare, Smith nonetheless draws the line at promoting space warfare, adamant that space is essential to information superiority, not weapons superiority.[46]

Many authors[47] are now making the distinction between the militarization of space and the weaponization of space, referring the term 'weaponization' to a means of aggression, defined as "destructive mechanisms [that] do not include observation, communication or other non-destructive activities, even if military in nature."[48] The employment of space resources in the Gulf War illustrates well how the militarization of space was used as an effective combat multi-plier enhancing communications, navigation, positioning, intelligence and surveillance.[49] Communications relied heavily on satellites such as the Defense Satellite Communications System (DSCS).[50] The NAVSTAR Global Positioning System (GPS) satellites were critical not only to navigation but also to many US targeting systems, which depended highly on GPS to provide accurate guidance of weapons.[51] US military and commercial satellites provided a multispectral sensing capability that provided optical, radar, and infrared (IR) high-resolution images, enhancing surveillance in the Gulf. Other capabilities included electronics intelligence gathering as well as rapid and intricate Battle Damage Assessment (BDA), which allowed for interpretation of damage caused by coalition ground-based weapons.[52]

Indeed, aerospace power has gone through quite an evolution over the last century. Founded by air power, aerospace power now includes among its characteristics the many contributions of space. The militariza-tion of space, showcased effectively during the Gulf War, demonstrated its significant impact on force enhancement as a combat multiplier. To protect information superiority, the US has established Space Command, which is dedicated to looking out for space and space-based assets by conducting missions aimed at space forces support, force en-hancement, space control and force application. While the support and enhancement missions can be categorized by the militarization of space, it is clear that the space con-trol and force application missions will require the weaponization of space. In fact, in January 2001 Air Force Space Command ac-tivated the 76th Space Control Squadron, which has become "…the first offensive and defensive counterspace technology squadron."[53]

SPACE-BASED WEAPONS

Canadian doctrine recognizes that strategic aerospace operations can be both offensive and defensive.[54] While the projection of aerospace power depends on many things, the capabilities provided by space and space-based assets have become increasingly important. The strategic leadership of modern forces acknowledges the importance of protecting existing space-based assets and at the same time appreciates the potential lethal-ity associated with force application from space. It is understandable, therefore, that a tremendous amount of space-based weapon research and development is ongoing. Current space-based weapons have been classified in terms of Directed Energy Weapons (DEWs) or direct impact weapons.

DIRECTED ENERGY WEAPONS (DEWs)

A DEW is characterized by its ability to deliver highly focused energy at extreme-ly elevated speeds.[55] Given modern capabil-ities in technology, there are already a number of devices being researched for employment as DEWs. Space-based weapons designs have included a variety of power sources such as particle beams and radio fre-quencies (RF); however, the bulk of the current DEW research is being conducted on space-based lasers.[56]

The function of an RF weapon is to direct RF energy at an adversary's electronic systems for the purpose of disruption. The effectiveness of an RF weapon, however, is dependent on the amount of energy generated by the device, which is proportional to the size of its antenna. Spacy points out that antenna diameters of 100 meters are typical of RF weapon designs.[57] For a space-based RF weapon, it is critical that the size of the device be minimized because of the requirements for it to be launched into space. The size of the RF weapon antenna, therefore, is a limiting factor for the use of an RF device as a space-based weapon. Spacy does broach the subject of creating virtual antenna structures with multiple microsatellites; however, he admits that the precision required to maintain satellite formation and position throughout the weapon's operation would necessitate an unfeasible amount of propellant for manoeuvring. Spacy concludes that significant advances in orbital antenna technology are required before space-based RF weapons become a reality.[58] Spacy also concludes that "it is unlikely that such systems can be fielded until the cost of routine access to space is reduced to the point that extensive experimentation can be undertaken."[59]

Particle beam weapons differ from RF devices in that they are designed to use electromagnetic energy to accelerate particles to extremely high velocities (estimated to be close to the speed of light).[60] According to Marshall, these high-energy particle beams have a destructive effect similar to that of a nuclear explosion in that they "either produce high surface temperatures, burning out the satellite electronics, produce high surface currents that would in turn produce electromagnetic fields that would penetrate the skin of the satellite and disrupt sensitive electronics, or produce ions, electrically charged par-ticles, that, depending on the particle type and energy, would disrupt satellite electronics by way of various radiation effects."[61] Similar to RF weapons, the effectiveness of space-based particle beam weapons is directly proportional to the output energy of the device, which must be delivered to a target over great distances. Although many advances have been achieved on developing high-en-ergy particle beams, Pike reports that present electromagnetic technology is not mature enough to support space-based weapons be-cause the concept has been proven only for relatively small particles and slow firing rates.[62]

Lasers, on the other hand, possess unique optical characteristics that can be exploited for military use, which makes them well suited for space-based weapons.[63] An acronym for 'light amplification by stimulated emission of radiation', a laser produces an intense, highly directional beam of light by exciting the transition of electrons, ions, or molecules to higher energy levels so that when they return to lower energy levels they emit energy.[64] Because lasers can be very narrowly focused, they are capable of generating intense heat when concentrated on a target. As well, since light does not have any mass, lasers can be directed against a target within line of sight and, because lasers operate at the speed of light, they can strike almost instantaneously.[65]

As with other space-based weapon designs, the challenge in making an effective laser weapon is maximizing its power gener-ation, which for a laser also depends on a number of factors including high reliability and the production of a high-quality beam of light. As Spacy contests, "[b]uilding lasers with enough power is only one of the hurdles to overcome before practical laser weapons become a reality."[66] Early laser designs incorporated solid crystals as energy sources, but low efficiencies and heat transfer problems plagued their development. Electrical lasers have also been eliminated as weapon contenders because of their low efficiency and the difficulties associated with generating electrical power in space. The type of laser receiving the most attention for use as a space-based weapon is the chemical laser because of its higher efficiency and good power generation.[67]

Chemical lasers produce an extremely intense light with energy concentrated in a narrow band of wavelengths by mixing chemicals at low pressure.[68] The main draw-backs of chemical lasers are the logistics as-sociated with fueling the chemical reaction in space, and the large quantities of high-temperature and corrosive chemical reaction gases, which must be processed continuously during laser operation. Although venting of reaction gases could be conducted symmetrically so as not to cause the laser to move, it is highly likely that venting would contaminate the environment around the laser.[69]

Regardless of the power source, highly reflective mirrors are essential components of lasers because they are required to "…focus and direct the powerful beams without overheating."[70] Because of the relationship between laser power and range, the effectiveness of a laser is also dependent on the size of the mirror. Mirror diameters in the order of 45 feet have been used in some laser design prototypes, which have proven difficult to manipulate accurately. Although limited success has been achieved with ground-based lasers, these successes have yet to be repeated in space.[71]

The employment of space-based lasers as weapons is further constrained by try-ing to achieve the right balance of minimizing the target range while maximizing the orbital altitude for coverage. As Spacy points out, a space-based laser needs to be positioned at an altitude of approximately 1,000 kilometers (km) in order to engage ballistic missiles effectively at a range of approximately 3,000 km.[72] At such a low altitude, it is impossible for a single laser to provide ad-equate coverage and, consequently, Spacy concludes that multiple space-based lasers would be required to ensure complete coverage of potential targets.[73]

Hence, there has been a fair amount of research and experimentation carried out on DEWs. Regardless of the concept being developed, the greatest challenge being faced by weapon designers is finding an effective method of maximizing the device output power. RF weapons are particularly restricted by the requirement for large antennae to transmit sufficient power. Although prospects, such as virtual antennae formed with microsatellites, have been examined, the reality is that technology has not advanced adequately for RF devices to be employed as effective space-based weapons. Particle beam weapon designs also suffer from similar constraints in that electromagnetic technology is currently not mature enough to support space-based weapon requirements such as larger particles and quicker firing rates. In fact, the bulk of current DEW research is being focussed on space-based lasers because of their ability to generate intense heat from a beam moving at the speed of light. Chemical lasers have shown the greatest potential as space-based weapons; however, shortcomings associated with chemical reaction gases, large reflection mirrors that are cumbersome to manoeuvre, and design constraints that trade off range for area coverage, have hampered space-based laser development. Therefore, even though much work has been conducted on DEWs, there is still a significant amount of research and development that needs to take place before a DEW can be activated as an effective space-based weapon.

DIRECT IMPACT WEAPONS

Direct impact weapons are the second category of space-based weapons and are de-signed in keeping with traditional weapon concepts that are quite feasible given existing technology. As the name suggests, direct impact weapons are based on hitting the target as the method of destruction. This has become known as a hit-to-kill technique. Current research efforts are focused on concepts that use directed kinetic energy and close proximity to destroy a target.

Kinetic energy is defined as "the energy of motion."[74] The kinetic energy of any object is proportional to its mass multiplied by the square of its velocity. A kinetic ener-gy weapon (KEW) such as a gun produces its destructive power by delivering its projectile at highly elevated velocities. KEWs are well suited for space because they can benefit from the weightless environment and lack of friction to optimize the weapons delivery speed. Additionally, KEWs aimed at space-based targets can also take advantage of the relative velocity with which they approach the target. Even for small projectiles, therefore, the destructive capability of a space-based KEW can be extremely high. For ex-ample, a piece of space debris (determined to be a fleck of white paint approximately 0.2 millimeters (mm) in diameter) with an estimated relative impact velocity of 3–6 km per second inflicted a 4mm-diameter crater on the windshield of the Space Shuttle Orbiter.[75]

One of the problems associated with the effectiveness of space-based KEWs is the complexity of actually hitting the target.[76] Because a direct impact is a precursor for successful target prosecution, it is therefore essential for a KEW to accurately anticipate the position of the moving target and to be able to manoeuvre should a course correction become necessary. In the development of space-based KEWs, it is anticipated that course corrections could readily be accomplished using boost motors; however, the extremely high relative velocities under which corrections to flight paths must be made complicate this process. Space-based KEW response time could be minimized and the target acquisition process simplified by identifying space-based targets in advance and pre-positioning KEW satellites throughout the space environment to take advantage of crossing orbits. Although this approach would enhance KEW effectiveness, the costs associated with such a strategy would be enormous, not to mention that any pre-positioning activities would have to be conducted covertly to hide the fact that the satellite is indeed a weapon.[77]

The other method of exploiting the di-rect impact weapon concept is to guide and detonate an explosive device in close proximity to a potential target. The benefits of this approach are the increased probability of target prosecution because of the enhanced kill zone of the proximity weapon as well as the reduced complexity of the targeting and acquisition system because the weapon does not have to be as precisely guided as the KEW. The main drawbacks from this approach include the time required to position the weapon in close proximity to a potential target as well as the transparency of intentions toward the target, which would provide time for the target to be manoeuvred away from possible interception.[78]

Space mines are examples of explosive devices that can be used effectively in close proximity to a potential target with the added benefit of being able to be located in orbit in advance of hostilities, to be activated when desired. Although early positioning of space mines would contribute to the covertness of the activity, the challenge becomes ensuring sufficient power available for manoeuvring and operating the space mine when the need arises. Solar energy is the typical source of satellite power; however, the requirement to orient the weapon for optimal energy transfer is inconsistent with stealth, which demands a reduced radar cross-section. Batteries and fuel cells are other potential sources of power, but they have been ruled out because of their low power capacities. Rogers discusses a novel concept of using ground-based lasers to beam power to space; however, inefficiencies and high ground-based laser costs have deterred development of this technology.[79] Finally, nuclear power is available but would provide a thermal sig-nature, which is contrary to stealth. Further-more, the employment of nuclear power in space could be perceived as a weapon of mass destruction and therefore considered contrary to the laws of space. In Spacy's es-timate, significant advances in technology are required before space mines can be effective-ly employed as space-based weapons.[80]

Therefore, direct impact weapon research, which is based on traditional weapon concepts, has produced a number of ideas that show promise for space-based weapon development. KEWs specifically have been designed to take advantage of the weightless and frictionless environment of space as well as relative velocity, which can significantly augment the destructive energy levelled at a target. The main drawbacks with these hit-to-kill devices are associated with the extremely high approach speeds under which the weapon must acquire and prosecute its target. Other direct impact weapon concepts requiring less precision involve explosive devices, such as space mines, that orbit in proximity to targets and are detonated when required. Although these devices can be manoeuvred close to target either during a conflict or in advance of hostilities, each approach has its shortcomings. The problems associated with moving explosive devices during a conflict include the long time required putting the device into position as well as the transparency attributed to such a manoeuvre. While space mines can be prepositioned covertly, there has yet to be developed an effective method to meet the power requirements to ensure the mines can still operate when required. Hence, even though direct energy weapons have the potential to be effectively employed as space-based wea-pons, there is much work to be conducted pri-or to their implementation in space.

SPACE CONTROL AND FORCE APPLICATION

The primary roles for space-based weapons have been identified similarly by Canada and the US as space control and force application with specific requirements for defensive and offensive capabilities.[81,82] Space control is defined as "[c]ombat and combat support operations to ensure freedom of action in space…and, when directed, deny an adversary freedom of action in space."[83] Force application, on the other hand, refers to support from space for operations such as BMD and orbital bombardment.[84,85] Both DEWs and direct impact weapons are being designed with characteristics that can support either the space control or force application role.

Space control encompasses surveillance, protection, prevention, and negation; however, it is the latter three missions that truly implicate space-based weapons.[86] Surveillance is limited to detection, tracking and identification of space objects and, while it also includes targeting and the ability to differentiate threats from non-threats, the mission is essentially passive in nature. Protection, on the other hand, involves the detection and reporting of space systems' malfunctions, the characterization and localization of an at-tack and its source, as well as the ability to restore mission capabilities. Protection can also be outwardly aggressive since it also involves the ability to withstand and defend against a threat or attack. Prevention and ne-gation are aimed at denying adversaries the use of space and also includes an offensive strike capability.[87]

Space-based lasers, KEWs and explosive weapons such as space mines can all be used effectively as anti-satellite (ASAT) weapons in support of the space control role. For space-based lasers to be employed as ASAT weapons, however, they need to be designed specifically to exploit the weaknesses inherent in satellite components such as solar cells and optical sensors, which are vulnerable to lasers. Regardless of the weapon used, though, targeting and acquiring a satellite promises to be an extremely difficult task because of the satellite's low infrared (IR) signature as well as a variety of countermeasures available to the potential target. Marshall states that it is not necessary that an ASAT destroy a satellite because ruining its sensors would render it inoperable.[88] Spacy, however, contends that the importance of being able to verify satellite destruction cannot be understated and, consequently, he predicts that any ASAT weapon will need to be designed to inflict maximum satellite damage to ensure successful prosecution.[89] More importantly, Spacy argues that space-based weapons need not be used for ASAT missions because these missions can be carried out quite effectively using ground-based weapons, which have the advantage of flexibility and less cost without the high technical risks and political ramifications.[90]

As previously discussed, the force application role for space-based weapons includes a BMD function as well as the means for prosecuting airborne or surface targets. An emerging concept for BMD involves a layered approach of targeting hostile missiles during their boost phase and mid-course flight.[91] The mid-course method is currently under development and involves the interception of a missile in the middle of its flight path. It is envisaged that satellites and early-warning radars would detect missile launches and pass along information to highly sophis-ticated radar systems with advanced process-ing capabilities to distinguish the real targets from the decoys. Interception would then be initiated based on preliminary missile trajec-tories, but would be updated in progress un-til the time of impact.[92]

Development of the boost phase method is still in its infancy, but is based on the concept of destroying the missile in the earliest stages of launch when it is the most vulnerable. By attacking a missile in the boost phase, the targeting and acquisition system of the interception device could take advantage of the IR signature emitted by the heat of the missile's rocket motor. Missile targeting would also be more effective if it could take place before the missile countermeasures could be employed. Finally, early missile interception would not necessarily entail destruction because disruption alone in the boost phase could cause the missile to fall short of its target and jeopardize the delivery of its payload. The drawback of the boost phase interception method, however, is the speed at which the process of detection, classification and prosecution must take place. As Coyle suggests, the boost phase interception technique "…will require extremely high-speed tracking/targeting radar and software processing."[93]

Space-based lasers are being examined as prime candidates for the BMD mission with the aim of achieving boost phase interception. The US intends to conduct tests on chemical space-based lasers, which if successful will lead to a technology demonstrator programme as early as 2012–2013, showcasing a small-scale laser satellite destroying a ballistic missile.[94] KEWs, on the other hand, have already been undergoing tests aimed at mid-course interception. Although preliminary results have been promising, ini-tial tests were conducted without countermeasures and contained artificial elements such as homing beacons to guide the interceptors.[95] More research, therefore, is required before space-based lasers or KEWs are demonstrated to be effective methods of conducting BMD.

Space-based lasers and KEWs are also being examined to carry out orbital bombardment of land and airborne targets. Although space-based lasers are viable options for this mission, existing technology is currently limited. Conceptually, though, an aircraft canopy is quite vulnerable to lasers and therefore could be exploited from space. In fact, "…the types of lasers being considered for BMD weapons are very effective at vaporizing Plexiglas provided they can dwell on the target for long enough."[96] Because an aircraft is much more manoeuvrable than a missile, however, Spacy points out that com-plications in targeting and acquisition are in-evitable especially considering the relatively low IR signature of an aircraft compared to that of a ballistic missile during the boost phase.[97] He concludes that using lasers to shoot down aircraft does not make sense giv-en that there are other weapons more suited to the task.[98]

On the other hand, orbital bombardment studies with KEWs have already been conducted using a variety of projectiles including "long thin rods, ultra hard penetrating warheads, or warheads that fragment shortly before impact."[99] Initial analysis revealed critical employment compromises that must be taken into consideration when producing an effective weapon configuration. For example, the higher the weapon is stationed in orbit the higher the impact velocities that can be generated by the weapon. On the other hand, the higher the weapon orbit, the longer it takes for a projectile to reach the intended target. In fact, a weapon stationed in orbit at 40,000 km, which is necessary to generate sufficient impact velocity for destruction, would require approximately five hours to reach its ground-based target (not including the time required for the weapon to move into proper position in space to initiate the attack).[100] Although weapons deployed in lower orbits could deliver quicker response times, the impact velocity of its projectiles would be reduced proportionally. The added complication in conducting orbital bombardment is the targeting of moving objects, which requires extremely high precision and responsiveness. Spacy contends that these problems need to be sorted out before space-based weapons moving at orbital velocities can be employed effectively to prosecute air-borne or surface targets.[101]

Thus, it is envisaged that the roles of both space control and force application can be supported by DEWs and direct impact weapons. Space-based lasers, KEWs and proximity weapons can all be employed in ASAT missions, while proximity weapons have yet to find application with BMD or orbital bombardment. The major stumbling block with respect to the ASAT role is the speed of the targeting and acquisition process, which is complicated by the inherently low IR signature of satellites as well as the satellite's ability to invoke countermeasures. In fact, not only is there still a tremendous amount of research and development to be carried out on space-based ASATs, but Spacy's in-depth analysis of space-based weapons also concluded that the ASAT role could be more effectively carried out by ground-based weapons with fewer risks and less political turmoil. BMD testing, on the other hand, is making progress. However, while initial results are promising, only ground-based interceptors have actually been used and it will likely be no sooner than 2012 before a small-scale laser demonstration can be conducted. Similarly, the investigations car-ried out with KEWs conducting orbital bom-bardment highlighted the compromise required between weapon delivery time and weapon reaction time. Hence, there are many challenges still ahead before DEWs and direct impact weapons are employed effectively in the role of space control or force application. In fact, weapons employed to carry out the ASAT role may be better off being ground-based.

CHALLENGES

A complication to the employment of space-based weapons is the inevitability of the development of effective countermeasures. As Garwin points out, "[b]ecause space weapons, unopposed, can have significant capability, both those contemplating the deployment of such weapons and those who might be on the receiving side have long considered how to counter them."[102] In fact, some studies contend that advances in countermeasure technology will always be in step with space-based weapon capabilities because it is more difficult to design an effective space-based weapon than it is to defeat one.[103]

Marshall uses the term "space hardening" to refer to an increase in survivability of a space-based asset and offers a number of solutions to various attack scenarios.[104] The most basic countermeasure is the capability of a satellite to be moved. Should the satellite be threatened from the ground, sufficient warning would allow it to be moved to a higher orbit, increasing the time available to analyse the threat and evoke other appropriate countermeasures such as threat interdiction. Should the satellite be threatened from space, a move to any orbit could be enough of a countermeasure in itself. Other basic countermeasures include spreading space-based assets apart, using decoys, and ensuring a high level of redundancy.[105] Canadian aerospace doctrine categorizes effective coun-termeasures in terms of warning, passive self- protection and active self-protection to enhance the survivability of any aerospace platform against a threat.[106] Space-based satellites could be warned of a threat by the use of radar and laser illumination sensors. Passive self-protection devices include infrared flares to confuse the aggressor's guidance systems, advanced materials to absorb radar energy, and extreme heat and electronic jam-mers to shield its position from the threat. Special filters and shutters are also viable op-tions for protecting space-based assets from laser threats. Active self-protection refers to the satellite's ability to shoot back and includes devices such as anti-radiation missiles.[107, 108]

Another looming challenge in the employment of space-based weapons is the necessity for them to be "…robust enough to survive years of inactivity in the hostile environment of space."[109] Adverse environmental conditions in space can have an undesirable impact on the operability of space-based assets, causing significant degradation in performance and reliability.[110] In addition, the existence of space debris is a distinct reality that poses a real threat of collision for all space-based assets. If a large enough debris fragment were to collide with a piece of equipment in space, the collision could result in the formation of a debris cloud, which is a concentration of particles in a specific area of space and which "…poses a magnified impact risk to any other spacecraft [or space-based asset] in the orbital vicinity."[111] If two satellites were to collide from different orbi-tal rings, two debris clouds would be created and the environment of the satellites remain-ing in both rings would be threatened.[112]

And so, there are many challenges facing the employment of space-based weapons even if and when the technical difficulties associated with the various weapons concepts are overcome. Space hardening techniques are already being contemplated as effective countermeasures for space-based assets. It has also been argued that the creation of a countermeasure is even easier that the creation of the weapon itself; therefore, countermeasure technology will always be a hindrance to the effectiveness of the weapon technology. Finally, it is exceedingly difficult to design weapon platforms that can stand the rigours of space since random debris particles can have a dramatic impact on the performance and reliability of any space-based asset.

POLITICS AND THE CANADIAN PERSPECTIVE

TREATIES AND AGREEMENTS

There are a number of existing treaties and agreements, which provide the foun-dation for the use of space and space-based assets. For example, the 1968 Return and Rescue Agreement necessitates the safe return of astronauts and space objects and dic-tates responsibility to the launching nation for the immediate rectification of any hazards caused by the space object.[113] In 1972, the Liability Convention extended this responsibility to include damage "…on the surface of the Earth or to aircraft in flight."[114] In terms of the weaponization of space, however, the most pertinent treaties are the 1967 Outer Space Treaty and the 1972 ABM Treaty.

The 1967 Outer Space Treaty was established at a time when space exploration was in its infancy. With the launching of an ever-increasing number of satellites, however, it quickly became evident that space exploitation was inevitable. The Outer Space Treaty, therefore, set out to define specific guidelines that would govern space as well as the moon and other celestial bodies. Fore-most, Articles I and II of the Outer Space Treaty stipulate that space should benefit all mankind and, thus, "…is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means."[115] The treaty also specifies that space is to be free for exploration and use without discrimination and that scientific space investigation is to be conducted freely as well.[116] While freedom of exploration and scientific investigation refers to space research, free use of space means freedom of flight. By virtue of the Outer Space Treaty, therefore, satellites are permitted to orbit anywhere in space and consequently should be able to do so without the threat of interference.[117]

In Article III of the Outer Space Treaty, there is a subtle but significant link to the 1947 United Nations (UN) Charter as follows:

> States Parties to the Treaty shall carry on activities in the exploration and use of outer space, including the moon and other celestial bodies, in accordance with international law, including the Charter of the United Nations, in the interest of maintaining international peace and security and promoting international cooperation and understanding.[118]

By extending the principles of the UN Charter to space, the Outer Space Treaty also provides for the inherent right of self-defence, which can be interpreted to include preventive self-defence.[119] Advocates of space weaponization consider the development of space-based weapons as a legal activity consistent with the Outer Space Treaty because the UN Charter places such an activity well within the rights of self-defence, especially considering the interpretation of preventive self-defence. Therefore, even though the treaty specifies the non-interference of satel-lites, the link with the UN Charter is being interpreted as a loophole for prosecuting sat-ellites.

Other difficulties associated with interpreting the Outer Space Treaty have also become contentious issues and areas for concern. For example, space is not well defined and remains quite ambiguous. While the aerospace environment is commonly accepted as extending from the earth's surface to infinity, there is no official dividing line between the atmosphere and space, although the distinction between the two is fundamentally understood. This ambiguity has yet to cause significant problems; however, it has been identified as an area that requires clarification because of its potential to become contentious in the resolution of space-based weapons issues.[120]

Equally vague are the constraints established for weaponizing space, which are in Article IV of the Outer Space Treaty as follows:

> States Parties to the Treaty undertake not to place in orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner.
>
> The Moon and other celestial bodies shall be used by all States Parties to the Treaty exclusively for peaceful purposes. The establishment of military bases, installations and fortifications, the testing of any type of weapons and the conduct of military maneuvers on celestial bodies shall be forbidden. The use of military personnel for scientific research or for any other peaceful purposes shall not be prohibited. The use of any equipment or facility necessary for peaceful exploration of the Moon

and other celestial bodies shall also not be prohibited.[121]

Although the Outer Space Treaty spec-ifies that space is to be reserved for peaceful use, the interpretation of the term 'peaceful' has evolved since the treaty was signed. The Concise Oxford Dictionary defines the term 'peaceful' as "…not violating or infringing peace…"[122] and the term 'peace' as "…free-dom from or the cessation of war…"[123] In other words, space should not be used for any purpose which violates or infringes on the freedom from or cessation of war. When the Outer Space Treaty was first invoked, the term 'peaceful' was viewed consistent with its dictionary definition and interpreted as meaning 'non-military'. Over the years, how-ever, the term 'peaceful' has become widely accepted as meaning 'non-aggressive'.[124] Ex-emplified by the use of space during the Gulf War, this subtle change of interpretation ov-er time has had a significant impact on attitudes regarding the militarization of space. It is now commonly accepted that space is an environment which is highly militarized.

Aside from the non-aggressive military use of space, developers of space-based weapons are taking advantage of the fact that the Outer Space Treaty does not specify the non-weaponization of outer space. Because the treaty merely prohibits the permanent placement of weapons of mass destruction in space or in orbit, many space weapons researchers have directed their efforts to devel-oping innovative concepts that ensure weapons launched into space return to the atmosphere prior to finishing one complete orbit of the earth.[125] Needless to say, the spirit of the Outer Space Treaty, which advocates the peaceful use of space, is clearly not being followed.

Because of the many concerns associated with the militarization and weaponization of space, the UN established the Committee on the Peaceful Uses of Outer Space, which during its latest session acknowledged outright that maintaining the peaceful use of outer space is a matter of priority.[126] As an indication of how complicated this issue can be, however, the committee, on one hand, expresses their concern for preventing the mili-tarization of space, while on the other hand, admits that "…some military use of outer space might be acceptable.…"[127] While the committee may be wrestling with the improp-erly defined use of the term "peaceful" in the Outer Space Treaty, their resolve toward the non-weaponization of space is quite clear.[128] Advocates for the peaceful use of space seem to recognize that space has become highly militarized and are now focused on prevent-ing the weaponization of space.

The 1972 US-Russia ABM Treaty has also become a source of controversy with regards to space-based weapons mainly because it stands in the way of the US implementation of the NMD programme. The ABM Treaty is based on the principle of mutual vulnerability, which is established by preventing either party from implementing safeguards in the form of national missile defence systems. Neither the US nor Russia, therefore, is capable of taking offensive action without the threat of retribution. It is felt that the ABM Treaty contributes to global stability "…via nuclear deterrence, which is based on the premise that mutual vulnerabil-ity to missile attack prevents nuclear war and lowers the probability of any direct confron-tation by creating risks that far outweigh any benefits of aggression."[129] The treaty, however, is not completely rigorous in deterring space weaponization because it contains clauses that permit the progression of ABM work. For example, while the treaty bans the development, testing and deployment of space-based ABM systems or components, it does not ban "…ABM systems or their com-ponents used for development or testing, [which are] located within current or additionally agreed test ranges."[130] Marshall con-tends that this loophole allows for the research and development of ASAT weapon technology, which is being currently conducted and is well within the parameters of the ABM Treaty.[131] Coyle and Rhinelander contend that development and testing in space is not even practical, and that initial develop-ment and testing of many of the components can, and should, be tested in laboratories and on test ranges.[132]

The US, however, has taken the opposite approach with NMD. Outwardly recognizing that the programme is contrary to the ABM Treaty, President Bush announced that the US would unilaterally withdraw from the treaty six months from 13 December 2001.[133] The ABM treaty does allow for unilateral withdrawal according to Article XV of the treaty as follows:

> Each Party shall, in exercising its national sovereignty, have the right to withdraw from this Treaty if it decides that extraordinary events related to the subject matter of this Treaty have jeopardized its supreme interests. It shall give notice of its decision to the other Party six months prior to withdrawal from the Treaty. Such notice shall include a statement of the extraordinary events the notifying Party regards as having jeopardized its supreme interests.[134]

The Bush administration believes that the US must withdraw from the ABM Treaty because of the extraordinary events of 11 September 2001, because of which President Bush has been quoted as saying that "…the ABM Treaty hinders the US government's ability to protect the American people from future terrorist or missile attacks."[135] The Russian response has been a threatened withdrawal from various other security agreements, which, if not handled correctly, could jeopardize global non-proliferation efforts.[136] "The ABM Treaty not only involves the sig-natory countries, but also bears critical importance and relevance to maintaining global strategic balance and stability as well as pro-moting international disarmament and non-proliferation process."[137] Without the ABM Treaty, the US will have to come up with another such initiative, which continues to strengthen its positive relationship with Russia and which provides a reasonable level of confidence to other nation states to ensure global stability.

And so, the Outer Space and ABM treaties have become key documents in establishing guidelines for the use of space. On one hand, the Outer Space Treaty stipulates that space, the moon and other celestial bodies are free and intended for peaceful purposes. However, its extension to the UN Charter and the inherent right of self-defence along with a number of ambiguities have led the way to the militarization of space and a valid concern for the deployment of space-based weapons. These concerns were deemed a matter of priority during a recent session of the UN Committee on the Peaceful Uses of Outer Space. The ABM Treaty, on the other hand, with its restriction on outer space for ABM work, was serving effectively to block the US NMD initiative and its space-based weapon component. The US decision to withdraw from the ABM Treaty, however, indicates that the US has every intention of pursuing the NMD programme and the weap-onization of space. Without the ABM Treaty, which has provided a sense of global stabili-ty for many years, the US and other nations are in need of a replacement agreement.

PITFALLS

From design shortfalls to space treaties, the road to weaponizing space is truly fraught with many pitfalls. While it is true that space is seen as the ultimate high ground, which is already militarized, the weaponization of space may come at an extremely high cost. Some of the consequences of developing and employing space-based weapons include the probability of increased global instability, the potential for an arms race in space, the contamination of the space environment and the endangerment of civilization as a whole. Furthermore, there are many other useful purposes for the significant costs being committed to space-based weapons-related programmes. Even so, some contend that it is purely a function of the evolution of warfare that necessitates the inevitable implementation of space-based weapons.[138]

With the demise of the Soviet Union, the US has emerged as the one remaining superpower. As Spacy points out, "[n]ever before has a single nation had such an uncontested ability to intervene in events around the world."[139] Even in outer space, the US leads all other nations with the sheer volume of space-based assets it has orbiting the earth.[140] Accordingly, as Hays contends, the US "…has by far the most to lose if space systems become increasingly vulnerable to attack and that as the world's preeminent air and surface power, it has the least to gain from developing [space-based] weapons."[141] Hence, the US venture into space with weapons is really quite risky. Just because the US enjoys a dominant role on land and in the air, does not guarantee the same in space. In fact, it can be argued that not only would US development and deployment of space-based weapons encourage others to follow, but al-so the advances in technology demonstrated by the US would make it easier for others to follow. An ensuing space race would be ve-ry counterproductive to ongoing arms control initiatives. In fact, the members of the Committee on the Peaceful Uses of Outer Space have recently documented their concern that "…the placement of weapons in outer space could undermine the global strategic balance, intensifying arms races on the ground, creating obstacles for established arms control and disarmament regimes and undermining mutual trust among countries."[142] As the main proponent of space-based weapons, the US is treading a fine line with global stability, so much so that it would appear to be in the best interests of humanity for the US to maintain the status quo with respect to weapons in space.

Whether or not the US will exercise restraint with respect to the weaponization of space is certainly doubtful with the pending termination of the ABM Treaty; however, before space-based weapons become a reality, there is a tremendous amount of research and development yet to come. The fact that space-based weapon technology is still quite immature makes it difficult to predict wheth-er research and development efforts will be successful at all.[143] For example, Spacy's analysis of lasers concludes that deficiencies in power and efficiency coupled with the challenge of producing a cost-effective prod-uct robust enough to withstand the rigours of space are hampering the development of the laser as an effective space-based weapon sys-tem.[144] Coyle and Rhinelander also point out that current space-based laser designs are much too heavy for existing rocket launch capabilities, making their deployment currently impossible.[145] Other critics argue that the technological hurdles associated with the development of space-based weapons are so great that they cast a shadow on the ability of any space-based weapon platform to ever operate successfully, let alone function relia-bly.[146] Spacy believes that space-based laser weapons "…will not be feasible without a number of fundamental breakthroughs in la-ser physics and engineering."[147] Other auth-ors are of the same opinion and contend that ABM development and testing will be carried out for many years to come.[148, 149] Such a high level of effort over a prolonged period of time makes the weaponization of space an extreme-ly costly proposal.

The US NMD programme is estimated at a cost of approximately $100 billion over a 10-year period.[150] While the current Bush administration is adamant that the money will be well spent, some argue that there are better uses for such a substantial amount of funding. In terms of defence spending, Pope suggests that tremendous gains would be made in the fight against terrorism by redirecting resources to the development of pro-grammes such as high-fidelity surveillance.[151] In fact, there are numerous other options available to carry out the functions that are intended for space-based weapons. Spacy, for example, has conducted an in-depth anal-ysis of the advantages and disadvantages of space-based weapons. Comparing the capabilities of space-based weapons to the capabilities of conventional weapons currently available and acknowledging the potential for adverse political ramifications, he concludes that "…the best method for protecting [space-based] assets does not appear to be deploying weapons in space."[152] DeBlois concurs that the politics associated with weaponizing space can all be avoided because "[w]hat can be done with space weapons can also be done from the air.…"[153]

With all the hype associated with NMD, it is easy to forget about the dangers inherent in the deployment and use of space-based weapons. The difficulties experienced with the Mars mission highlight the risks as-sociated with actually operating technology in space. Closer to home, the Space Shuttle Challenger disaster is testament to the hazards of space launches. If a weapon intend-ed for space were to be similarly affected during launch, the result could be even more catastrophic, especially considering the potential nuclear dimension. The use of space-based weapons, therefore, needs to address the issue of collateral damage. From a space perspective, the destruction of a single satellite could create a debris cloud that would not only contaminate the space environment but also cause considerable concern on earth from falling debris. If nuclear power were to gain support for use in space, the resultant effect of a space-based accident could be devastat-ing to all mankind.[154]

The Institute for Cooperation in Space (ICIS) is an organization that supports a world treaty to ban all space-based weapons. Notwithstanding its commitment to peace, ICIS contends that the emerging space-based weapons industry needs to refocus its efforts to solving problems affecting humanity and the environment.[155] The ICIS makes a solid argument stating that "[w]e can have battle stations and weapons pointed towards earth and into space, or we can build space habitats, hospitals, schools, farms, laboratories, industries, hotels and resorts, elevators and craft that will free us to explore the universe to find out more about ourselves and our neighbours."[156] The UN delegates of the Committee on the Peaceful Uses of Outer Space are also proponents of a world treaty, stipulating recently the absolute necessity of "…one or more international agreements pro-hibiting the testing, deployment and use of any weapons, weapon systems or their components in outer space, the testing, deployment and use on the ground, in the sea and in the atmosphere of any weapons, weapon systems or components aimed at outer space warfare and the use of any object launched into outer space for the purpose of warfare."[157]

The weaponization of space, therefore, is an extremely complicated proposal. Although the evolution of warfare seems to dictate that space will become the battlefield of the future, the cost of expansion into space may be excessive. The US, with its current position of global influence as the sole superpower, has become increasingly reliant on space-based assets and therefore has much to lose by waging war in space. The risks being taken by the US could also have an impact on global stability if a space arms race were to be instigated. These risks seem to be inappropriate, especially considering the technological hurdles that must be overcome prior to the actual realization of a space-based weapon capability. Advocates for the peaceful use of space contend that the roles being envisaged for space-based weapons can be performed effectively from the ground and that the large amounts of funding being ded-icated to space-based weapon initiatives such as NMD are excessive and could be put to better use. In fact, both ICIS and the UN Committee on the Peaceful Uses of Outer Space support a world treaty to ban space-based weapons so that research efforts and funding can be dedicated to solving human and environmental problems.

CANADA'S POSITION

According to foreign policy, Canada remains committed to non-proliferation efforts, arms control and disarmament as well as the elimination of nuclear weapons.[158] As articulated in the 1994 White Paper, Canada also recognizes the increasing importance of space to global security and acknowledges the effective use of space in support of tradi-tional military activities such as "…com-mand, control and communications, intelligence gathering, surveillance, navigation, mapping, meteorological services and arms control verification.[159] Canada's White Paper also provides flexibility for the possible future employment of a surveillance system in space for the defence of North America, al-though the approval of such an activity would be subject to a number of considerations.[160]

The growing concern for BMD, the protection of space and space-based assets has increased the significance of space from a military perspective, especially considering the events of 11 September 2001, which highlighted the vulnerability of North America to terrorist attack. Canadian Defence policy does appreciate that space has become militarized and even defines space control and force application as potential roles for space-based weapons; however, "Canadian policy prohibits the weaponization of space and anti-satellite weapons."[161] From a Defence perspective, the protection of space is viewed as a Canadian Forces (CF) responsibility because "...the CF, within the international legal context and its domestic national defence mandate, has the responsibility to be prepared to address any sovereignty and security infringements which may be generated within or through the space medium."[162] In fact, Canadian and US military forces have worked together in defence of North American airspace since 1958 when the North American Aerospace Defence (NORAD) Agreement was established. Reviewed and renewed a number of times since its inception, the NORAD Agreement is currently valid until June 2005;[163] however, the recent creation of Northern Command, which establishes a new military area of concern that reaches from the Canadian Arctic to southern Mexico,[164] may have a profound impact on the future of NORAD.

Currently, NORAD's primary missions are aerospace warning and control. The activities involved with aerospace warning include the monitoring and tracking of man-made objects in space as well as detecting, validating and warning of attack by aircraft, missiles or space vehicles. A critical part of aerospace control is the surveillance of airspace, which for North America is made possible by the North Warning System (NWS), primarily based in Canada.[165] The aerospace control function is still limited in capabilities, but refers to the protection of airspace against air attack within the constraints of each country's national policy. As the former Deputy Commander-in-Chief NORAD, Lieutenant-General Macdonald, explains, "…NORAD provides warning of any aerospace threat, but can only provide defence against an air-breathing threat, such as that posed by a manned aircraft or a cruise missile."[166] In other words, NORAD is neither mandated to defend, nor capable of defending, against a ballistic missile attack. However, because of its current mission capabilities as well as its proximity to US Space Command, NORAD is considered by Macdonald and others to be the ideal focal point for the US NMD initiative.[167, 168]

When the Clinton administration first announced its intentions to implement NMD, Canada was not provided with enough details of the programme to take a firm position.[169] Since then, there has been a fair amount of dialogue between Canadian and US officials in an effort to better understand each other's position and concerns. In fact, consultations in May 2001 have been viewed by the Department of Foreign Affairs and In-ternational Trade (DFAIT) as "…the beginning of a meaningful and measured dialogue to explore the issues raised by US thinking about the strategic framework and about missile defence specifically."[170] Canada has yet to take a position on missile defence, although the 1994 Defence White Paper does emphasize Canada's interest in gaining a more comprehensive understanding of the issues by en-gaging in research efforts and consulting with nations having similar interests.[171] DFAIT contends that "…the position Canada ultimately adopts will reflect a careful consideration of all the facts and will be predicated on what is best for Canada and for global se-curity."[172] Notwithstanding Canada's indecision on the US NMD initiative, Canada's position on weapons in space is quite clear. Foreign Affairs Minister John Manley recent-ly responded specifically to US proposals of implementing space-based weapons, stating that "…the idea of [weaponizing] space is a dangerous trend, but…Canada's position of being unalterably opposed to the weaponi-zation of space is understood and appreciat-ed by the US government."[173]

Indeed, Canada is very much in support of banning space-based weapons, believing that space should be used for peaceful purposes such as the international space station, which has been built for scientific research and discovery through the cooperation of a number of nations.[174] The reality is, however, that Canada's closest ally is about to embark upon an NMD initiative intent on the use of space-based weapons and Canada could become directly involved by participating in NORAD. As Weston points out, "[i]t is this linkage that draws Canada into a situation where it will be increasingly difficult to be ambivalent on NMD."[175] In fact, the creation of Northern Command further complicates the issue since its relationship with NORAD and NMD is just being developed. The truth is that Canada has a lot to offer an NMD system in terms of "…the de-velopment of space-based sensors, surveillance of space, satellite communications, high speed data transmission, data fusion and so on."[176] If Canada embraces NMD, the result would undoubtedly be a strengthening of re-lations with the US, not to mention the obvi-ous benefits to national security. Ballistic missile defence, however, is not currently one of NORAD's missions and, therefore, Canadian consent would be required for NORAD to become involved with NMD. Notwithstanding Canada's position on the weaponization of space, Canada's involvement in NORAD as a participant of NMD would enable Canada to be in a position of influence when discussing space weaponization issues. Rauf contends that the NWS is "…indispen-sable not only for warning against over-the-horizon attack but also to provide the critical backup to any space-based radar."[177] Rauf concludes, therefore, that because the Canadian NWS radar is essential to an effective continental NMD system, Canada is in a ve-ry good position to influence the future of NMD and space-based weapons.[178]

Although many believe that the weaponization of space is inevitable, there are currently no known weapons in space.[179] As a matter of fact, with the many technical difficulties and political hurdles being experienced, it is likely to be quite some time before the first space-based weapons are opera-tional. Therefore, even though the US is con-tinuing to pursue NMD and will be withdrawing from the ABM Treaty in less than six months, there is still ample time for the negotiation of a global position on space-based weapons before space weaponization actually begins. For Canada, simply because it may be determined through time that missile defence may not need to be conducted from space at all, participating in NMD should not be viewed as Canadian support for the weap-onization of space. Therefore, it is recommended that Canada continue to strengthen its alliance with the US through NORAD even if it means participating in NMD. Can-ada could then take advantage of its relationship with the US, solicit support from other nation states and continue an open dialogue on space-based weapons to help prevent the weaponization of space.

CONCLUSION

Significant advances in technology over the years have enabled the use of space in a diverse number of capacities, resulting in many nations, not the least of which is the US becoming increasingly reliant on space for civil, military and commercial applications. The evolution of modern warfare has proven the dominance of space to be an issue of power. From a military perspective, the Gulf War was a clear demonstration of the many contributions of space to aerospace power, contributions that have secured the role of space as a combat multiplier. As well, the concern for ballistic missile defence, the protection of space and space-based assets has spawned a tremendous amount of research and development of space-based weap-ons, the roles of which have already been cat-egorized as space control and force application. Finally, the US establishment of Space Command and the 76th Space Control Squadron indicates a clear intent for the weaponization of space.

Current space-based weapons designs include DEWs and direct impact weapons. Although the various concepts do show potential, there are significant technical difficulties being experienced with each design development. The greatest challenge facing DEW research, for example, is maximizing output power. For RF or particle beam weapon concepts, the technology is just not advanced enough for them to be applied effectively yet as space-base weapons. The bulk of DEW research is being directed at chemical lasers; however, problems associated with chemical reaction gases, large reflective mir-rors and range design constraints have hampered their development for use in space.

Direct impact weapon research is further developed than DEW research because it is based on traditional weapon concepts; however, problems with technology have also hampered their development. KEWs, which are hit-to-kill devices that take advantage of the space environment, and optimize impact velocity for a remarkably high destructive capability, but are extremely challenging to control. Orbital proximity devices such as space mines require less precision, but are hampered by transparency and power requirements.

Although space-based weapons design is facing many technical challenges, it is envisaged that DEWs and direct impact weapons could support the roles of both space control and force application by performing ASAT missions, BMD and orbital bombard-ment. ASAT development, however, is being plagued by shortcomings in responsiveness of the targeting and acquisition process and some research even suggests that the ASAT role need not be conducted from space because of current ground-based capabilities that could be used with fewer risks and less political turmoil. BMD development has been more promising, although initial testing was only ground-based and extremely limited in scope. In fact, it could be as late as 2012 before even a small-scale laser demonstration can be conducted. Hence, while DEWs and direct impact weapons are concepts that have the potential to become effective space-based weapons that can conduct the roles of space control and force application, there is still a significant amount of re-search and development that need to be conducted.

Should the technical hurdles be overcome, there are still many other challenges facing the employment of space-based weapons. Space-hardening techniques, for example, are being readily developed and will always be a hindrance to the effectiveness of the weapon technology. As well, the harsh operating conditions of the space environment place an added burden on weapon designers to build platforms sufficiently robust for survival in space. Finally, associated with the weaponization of space are many political issues that make the deployment of space-based weapons very controversial.

The Outer Space and ABM treaties establish guidelines for the peaceful use of space, but have not been successful in preventing the militarization of space. The extension of the Outer Space Treaty to the UN Charter has been interpreted as providing the inherent right of self-defence in space, including preventive self-defence. This interpretation and other ambiguities in the Outer Space Treaty have raised valid concerns for the deployment of space-based weapons, which have been deemed a matter of priority during a recent session of the UN Committee on the Peaceful Uses of Outer Space.

The ABM Treaty was a good framework that restricted ABM weapons from outer space, blocking the US NMD initiative and its space-based weapon component. However, the US has decided to withdraw from the ABM Treaty so that NMD and the weaponization of space can continue. Without the ABM Treaty, the US and other nations are in need of a replacement agreement that can serve to strengthen global stability.

Space dominance is seen to be the natural evolution of warfare; however, the expansion of warfare into space may come at an extremely high price. The US, which has become increasingly reliant on space-based assets, may jeopardize its current po-si-tion of global influence as the sole super-pow-er by instigating a space arms race, which it is not guaranteed to win and which may adversely affect global stability. Advo-cates for the peaceful use of space contend that the risks of placing weapons into space are inap-propriate, especially in the face of current technological hurdles and sugges-tions that space-based weapons roles may be performed effectively from the ground. In fact, ICIS and the UN Committee on the Peaceful Uses of Outer Space are proposing a world treaty to ban space-based weapons so that the large amounts of funding dedi-cated to space-based weapon initiatives, such as NMD, could be redirected to better address terrorism and re-solve human and environmental problems.

Canada does not support the weapon-ization of space; however, Canada's associa-tion with the US through NORAD, which may be influenced by the creation of US Northern Command and the implemen-tation of the US NMD programme, may jeopardize that position. Simply because it is too early to know whether or not NMD will actually lead to the deployment of space-based weap-ons, Canada's participa-tion in NMD should not be interpreted as Canadian support for the weaponization of space. Therefore, it is recommended that Canada continue to participate in NORAD even if it means participating in NMD since Canada would then be in a better position to influence the future of space-based weap-ons.

Currently, there are no known weap-ons in space, but the US has shown a clear in-tent to deploy space-based weapons in sup-port of the NMD programme. However, with the many technical difficulties and political hurdles being experienced with space-based weapons, it is also clear that much research and development are required before the weaponization of space can begin. There-fore, even though the US will be withdraw-ing from the ABM Treaty in less than six months, there is ample time to prevent the weaponization of space. The Outer Space treaty has not been sufficient to deter the militarization of space and, with the pending US abrogation of the ABM treaty, the global community will be in need of another such document to help influence global stability. Therefore, as recommended by ICIS and the UN Committee on the Peaceful Uses of Out-er Space, it is time to negotiate a world trea-ty banning space-based weapons to prevent the weaponization of space.

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