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Weaponisation of Space

Puneet Bhalla

Centre for Land Warfare Studies
New Delhi

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Centre for Land Warfare Studies
RPSO Complex, Parade Road, Delhi Cantt, New Delhi 110010
Phone: +91.11.25691308 Fax: +91.11.25692347
email: landwarfare@gmail.com website: www.claws.in

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Contents

Abbreviations

ABL	Airborne Laser
ABM	Anti-Ballistic Missile
ALMV	Air-Launched Miniature Vehicle
ASAT	Anti-Satellite
BMD	Ballistic Missile Defence
C4I2SR	Command and Control, Communications, Computers, Intelligence, Information, Surveillance, and Reconnaissance
COPUOS	Committee on Peaceful Uses of Outer Space
COTS	Commercial Off The Shelf
DEW	Directed Energy Weapons
DSC	Defensive Space Control
EBO	Effect-Based Operations
EKV	Exoatmospheric Kill Vehicle
EMI	Electromagnetic Interference
GEO	Geosynchronous Earth Orbit
GGE	UN Group of Governmental Experts
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
HEO	Highly Elliptical Orbit
IADC	Inter-Agency Space Debris Coordination Committee
ICoC	International Code of Conduct on Outer Space Activities
IRBMs	Intermediate Range Ballistic Missiles
IRNSS	Indian Regional Navigational Satellite System
ISRO	Indian Space Research Organisation
LEO	Low Earth Orbit
LTBT	Limited Test Ban Treaty
LTSSA	Long-Term Sustainability of Outer Space Activities
MIRACL	Mid-Infrared Advanced Chemical Laser
NTMs	National Technical Means of Verification
ORS	Operational Response Systems
OSC	Offensive Space Control

OST	Outer Space Treaty
PNT	Position, Navigation and Timing
PPWT	Prevention of the Placement of Weapons in Outer Space Treaty
RMA	Revolution in Military Affairs
SBIRS	Space-Based Infra-Red System
SBSS	Space-Based Space Surveillance
SDI	Space Defence Initiative
SSA	Space Situational Awareness
SSN	US Space Surveillance Network
TCBMs	Transparency and Confidence-Building Measures
WMDs	Weapons of Mass Destruction

Chapter 1
Evolution

Space has become integral to most activities of the modern world, affecting an ever increasing part of the human population. Today, almost 60 countries have deployed more than 1,000 satellites in orbit and many more are dependent on these assets for military, civil and commercial applications. Space security, always on the minds of space-faring nations, has taken centre-stage in recent years. Militarisation of space took place with the launch of the first reconnaissance satellite that sought the high ground to look further into enemy territory to provide strategic advantage. While placement of weapons in space was researched in the initial years, the space environment has been kept free of weapons till now because of a number of technological and geostrategic imperatives. Nations though, have continued to develop systems and weapons that, while being deployed on the Earth, could be used to target satellites in space. In recent years, worldwide developments in the domain have rekindled the fear of weapons being put in space. These could be used to target other satellites in orbit or for attacks against terrestrial targets. Meanwhile, commentators around the globe have been espousing the inevitability of weaponisation of space.

Ironically, even though during the International Geophysical Year (July 01, 1957, to December 31, 1958), both the US and Soviet Union had pledged to launch their first satellites for scientific quests, the early years of space development were intrinsically for strategic and military purposes. Subsequently, these satellites were used extensively for providing information on enemy deployments, especially the ballistic missile dispositions. They enabled communication among dispersed forces and provided meteorological reports. Space systems also provided better geodetic surveying and provided rudimentary navigation inputs – both helping in improving ballistic missile accuracy. They provided early warning of missile launches and detection of nuclear detonations. As all these contributed towards gaining a strategic advantage over the adversary, they came to be seen as valid targets by both superpowers. This led to an interest in development of Anti-Satellite (ASAT) weapons to target them in a similar fashion as the aerial platforms had been targeted in the past.

Both the US and the Soviet Union developed and tested different methods of destroying or damaging satellites or causing disruption of their operations. Since the interceptor guidance and homing capability had not been perfected, the initial ASATs were modified Intermediate Range Ballistic Missiles (IRBMs) used as direct ascent weapons with nuclear warheads. In 1962, the United States conducted a 1.4-megaton nuclear test blast called Starfish at an altitude of 400 km above Johnston Island in the Pacific Ocean. The explosion disabled seven satellites in seven months in Low Earth Orbit (LEO) and disrupted power, telephone service, and radio stations in Hawaii, 1,300 km away.[1] This brought the realisation that nuclear explosions in space are indiscriminate and would destroy all nearby satellites in their line of sight and damage many more in the ensuing weeks by the increased radiation in LEOs. Consequently, the 1963 Limited Test Ban Treaty (LTBT, 1963), signed by both the US and Soviet Union, banned any nuclear explosion in space. The LTBT further led to the Outer Space Treaty (OST) that in 1967 banned placing of Weapons of Mass Destruction (WMDs), including nuclear weapons, in space. The OST, however, did not explicitly prohibit deliberate attacks on satellites or conduct of ASAT weapons tests.[3] Ballistic Missile Defence (BMD) systems also continued to use nuclear-tipped missiles. The Russian Galosh BMD system surrounding Moscow employed nuclear-tipped interceptors from the early 1960s through the 1990s.[4]

Meanwhile, other ASAT technologies continued to be developed and tested as space negation ability was considered integral to the larger strategic domination effort during the Cold War. Following a number of tests, the Soviets developed a radar guided co-orbital ASAT system, the IS (Istrebitel Sputnikov – the satellite interceptor) system that was accepted for service in 1972.[5] The US modified its IRBMs for a direct ascent Kinetic Energy (KE) role. The Soviets had also planned a direct ascent ASAT, the "Naryad-V", that was to be deployed on existing silo-based Intercontinental Ballistic Missiles. (ICBMs)[6] The renewed US interest in 1983 in the "Star Wars" programme that envisaged development of several types of space-based interceptors with intrinsic ASAT capabilities, instigated the Soviet Union to propose a ban on space-based weapons and unilaterally suspend

ASAT testing in 1983. Their existing systems, however, continued to be operational.

Both superpowers also tested air-launched ASAT versions in the 1980s. Though more technically challenging than the ground-launched version, these systems would have provided the flexibility of location and time of launch and significantly reduced the time between missile launch and target destruction. The US tested its Air-Launched Miniature Vehicle (ALMV),[7] a two-stage missile launched from an F-15 aircraft flying at high altitude.[8] Following this test, in December 1985, the US Congress banned further testing of the system on satellites.[9] The Soviet programme, called the "Kontakt" system, envisaged a MiG-31 in a similar role.[10] This programme failed to take off and tests of the US system were also discontinued in 1988. Besides this, the Soviets identified the ASAT potential of the US Space Shuttle and had a programme to develop a 'space interceptor', the Uragan, specifically to deal with shuttles in space.[11] There were many other varied programmes on both sides. The US SAINT (SAtellite INTerceptor) programme[12] contemplated interceptor satellites for inspecting enemy space assets from orbit with a subsequent planned upgradation to a capability to attack them. The Soviets reportedly deployed satellites with specially designed recoilless guns for self-defence.[13]

Despite the testing of these systems, both sides realised that targeting strategic systems would be detrimental to their relations. Any targeting of the other's satellite, in the form of either disruption or damage, would have been escalatory in the highly charged environment and could have even resulted in a nuclear exchange. They, hence, refrained from carrying out any actual interceptions of any kind. These satellites also provided the means of early warning of missile launches and intelligence on each other's capability. They were, thus, essential elements of strategic stability. Their importance was reaffirmed in the 1972 US-Soviet Treaty on the Limitation of Anti-Ballistic Missile Systems (the ABM Treaty) that prohibited interfering with "National Technical Means" (NTMs) of verification or reconnaissance satellites. Protection also began to be formally extended to other types of satellites through the 1971 Accident Measures Agreement and Hotline Modernisation Agreement, which protected satellites essential to US-Soviet communications in the event of a crisis.[14] Consequently, there was no actual satellite targeting till the 2007 Chinese ASAT test. Instead, Washington and Moscow chose to limit their competition in space by means of formal agreements and tacit understandings.

Since the end of the Cold War, there have been huge developments in the space domain that have transformed the threat environment. The first has been the ever growing reliance on space-based assets in support of military operations providing intelligence, communications, navigation and weapon guidance, strategic and theatre level warning and supporting command and control functions. They have been at the heart of the modern Revolution in Military Affairs (RMA). Precision targeting that would form an important part of Effect-Based Operations (EBO) – operations that aim to influence the enemy through attacks against its Centres of Gravity (CoGs) – relies on the Global Positioning System (GPS). Coordinated battlefield operations can be made possible through use of these assets. In a revolutionary application, it is allowing US operators to control Unmanned Aerial Vehicles/Unmanned Combat Aerial Vehicles (UAVs/UCAVs) operating over Afghanistan from half a world away. All force modernisation efforts the world over are centred on space enabled capabilities. Taking lessons from the US employment, most nations have incorporated these capabilities into their contemporary and evolving policies and military doctrines. Thus, satellites that were once seen as harmless passive space systems have emerged as integral components of destructive terrestrial military operations.

In the globalised world, national security imperatives have evolved beyond securing of borders to all aspects critical to the nations' political and economic well-being. In the past few years, space-based capability has become integral to social and commercial interests and any disruption of these capabilities would have huge operational and economic ramifications for most countries. Criticality of space for such diverse applications also makes space-based assets lucrative targets during conflicts. Conflicting interests in space have the potential to lead to hostilities. The increasing globalisation and commercialisation of space activities has had diverse effects on the security of these assets.

Proliferation of technology and its reduced cost have allowed an increasing number of states to have the ability to develop or possess more complex and devastating weapons. Similarly, there are more seekers of ballistic missile technology and capabilities for access to space. Consequently, the threat environment confronting the existing space-faring nations is also broadening and becoming increasingly complex.

Despite these developments, however, space has continued to be a sanitised environment with very few instances of intentional interference and almost none which involves intentional targeting of these assets. This has not been because of altruism but sheer pragmatism on the part of the space-faring nations. They realise that short of an imminent or actual war, there is little to be gained from the use of such weapons as the debris created would adversely affect all assets, including friendly ones, and limit the use of the domain without discrimination. International condemnation and sanctions would also follow. Use of such weapons also has the potential to increase the level of conflict. A number of recent developments have brought discussions on space security, including matters related to weaponisation of space, to the forefront.

Chapter 2
Vulnerabilities, Threats and Counter-Measures

Satellites in orbit are intrinsically vulnerable to a number of natural and man-made threats that are not limited to only space-based ones. Owing to the unique characteristics of space, the effects of any interference could have much wider ramifications. A satellite system has a number of components among its three segments that could be targeted to interfere with its optimum utilisation:

- on the ground (such as ground control stations or space launch complexes);
- assets in space—these would include the sensors, antennae, solar panels and other power equipment;
- satellite communication links.

Threats

While space-based assets are threatened by natural and unintentional interference, this paper will restrict itself to discussions on deliberate man-made threats. Attacking satellites is easy as they travel in predictable targets that can be accurately tracked and, at present, they do not employ counter-measures.

Electronic Interference

Intentional interference in electronic operations could be as a result of jamming or spoofing.

Jamming is transmitting a high-power electronic signal that causes the bit error in a satellite's uplink (ground to the satellite) or downlink (satellite to the ground) signals to increase, resulting in the satellite or ground station losing lock.[15] Ground- based jammers are more effective against the downlink signal than the uplink. This is because the jammer would have to be very powerful to overwhelm the emitting signal from the ground station.

However, it would take little power to jam the relatively weak signal being received from the satellite.[16] Jamming is the most common anti-satellite measure being undertaken during peace-time. The most lucrative space segment for jamming, with disproportionate benefits, comprises the Global Navigation Satellite System (GNSS) that provides the Position, Navigation and Timing (PNT) services. Receivers in the modern battlefield may be prone to interference from any of the other systems in an environment with a high density of electromagnetic waves.

Because the equipment required for jamming is so similar to legitimate satellite communications equipment, an adversary need not be technologically advanced to attempt a jamming attack. There are varied inexpensive and even commercially-based systems that could be employed to cause disruptions. Though jamming attacks are difficult to attribute, once located, the jammers can be neutralised by the use of various hard and soft kill options. The effects of such attacks are also temporary and reversible and have little potential to add to the instability or debris in the space domain.

Spoofing involves taking over a space system by appearing as an authorised user. An example is establishing a command link with an enemy satellite and sending anomalous commands to degrade its performance.[17] Spoofing is one of the most discrete and deniable non-lethal methods available for offensive counter-space operations.[18]

Kinetic Energy (KE) ASATs

Satellites may be targeted by Earth-based, aerial or space-based KE weapons, which may be designed to destroy their targets either through direct impact or by using an explosive warhead. As there is no atmosphere in space, there are no shockwaves produced. Therefore, a space weapon must include pellets or fragments so that, when the warhead is detonated, they impact the nearby target. Also, multiple shots can be taken at the satellite if the initial attack is not successful.[19]

Ground-based "Direct Ascent" ASAT: This requires a launch vehicle that follows a direct path to the intended target, an effective homing device and a warhead. Direct attack would require availability of information of the satellite and timing of the attack with the satellite approaching overhead the launcher. Technology for launch and ascent, which is available with all countries having IRBM capability, provides an inherent counter-space capability. In the absence of tracking and homing abilities, they could resort to releasing clouds of pellets in the path of a satellite. However, such a method would increase the threat for all satellites at that altitude, including friendly ones. Nations that possess the additional capability to track satellites as also those that can build homing interceptors for Ballistic Missile Defence (BMD)[20] have a more refined ASAT potential.

Co-orbital: A co-orbital ASAT is one that is deployed in the same orbit as the intended target satellite. It would then manoeuvre to become aligned for KE interception. Technological capability required for such a weapon is more complex than that required for a direct ascent ASAT. The advantage is that a co-orbital satellite can be placed in orbit at any time to be activated when required for a quick attack. These ASATs are being referred to as space mines and microsatellites are proving to be especially suitable for this role.

Parasitic: Hard kills could also be carried out by "parasitic" ASATs—small explosive packages that covertly manoeuvre and attach themselves to their intended victims[21] and are activated through a remote command. All kinetic kill mechanisms would, of course, create their own debris fields that could potentially inflict widespread damage on other space systems, including friendly ones and undermine the sustainability of outer space.

Nuclear Threats

The coming together of direct ascent capability with a nuclear warhead would provide the ability to cause a nuclear explosion in space. Such an explosion at an altitude of several hundred kilometres would create an intense Electromagnetic Pulse (EMP) that would likely destroy all unshielded satellites that are in LEO and in the line of sight of the explosion, without discrimination. This kind of EMP could even potentially disable a high orbit satellite.[22] Even if not directly affected, the radiation environment could make it more difficult for Geosynchronous Earth Orbit (GEO)- based satellites to communicate with ground stations.[23] In addition, persistent radiation created by the explosion in LEO would be trapped in the Earth's magnetic field, slowly damaging unshielded satellites at altitudes near that of the detonation[24] and shortening their lifetimes. Redeployment in the orbit might have to wait for months until the radiation levels drop to the point where satellite electronics could survive. Very small nuclear weapons, perhaps with yields as low as 1-2 kilotons, could produce more discriminate effects, destroying a satellite at a distance of a few hundred metres while not producing enough radiation to significantly reduce the lifetimes of other LEO assets or to damage installations on the Earth.[25] As already covered, both the US and the Soviet Union explored nuclear-tipped missiles as missile defence interceptors and ASAT weapons during the Cold War era and decided against their development and deployment. Apprehensions remain about such weapons in the hands of rogue nations and non-state actors.

Directed Energy Weapons

Directed Energy Weapons (DEWs) produce a beam or field of electromagnetic energy or atomic/subatomic particles. This is then delivered to a distant target at the speed of light, much faster than conventional projectile weapons. This energy can potentially be used with differing levels of intensity focussed onto a target long enough to deposit sufficient energy to either dazzle, disable, damage or destroy it. Among the different DEWs, lasers are the most efficient at propagation and in focussing and directing of energy.

Just as a satellite's receiver can be overwhelmed by a jamming signal, a satellite's optical sensor can be overwhelmed by a light source that s brighter than what it is optimised to view. In 1997, a 30-watt chemical laser intended for alignment and tracking of a target satellite for the US Mid-Infrared Advanced Chemical Laser (MIRACL) was directed at a satellite in a 420-km orbit. The laser was able to blind the satellite temporarily, although it could not destroy the sensor. This suggests that even a commercially available low-watt laser functioning from the ground could be used to "dazzle" or temporarily disrupt a satellite.[26] The most publicised use of a laser blinding a satellite's sensor was that of the Chinese ground-based laser achieving it on an American Keyhole reconnaissance satellite in 2006 over China.

Optical sensors are sensitive to specific wavelengths for which they are designed. A laser operating in this band, with sufficient energy, could permanently damage these sensors. Imagery satellites that carry multiple detectors and filters would require an attacker to know the frequency band of each filter and have a laser operating within each of these bands.[27]

Some of the optical sensors that are part of the altitude control system of most satellites are also susceptible to laser interference that might cause the satellite to malfunction. Physical damage to a satellite can be achieved when the high intensity beam of energy can sufficiently heat up the body to produce structural and incendiary damage effects. Such destruction can be achieved without creating debris.[28]

Laser attacks are not simple to execute. Ground-based lasers require large, fixed infrastructure, including tracking systems, mirrors and other optics and would consume an incredible amount of energy to create a beam strong enough to compensate for atmospheric effects that tend to spread a laser's energy over a larger area.[29] Weather is also an issue as lasers tend to lose energy in the presence of dust, fog or smoke. Increasing their intensity requires more power, further pushing up the size and weight of the infrastructure. The ground-based laser can "see" the target over its horizon for a few minutes only and this may be insufficient to acquire, track and aim and to sufficiently heat up the target to cause the requisite damage. For targeting the sensor, the attacking laser would need to be in its field of view. To effectively 'jam' all imaging satellites, with their varied payloads, just over the critical area of the country, would require deploying many such units with their associated infrastructure. It is difficult to justify the cost of such equipment whose success rates are expected to be low. As a result, while there have been cases of opportunistic targeting of satellites, a lot more innovation would be required before this can be considered a viable weapon system.

Much of the limitations of ground-based lasers can be overcome by placing them in the air. The **Airborne Laser (ABL)** is a concept that has been tested in the past by both the US[30] and Russia.[31] The US ABL programme has been shelved due to technological limitations that have been unable to bring down the size, weight and associated cost of the equipment. The Russian programme, however, continues. Unlike the US system that was reportedly being developed for boost phase interception, the Russians claim that their ABL is being "designed for space counter-warfare" to "serve as an asymmetrical response to the world's looming space arms race."[32] Hence, interest in these systems would not wane. Developing technologies such as microtechnology and nanotechnology are expected to contribute to development of phased-arrays that would help increase laser intensity, reduce size and overcome problems related to atmospheric attenuation.[33]

High-power microwave weapons can disrupt or damage the electrical systems of a satellite if enough of their energy enters these systems. Microwave attacks could attempt to enter the satellite through its antennae (a front-door attack) or through other routes, such as seams in the satellite's casing (a back-door attack).[34] Such attacks would be more effective if conducted from space rather than from the ground.

Satellites in LEO, closer to the Earth, would be more vulnerable than those in higher orbits to ground-based ASATs (both KE and Directed Energy Weapons). The technological sophistication required to reach these higher orbits is presently available with very few countries.

Space-Based Negation Capabilities

Space-based ASATs would employ similar techniques as the terrestrial ones—kinetic-kill, directed energy or conventional explosives. The enabling technologies required for these would be somewhat more advanced than the fundamental requirements for putting a satellite into orbit, such as precision on-orbit manoeuvrability and space tracking. Such weapons once placed in orbit will provide a rapid reaction capability and a higher probability of success. Manoeuvrable microsatellites in space have dual use potential as KE ASATs and can even be used for directed energy missions. They can also offer targeting assistance for other kinetic-kill vehicles. Space-based weapons could also be utilised to target terrestrial targets. Such weapons would have a global reach and require less time for activation while, at the same time, being relatively less vulnerable to negation attacks.

However, even here there would be a requirement to deploy large numbers for effective coverage (with their corresponding high costs). They might have to be deployed for prolonged periods before an opportunity arises for their employment. As satellites operate without any maintenance, their reliability would always be under a shadow of doubt. They would be susceptible to counter-measures as any other ASAT. Such factors have consistently put a question mark on their employability for a purpose that could equally be achieved through cheaper and less complex terrestrial measures.

Space-based assets form an important and effective component of the defence against ballistic missile attack. Land and sea-based detection, interception and destruction capabilities can only aim at targeting an incoming missile in the mid-course and terminal stages. A truly global capability and one that is most effective for boost phase detection and interception cannot be achieved without incorporating interdiction capabilities in space. The boost phase is when the missiles are easily detectable because of their large infrared and visible light signal caused by the rocket plume. Because of the relatively low speeds and minimal manoeuvrability, this is also the stage when they are the most vulnerable. Boost phase destruction precludes launch of multiple warheads or decoys that would be difficult to track and ensures that any debris caused by the engagement falls onto the launching state itself. Space-based weapons would also improve capability to intercept missiles in the mid-course phase or even in the high endoatmosphere before the re-entry phase.[35] Aerial assets could provide for some of this capability, but they cannot truly replace the coverage provided by the space-based assets, which are also less vulnerable to surface launched negation attacks. Theoretically, these capabilities could be used offensively against satellites in geostationary orbit that would otherwise be out of reach.

The earlier space plane, the space shuttle, had a number of capabilities that provided it ASAT potential. The US is now experimenting with another technology, the reusable unmanned hypersonic space plane, the X-37, whose mission details have been kept classified. Its first orbital mission was launched on April 22, 2010. Its third mission, which was successfully launched on December 11, 2012, has already been in orbit for more than 400 days.[36] There is speculation on the potential of such a platform to carry a multitude of payloads, including weapons.

Threats to Ground Segments

Attacks on ground segments are easier than many other satellite disruption techniques, while achieving similar degradation of space capability. Both satellite launch sites and ground stations are few in number and hostile acts against them would adversely affect a nation's space launch and operating efforts. A vast majority of space assets depend on cyber networks, while many information and transmission networks rely heavily on satellites. The link between cyber space and outer space, thus, constitutes a critical vulnerability that can be targeted by states as well as non-state actors. In the worst case, it could even send a satellite spinning out of control. In 1998, a US–German–UK satellite, the ROSAT, turned toward the sun for no apparent reason, causing damage to its optical sensor. While the exact reason could not be ascertained, circumstantial evidence of the time indicated that it could have been because of a cyber attack. [37] In another such reported instance, hackers apparently gained access to the US Landsat-7 and Terra AM-1 satellites four times in 2007 and 2008. In one such incident, the attackers gained access to the US satellites by hacking a control station in Norway.[38] Commercial ground stations are more prone to such attacks as they are fewer in number and are relatively lightly protected. These attacks have now made cyber protection a core concern among nations, prompting them to initiate steps towards protecting their networks and satellites, as well as to increase redundancy by diversifying and multiplying ground segment nodes.

Defending Satellites

Space assurance requires nations to seek methods of reducing system vulnerabilities that can be accomplished by passive measures, semi-active defences, and active defences — or a combination of these to minimise any adverse consequences in the event of space warfare initiatives by adversaries. Passive measures are design features that make satellites less vulnerable to the effects of attacking weapons. Semi-active measures would involve response mechanisms that would be activated on identification of specific threats. These may involve shutting down or turning away of receivers when the incident signal strength crosses the limits or manoeuvring the satellite away from danger in its orbital path. Active measures would involve offensive means to deter any attack or as a response to an attack. Some of the defensive measures that could be employed are:

- **Hardening:** One of the most important passive defence measures is hardening the satellite against various kinds of envisaged threats. These would include hardening against Direct Energy Weapons (DEWs) through simple shields of reflective, absorptive, or conductive material for heat dissipation and to shield the more delicate subsystems against direct exposure. It would also include hardening against the EMP and radiation generated by a nuclear explosion. Such measures are required more for satellites in LEO which are prone to attacks from the ground. Hardening satellites against explosions or impact, either accidental or from KE ASATs, is not considered practical or effective.

- **Anti-Jamming:** Defences against jamming and other forms of electronic interference are quite advanced, and could be applied to satellites as they are to other defence electronic systems. These would involve electronic protective measures and anti-jamming techniques such as encryption and frequency hopping. These would, however, have an effect on the weight of the satellite and the data transfer rate of the communication. Additionally, it might not be technologically feasible to achieve a totally jam resistant satellite, even as these measures continue to add costs to the project. Instead, jamming could also be overcome by an improved communication architecture that mixes jam-resistant systems with multiple nodes for redundancy. It would be easier to equip ground segments with suitable "filters" to help them pick up signals through the jamming noise.[39] Self-inflicted Electromagnetic Interference (EMI) can be addressed through better management of the frequency and spectrum, technological advances and through policy and training measures.[40]
- **Manoeuvrability:** Satellite manoeuvrability would be more useful against a direct impact weapon as most KE ASATs do not have the capability to deal with manoeuvrable targets. Such manoeuvres would expend valuable fuel that would shorten the effective life of the satellite. Evasive manoeuvring action may also include turning sensitive elements to face away from a laser beam. This would, however, affect achievement of the mission objectives.
- **Deception:** There may be ways and means devised to design stealthier satellites that provide reduced visibility to either radar or optical systems that would complicate the tracking and, hence, the targeting of satellites. The techniques involved would be similar to those being used to provide stealth to aerial and terrestrial vehicles. Further, onboard decoys could be used to divert an attack. These decoys would mimic the radar, and thermal and optical signatures of the satellite.
- **Self-Protection:** Important satellites could be provided with their own means of self-defence, such as recoilless guns or small homing missiles

that would destroy ASATs before they can be effective. Microsatellites could be deployed around a high value satellite and they could either carry these weapons or protect the target by manoeuvring and colliding with the incoming ASAT. However, this would also require satellites to have their own space awareness suite that would include onboard systems, such as a 360 degree radar or proximity warning sensors, for attack detection and reporting.[41] As response times would be minimal, satellites would require to be programmed to take autonomous evasive manoeuvres when faced with threats.

- **Autonomous Operation:** The ability of a satellite to undertake a number of operations without the requirement of control from the ground would lessen its vulnerability to jamming.

All these measures would involve weight and cost penalties that along with the reduced life of the satellite have discouraged such measures being incorporated on most satellites. Nations are awakening to the potentially hostile environment of space. As contributions from commercial space assets are becoming critical, even their operators are under pressure to undertake satellite protection measures. Future designing efforts, which would gain from the advent of miniaturisation and nanotechnology, would focus on these measures in the design of satellites and systems.

System Redundancy

Besides the measures undertaken to reduce the satellite vulnerability, nations are also looking at methods that assure continued availability of the services from space. These would involve redundancy measures in satellite design and operations. Satellites already employ redundant electronic systems to avoid single-point failures and similar redundancy could be designed and incorporated for other crucial systems.

System and operational redundancy would also involve measures such as increasing the number of assets in space and distributing tasks among them so that the loss of any satellite does not incapacitate the system. It also increases the degree of difficulty for the attacker as more satellites would need to be negated to disable the system. Microsatellites are enabling constellations that would replace larger stand-alone satellites in the future to provide equal or even better capability while providing inherent redundancy. Aerial and terrestrial capabilities could also supplement or, if need be, help compensate for inoperable satellites. Such measures would present fewer high value targets in space and deter adversaries from attacking space assets that might not bring about effects commensurate to the large amounts of effort required for such attacks.

Another method is to have back-ups, spares, or alternative means ready to rapidly replace or compensate for satellite losses in the wake of a space negation attack. This, in turn, would require to be launched at short notice for timely replacement. Countries are already researching and developing Operational Response Systems (ORS) that would aim at augmenting operational capability during war, crisis, or contingency or for replacing any inoperable satellite. In 2004, Russia conducted a large military exercise that included plans for the rapid launch of military satellites to replace space assets lost in action.[42] Microsatellites, along with micro launch vehicles could enable short-term replacement of any larger satellite that has been damaged or lost, in order to undertake critical operations. Commercialisation of launch services that are using modern, less expensive technologies and Commercial Off The Shelf (COTS) components are promising smaller, less expensive and more responsive space systems. Commercial launch systems would themselves provide such back-up capability.

Chapter 3
US Concerns and Space Control

Major discussions regarding weaponisation emanate from the US whose economy and national security apparatus are far more dependent on space systems than is the case in any other country. The sensitivity of its space systems continues to dominate American thought. In the words of the then US Air Force Chief of Staff General Norton A. Schwartz:

> What might be a relatively minor disruption for a less space-dependent adversary could be a consequential setback for our nation. As technology continues to effectively lower the barrier to entry, and enable more actors in this vital and increasingly competitive domain, both the capability and the vulnerability gaps might narrow. But for the foreseeable future, we will face the possibility of cunning or aggressive acts by adversaries to leverage this current reliance, and exploit our potential loss of wide ranging capabilities.[43]

General William Shelton, the Commander of the US Air Force Space Command, reiterated in January 2014 that "dependence on cutting-edge space technologies has become a "double-edged sword" for the US" and that "American satellites are defenceless against a possible attack in space, and their destruction "would create a huge hole" in the country's capability for high-tech warfare".[44]

That space would be a centre of gravity in any future conflict with the US has also been evident to the world for long. In a July 2000 article, Chinese defence analyst Wang Hucheng posited, "For countries that can never win a war with the United States by using the method of tanks and planes, attacking the US 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."[45] In any military conflict, US space systems would comprise a strategic vulnerability. Any damage to these systems would adversely affect the US Command and Control, Communications, Computers, Intelligence, Information, Surveillance, and Reconnaissance

(C4I2SR) capabilities, thus, providing asymmetric advantage to any adversary.

The US has believed in the doctrine of dominance to dissuade or deter potential adversaries, and space-based assets play a pivotal role in maintaining its dominant geopolitical, military, and economic status. It fears other nations' capability development as threats to its space assets and those of its allies. In 2003, during the Presidency of George W Bush, it talked of a probable "Space Pearl Harbour" and pushed for missile defence and space weapons. The US has since withdrawn from the 1972 ABM treaty and has been pursuing different programmes as part of the Space Defence Initiative (SDI) to protect the mainland and its satellites against attack. These consist of offensive weapon programmes, including DEW and KE weapons which it justifies as essential to counter the growing missile threat from rogue countries and counter-balance the increasing military potential of China. It has also expressed apprehensions about satellite disruptive technology being available to non-state actors. While its response to the Chinese ASAT test of 2007 was subdued, recent releases have revealed its great concerns that were communicated to the Chinese.[46] It subsequently carried out a controlled destruction of its ageing satellite, the USA-193, by modifying three ship-based Aegis Exoatmospheric Kill Vehicle (EKV) interceptors, their parent ships and the system's command and control software. It denied that it was part of an ASAT test or demonstration, instead projecting it as a measure taken to prevent a toxic fuel tank, which would pose a health hazard, from returning to Earth. Others saw it as a response to the Chinese ASAT test. The US National Space Policy 2010 states, "Any purposeful interference with US space systems will be interpreted by the United States as an infringement of its rights and considered an escalation in a crisis or conflict. The United States reserves the right, consistent with the UN Charter and international law, to defend and protect its space systems with a wide range of options, from diplomatic to military."[47]

Space Control

The US Joint Space Doctrine talks of space control as one of the space mission areas to extract the maximum benefits from space. As per the paper, space control "supports freedom of action in space for friendly forces, and when necessary, defeats adversary efforts that interfere with or attack US or allied space systems and negates adversary space capabilities."[48] This is similar to the classic military definitions of sea control and control of the air and is aimed at dissuading and deterring its potential array of adversaries from misadventure. It explicitly talks of using defensive as well as offensive measures to "preserve its rights, capabilities, and freedom of action in space."[49]

Offensive Space Control

As per the doctrine, Offensive Space Control (OSC) comprises measures taken to prevent an adversary's hostile use of US/third-party space capabilities or offensive operations to negate an adversary's space capabilities used to interfere with, or attack, US/allied space systems. It goes on to say that OSC actions target an adversary's space-related capabilities and forces, using both lethal and non-lethal means. Thus, it explicitly talks of negation capabilities against space systems through different hard or soft kill measures. As these capabilities are already available in some measure with the US, it is evident that the use of such means would be dictated by geostrategic imperatives. Once the decision has been taken, the type of attack would depend on the threat and the level of conflict. Measures (would) include actions against ground, data link, user, and/or space segment(s) to negate the adversary's space systems, or to thwart hostile interference with, or attacks on, US/allied space systems.[50] These would involve:

- **Deception:** Those measures designed to mislead an adversary by manipulation, distortion, or falsification of evidence to induce the adversary to react in a manner prejudicial to its interests.
- **Disruption:** Those measures designed to temporarily impair specific targeted nodes of an adversary system, usually without physical damage to the space system.
- **Degradation:** Those measures designed to permanently impair (either partially or totally) the utility of targeted adversary systems, usually with physical damage.
- **Denial:** Those measures designed to temporarily eliminate the utility of targeted adversary systems, usually without physical damage.
- **Destruction:** Those measures designed to permanently eliminate the utility of targeted adversary systems.

Defensive Space Control

Defensive Space Control (DSC) comprises operations conducted to preserve the ability to exploit space capabilities via active and passive actions, while protecting friendly space capabilities from attack, interference, or unintentional hazards.[51] DSC can be a prelude to OSC operations.[52] It further states that DSC will contribute to space deterrence by employing a variety of measures that help assure the use of space, and consistent with the inherent right of self-defence, deter others from interference and attack, defend own space systems and contribute to the defence of allied space systems, and if deterrence fails, defeat efforts to attack them.[53] Therefore, some kind of offensive capability would form part of DCS.

Space Surveillance

Space control measures would depend on capabilities to detect and characterise an attack and the ability to attribute an attack to an adversary. The fear of detection would deter potentially hostile states from undertaking any unwelcome step. At the same time, it would enable positive action against the perpetrator of such action, including space negation efforts. Space Situational Awareness (SSA), thus, forms the foundation of space control efforts. It is defined as "the requisite current and predictive knowledge of the space environment and includes the ability to detect, track, identify, and catalogue objects in outer space."[54] To exercise space control, a detailed intelligence picture would be required of all objects in space, as nearly all of them would pass over a country at some time or the other. SSA also indirectly supports space security by providing the ability to distinguish space negation attacks from technical failures or environmental disruptions, thereby helping prevent misunderstandings and false accusations of hostile actions.

While these capabilities are increasing worldwide with a number of nations investing in space and terrestrial surveillance technologies, the US Space Surveillance Network (SSN) remains the most advanced and comprehensive global network. SSN is a worldwide network of 30 space surveillance sensors (phased array radars, conventional radars and electro-optical sensors, both military and civilian), strategically located at more than two dozen sites worldwide, that tracks and catalogues objects in space. SSN sensors use a "predictive" technique to monitor space objects, i.e., they spot check them rather than tracking them continually. This technique is used because of the limits of the SSN (number of sensors, geographic distribution, capability, and availability). This input is then utilised for analysing intentional threats and conjunction assessment. The information on hostile events that could directly or indirectly threaten US or allied space assets is then compiled. This information is analysed to determine potential impacts on assets so that timely warnings and recommendations for suitable counter-measures can be made.

Despite the advances, the current capability is considered inadequate to address the emerging threat environment. The spot detection capability that depends on availability of data and predictability of satellite orbits is not conducive to detect most emerging threats. The capability in terms of the size of the object being tracked gets severely degraded in the higher orbital regions. The US is graduating onto an S-Band Space Fence that is expected to be operational by 2017 and replace the current VHF Radar Fence. It is also looking at expanding the coverage of the space over the Southern Hemisphere and, as part of this effort, has moved one C-Band radar from Antigua to Australia.[55] Its Space-Based Space Surveillance (SBSS) programme, composed of a constellation of four satellites (the pathfinder satellite of which was launched in September 2010), is expected to track orbital objects from space. Space-based sensors use optical or infrared sensors which either scan or quickly focus between targets without having to expend time and fuel to reposition the entire spacecraft. They also have the ability to detect objects in space without being affected by weather, atmosphere, or time of day.[56] Budget projections also indicate continued emphasis on the Space Fence.[57] The US aims to further enhance its early warning capability through its Space-Based Infra-Red System (SBIRS). It includes a mix of four satellites in GEO and two in Highly Elliptical Orbit (HEO) and ground-based data processing and control.[58] However, the programme has seen budget cuts in the 2014 Defence Authorisation Bill.[59]

Weaponisation of Space

There have been discussions in the US, at different levels, in which experts have pointed to the inevitability of weaponisation of space and propounded a number of reasons for the US to seize the initiative by being the first one to place weapons in space. Some of the arguments are:

- Dominance of the space domain is essential for the US' role as the sole global superpower and for exercising influence over other nations.
- Space weapons would provide more effective defensive and offensive capabilities. They would also contribute towards a comprehensive BMD architecture.
- Other nations would vie for, and surely fill, any void that is left by the US and this would be detrimental to its own survival.[60] The present superiority that the US enjoys in space should be maintained and exploited to entrench itself before the other nations narrow this gap. Such capabilities would help undermine opponent attempts to militarise space, thus, helping achieve total military dominance.

However, deployment of weapons in space has not yet become a reality because of a combination of technological, economic and geopolitical compulsions. Meanwhile, the US also recognises that owing to its dependence on space-based assets, any attack by it against targets in space may prove to be self-defeating. The US National Space Policy 2010, thus, also claims the United States' right to "retain the capabilities to respond at the time and place of our choosing."[61] These would include conventional or nuclear attacks against terrestrial targets.

Chapter 4
Capabilities and Concerns Across the Globe

Proclamations regarding maintenance of supremacy and dominance in space by the US, its explicit space control doctrine and pursuance of offensive counter-space measures have made space a domain of potential competition and conflict. Other states such as Russia and China have expressed concerns regarding the intentions and directions of the US military space programme and how these policies can lead to destabilisation of the environment. Less developed nations are apprehensive of the asymmetric advantages that such capability provides the US to accentuate terrestrial military superiority as it has done in Iraq and Afghanistan. Due to the sensitivity related to placement of weapons in space, no other nation has openly declared any such intentions. However, space-faring nations continue to develop related and dual use technology that is being helped by technological advancements and proliferation. As with most other contemporary doctrines, employment of space capabilities is expected to follow tenets similar to those enumerated in the US space doctrine.

Russia

Russia has not carried out any ASAT test since 1982 and its capability has been restrained because of limited funding and relative mismanagement of the space sector. However, it has been conducting tests of its missile systems to demonstrate its capabilities. The activation of the first stage of the North Atlantic Treaty Organisation (NATO) missile defence shield in Europe in May 2012 was greeted by an intercontinental missile test that Russia claimed to be "in response to the US deployment of a global anti-missile system."[62] Besides this, Russia also has a long history of work on laser programmes and cyber attack capacity. As covered earlier, its Airborne Laser (ABL) programme continues to be active with counter-space objectives. In recent times, it has shown signs of revitalising its space organisation and capabilities and is seeking its erstwhile prominent position in the global arena. It would surely leverage its relative dominance in space for its reemergence and, therefore, would take all measures to protect these capabilities.

China

China has already started exerting its influence regionally and its global aspirations have been obvious. As it continues to gain economically and progress technologically, its earlier inhibited ambition has evolved into a more overt display as it seeks to regain its traditional position as the preeminent power in East Asia. It understands the importance of progress in space in supporting these ambitions. China seeks to develop technologies and doctrine to counter the US hegemony in space as part of its larger plan to gain parity in the emerging power equation. It sees the build-up of US capabilities as detrimental to its own interests and cites the US national policy that indicates denying adversaries the use of space capabilities hostile to US national interests and the ensuing military doctrine that talks explicitly of offensive counter-space measures. The Chinese ASAT test in 2007 was seen by analysts as a response to the US withdrawal from the ABM Treaty and as a projection of its capability against US satellites in case of an armed conflict.

Chinese commentators describe the US BMD system as strategically destabilising due to its potential to threaten the viability of China's small nuclear force. [63] China has been concerned about US plans to place missile defence radars in Japan. Beijing has also raised concerns about the development of the space-based laser that intends to target missiles in their boost phase. The then Chinese Assistant Foreign Minister had complained to the US that its (the US') missile defence programme was not simply "defensive" but also "offensive" because "it includes lasers that attack a missile in the launch phase over the sovereign territory of the launching country".[64]

In a recently translated Chinese defence paper, it is stated that limiting or preventing the use of space-based assets by potential adversaries during times of conflict is one of China's objectives, and it has gone on to call the kinetic energy anti-satellite missile a revolutionary new concept and a deterrent mode of operation.[65] Consequently, it continues to develop technologies and concepts for anti-satellite operations. Most of these programmes, though, are shrouded in secrecy. Studies have concluded its growing capabilities in its DEW programme, including laser and radio frequency directed energy weapons. These were also corroborated by its firing a ground-based high-power laser at, and blinding, US surveillance satellites in orbit over China in 2006.[66] Its manned space and lunar programmes have potential military offshoots and provide it with capabilities to enhance its ASAT development. It is also striving to make improvements to its space surveillance programme that is seen as a prerequisite for an effective, precise counter-space programme. Its asymmetric warfare efforts include cyber warfare and it has been actively pursuing offensive capability in this domain. The People's Liberation Army (PLA) has integrated cyber warfare into its military exercises and its formal doctrine.

While the Chinese ASAT test of 2007 had sent alarm bells ringing across the world, experts had brought out that it was still far away from actual operational ASAT capabilities that would require a much more sophisticated endeavour. These would involve improving the systems accuracy and reaction time and also developing an effective command and control system. Since then, it has carried out tests of its BMD capability that also have latent ASAT potential. In January 2010, in its first BMD test, it destroyed one of its own missiles at an altitude of 150 miles. Another ground-based mid-course BMD test was conducted in January 2013. After the international condemnation of its 2007 test, China has avoided creating debris in its ASAT tests.[67] On May 13, 2013, China launched a rocket which it claimed was for a high altitude scientific research mission. US government sources say it was actually a test of a new ballistic missile related to China's ASAT programme[68] that would provide it capability to target satellites at higher altitudes. According to the latest annual report of the Congressional US-China Economic and Security Review Commission, the test reflects "China's intent to develop an [anti-satellite] capability to target satellites in an altitude range that includes US GPS and many US military and intelligence satellites."[69] The US apprehensions stem from the fact that while damage or destruction of satellites in LEO would only result in gaps in the surveillance capabilities, the same effect in the Middle Earth Orbit (MEO) and GEO would adversely affect the GPS and communication capabilities respectively.[70]

In September 2008, a BX-1 microsatellite was launched from the Shenzhou 7 mission, which flew within 27 miles of the International Space Station. In

July 2013, China launched three small satellites into orbit which carried out manoeuvres in relation to each other. Such capability has ASAT potential as it provides the ability to perform co-orbital surveillance as well as kinetic kill capability. One of the satellites was equipped with a robotic arm,[71] which while having space-based maintenance capability also has ASAT potential.[72] While such claims of the US have been questioned by some experts, it is evident that these tests have raised concerns among the US and other nations that continue to watch Chinese ASAT developments closely, fearing threats to their own satellites. On the other hand, the subdued response of the US to these tests has been attributed to its own possessions and its efforts at bolstering of ASAT capabilities.

Other Asian States

Many more nations in the region are seeking or acquiring such technology and with Asia becoming the global hotspot of the 21st century, such capabilities would surely come into play to gain strategic and geopolitical advantage. Japan has been affected by the emergence of China as a regional power in the last decade or so and it has repeatedly voiced concerns about North Korea's nuclear and missile capabilities. As a result of these, it has changed its erstwhile pacifist approach and in the past few years, has been actively pursuing capabilities in space that have military applications. It has modified its Aegis destroyers with the updated Aegis BMD system[73] that could have ASAT potential. Israel is already a global player in space and also has ballistic missile capability. Pakistan's progress in space is still in the nascent stages, with a lot of assistance from China. Its ballistic missile programme, however, has been quite successful, providing it with direct ascent KE ASAT capability.

At the same time, there is a tacit understanding of the legitimate rights of nations to develop capability for the defence of their own assets in space. Consequently, the discussion has shifted from capability-building to the intent of an adversary to use such weapons. Intent could be dependent on geostrategic considerations and a host of other more localised factors, including the perceived threat to a nation's own space systems. In most cases, the intent of most nations to employ ASATs would be restrained because of the consequent threat to their own assets.

'Rogue' States and Non-State Actors: However, the same would not hold for malevolent states and non-state actors who have acquired this technology. The vulnerabilities are increasingly being discussed in the context of asymmetric warfare by low cost and low-tech means by weaker, technologically inferior 'rogue' states or by non-space actors who have little dependence on space-based assets and, hence, have little to lose by bombarding the orbits with debris. A simple anti-satellite weapon that could be used by an attacker with a relatively low technical sophistication is a cloud of pellets or even sand and gravel lofted into the path of a satellite by a medium range ballistic missile.[74] Global fears have emanated from reports of North Korea possessing nuclear weapons and having carried out ballistic missile and rocket launches that it claimed were for peaceful use. Its weapons have sufficient range capability to reach the US mainland, making even other nations in the region feel threatened. Iran has already displayed its prowess in the domain by having carried out successful space launches while the state of its nuclear programme continues to be under international scrutiny.[75] These efforts are seen as destabilising for the prevalent regional power equations.

Space Surveillance: While nations have been developing missile and space going technologies, the SSA capabilities of other space-faring nations are severely restricted as compared to the US. France is currently developing a space-tracking radar system, which is set to begin operation in 2014. Russia also has a LEO surveillance system of ground-based radars placed around Russia and in other countries, although it does not share much data. China and India have significant satellite tracking, telemetry, and control assets essential to their civil space programmes.[76] No individual state could hope to achieve comprehensive SSA capabilities to match those of the US. However, international collaborative efforts that would complement individual ability would go a long way in contributing to the overall space security. Sharing of resources and data would reduce apprehensions among nations as well as allow for more coordinated efforts against any untoward activity in space.

Chapter 5
Weapon Control Regulation for Space

Technology developments and policy measures related to satellite negation possibilities have formed a major part of most recent debates on space security. While countries continue to build capabilities, they also accuse each other of hiding space weaponisation behind a facade of peaceful uses.[77] Military or dual purpose programmes and any development with potential ASAT capability are being viewed with suspicion and being considered as destabilising. There is, however, substance in the view that says that it would be prudent to play down the rhetoric and treat these assessments and development of capabilities as an essential and legitimate part of national security that most advanced nations would resort to as part of the hedging strategy against other nations doing the same.[78] The emphasis should be on policy and regulation and other diplomatic initiatives to prevent its escalation into an uncontrolled space arms race.

All states agree on the concerns about the increasing threats to space security and the need to contain the problem. There is no consensus, however, on the best course of action to achieve this. At the very outset, there is disagreement on the definitions related to space security. Then is the debate about what forms the biggest threat, the space debris or the possibility of space weaponisation. Consequently, while one group of states led mainly by China and Russia, prefers the adoption of a legally binding treaty to prevent an arms race in outer space, others argue in favour of voluntary, non-binding Transparency and Confidence-Building Measures (TCBMs).

The OST, which was devised to deal with the contentious issues that had relevance to the two superpowers at that time, has played its part in maintaining space as a sanitised environment. The LTBT of 1963 prohibited all nuclear weapons test in space and the OST banned placement of Weapons of Mass Destruction (WMDs) in space. However, the OST does not cover conventional weapons and the transit of such weapons through space (mainly to allow ballistic missiles). There has also been no effort at defining space weapons. Therefore, as per the OST, the document on space regulation that has been ratified by most countries, none of the existing ASATs is prohibited. It, however, does forbid the "testing of any type of weapons and the conduct of military manoeuvres on celestial bodies." The treaty does not include much in the way of verification, compliance management or enforcement. This has found favour with the established and dominant space-faring nations because of the weak mechanisms which have helped them maintain their superiority and freedom of action in space. There has been a reluctance to pursue any fresh initiatives that would compromise these benefits[79] and also impose economic costs for the sake of more equitable rules and access to the space environment. However, there are growing concerns, because of the failure of the earlier technology denial mechanisms to control the proliferation of technology that has put the capability to interfere with, or destroy, a satellite in the hands of an increasing number of players. The renewed emphasis on ASAT capabilities in the last few years has led to mistrust and tensions. There are growing fears in the US about the asymmetrical vulnerability of its space assets.[80] Such apprehensions are forcing a rethink on negotiations of more relevant regulatory instruments.

A major factor that has delayed negotiations on the formulation of a regulatory regime in space has been the relative invisibility of the domain. Till a few years ago its access was restricted to a few nations that had the technological prowess and economic capacity to use it. Its benefits were also limited to strategic and relatively obscure scientific and civil applications. The effects of any misadventure in space were, thus, also limited and would have evoked very little international response. The vulnerability, threats and effects related to conventional and nuclear weapons were more real and the proliferation of these technologies a bigger possibility.[81] Growing participation and commercial benefits of space that are affecting the day to day affairs of the human race are resulting in increased awareness as also apprehensions about the vulnerabilities of space systems and probability of offensive action in space.

Security concerns about the development of negation capabilities are compounded by the fact that many key space capabilities are dual-use, making any space technology development a potential weapons programme. This dual use potential makes it difficult to put in place mechanisms to verify any control regime or weapons ban related to space. It also makes it difficult to apportion blame in case of a mishap. Such inconsistencies have prevented a consensus on the exact nature of a space security regime.

In February 2008, Russia and China, citing the inability of existing arms control and disarmament agreements to "effectively prevent the placement of weapons and an arms race in outer space", introduced a draft of the "Prevention of the Placement of Weapons in Outer Space Treaty" (PPWT), an international, legally binding treaty that would ban the weaponisation of space. Other nations have voiced their concerns with regard to the draft. There is ambiguity on the very definition of space weapons. While the draft treaty relates it to all weapons or objects with destructive ability being placed in space, the US and other Western states want it to address the development, testing, and deployment of ground-based counter-space systems. The US sees the proposal as an attempt by the two countries to target the technological asymmetry they have against the US through regulation, while buying time to develop their own programmes. It also fears that some countries could acquire such systems covertly and then use them when required by breaking away from the treaty, thereby putting any unprepared adversary at a strategic disadvantage. Proponents in the US argue that legally binding treaties that are not ratified by rogue nations and do not apply to non-state actors only end up weakening those states that act in good faith.[82] The draft treaty also does not prohibit debris-generating ASAT tests or prevent the proliferation of ASAT capabilities. Absence of verification provisions remains its biggest criticism.

This disdain about regimes or bans related to space being inherently unverifiable – thereby leading to difficulty in effective implementation and ensuring compliance – has resulted in shifting of the discussion to TCBMs and measures to ensure safe and sustainable use of outer space. These are:

- The European Union introduced a draft International Code of Conduct on Outer Space Activities (ICoC) in 2010 and in June 2012, it launched a multilateral diplomatic process for discussion and negotiation. The main purposes of the ICoC as listed in the document are the enhancement of the security, safety, and sustainability of outer space activities by encouraging responsible behaviour in space by developing best-practice guidelines. It does not address the arms control issue of space weapons or the prevention of an arms race in outer space but focusses on issues such as debris mitigation, collision avoidance and data sharing. The closest it gets to security issues is by asking subscribing states to take appropriate measures to minimise the possibility of accidents/collisions in space between objects and also to refrain from any form of harmful interference in legitimate activities undertaken in space by others. It also talks of the inherent right of all states to individual and collective self-defence and recognises the right to use outer space for military purposes subject only to limitations imposed by international law and to prevent outer space from becoming an area of conflict. However, all this is to be achieved through voluntary measures and the ICoC has no binding mechanism. This, as has been highlighted by many countries, including India, makes it an ineffective mechanism. China has objected to space debris being an issue in the code, raising questions about its intentions in the future in relation to ASAT tests. The US has shown support to the ICoC and expressed its willingness to work together with the European Union (EU) to draft a better international code of conduct. [83]

- The Committee on Peaceful Uses of Outer Space (COPUOS) that had been established by the UN General Assembly in 1959 has been entrusted with the implementation of five key UN backed agreements on outer space. Military activities do not form part of the COPUOS mandate. The UN COPUOS Long-Term Sustainability of Outer Space Activities (LTSSA) Working Group is expected to propose measures to ensure safe and sustainable use of outer space for peaceful purposes and for the benefit of all countries. It aims to produce a consensus report outlining voluntary best practice guidelines.
- The UN Group of Governmental Experts (GGE) that was constituted in 2012 is looking into a range of TCBMs in space that have the potential to mitigate the dangers and risks in an increasingly contested and congested space environment. These TCBMs would be non-legally binding and nations would sign them on a voluntary basis.
- The Inter-Agency Space Debris Coordination Committee (IADC) is an international governmental forum for the worldwide coordination of activities related to the issues of man-made and natural debris in space.

None of these directly addresses the issue of weaponisation of space. However, supporters advocate that TCBMs would contribute towards more responsible behaviour in space. They are expected to lead to greater understanding of the domain and concerns of individual nations that through further dialogue might evolve into a more universally accepted and, hence, implementable regime for space security. India, as part of the G-21 countries actively supported the legislation of a treaty banning the placement of weapons in outer space. It had been insisting on legal and binding measures towards space security efforts but of late has accepted that any such initiative would start from a normative exercise and expects it to graduate to a legally binding instrument in the future. It has, however, emphasised that the drafting exercise should be an inclusive one and not limited to a few developed nations.

Arms control regulation has always been a complicated exercise because of conflicting interests and it is even more so in space. Increasing commercial interest and participation and its dual use potential is only going to increase this complexity as it would be difficult to differentiate it from military efforts. The OST has theoretically forbidden any nation from claiming sovereignty over any celestial body. However, this approach may be challenged in the future as more nations embark on exploration in quest of resources. There are other concerns like commercial space launch activities resulting in proliferation of advanced ballistic missile technology.

Lack of an effective regulatory mechanism has resulted in individual nations undertaking defensive and precautionary steps to reduce current and future vulnerabilities of their assets. Some nations are also seeking offensive capabilities as part of hedging strategies to deter hostile activity that would adversely affect their capability. Development of such alternatives may not always be overt, because of the latent dual use capability of such technology. Deployment of weapons in outer space by one state will inevitably result in a new spiral in an arms race. No nation would subordinate its security interests to the larger agenda of space security. Denial of capability would be seen by aspiring nations as an unfair restriction on their legitimate right to progress and defend. While the process may be gradual, all efforts must be made for an effective space regime that ensures the security of space for all and measures must be instituted to dissuade nations from developing and deploying offensive space capabilities. An early resolution of contentious issues and implementation of some kind of regulatory mechanism would help in preventing this from turning into an arms race. The emphasis should be on intent and operational practice rather than technology proliferation.

Global cooperative efforts in SSA, disaster mitigation, debris removal, scientific exploration and other space related fields will not only optimise the benefits of exploration but also contribute to transforming the outlook towards national ambitions and suspicions.

While TCBMs would be a desirable first step in this regulatory exercise, true deterrence on placement of weapons can only be achieved through enforceable international regulatory mechanisms that also spell out the repercussions for non-adherence. Norms or treaties being negotiated should cater to evolving technologies and the ever increasing number of participatory nations and, thus, be amenable to ongoing dialogue and future negotiations.

Chapter 6

Options for India

Regional developments with potential counter-space capability that ostensibly are in response to the US plans, pose a potential threat to India's space assets. Like any other space-faring nation, these assets are vulnerable to attacks from other state and non-state actors. India has rightly opposed all efforts that could potentially weaponise space. However, developments in the region would force a rethink in the future.

India was an early entrant to the space club and has continued to develop capabilities that in most cases match the best in the world. As a result, there is growing awareness and dependence on these assets for governance and other civilian and socio-economic applications. In the first three decades, India's space programme pursued remote sensing, weather forecasting, telecommunications, and broadcasting applications for civilian use only. However, the launch of the GSAT-7 for the Indian Navy has meant tacit acceptance of the use of assets in space in support of military operations. Reportedly, there are other satellites in the pipeline for use by the other two services. The Cartosat series remote sensing satellites are generally considered to be dual-use in nature, although organisations such as the Union of Concerned Scientists have classified the primary users of Cartosat-2A as military.[84] The Indian Regional Navigational Satellite System (IRNSS), expected to be operational by 2015-16, would also provide geo-location services to the defence forces. The growing dependence on space-based assets for military C4ISR efforts is evident. India's force modernisation effort is also banking on assets that have heavy dependence on Space for their effectiveness. There are plans to launch a number of satellites in the coming years, most of which would be for civilian purposes but their vulnerability to ASATs of the adversary cannot be ruled out.

The threat to Indian satellites came to the forefront after the Chinese ASAT test of 2007. Dr K. Kasturirangan, former head of the Indian Space Research Organisation (ISRO), had voiced concerns in September 2009, "Obviously we start worrying. We cannot overlook this aspect... India has spent a huge sum to develop its capabilities and place assets in space. Hence, it becomes necessary to protect them from adversaries. There is a need to look at the means of securing these."[85] The concerns were reiterated by the then Chief of the Air Staff, Air Chief Marshal PV Naik, when he said, "Our satellites are vulnerable to ASAT weapon systems because our neighbourhood possesses one." He even went on to underline the need for India to develop ASAT technology referring to it as "one of our challenges of future war capability."[86]

Since then, China has continued to improve its capabilities in space, keeping it well ahead of other space-faring nations of the region. Pakistan, on the other hand, has rudimentary capability in space. However, it continues to gain support from China and such help cannot be ruled out in case of a conflict. Also, availability of commercial services would be able to support most of its operational requirements unless some kind of control is exercised by the parent country during hostilities. Its ballistic missile capability also gives it latent ASAT capability.

India needs to build ability against the potential regional adversaries to ensure assured use of its assets in space under all conditions. Taking a leaf out of the US doctrine, the options available are both active and defensive measures. Defensive measures can involve semi-active and passive measures. Active measures that take the logic of developing a credible deterrent entail development of ASATs, either for hard kill or soft kill. Considering that the threat environment from its two potential adversaries is so diverse, the best approach is to pursue comprehensive capability building rather than respond to each threat individually.

At present, Indian satellites, like most others across the world, do not have passive defensive measures incorporated into them. However, vulnerabilities need to be an important aspect of design of all future ventures including strengthening measures and resilience to jamming. Measures like Operationally Responsive Systems need to be pursued to build upon greater redundancy in space capabilities.

The greater debate, however, is development of offensive capabilities in space or ASAT capability. India last talked about ASAT technology after the April 2012 Agni-V test. That was when the then Defence Research and Development Organisation (DRDO) Chief Dr. VK Saraswat had claimed, "Today, we have developed all the building blocks for an Anti-Satellite (ASAT) capability". The technology he talked of was the hard kill direct ascent KE weapon. He said that the ASAT weapon would include marrying Agni-V's propulsion system with the "kill vehicle" of the under-development two-tier BMD system that has been tested a few times to track and destroy hostile missiles both inside (endo) and outside (exo) the Earth's atmosphere.[87] Thus, technologies that India pursues for its BMD programme, with the required modifications, could be employed for ASAT missions.

Even earlier, Dr. Saraswat had spoken of India's interest in building capability that could then be used for developing ASATs, stating that these would be demonstrative technologies—to be tested through simulation rather than actual tests that could potentially add to the space debris. He had, at the same time reiterated, that India did not believe in weaponisation of space and that these were only technological capabilities and were not part of any government approved ASAT programme. Subsequent to these utterances, there have been no other public statements related to the development of this technology. This underpins the huge political and diplomatic ramifications of any such test.

However, questions related to demonstration of ASAT capability continue to be raised because of China's BMD tests and its demonstration of improving capabilities in space. While these concerns have been underplayed by the government, experts feel that sooner rather than later, India would have to take policy decisions on such an important aspect of national security. The most important question is whether India should be happy with the present state of possessing latent ASAT capability that acts as a deterrent or demonstrate it through a test. The current Indian stand is in line with the advanced nations' policy on testing. Michael Krepon in his essay, "A Code of Conduct for Responsible Space-sFaring Nations", has highlighted this aspect by stating: [88]

> Advanced space-faring nations are also pursuing hedging strategies ... Hedging strategies take the form of research and development programmes; the flight testing of multi-purpose technologies that could be used for peaceful or for war fighting purposes in space; ... Tests of dedicated ASAT weapons have been relatively infrequent phenomena during the space age.

The hedging strategy is, thus, the more accepted global norm that is less likely to raise shackles. However, there are other valid concerns on this which invite due consideration:

- Credibility is a major aspect of any deterrent and this can be achieved only through demonstration of capability. India was taken seriously as a nuclear power only after the conduct of the Pokhran nuclear tests. [89]
- With growing capabilities and tensions in space, sooner or later, nations would have to negotiate on treaties or norms to regulate conduct in outer space. The history of negotiations related to arms control, including nuclear weapons, does not give much confidence to the emerging nations. Existing players have, after testing their own systems, favoured composition of restrictive regimes on other countries seeking to acquire the capability in support of their own security needs. With this in mind, whenever such multilateral treaties or formal agreements are debated, India would prefer to be a part of it as a 'have' rather than a 'have-not'. A nation with proven capability would also be able to negotiate from a position of strength.

The decision to undertake an actual demonstrative test would have to be a political one. Technically, conduct of such tests does not violate any international law. However, due consideration would have to be given to the benefits that would accrue to the national security and the space programme as against the negative international opinion that it would generate along with the diplomatic ramifications. As Ajay Lele puts it, "It is not only about reacting to a major event but also about influencing global events to favour the state's agenda either through diplomacy or through actions that would force others to take notice of its concerns... There is a need to undertake a detailed appreciation of this issue by assessing various geostrategic, geopolitical and technological factors". [90]

Even if a decision is taken in the future to undertake such a test, it should only be conducted after the international community has been informed of the compulsions for such an action. There should also be transparency regarding the non-classified aspects of the test (Article IX of the 1967 OST calls for prior international consultation if a state believes its planned space activities may be harmful to others and Article XI calls for informing the Secretary General of the UN as well as the public and the international community of their activities in outer space). It should be supported with other diplomatic initiatives to contain the negative fallout. The test can then be conducted at relatively low altitudes (150 to 250 km) where the created debris would enter the Earth's atmosphere and burn off.[91] While a brazen test would tarnish India's credibility, following this methodology for its conduct would accentuate its position as a responsible space-faring nation. Such a course of action has precedence in the US' bringing down of the US-193 satellite in 2008. Even though the mission was evidently in retaliation to the Chinese ASAT test, the transparency of the operation made it relatively more acceptable.

Conduct of a test is only the first step and there would be many other developments required before the system as a whole can be operational. To give credence to the hedging strategy, India, thus, also needs to develop its soft kill options like electronic jamming and development of DEWs. Such weapons that do not cause permanent damage to the satellite would be more acceptable. However, their credibility as a deterrent would also be limited.

All such measures will be fruitful only after heightened space situational awareness and India needs to build upon its existing capabilities. It should also support global data sharing efforts. Besides improving upon the indigenous competency, India could also seek cooperation with like-minded countries to develop capabilities and capacities in space to counter the growing threat in the region. The aim should not be to seek parity with others but to look after its valid defensive needs.

Notes

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3. Ibid.
4. Space Security Index Report 2013, accessed at http://www.spacesecurity.org/SSI2013.pdf
5. Norman Friedman, *Seapower and Space, From the Dawn of the Missile Age to Net-Centric Warfare,* (London: Chatham Publishing, 2000).

6. Ibid.
7. Grego, n.2.
8. Among the several tests of the ALMV in 1984 and 1985, was one in which an ageing US satellite was destroyed, creating large amount of debris.
9. Grego, n.2.
10. Friedman, n.5.
11. Ibid.
12. SAINT was a proposed programme in the 1950s but was eventually cancelled in 1963. It did not materialise because of technological shortcomings and economic reasons. Also, it was realised that similar inspection or satellite destruction could have been carried out more effectively at less cost through alternate means.
13. Friedman, n.5.
14. Grego, n.2.
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16. David Wright, Laura Grego, Lisbeth Gronlund, "The Physics of Space Security: A Reference Manual", American Academy of Arts & Sciences, accessed at http://ucsusa.org/assets/documents/nwgs/physics-space-security.pdf
17. Robert H. Zielinski, Robert M. Worley II, Douglas S. Black, Scott A. Henderson, David C. Johnson, "Counterspace Operations in 2025", accessed at http://www.fas.org/spp/military/docops/usaf/2025/v3c9/v3c9-1.htm
18. "Key Technologies and System Descriptions," USAF document, accessed at https://www.fas.org/spp/military/docops/usaf/2025/v3c9/v3c9-3b.htm
19. Wright,et.al., n.16.
20. It is easier to target a satellite in space than a missile.
21. Ibid
22. Friedman, n.5.
23. Wright,et.al., n.16.
24. Ibid
25. Krepon, and Clary, n.1.
26. n. 4.
27. Wright,et.al., n.16
28. Ibid
29. Grego, n.2.
30. The Boeing YAL-1 Airborne Laser Test Bed (ALTB) system is the most recent effort that was being developed for Boost Phase Defence. It would have had potential ASAT capabilities. Although significant technological challenges were overcome to carry out the first successful ballistic missile interception in February 2010, the programme has been shelved for now, due to the huge costs involved. Meanwhile, the Defence Advanced Research Projects Agency (DARPA) has been supporting a solid state laser system designed for tactical aircraft called the High Energy Liquid Laser Area Defence System (HELLADS).
31. The Russian ABL is called the Beriev A-60 that is based on a modified IL-76 transport aircraft.
32. "Beams Away: Russia Boosts Airborne Combat Laser Program", RT, November 19, 2012, accessed at http://rt.com/op-edge/soviet-airborne-laser-restarted-600/
33. Black, n.15.
34. Zielinski,et.al, n.17.
35. Wright,et.al., n.16.
36. Its second mission had lasted 469 days in orbit.

37. Space Security Index 2010, accessed at http://swfound.org/media/29039/space%20 security%20index%202010%20full%20report.pdf
38. John Reed, "China May Have Hacked US Satellites", Defence Tech, October 28, 2011, accessed at http://defensetech.org/2011/10/28/china-may-have-hacked-u-s-satellites/#ixzz2jTMMP9Sr Defense.org http://defensetech.org/2011/10/28/china-may-have-hacked-u-s-satellites/#ixzz 2jTLsiUYm
39. Wright,et.al., n.16.
40. Assured Tactical Access to Space 2016 – 2028, USASMDC/ARSTRAT Whitepaper, April 18, 2011, accessed at http://www.smdc.army.mil/CG/AUSAILWNetworkPanel.pdf
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42. Krepon and Clary, n.1.
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47. National Space Policy of the United States of America, accessed at http://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf
48. Joint Publication 3-14, Space Operations, May 29, 2013, accessed at http://www.defenseinnovationmarketplace.mil/resources/JointSpaceOperations2013.pdf
49. Ibid.
50. Ibid.
51. Thus, DSC actions also safeguard assets from unintentional hazards and other naturally occurring phenomena such as radiation and weather.
52. Black, n.15.
53. Ibid.
54. Ibid.
55. Bradley Perrett, "Australia-Based US Radar To Watch China Launches", *Aviation Week,* March 25, 2013, accessed at http://www.aviationweek.com/Article.aspx?id=/article-xml/AW_03_25_2013_p33-561203.xml
56. "Space-Based Space Surveillance, US Air Force Fact Sheet," US Air Force Space Command, accessed at http://www.afspc.af.mil/library/factsheets/factsheet.asp?id=20523
57. Mike Gruss, "Defense Bill Trims Funding for SBIRS, Boosts Some Missile Defense Accounts", Space News, 27 December, 2013, accessed at http://www.spacenews.com/article/military-space/38854defense-bill-trims-funding-for-sbirs-boosts-some-missile-defense
58. n.56.
59. Gruss, n.57.
60. Everett Carl Dolman, "Rules of the Road Responsible Use of Weapons in Space", Public Interest Report Winter 2011, Federation of American Scientists, https://www.fas.org/pubs/pir/2011winter/2011Winter-RulesoftheRoad.pdf
61. n.47.
62. "Russia Tests 'Fifth Generation' Missile That can Penetrate NATO Defence System", *The Telegraph,* May 23, 2012, accessed at http://www.telegraph.co.uk/news/worldnews/europe/russia/9285130/Russia-tests-fifth-generation-missile-that-can-penetrate-Nato-defence-system.html

63. Michael Krepon, "Can the U.S. and China Get Along in Outer Space?", Defence One, September 17, 2013, accessed at http://www.defenseone.com/technology/2013/09/can-us-and-china-get-along-outer-space/70436/?oref=d-interstitial-continue
64. n.46.
65. Bill Gertz, "China Launches Three ASAT Satellites", *The Washington Free Beacon,* August 26, 2013, accessed at http://freebeacon.com/china-launches-three-asat-satellites/
66. Some experts did dismiss the Chinese misadventure as a less alarmist test of Satellite Laser Ranging (SLR) technology. They point out that not all lasing in space is malicious and that typical lasers used for SLR activities are relatively weak but can still illuminate the optics indirectly. Others contest that any intentional lasing of another country's satellite should have been done only with prior consent and the absence of such a notification pointed to malicious intent. Source: Ibid.
67. Ibid.
68. Ibid.
69. n.44.
70. However, rockets launched to MEO and GEO would take between 4-6 hours to reach the target and, thus, provide time for detection by SSA radars and evasive manoeuvres by satellites.
71. Chinese state-run media identified the satellites as the Chuang Xin-3 (Innovation-3); the Shi Yan-7 (Experiment-7); and Shi Jian-15 (Practice-15). The Shi Jian-15 is believed to be the satellite with the robotic arm.
72. Gertz, n.65.
73. Similar to the one used to bring down the US 193 satellite in 2008.
74. Krepon and Clary, n.1.
75. Krepon, n.63.
76. n.4.
77. Krepon and Clary, n.1.
78. Ibid.
79. The US and Israel have continued to resist negotiations on the Prevention of an Arms Race in Outer Space (PAROS) treaty in the UN Conference on Disarmament (CD).
80. Nancy Gallagher, "Approaches to Regulating Weapons in Space", Centre for International and Security Studies at Maryland, accessed at http://www.cissm.umd.edu/papers/files/chap8nancygallagheros05.pdf
81. Krepon and Clary, n.1.
82. One of the reasons for the US' withdrawal from the ABM Treaty was the perception that while its own missile defence programme was constrained by the treaty, other nations continued to pursue development of their own capabilities, thus, narrowing the gap.
83. The US says that it will continue to shape an international code through active participation in international negotiations. Additionally, it has .... "developed steps to ensure that a final Code fully supports our national interests and strategy." Source: Statement of Ambassador Gregory l. Schulte, Deputy Assistant Secretary Of Defence for Space Policy before the House Committee on Armed Services Subcommittee on Strategic Forces, March 8, 2012, accessed at http://www.defense.gov/home/features/2011/0111_nsss/docs/Committee%20hearing%20on%20Fiscal%20Year%202013%20National%20Defense%20Authorization%20Budget%20Request%20for%20National%20Security%20Space%20Activities.pdf
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91. Ibid.