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Space Power and Space Warfare: A Review

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A photograph of a Space Shuttle in orbit above Earth. The shuttle is white with black and grey panels, and its large external tank and solid rocket boosters are visible. The Earth's surface is covered in a dense layer of white clouds against a deep blue background.

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Executive Summary

The modern space age is characterised by low cost access to space. One consequence of this development is increased competition in the military sphere. This review paper examines the current literature on space power and space warfare to explain why technology in both the civilian and military domain will be the major driver of competition in space, both militarily and economically. From the existing literature, we can draw that traditional forms of thinking about deterrence and warfighting limit our ability to assess competition and deterrence in space. This paper has three primary insights. They are:

One, the requirements for becoming a space power are relatively low but the capabilities required to establish dominance in space is significantly higher.

Two, offensive space capabilities such as small co-orbital satellites, satellite jammers, and spoofing technologies can yield significant benefits to a small space power, as offensive capabilities will hold a clear advantage against defensive capabilities for defending satellites is expensive and infeasible.

And three, the weaponisation of space adds a new layer of complexity to the existing dynamics of deterrence and warfighting among states, which may lead to a greater level of brinkmanship and entanglement with nuclear assets.

In light of these dangers, having arms control mechanisms to reduce war-like situations in space is desirable, but the difficulty of verifying dual-use space systems makes arms control initiatives extremely difficult.

Introduction: The New Space Age

On March 27, 2019, the Indian Prime Minister Narendra Modi addressed the nation, announcing that India had successfully tested an ASAT weapon, becoming the fourth nation to acquire this capability after China, the United States and Russia.¹ The Union Government announced plans to set up a new agency called the Defence Space Agency (DSA) comprising members from the Army, Navy and Air Force, and supported by a new research organisation, the Defence Space Research Organization (DSRO).

In June 2018, President Donald Trump announced that the US will establish a separate branch of the armed forces known as the Space Force to protect the interests of the United States. China established the Strategic Support Force in 2015 to carry out and assist in space and cyber operations, along with information and electronic warfare. Russia, on the other hand, also maintains some form of limited military space command and operational capabilities. More recently, France has also announced that it will establish a space command to protect its space interests and assets. The need to protect space assets is becoming an imperative.²

At the same time, there has been a sharp growth in the commercial space industry. New private players, collectively known as NewSpace, are innovating in areas of quick launch services, micro, and nanosatellites, geolocation and geo-sensing making space more accessible. Their technologies are also available to the national space programs and their respective militaries. These private players will increasingly become components of national space power in the future.

Collectively, these developments provide the imperative to study the relevance and impact of space power, space warfare and understand how space ties into a state's overall strategy.

This paper reviews existing literature on space power and the militarisation of space. The first section explores various definitions of space power. The second section examines technologies required for a state to become a space power. Section three provides an overview of different types of space weapons technology in development today. Section four outlines current views on the weaponisation of space. Section five investigates the theories of space deterrence and space warfighting. Section six discusses the role of private players in space security. Section seven identifies efforts in conducting space diplomacy and introducing arms control efforts. The paper concludes by summarising the current views on space power and space warfare and highlights some key questions that need further research.

Defining Space Power

To understand how space warfare will unfold in the future, it is critical to understand what constitutes space power and how it can be wielded by states.

The costs of accessing space is substantially higher than the costs incurred to access land, sea, or air.³ The inherently different nature of space necessitates the study of space power as an entirely new military domain. However, like the military domains of land, sea and air, space must be treated as a means to achieve strategic objectives.⁴

Ever since the beginning of the first space race in the 1950s, scholars and practitioners have attempted to define space power and its constituents.

One line of thought is that space power is seen through the lens of either maritime theory or air power theory – sometimes called air and space power, both being seen as complementary.⁵ For example, through a purely military lens, the US Air Force defines air and space power as “The synergistic application of air, space, and information systems to project global strategic military power.”⁶ Space as a medium is not seen as a distinct domain for carrying out military activity.

The second line of thought states that space is geographically distinct from other domains and space power augments air power. Colin Gray, a strategic thinker, argues that land, sea and air are both environmentally and geographically distinct from space, though they are conceptually not that different from each other.⁷ Gray further argues that “space power augments the military effectiveness of air power” similar to how air power augmented the military effectiveness of the land and maritime domain.⁸ He further draws an analogy from air and sea power, and defines space power as: “the ability to use space for military, civil, or commercial purposes and to deny the ability of an enemy to do the same.” He also emphasises that weapons in space will alone not win wars, and space power must be used jointly to solve strategic problems.⁹

Others provide a different definition wherein space power is closely tied to the overall national power of a state. Scholar John J. Klein acknowledges that maritime strategic frameworks provides some understanding of space, but understanding the medium requires a lexicon of its own.¹⁰ Klein broadens the definition of space power and says that space power is tied to the overall national power – which includes a countries military, economic and diplomatic strengths. “Space power is defined as is the ability to influence others through international diplomacy, economic incentives or pressure, information services, or through the threat or application of military force”.¹¹

He further argues that the “..range and pervasiveness of activities in space have resulted in these activities becoming critical, and therefore they have become tied to national power.” Ajey Lele, a scholar at the Institute for Defence Studies and Analysis (IDSA), echoes the opinion and defines space power as the subset of national power, which is the capability to use various resources to achieve national objectives.¹² Arguments from this perspective is captured by Dana J. Johnson and others’ definition of space power as “the pursuit of national objectives through the medium of space through the use of space capabilities.

These three perspectives represent current views on space power. The first school derives a theory of space power directly from maritime principles. The second school uses maritime strategic principles to derive a theory of space power, but acknowledges the inherent jointness of space, land, air, and sea domains involved in achieving strategic objectives. Finally, the third school incorporates the economic, diplomatic, and military tools of power projection to derive a definition of space power.

The literature on space power examined in this paper broadly explains the strategic value of placing military assets in space. However, two important questions remain unanswered:

- (i) How space powers use their capabilities to exert influence, either coercively or economically?
- (ii) What are the different kinds of space powers that exist in the world today classified based on capabilities?

Providing the answers to these questions is beyond the scope of this paper. However, they provide a useful direction for future scholarly inquiry.

This section has presented the various definitions of space power available in the existing literature.¹³ The next section examines what it takes for a state to become a space power.

What does it take to be a space power?

Any state that wants to become a space power must have a presence in space. A bare minimum presence in space empowers states to influence space activities via anti-satellite missile, offensive cyber-attacks or physical and non-physical sabotage capabilities.

This section looks at the various prerequisites for a state to be known as a space power.

The basic minimum requirement for any state to carry objects into space is to own a rocket. States like Iran, North Korea, and Pakistan which possess short or medium-range ballistic missile capability can place small and microsatellites in Low Earth Orbit (LEO) by making certain modifications.

However, they cannot rely solely on their ballistic missile programmes to place more advanced satellites or weapons in space.¹⁴ Since ballistic missiles must travel vertically and reach orbital velocity, the amount of payload it can carry is limited. Satellites travelling in LEO typically orbit at speeds between 7 km/s and 8 km/s. Hence, if a rocket must place a satellite in LEO, then, the rocket's speed must exceed 7 km/s.

If states want to launch small payloads, then an existing ballistic missile can be converted for carrying relatively small payloads.¹⁵ States can also use air-launched ASATs, which are air-to-air missiles fired into Low Earth Orbit, to launch relatively small payloads. These delivery systems are relatively inexpensive and can launch payloads into orbits with greater precision.¹⁶ On the other hand, if countries want to place larger satellites that have military capabilities, then this would require the country to build larger rockets with a terrestrial range greater than 10,000 km.

A state's ability to produce advanced satellites and space systems indigenously allows a state to sustain space power. Space systems and components are dual-use platforms sourced from a global supply chain. Because of this reason, the supply of components is susceptible to sudden cut-off from a major supplier or various international technology control regimes. Hence, an efficient and innovative private and public aerospace industry is a requirement to remain independent and develop resilience in the space domain and overcome dependency on the international supply chain.

The other requirement for being a comprehensive space power is to have space domain/situational awareness. This means that a state must be able to detect, monitor, and track space objects, satellites, and space debris. The ability to monitor activity in space is not only a technical necessity for states with assets in space, but also for countries like Iran, North Korea and Pakistan to detect and attack enemy satellites using ground-based ASAT weapons.

The United States has currently deployed the Space Fence surveillance which detects hostile objects and space debris.¹⁷ The more advanced Self-Awareness Space Situational Awareness (SASSA) acts as an early-warning system for space assets capable of detecting ASAT launches and even lasers.¹⁸

The table below maps the distribution of space capabilities of countries, which helps rank various space powers. The sample represented in the table below is not a sample of *all* space powers in the world. The countries chosen here, however, are representative of countries with comparable space capabilities. For example, Pakistan's space capabilities are comparable to that of North Korea's as both countries, on the one hand, sophisticated ballistic missile capabilities, but on the other, have significantly lack in maintaining sizeable space assets.

	Ballistic Missiles	Satellites in LEO	Reusable Rockets	Independent navigation system	Early-warning systems	Outer space exploration
United States						
Russia						
China						
India						
North Korea						
Iran						

Capabilities present
Capabilities absent

Table 1: Mapping space capabilities of different countries

In the next section, we examine the types of space weapons countries have developed and systems in development. Furthermore, we discuss the operational dynamics and limitations of space weapons that affect their employment.

Existing and Future Space Weapons

The previous section dealt with the literature on the capabilities required to become a space power. Among these capabilities, the possession of space weapons is a way of projecting power. This section studies the literature on existing weapons that can be used in space or used to target space assets and looks at the advantages and disadvantages of these systems.¹⁹ (see Table 2 for a list of existing types of space weapons).

Weapon type	Attack type	Basing type	Attack Effect	Attack Attribution	Current Status of System
Direct-ascent ASAT	Kinetic physical attack	Earth-based	Debris creation, satellite de-orbiting	Fully attributable	Deployed
Co-orbital ASAT	Kinetic physical attack	Space-based	Debris creation, satellite de-orbiting	Partially attributable	Tested
High-altitude nuclear detonation	Non-kinetic physical attack	Earth-based	Non-physical damage, fully/partially disabled	Fully attributable	Tested
High-power lasers	Non-kinetic physical attack	Earth-based and space-based	Physical damage, fully/partially disabled	Partially attributable	Tested
Jamming (satellite uplink and downlink)	Electronic attack	Earth-based, space-based	Partially disabled	Partially attributable	Unknown
Cyber attacks (against ground stations and	Cyber and Electronic attacks	Earth-based, Space based	Non-physical damage, fully/partially disabled	Difficulty in attribution	Unknown

satellites)					
Satellite spoofing	Electronic attack	Space-based	Corrupt signals	Difficulty in attribution	Unknown
Space drone ²⁰	Unknown	Unknown	Unknown	Unknown	Tested

Table 2: Types of space weapons ²¹

While emerging space weapons sound promising they also come with several operational limitations. Given below is an examination of the operational limitations of some of the weapon systems listed in Table 2.

Land-based ASATs: Among all weapons available to threaten space assets, the most popular among them are ground-based anti-satellite weapons or ASATs. These missiles – directly derived from ballistic missiles and interceptors – are launched into space to target communication, imaging and reconnaissance assets. Ground-based anti-satellite missiles are relatively easy to manufacture and deploy, requiring minimal changes to existing surface-to-surface or surface-to-air missiles. At first glance, these weapons may seem very attractive. However, ground-based ASATs have several operational limitations. political considerations. ²²

For example, China's ASAT weapon tested in 2007, could only reach LEO where the critical systems of communication and navigation do not operate.²³ Even if China can build an ASAT capable of reaching Geosynchronous Earth Orbit (GEO) where GPS and intelligence-gathering assets operate, such an offensive operation will face two critical issues. First, in a crisis situation, it would take Chinese ASATs an average of five hours or more to move from LEO to GEO in order to target US strategic space assets.²⁴ Such a delay would give the adversary enough time to relocate the assets to safe distances from attack. Second, even if China manages to take out a few GPS and communication assets, the US would still retain several redundant systems to maintain a functional C4ISR infrastructure. This severely reduces the strategic advantages that ground-based ASATs have to offer. ²⁵

Furthermore, simulations of ASAT attacks by India and China conducted by scholars Gopalaswamy and Kampani demonstrate that even a small skirmish in space will have devastating effects. For example, take a scenario where India and China both target two satellites each. The result shows that the debris created from such a scenario would result in anywhere between 0.7 and 1.2 collisions once every 10 years. According to what is known as the “Kessler syndrome,” the debris

created from these collisions would create even more debris, and continue having a cascading effect.²⁶

At the same time, the political consequences of using ground-based ASATs would also be severe since systems like GPS are used several countries across the globe. Therefore, ASATs are high-risk weapons and yield limited rewards.

Co-orbital ASATs: The development of microsatellites and other forms co-orbital weapon systems that have emerged in recent years also threaten assets in space. These miniature devices can easily be concealed in space and be more difficult to track. They are also capable of being used as co-orbital weapons. Indeed, non-state actors in the future could use commercial rockets to launch small satellites that are capable of acting as co-orbital ASATs. This makes it much more difficult to attribute attacks by non-state actors.

Offensive Cyber Operations: Cyber-attacks against satellites and offensive cyber operations in space are considered highly effective weapons. This assumption, however, comes with certain limitations. As Jon R. Lindsay points out that the task of carrying out cyber operations is complex and dependent on the vulnerabilities in the adversary's networks, while at the same time the success of cyber-attacks offers marginal gains.²⁷

Irrespective of these disadvantages, space operators and satellites are still vulnerable to cyber-attacks and hacking which may halt ground station operations. Attackers can use cheap off-the-shelf tools to targets computers in control stations, either in the form of malware or ransomware to put work on hold, taking away either partial or full control from the operators for a brief period. Though the steps that can be taken to avoid such attacks are simple and a matter of digital hygiene, organisations are still vulnerable due to common human errors and misjudgements.²⁸

Jamming and spoofing weapons: Satellite jamming and spoofing technologies on the other hand are relatively low-cost weapons, which promise high-investment returns.²⁹ However, these weapons are time-sensitive as the time available for jamming a satellite when passing overhead is relatively low. Moreover, jamming may also be rendered useless against an adversary possessing a large number of redundant assets.

Directed Energy Weapons: High-energy laser weapons can be used to disrupt, degrade or destroy satellites. Ground-based lasers – which consume a high amount of power – could be used for this purpose. Laser satellites, however, are

impractical as a large amount of power would be required to carry out any effective operations.³⁰

From the critical analysis presented above, we can derive the following insights by studying the recent trends:

- 1) A panoply of choices will be available for states to conduct offensive space operations.
- 2) Non-state actors might be able to use micro and nano satellites to disrupt space operations.
- 3) Certain kinds of attacks in space will not be easily attributable to any one state or non-state actor.
- 4) Any offensive operation carried out in space must be done with caution as the danger of creating space debris could be catastrophic.

Space weapons, ultimately, are merely tools for achieving strategic objectives. Yet, there is stark disagreement on the utility of space weapons for achieving national objectives. The next section is broken down into two parts. First, it examines objectives of pursuing space warfighting and the current debates around the weaponisation of space.

Objectives of Space Warfighting and Perspectives on Weaponisation of Space

If states are willing to develop space weapons in order to project power in space, such actions will remain futile without concrete objectives. What objectives can a state achieve through weaponisation? This section delves into the existing writings on how states in the international system view space weapons to provide answer this question.

The use of space for commercial purposes and exploration has expanded rapidly, with nearly 4987 satellites orbiting the Earth, with 382 objects being launched into space in 2018, according to the Index of Objects Launched Into Outer Space. While a majority of these satellites are used for communication, the rest have been used for Earth observation, technology development, navigation and scientific exploration, a significant number of these satellites are also used by governments and militaries with many having dual-use capabilities, such as the Global Positioning System (GPS) satellite constellation.³¹

Communication and navigation satellites, both civilian and military, are placed in Medium-Earth Orbit (MEO). These satellites act as critical components within a state's national infrastructure. Moreover, early-warning assets, remote-sensing satellites and weather satellites are critical for a state's national defence and arms control verification efforts. Though these space satellites provide a number of advantages, they are increasingly vulnerable to attack or damage in space. Hence, in a crisis situation or conflict, a state with an anti-satellite capability may find an incentive to either coerce the adversary by threatening to attack, disable or temporarily jam the adversary's satellites.³²

A state may further find it useful to disable or destroy an enemy's satellites. Unlike other weapons used on land, attacking assets in space do not harm the lives of soldiers and civilians directly, albeit causing massive disruption to a networked military and society.³³

Emerging trends in space laws and commercial space activities also suggest that the mining and commercial exploitation of asteroids and celestial bodies will become a domain of geopolitical contestation, making it imperative to states to think about protecting commercial interests.³⁴

Hence, the objective of space weaponisation arises from the need to deter aggression in space, prevent hostility and protect assets that remain highly vulnerable to attack. Indeed, there exists a strong consensus among scholars and policymakers that the militarisation and weaponisation of space are inevitable. As more and more countries begin to compete in space to place both civilian and military satellites, this contestation and competition in space will become an extension of geopolitics.³⁵ This consensus was solidified after China conducted its first ASAT test in 2007.

Though there exists a consensus that the full militarisation of space is inevitable,³⁶ scholars and policymakers disagree on what the future course of action must be in a militarised space environment. There exist four distinct views on how states must perceive the militarised space environment.³⁷ They are:

1. *Space Dominance*: According to this school of thought, space is seen merely as an extension of the battlefield on the ground, the air and the maritime domains. The principles of warfighting in conventional domains have been extended to the space domain as well. Scholars and policymakers believe that success in warfighting can be achieved not simply through a presence in space but through space dominance and space control.³⁸ This view has been repeatedly promulgated in the U.S. space doctrines in the past, and more recently by the

Rumsfeld report of 2000.³⁹ Some scholars have attributed this view to China's thinking about space as well.⁴⁰

2. *Space Deterrence and Stability*: This line of thought suggests that though the militarisation and weaponisation of space are inevitable, a state must develop the necessary capabilities to deter and defend against any aggression from an adversary and prevent the escalation of war. Using the analogy of nuclear deterrence and war-fighting, aggression in space can be prevented either through deterrence by punishment or deterrence by denial. Scholars holding this view, however, identify the dangers of escalation of conflict in space.⁴¹

3. *Arms Control Mechanisms and Space Diplomacy*: The weaponisation of space is indeed inevitable, and states are guaranteed to defend their space assets against physical attacks and cyber vulnerabilities. However, an impending arms race in space and the degree of militarisation in space can be managed through arms control agreements and technology control. The argument is that space weaponisation can be increasingly destabilising, particularly as ASAT weapons threaten nuclear early-warning systems, risk the outbreak of a full-fledged war and increase the overall cost of armament.⁴² Furthermore, Krepon and Clary for example, argue that the weaponisation of space will increase the cost of placing commercial satellites will likely raise the cost of insurance, which may slow down the commercialisation of space.⁴³

4. *Banning Weaponisation*: Though space exploration started as military programs, the exploration of space today has expanded worldwide due to globalisation. The view, therefore, is that space is a sanctuary for human endeavour in exploring the heavenly bodies. Hence, space must be free of any form of weapons and offensive space assets.⁴⁴

These four perspectives on the militarisation and weaponisation of space have led the debate on how states must think about using space in the future, and what are the benefits and challenges.

In the next section, we examine the theories of space deterrence and warfighting, and how private players in space are shaping the dynamics of space deterrence.

Theories of Deterrence and Warfighting in Space

If states indeed deploy weapons in space, we must understand how these space weapons will be employed, and what strategies will states develop to operationalise their space weapons. This section explores the literature on the theories of deterrence in space and the use of space weapons in warfighting.⁴⁵

As noted earlier, space dominance and space deterrence are two different schools of thought on the militarisation of space. However, the *concept* of deterrence, which is an essential component of military strategy, is a matter of interest of both schools, which is a matter of discussion in this section.

The theory of deterrence in space draws heavily from the existing literature on strategic deterrence and nuclear deterrence theory. Given that the field of deterrence research spans over seven decades, the literature of deterrence is vast.⁴⁶

Drawing from existing literature, space deterrence not only involves a state's ability to threaten to impose heavy costs on the adversary in order to dissuade the adversary from committing hostile acts. This is *deterrence by punishment*, where a state must make credible threats of punitive actions to achieve deterrence. This form of deterrence can fail if threats made by the state are not viewed as credible by the adversary.⁴⁷ In the space environment, this translates to threatening to destroy an adversary's satellite, using ASATs and offensive cyber-attacks.

Deterrence by denial, on the other hand, involves a state's ability to deny the adversary an opportunity to commit hostile acts or making it infeasible for an adversary to achieve the intended objectives.⁴⁸ The jamming of satellites in space, using high-energy laser weapons to temporarily disabling satellites over a state's territory or attacking the adversary's communication assets, paralysing the efforts of the enemy to coordinate on the battlefield are some ways of achieving deterrence by denial.

However, space deterrence is also quite different from general deterrence and nuclear deterrence. Firstly, while a state may be able to achieve deterrence through numerical superiority alone, numerical superiority in space increases a state's vulnerability and opens the window for an adversary to attack.⁴⁹ Second, weakness in space deterrence could weaken general deterrence. For example, an adversary may choose to attack space systems of the U.S., which it heavily depends upon for conducting operations on the ground, to achieve its objectives at reasonable costs, thus weakening general deterrence.⁵⁰ Third, offensive space capabilities will always maintain an advantage over defensive space capabilities as it is harder to defend space assets due to physical constraints.⁵¹ The three caveats discussed above make space deterrence unique to other forms of deterrence.

The literature on cross-domain deterrence on the other hand brings about a new perspective on deterrence, technology and complexity. Cross-domain deterrence is defined by Linday and Gartzke as "the use of threats of one type, or some

combination of different types, to dissuade a target from taking actions of another type to attempt to change the status quo.”⁵² This, in essence, means that states will threaten to use weapon-systems across domains to deter an adversary from achieving objectives. The authors further argue that new technologies such as space, weapons and cyber capabilities provide states with new ways of coercing the adversary. Space weapons, therefore, adds an additional component to a country’s deterrence value.

On the contrary, the theory of strategic substitution argues that states like China pursue the development of new technologies such as conventional ballistic missiles, cyber and space capabilities to substitute for the limitations and constraints it faced by adopting a No-First Use (NFU) posture. These constraints are overcome by adopting non-nuclear strategic weapons to maximise leverage in a limited war. These strategic leverages include making coercive threats to maintain the *status quo* or bargain for a more favourable end to a conflict. These can be achieved by attacking an adversary’s communication networks and critical space assets. The theory of strategic substitution aims to explain why China has in recent years gone on to develop these new capabilities.⁵³

What lessons do we take away from the existing theories of space warfare and deterrence? Both theories presented above make it clear that space warfare will be intrinsically tied to war and conflict on Earth, and states will attack or hold assets in space at risk to bargain with the adversary. Earlier literature on the theory of space warfare by Kleinberg and others, for example, acknowledged that space warfare will play a role in the overall joint operations in warfare, however, it has overlooked the overall interdependence among the domains across the military sphere.⁵⁴ As more countries modernise their militaries and adopt new technology, they will inevitably explore new domains to gain strategic advantages, therefore introducing new complexity to warfare.

Yet deterrence and warfare in space hangs in a delicate and dangerous balance. As mentioned earlier, many countries today are highly dependent on satellites in space for early-warning and C4ISR systems. Many of these systems, are dual-use in nature, except those systems directly linked to nuclear weapons control. This “entanglement” of nuclear and non-nuclear assets, as James Acton points out, could lead to misinterpretation and inadvertent escalation if an adversary holds C4ISR assets at risk during a crisis or limited war.⁵⁵

Any attack on dual-use or non-nuclear assets in space, therefore, could be misinterpreted as an attack against nuclear assets and could quickly escalate to a nuclear conflict – lowering the thresholds on nuclear responses against non-nuclear attacks.⁵⁶

From the above discussion, it is evident that traditional theories of deterrence still play a major role in determining the strategic outcomes. Consequently, the weaponisation of space also adds a new layer of complexity to the existing deterrence relationship among states, where technology will be the primary driver of competition and contestation. Any military action in space will inevitably have reverberating effects in other domains.

This deterrence relationship, as we observe, is complicated yet again by the private corporations and non-state stakeholders who operate in space. First, through the non-attributable nature of offensive operations carried out by states by using commercial operators as proxies. Second, non-state actors may use commercial services for carrying out sabotage operations against large space powers at relatively low cost.

The next section examines the role of private players in space security and space operations.

Role of Private Players in Space Security

The introduction of private players in space brings two distinct challenges. First, it is possible for a country to operate through private players, either to conduct espionage operations against adversary/hostile states or conduct counter-space operations that may not be easily attributable directly towards any state. Second, while access to space becomes easy to a large number of companies, the private space industry could potentially open doors to non-state actors whose intentions may be to sabotage a country's satellites and communication networks and therefore create havoc. In such cases, states will not only have to deal with the problem of securing space assets from adversary/hostile states but also deal with the potential threat posed by non-state actors.

Broadly, a country's space power is also measured by the commercial and economic influence it has over other countries – meaning any country which wields the advantage of launching satellites of other states and provide space services at a reasonable price, holds the advantage of controlling space through economic means. At the same time, the commercial assets of a state and its allies may also be used to build sustenance, mission assurance and resilience in space, which is necessary for building effective space deterrence and security architecture.⁵⁷

While companies providing space launch and space services like Boeing, Northrop Grumman and Lockheed Martin have existed for some time, the need to make space more accessible, along with reducing the overall cost of space operations

has spawned several private launch companies like Space Exploration Technologies (SpaceX), Blue Origin and Rocket Lab, known as NewSpace companies, have brought about new innovations in the space industry.⁵⁸ Services such as high-resolution imaging, geolocation and remote sensing are now available through cube and microsatellites, and they can be purchased on the commercial market. These capabilities were once accessible only with large satellites, which required large investments.

As suggested by Moltz, innovation in space technologies adopted by the government space agencies or the military will primarily be driven by the innovation from the commercial space industry, as it is more cost-effective and efficient.⁵⁹

Though these commercial entities serve both government and non-government organisations, their business is largely driven by government contracts.⁶⁰ Indigenously-grown private space industries, therefore, not only help in reducing the launch of assets but also provide services that improve the space situational awareness of a country, hence acting as an extended arm in a state's overall national space strategy and space operations.

The rise of commercial rocket and space services companies is not just restricted to North America. A large number of private companies have spawned in China and India, which claim to offer affordable and reliable launch services for small, micro and nanosatellites.⁶¹ If these companies are indeed successful in their efforts, both China and India could potentially lead the micro and small satellite market in the world, becoming a hub for affordable and reliable launches and space services.

In short, private space companies, on the one hand, extend the capabilities of a country to operate in space and on the other, raises the potential threats of non-attributable from states as well as non-state actors.

The dangers of a potential arms race in space brings us to yet another important question: How do we reduce the risk of a conflict in space? We delve into this problem in the next section, where we bring out the arguments made in favour of arms control in space, and efforts taken to introduce peaceful norms in space.

Arms Control and Norm Dynamics in Space

During the Cold War era, the placement of weapons of mass destruction (WMD) in space became an increasing concern for the international community, leading to the signing of the Outer Space Treaty in January 1967. This treaty banned states

from placing WMDs in the Earth's orbit, on the Moon or any other celestial body. The treaty also promotes the use of space for peaceful purposes, and explicitly mentions that the exploration of space and celestial bodies shall be carried out "for the benefit and in the interest of all countries, irrespective of their degree of economic and scientific development, and shall be the province of all mankind." ⁶²

The Outer Space Treaty (OST) was eventually followed by other treaties such as the Rescue and Return Agreement (1968), the Liability Convention (1972), and the Registration Convention (1975). However, the efforts to negotiate an International Code of Conduct in Outer Space have remained futile and no consensus exists among the key players today. ⁶³

Yet, neither the OST nor any of the other treaties regulating the use of space banned the militarisation of space or the placement of conventional weapons in the Earth's orbit, allowing states to place offensive military assets in space without any direct legal consequences. As Johannes Wolff argues, the OST and other legal mechanisms allow the term "peaceful use of space" to remain ambiguous. This not only allows states to place passive military assets such as early-warning assets, spy satellites and military command and control assets but also blurs the distinction between defensive and offensive weapons that could be placed in space. ⁶⁴

US President Ronald Reagan's ambitious Strategic Defense Initiative (SDI), popularly known as Star Wars, for example, aimed to place missile defences and laser weapons capable of countering or destroying incoming ballistic missiles. Though it was intended purely for a defensive role, SDI raised concerns over the placement of space weapons and concerns of nuclear escalation. However, the project was ultimately cancelled due to its high costs and impracticality.

The pursuit of arms control in space must achieve the following objectives ⁶⁵:

- a) Reduce the risk of war
- b) Reduce the cost of preparing for war
- c) Reduce the extent of damage in war

Arms control agreements also improve the relations between countries, and foster further collaboration, while at the same time helping manage competition. ⁶⁶

Despite witnessing a high degree of cooperation in space, ⁶⁷ recent trends in the development of space weapons have once again sparked the debate on the

peaceful and military use of space. Initial efforts by Russia and China to introduce a space weapons ban failed to garner support.⁶⁸

More recently, the European Union proposed a draft Code of Conduct in March 2014, setting the guidelines for all military and space activities, but it did not gain traction due to diplomatic and legal constraints.⁶⁹ Although the Code of Conduct is a step towards creating peaceful norms and transparency in space, it still has its limitations as it does not prevent an arms race in space, as it still allows countries to deploy both offensive and defensive weapons.

An international treaty that includes mechanisms of data sharing, missile test notifications and cooperation in the removal of space junk could pave the way for further agreements. However, establishing robust verification mechanisms on the deployment of space weapons still remains the biggest challenge.⁷⁰

The unfolding of an impending arms race in space in the absence of arms control agreements and code of conduct presents us with the challenge of mitigating risks in space in light of increasing commercial activity. Yet, the challenges of implementing a technology-control regime for dual-use space assets remains one of the biggest roadblocks establishing to arms control mechanisms in space.

Conclusion

The vast literature on space warfare and space strategy have helped envision what competition, contestation and warfare might look like in the future.

Technology and innovation will be the primary drivers of competition in space, and the proliferation of commercial and private space companies will also play a leading role in shaping the dynamics of cooperation, competition and deterrence in space. This review paper brings out three key findings for understanding competition in space.

First, the requirements for becoming a space power are relatively low but the capabilities required to establish dominance in space is significantly higher.

Second, offensive space capabilities such as small co-orbital satellites, satellite jammers, and spoofing technologies can yield significant benefits, as offensive capabilities will hold a clear advantage against defensive capabilities, as defending and hardening satellites is expensive and infeasible.

And third, the weaponisation of space adds a new layer of complexity to the existing dynamics of deterrence and warfighting, which may lead to a greater level of brinkmanship and entanglement with nuclear assets.

As states start to build-up their space arsenals and posture their forces in space, many of the perspectives offered by scholars have differed from the policies and postures of states. Hence, as space will continue to be weaponised, future research must answer the following questions:

To what extent will states weaponise space?

How will states use space, both commercially and militarily, in their grand strategy?

What will be the role of private and non-state actors in space?

How will private actors tie-in to a state's space strategy?

What are the different postures that space powers will adopt as a warfighting strategy with respect to the available capabilities?

Previous proposals of arms control in space have proven to be futile. States must explore arms control mechanisms to ensure that the risk of war and protect common economic interests.

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