

interoperability of assets belonging to different member states. Here, the focus is expected to be more on these assets as enablers of military operations (such as for communications and ISR) rather than those with the capability of denying space to adversaries [48]. They view space as the fifth dimension of warfare (the others being land, sea, air, and cyber) and hence strategic investments in the space domain are important to keep NATO members safe. It is also important to tackle various other security challenges. NATO feels the need to ensure the upholding of international law in this regard. Additionally, they may help them to assure the US administration that NATO can be key allies in deterring the investments made, both by China and Russia to develop counterspace capabilities.

All this indicates that the geostrategic aspirations of states such as Russia, China, and important NATO members such as the USA, France, United Kingdom, and Canada are going to dictate the future of space security. However, unfortunately India has also caught into the geostrategic space security conundrum mainly due to the China factor. Therefore, India must be proactive and effective in its policy and structural approach to ensure the security of its assets in the space. It should be emphasised that China is an important, but not the only factor for India to consider from the space security perspective. India's concerns do emerge from the overall reluctance of major powers to evolve a rule based and legally binding mechanism for the space domain.

The following diagram presents some details about the capabilities of important states with respect to their counterspace technology competence.

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	U.S.	Russia	China	India	Aus.	France	Iran	Japan	North Korea	South Korea	U.K.
LEO Co-Orbital	■	▲	■	●	●	●	●	●	●	●	●
MEO/GEO Co-Orbital	■	▲	■	●	●	●	●	●	●	●	●
LEO Direct Ascent	■	▲	■	●	●	●	●	●	●	●	●
MEO/GEO Direct Ascent	■	▲	■	●	●	●	●	●	●	●	●
Directed Energy	■	▲	■	●	●	●	●	●	●	●	●
Electronic Warfare	■	▲	■	●	●	●	●	●	●	●	●
Space Situational Awareness	■	▲	■	●	●	●	●	●	●	●	●

Legend: none ● some ■ significant ▲

<https://swfound.org/counterspace/>, accessed on Jun 24, 2022. It may be noted that the majority of information in this section has been taken from various reports published by the Secure World Foundation (SWF).

5. India's military space administration

The 1991 Gulf War is seen as a showcase for military technologies in general and space technology in particular. There was a lot of learning for the Indian armed forces too. It was all about how best India could use space technologies to support its army, navy and air force. However, a different type of impact occurred when China conducted the ASAT test during 2007. This test made India realise the importance of space security. There was a realisation that India lacks 'structures' to address such new treats. In 2010, the then Defence Minister of India had announced the formation of an Integrated Space Cell. This space cell was formed under the aegis of the Integrated Defence services headquarters, as a single window between armed forces, Department of Space and Indian Space Research Organisation (ISRO) to work out measures to protect India's space-based assets.

While speaking at the unified Commanders Conference during 2008, the then Defence Minister had mentioned that India is committed to non-weaponisation of space but needs to counter any emergence of offensive counter space systems and anti-satellite weaponry. He had mentioned that new threats to space-assets were also emerging from the building of a new class of heavy lift and small boosters and the improved array of military space systems in the country's neighbourhood [49]. It has been found that Space cell being a tri-service organisation, was working towards catering the needs of all the three services. These needs were essentially about using space systems to help various services improve their efficiency. During 2019, this space cell was upgraded to the Defence Space Agency (DSA) [50] and is currently headed by a two-star general. Actually, DSA was established on 28 September 2018 and it became operational during November 2019.

In June 2011, the Indian government appointed a Task Force on National Security, which was famously known as the Naresh Chandra Task Force. This task force had made various important recommendations, including the creation of three new tri-Service commands to better manage future challenges and vulnerabilities: Special Operations Command, Aerospace Command and Cyber Command [51]. The government had down-sized implementation of this proposal, and as a substitute to commands, agencies have been established. This announcement was made by the Indian Prime Minister during September 2018, and thus DSA was born. The Defence Imagery Processing and Analysis Centre (DIPAC) in Delhi and the Defence Satellite Control Centre (DSCC) in Bhopal merged into the DSA. [52].

It appears that, since the Integrated Space Cell was essentially collaborating with ISRO, the focus was mainly to cater for the increasing military needs of all army, navy, and air force. There has not been much of a debate (at least in open sources) in regards to space cell majorly concentrating on development of counter space capabilities. Integrated Space Cell essentially focused towards finding a more effective utilisation of the nation's space-based assets for military purposes. The Indian Army Chief, General Deepak Kapoor (2007–2010), has noted that India should 'optimise space applications for military purposes', given that 'the Chinese space programme is expanding at an exponentially rapid pace in both, offensive and defensive content' [53]. It was found that during the early period of the 21st century, the Indian Army and Indian Air Force (IAF) were developing their own individual space policies. The Indian Air Force was keen to deploy four to six satellites eventually to be managed by an Aerospace Command to exploit space in order to enhance India's strategic reach and capabilities [54].

Even though there has been a demand for the Space Command for long there was no joint structure available in India before formation of the space cell, which could look at the space related requirements of all the three services. At the individual service level, there were some structures available to meet operational needs. For example, in the case of the Indian Air Force (IAF) the office of Assistance Chief of Air Staff (ACAS) is responsible to deal with all space related issues. Agencies such as the Defence Image Processing and Analysis Centre (DIPAC) were established for specific tasks mainly associated with imagery interpretations for intelligence analysis. Obviously, the space cell appears to have filled this void.

It is important to note that the idea for setting up an aerospace command was proposed by the IAF in the late 1990s, much before China conducted an ASAT test. At the International Aerospace Power Seminar held in New Delhi during 4–5

February 2007, the then Air Chief had argued that India needs to be an aerospace power with *trans*-oceanic reach and, hence, the exploitation of its outer space is necessary. In general, India had always felt the need to invest in space technologies essentially for persistent surveillance and rapid response. India's geographical location at the base of continental Asia across the Indian Ocean puts it at a vantage point in relation to maritime trade in the Indian Ocean. The IAF and the Indian Navy continue to play a major role in that context [55]. Broadly, it could be said that India has vital strategic interests which cover the area from Persian Gulf to Malacca Strait.

Since the beginning of the 21st century, there has been a noticeable change in India's strategic thought. There has been a partial reorientation in India's strategic outlook towards the maritime dimension. Indian strategic thinking has traditionally had a continental outlook, essentially thinking that the major part of any military aggression from its advisories namely, Pakistan and China could emerge from land and aerial route. In conventional wars fought by India in the past, there has been very limited sea ingress. However, there has been an increasing realisation that Indian landmass has been surrounded by oceans in three directions and with the ever-increasing challenges in the Indian Ocean region, it is important for India to recalibrate its security thinking. There is also a view that India's maritime ambitions are linked to its destiny as a great power [56].

As Mr. Pranab Mukherjee, the then Indian Foreign Minister commented during 2007, 'after nearly a millennium of inward and landward focus, we are once again turning our gaze outwards and seawards, which is the natural direction of view for a nation seeking to re-establish itself, not simply as a continental power, but even more so as a maritime power, and consequently as one that is of significance on the world stage (emphasis added)' [57]. Furthermore, it was argued that all present and future military operations, and various military training activities and exercises undertaken during peacetime, would be heavily dependent on satellite technology. The Army, Navy, Air Force, and other paramilitary services like the Coast Guard and the Border Security Force (BSF) are likely to increase their reliance on satellites for purpose of intelligence gathering, communication, navigation, and operating various weapon systems. Obviously, there would be a need to develop from Persian Gulf to Malacca Strait. Intelligence-Surveillance- Reconnaissance (ISR) capacities in space to support network centric

Strategies [58]. Against this backdrop, it could be viewed that the focus of the Indian armed forces in the first decade of the establishment of the Integrated Space Cell has been more towards ensuring that how Indian armed forces could get benefited towards deriving maximum advantage from the assets in the space. The demand for space command emerged out of strategic necessity. Fortunately, India has already established a space programme that is capable of catering to the military requirements for reconnaissance, commination, navigation, signals intelligence (SIGINT), communications intelligence (COMINT), electronic intelligence (ELINT) and meteorology purposes. The establishment of Defence Space Agency (DSA) in principle, a tri-service agency of the Indian Armed Forces, should have happened on the lines of this thought process. Also, it is important to note that technically DSA was established before India undertook the ASAT test.

Although India had established the Integrated Space Cell (2010), possibly in response to the China's 2007 ASAT test, the approach of this agency has still been mainly to look at the immediate

needs of the three services rather than to evolve any strategy to counter China's counterspace designs. The focus appeared to be tactical in nature to ensure how best the satellite systems could be effectively put to use to enhance the performance of the operational units.

DSA is an upgradation of the earlier existing space cell, possibly with a diverse mandate. Perhaps, it is addressing both counterspace and military space related requirements of army, navy and air force. Unexpectedly, the arrival of DSA and India conducting an ASAT test almost happened together (April/March 2019). Obviously, the focus of DSA favoured towards addressing issues related to possible wars in space. During July 25–26, 2019 Defence Space Agency (DSA) conducted a table-top first-ever space war exercise called 'IndSpaceEx'. It has been reported that, along with serving officers from the Army, Air Force, and Navy, scientists from the Defence Research and Development Organisation (DRDO) and Defense Space Research Agency (DSRO) and few other experts had participated in this exercise. The conduct of such an exercise within a few months after the establishment of the agency clearly demonstrates the direction of the possible focus of the DSA. By February 2021, the DSA has also formally started exploring technologies to enhance its abilities to tackle threats in and from space. They have made proposals to several companies to avail technologies that give complete space situational awareness (SSA). The idea behind this is to have a system that can assess, recognise, and track assets of the enemy. The agency is also looking for a system that can combine available surveillance data from different sources into a common operating picture (COP) [59]. SSA helps to get a sense of actions on orbit. This knowledge is important to detect any change in a timely manner or assess any potential threat.

In fact, ISRO has already invested in the domain of SSA. For the last few decades, ISRO has been carrying out SSA activities, primarily focused on safeguarding the space assets of India. Identifying the need for committed efforts to tackle the emerging challenges of operating in an exceedingly crowded and contested space domain, the Directorate of Space Situational Awareness and Management (DSSAM) has been established at ISRO. On 14 December 2020, the ISRO SSA Control Centre, got formally inaugurated. The Network for space object TRacking and Analysis (NETRA) project has been initiated as a first step towards meeting this goal, its main elements being a radar, an optical telescope facility, and a control centre. ISRO SSA Control Centre, 'NETRA', is now set up within the ISRO Telemetry, Tracking and Command Network (ISTRAC) campus at, Bangalore [60].

For DSA, there is a necessity of maintaining robust SSA and, to do so, there is a need to improve on the traditional SSA structure that emphasises mainly on catalogue maintenance. For defence services in the present times, there is a need to establish a more tactical, predictive, and intelligence-driven SSA directed by an integrated Battle Management Command, Control, and Communications (BMC3) infrastructure. It is important to build a new space superiority initiative around SSA sensors that utilise common data models to support rapid tasking, processing, exploitation, and dissemination across multiple classification levels. It must integrate tactical intelligence to ensure timely characterisation and identification of threats. Also, there is a need to include a robust set of executable space-control BMC3 courses of action that, given enough warning, and which could be exploited to mitigate a threat [61]. Now the question is, 'how India would be able to manage the dual requirements of space

situational awareness (SSA) capabilities, one from the Indian Space Research Organisation (ISRO) and the other from the Defence Space Agency (DSA)? Here, there could be some conflict of interest happening between ISRO and DSA. More importantly, SSA is just one arena, as DSA starts developing its infrastructure and if proper planning is not done, then there could be various other technology fields where interests of ISRO and DSA could cross the paths. There are bound to be many areas of common interest amongst ISRO and DSA and there could also be some areas where there could be overlap of interest.

In June 2019, India's Cabinet Committee on Security cleared the formation of a new agency called the Defence Space Research Agency (DSRA). This agency is expected to work towards creating space warfare weapon systems and technologies. This agency is responsible for providing research and development support to the DSA. Surprisingly, little is known about this agency and its role in DSA scouting for SSA sensors. Also, there is the possibility that various aspects of DSRA participation were not made public. Accepting all such possibilities, still a question remains that, 'actually which agency is responsible to address the issues concerning possible space warfare'? This is because at present, it appears that there are different agencies which are more independent in nature (with limited mandate and authority) and this could hamper fulfilling the overall goal. It appears that there are somewhat defused objectives in front of these agencies, and in spite of them being smaller agencies, but are tasked for much bigger roles.

ISRO is a civilian space research organisation and should remain so. They can assist the military structure as per the requirement. At present, there are broadly four agencies which have their (broadly) defined roles in the space domain. They are Indian Space Research Organisation (ISRO), Defence Research and Development Organisation (DRDO), Defence Space Agency (DSA) and Defence Space Research Agency (DSRA). In addition, Hindustan Aeronautics Limited (HAL) and several organisations in the private industry are found to play a role mainly in the satellite and rocket manufacturing sector. The major question, which remains unanswered with all these agencies around is which of those agencies would be focussing on the military (not space warfare) requirements of the all the three services? The space cell has got upgraded to DSA and it appears that now the focus has shifted (could be partially) towards the issues concerning counterspace capabilities. Actually, the DSA is a dwarf form of the actual demand for a space command by the armed forces, which has been on the table for many years. The basic logic behind such demand has been the need of an agency, which could plan and execute the needs for three services for intelligence gathering, communications, and navigation purposes. There is no reason to change this logic now. It needs to be appreciated that the standard military space aspects are far too important and should not be sidelined at any cost. May be the present arrangement of DSA with the merging of Defence Imagery Processing and Analysis Centre (DIPAC, New Delhi) and the Defence Satellite Control Centre (DSCC, Bhopal) in it, is catering for immediate needs of the services. However, India must look at the issue of space security more holistically. By undertaking an ASAT test, India has entered into an entirely different zone of space security and policies. It needs to be realised that ASAT is the first step and there is a requirement to make further progress to create an effective space deterrence mechanism. DSA, possibly a relatively small agency with mixed mandate may not be able to do justice in regards to addressing the issues related to space warfare and space security.

6. India's options

In the context of the above, the question of whether the existing structure is sufficient to meet the futuristic challenges in the domain of space should be addressed. The purpose over here is not to highlight the limitations of existing agencies, but to argue that these agencies were established to cater for specific requirements and now since the nature of task has changed, there is a need to check the requirement of an additional structure. Agencies such as ISRO and DRDO are well established and have a clear mandate. In addition, they would be required to play a major role towards dealing with the space security. Their role is expected to be limited towards technology development and testing.

India's military leadership needs to ensure that there is a dedicated agency, which would cater for the space-related needs of the three services. The DSA (or futuristic Space Command) could be the best organisation to accommodate such needs. Regarding the issues related to handling the challenges of counterspace technologies, getting prepared to address the possibilities of space warfare, and ensuring that India's space defence preparations have a deterrence potential, it is necessary for India to think bold. It is important to check, 'whether there is a need for India to establish a separate vertical for space'? Such a move could require the addition of one more (fighting) force to India's security architecture, which presently consists of Indian Army, Indian Navy and Indian Air Force.

The US established a space force on 20 December 2019. On 11 September 2020, the French Air Force became the French Air and Space Force. In July 2019, the French President announced the creation of a space command and the formation of the French Air and Space Force could be viewed as the completion of this process. In 2021, the UK government launched a new space command. Military officials in the UK argue that Britain's Royal Air Force is facing an immediate need to 'catch up with its adversaries', and prepare itself for a potential 'space war' [62]. Japan has announced the formation of space defence command during January 2020 [63]. During the celebrations of the Royal Australian Air Force (RAAF) completing 100 years (31 March 2021), their Chief of Air Force announced the intention to create a new space command on the lines with Canada, France and Japan. Finally, on 22 March 2022, Australia's government launched its space Command [64]. This need has been felt because the three branches of the Australian armed forces depend on space-based technologies and hence centralised coordination is essential [65]. China has its space force as a part of the PLA's Strategic Support Force. Russia had a space force (not as an organised military service) almost a decade back. Now Russia has an aerospace force and so does even a state like Iran, which has a very nascent space programme. The space forces or agencies dealing with military aspects of space for various non-US states are not independent services, but are under a single military branch and that too in most cases as a part of Air Force.

Now, a simple argument could be put forth, 'that if almost every country can manage without a space force, then why India should be establishing one'? The geostrategic reasoning for this could be simple. The US is known to have established a separate space for multiple reasons like fixing military space acquisitions, possible danger from Russia and more importantly owing to the threat from China. The China logic holds true for India, also. However, there is no need for India to blindly follow the US and establish its own space force. There is a need to clearly identify the need for such a force. If there is a clear strategic logic for the establishment of such a force, then only India should try to build one. It is also important to note that states are forming a space command essentially to cater for the requirement of the various arms of their military services. Their purpose is to enhance the fighting capability of their

militaries. However, India's challenges go much beyond such routine military needs.

The history of India-Pakistan rivalry since 1947 indicates that even after fighting the wars of 1947–48, 1965, and 1971 and the Kargil Conflict (1999) there has been very little improvement in their relationship. All these wars have been mostly of low intensity and short duration [66]. All three wars were fought in the era of the absence of nuclear weapons. However, from 1998 onward both these states have established themselves as nuclear weapons states. The Kargil conflict provides empirical support for the notion of the stability-instability paradox. It demonstrates that the mutual presence of nuclear weapons can witness a low-intensity violence, but not a full-scale war [67]. Presently, nuclear deterrence could be one important reason for this region to hold on to an uneasy peace (that is, no war). However, clashes on borders are continuing sometimes leading to the deaths of soldiers on both sides.

Pakistan is known to have (theoretically) completed the process of establishing the nuclear triad. On 9 January 2017, they successfully test fired submarine-launched cruise missile (SLCM) Babur-3 at an undisclosed location in the Indian Ocean region. They already have land-based missiles and aircrafts, which can deliver nuclear weapons to predesignated targets. They have the F-16 combat aircraft, along with some Mirage III and V aircrafts available for this purpose. Pakistan's nuclear missile arsenal consists primarily of short to medium-range ballistic missiles. They are making significant progress towards enhancing their cruise missile capabilities. Pakistan has nuclear-capable, road-mobile ballistic missiles, including the short-range Abdali, Ghaznavi, Shaheen-1 and NASR and medium-range Shaheen-2 and Ghauri [68]. Pakistan is also known to develop tactical nuclear weapons.

Normally, the Pakistan factor is never at the centre stage for debates on issues related to outer space, since they have very limited space canvass. Still, it must be noted that Pakistan has good potential to develop counterspace capabilities. It has well proven missile expertise and there is a possibility that they could develop cyber and jamming capabilities quickly, possibly with the covert assistance from China. There is not much celerity (and confidence) about the 'stealth' of their nuclear command, control, communications and intelligence structures. They could accidentally or otherwise start a nuclear standoff. India must take into account the unpredictability factor with respect to nuclear Pakistan and its possible interests in counterspace technologies and emerging threats to India's space security.

India can also learn from Japan's experience. Japan for long had a policy about not making investments in the space domain for military/security purposes. The Diet resolution of 1969 prevented the Japanese Self-Defence Forces from owning, developing, operating and using space assets. Also, the accord of 1990 with the USA was limiting them the public procurement of non-R & D satellites. However, owing to security considerations, Japan's space policy has undergone a dynamic change over the years. In Particular, following the North Korean missile launch in 1998 into Japanese airspace, the state did realise the need for having their own spy satellites. During May 2008, a bill for basic space law was enacted by the Japanese government, which makes a mention about the development of space assets for the benefit of security of Japan. This typical shift of policy of Japan owing to increasing security challenges clearly indicates that states are bound to use new technologies as an instrument in their security calculus and space is one such option. It is somewhat premature to predict; however, North Korea has a developed missile programme and there could be a possibility that in the future they could conduct an ASAT test. As such, Sino-Japanese have mostly strained relations. All this in the future could even force Japan to move in the direction of developing counterspace technologies [69].

Space is a crucial domain in India's growth story. India is also increasing the commercial stakes for its space programme. This makes space a lucrative target for India's adversaries. Since, India's remote sensing satellite network caters, both for civil and military usage, automatically it becomes an important military target. India has communication and navigational satellites that are of great importance for its armed forces. Obviously, there is a need for India to protect its space systems and ground infrastructure from any enemy attack. Obviously, to address such challenges there is a need for formation of a separate agency.

Universally, critics are known to question the wisdom of establishing a new military force without first developing an effective theory of waging a space war and the same would go true with the space force. Till date various other military arms like Army, Navy and Air force are known to have achieved their organisational independence after extensive demonstrations of their worth on the field of battle and mostly when they were established by different states, the theories of airpower, maritime power etc. were already getting debated. There was a theoretical and/or doctrinal grounding for the establishment of such forces existing. However, that is not the case for the domain of space. Obviously, questions could be raised as to why India should decide to create its own space force when there is no theoretical understanding of space warfare itself. Nevertheless, there is a view that actually, the states have no time to waste in the pursuit of theoretically identifying about what could be the military advantage in space [70] and same is the case with India [71]. Since 2015, various official and private Chinese writings have been found debating about space warfare, including offensive and coercive usages. China has a major focus towards developing various forms of counterspace capabilities, which include both destructive and non-destructive offensive counterspace capabilities. These developments include co-orbital rendezvous operations to direct ascent anti-satellite interceptors and electronic and cyber warfare [31]. China is known to be keen to reduce the advantage which the US has in outer space. Their counterspace technology development is guided in that direction. But the same capabilities could be easily tweaked for use against India, also. Therefore, India's overall strategic interests and the security of its space assets are at stake. It is important not to look at China only from the point of view of the unsettled neighbourhood of India. China's presence, as a dominant global power, must be factored in, to understand the possible trajectory of China's strategic positioning and its impact on space security, in general.

There is a need for India to have a critical look at the China's overall digital and space strategy. China's conceptualisation of the new age Silk Road [72] (known as the Belt and Road Initiative or BRI) is expected to play an important role in the formation of their immediate and future strategic alliances and security ties. China's progress in various technology fields has been very systematic. Particularly, their investments and scientific achievements in artificial intelligence (AI) and quantum technologies do indicate that they would most likely emerge as global leaders in this field. Their success with 5 G technologies is well known. In November 2020, China launched the world's first 6 G satellite into space to test the technology [73]. Interestingly, the global telecoms industry is still some years away from agreeing on the specifications of 6 G, however, with this launch China has put its 'hat in the ring'. Some BRI investments for China are bound to help them towards expanding their military alliances. BRI is all about reach and connectivity. The Bei Dou navigation system would play a major role in this context. China's technological investments in the realm of security (directly or indirectly) could eventually pose a challenge to global security dynamics. However, some of the technological developments happening in China are still at the nascent level and it may take some time for them to reach a level of maturity.

Russia is a very important partner and friend for China. The 1991 Gulf War had a profound effect on Chinese military thinking. Their strategic focus has been to use economic opportunities to gain broader strategic access to various regions in the world. Economy, technology, and strategic engagement are the basic tenets for their power projection. It is becoming evident that China has the ambition of becoming a global technology superpower [74].

China is learning from its own experiences and may decide on its future investments accordingly. One of the important factors [75] that probably has made a radical change in Chinese strategic thinking and could be held responsible for China's military modernisation [76] in general and making investments in space technologies in particular, is the incidence of the so-called accidental bombing of their Embassy in Belgrade by an American B-2 bomber. During 1999, China and the US relations experienced extreme strain as a result of North Atlantic Treaty Organization (NATO)'s Kosovo intervention, and in particular by the bombing of the Chinese Embassy in Belgrade by an American B-2 bomber [77]. China was convinced that it was a GPS guided bomb, and hence the explanation of accidental bombing by NATO was not palatable to them. US President Trump (2017–2021) started his innings with a major economic offensive against China. However, when he left the Whitehouse, the reality on the ground showed that little has changed [78]. At present, the US-China relationship stands at a critical juncture. The changing balance of power and the limitations of the US in determining the course of development of China have called into question the fundamental assumptions of their China policy. As also seen in the past, the US power is unable to shape China to its liking [79]. The current US President, Mr Biden also brings no relief to tensions between US and China [80]. From economics to climate change to human rights there are various areas of disagreement. All this indicates that China is bound to continue modernising its defence architecture. China would not like any interference from the US in the matters related to Tibet, Taiwan and Hong Kong. During peacetime (and during war), for the US, the best option to gather intelligence, use social media and monitor economy would be to depend on space technologies. Hence, China is unlikely to stop its investments towards developing counterspace technologies. Obviously, India needs to remember that any counterspace capability developed with different threats in mind would also prove useful against India, too. India's military space discourse needs to factor in these aspects.

7. India's investments and concerns

India's military needs from space technologies are expanding. There are issues of replacement of old communications and earth observation satellites and designing of new satellites. In addition, there is a need to introduce new (and faster) methods to assess data and conduct internal training activities. In the absence of any other agency to undertake such tasks, the DSA would be required to project, plan and execute such developments. They also would be required to develop the proposals for the future requirements of the armed forces for weather monitoring and other electronic intelligence gathering mechanisms. Collaborating with the three services and undertaking advanced planning for additional space assets increases the scope of work for the DSA. In addition, managing India Navigation Services (NavIC) and ensuring maximum applicability for this system would also be a great task. The ground infrastructure is another important arena, which requires focussed attention and the process remains dynamic. For this purpose, maintaining and improving the existing ground station network, adding to more redundancy in the system, and planning future networks is essential. The network of ground stations on foreign

soil needs to be expanded, since a larger number of satellites are going to be available in the future.

Possibly, there is limited involvement of the agencies of the armed forces for undertaking space operations, collaborating with friendly countries on the military space area, developing technologies for jamming and for undertaking cyberspace operations (if, required), collecting and analysing geospatial intelligence, and keeping the track of the existing weather systems and undertaking their prognosis. The increasing importance of satellites for the Indian Armed forces is obvious, and there could be a need for developing an independent agency which would exclusively address various aspects of space technologies for the military and also work towards ensuring space security. Such an agency would be required also to remain prepared to ensure real-time connectivity of various agencies associated with the operations, control navigational units during the conflict stage to correctly identify enemy positions and their movements, assist in standoff weapons delivery and in undertaking targeting, and subsequently to carry out post-damage assessment analysis.

Today, for India, there is a major challenge emerging in the strategic domain, and that is about the possibility of space warfare. Much needs to be done in this field. India needs an agency to meet its larger strategic needs in the space domain. For this purpose, India must clearly differentiate its requirements (at doctrinal, technical, policy, and structural levels) from space assets to assist its military services and address the challenges of possible space weaponisation.

There is no specific policy (globally) in regards to the notion of space-based defences. A space-based laser weapon defence capability has been the long-term goal for the US, and others, for many years [81]. There are various other ideas (like directed energy weapons, space-based interceptors and sensors [82]) also been looked at, as possible technologies and/or techniques for building space-based defences. Some developmental work appears to be happening in this arena; however, states are yet to bring such ideas in their security architecture. If this happens, then it could mark a major substantial policy shift. China is leading the world in the arena of hypersonic weapons which can fly at a speed of more than 5 Mach. The existing missile defence system cannot neutralise such threats and there is a need to develop a counter for hypersonic missiles.

The Pentagon is known to be studying whether laser-equipped satellites might be able to disable enemy missiles coming off the launch pad. They are researching space-based neutral particle beams, a different form of directed energy that disrupts missiles with streams of subatomic particles traveling close to light speed — as opposed to lasers, whose photons travel at light speed [83]. Research (and possibly development) is happening on the development of attack satellites, space lasers, space-based ray guns and some technologies which could be viewed as technologies leading to space weaponisation. In addition, various debris removal technologies like space fence, space lasso and few others are being researched on. Such technologies could actually help to make outer space cleaner. However, in the absence of any globally recognised legal mechanism, it could be difficult to decide on the exact intent of such missions. In March 2021, the first commercial mission to demonstrate technologies to remove space junk from orbit has taken off. There is a need for India to address various ideas about space-based defences. India is known to develop hypersonic technology. During September 2020, India's Defence Research and Development Organisation (DRDO) has successfully demonstrated the hypersonic air-breathing scramjet technology with the flight test of Hypersonic Technology Demonstration Vehicle (HSTDV). India has a long way to go and it would take a few more years to reach the level of actual hypersonic missile development. However,

India should also focus on developing a space-based missile defence system to address the futuristic China's hypersonic missile threat.

From on-orbit servicing to managing space traffic, addressing issues related to satellite swarms, space tourism, and developing technologies for space debris removal, there are various issues that demand the focus of India's space establishment. In addition, there are issues like space solar power, developing launch on demand facilities & ship-based launch vehicles, asteroid mining and mining on moon and mars, providing internet services via satellites and human space programme and space station, which would demand major technical and financial investments by the Indian state. In the future, India could be required to develop the ability of the human spacecraft to move from one orbit to another. With possible developments taking place in the field of quantum physics, there could be major changes in communications and cryptographic systems. Also, the need for space weather forecasting is becoming obvious. ISRO would be at the centre of most of these activities, but more as a project executor rather than as a policy planner. Therefore, now is the time to establish a separate structure at the policy level to look at all of these issues holistically.

In general, from India's perspective, there are various major tasks waiting for attention in the space domain. By undertaking ASAT, India has already identified space as its strategic domain of interest. Now the time has come to make a clear distinction between India's military and civil space programmes. Also, within the military realm, it is important to differentiate between space applications which are used as a force multiplier, in the aid of army, navy and air force, and the technologies having a bias towards addressing the possible space weaponisation issues. For this purpose, India needs to evolve its overall space security agenda in a more inclusive fashion. It is necessary to realise that some specific issues are beyond the mandate of existing agencies that deal with space. Possibly, if India wants to evolve a space deterrence mechanism, then there is a need to create an explicit structure for this purpose, which could be a separate force for this purpose, called the Indian Space Force.

8. Conclusion

India is a rising power with increasing global influence. Its security interests remain restricted towards guarding its own borders. Owing to typical geostrategic challenges, India is required to remain prepared to fight conventional, nuclear, and asymmetric challenges. India's neighbour and adversary, China, has well-established strategic space programme. During 2019, India has taken a first step towards establishing its own strategic space programme by conducting an ASAT test. Now India needs to build on this success. The conduct of an ASAT test is only an announcement of intent. Much needs to be done to develop a strategic deterrence. At the same time, India needs to maintain a delicate balance towards ensuring that their activities in the space domain do not get bracketed as an attempt to weaponise the space, but simply gets regarded as an attempt to create an effective deterrence mechanism.

Establishing a fourth vertical for the armed forces to exclusively address the issues of space security would be an audacious task. Such decision would require a major change in mind-set. There could be major resistance from the military establishment itself; they could try hold on their turf. The state administration would be required to be bold. The type of delay experienced towards appointing the CDS should be avoided. It is important to realise that the abilities of India's adversaries in the arena of developing counter space technologies and conducting dubious activities in space would affect India in both, peacetime and during the conflict situation.

Indian armed forces have limited experience handling space-related projects. Indian agencies would be required to leapfrog in various space related fields from doctrines to technologies to policy. India would be required to do all this and much more due to strategic requirements. As time progresses, the challenges in the outer space domain will increase. Now, the time is ripe for India to develop an independent military arm for this purpose. In the future, by the time the situation in outer space (possibly) starts to become grimmer, India would already have an established force (Indian Space Force) to address such challenges. This would also serve as effective 'optics' associated with sending a 'message' to adversaries.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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