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Emergence of China as a Military Space Power and Ramifications for India's Security

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Image Source: China News Service (https://commons.wikimedia.org/wiki/File:LM2F-Y13.png) The Long March 2F rocket carrying Shenzhou 13 spacecraft.

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Contents

List of Abbreviations

ABM	-	Anti Ballistic Missile (Treaty)
AD	-	Air Defence
ASAT	-	Anti-Satellite (Weapon)
ASBM	-	Anti Ship Ballistic Missile
A2AD	-	Anti-Access Area Denial
BMD	-	Ballistic Missile Defence
BRI	-	Belt and Road Initiative
C2W	-	Command and Control Warfare
C3	-	Command, Control & Communication
C3I	-	Command, Control, Communications and Intelligence

C4ISR	-	Command, Control, Communication, Computer, Intelligence, Surveillance and Reconnaissance
CAS	-	Chinese Academy of Sciences
CASC	-	China Aerospace Science and Technology Corporation
CASIC	-	China Aerospace Science and Industry Corporation
CCP	-	Chinese Communist Party
CGWIC	-	Chinese Great Wall Industrial Corporation
CMC	-	Central Military Commission
CMSA	-	China Manned Space Agency
CNSA	-	China National Space Administration
COSTIND	-	Commission of Science, Technical and Industry for National Defence
DEW	-	Directed-Energy Weapons
DIA	-	Defence Intelligence Agency
DOS	-	Department of Space
DRDO	-	Defence research and Development Organisation
ECM	-	Electronic Counter Measures
EHF	-	Extremely High Frequency
ELINT	-	Electronic Intelligence

EO	-	Electro Optical
EW	-	Electronic Warfare
FH	-	Fenghuo
GAD	-	General Armaments Department
GAGAN	-	GPS Aided Geo Augmented Navigation
GEO	-	Geostationary Earth Orbit
GPS	-	Global Positioning System
GSLV	-	Geosynchronous Satellite Launch Vehicle
GSD	-	General Staff Department
GTO	-	Geostationary Transfer Orbit
ICBM	-	Intercontinental Ballistic Missile
IDS	-	Integrated Defence Staff
IMINT	-	Imagery Intelligence
INEW	-	Integrated Network-Electronic Warfare
INSAT	-	Indian Satellite
IRBM	-	Intermediate Range Ballistic Missile
IRNSS	-	Indian Regional Navigation Satellite System
ISR	-	Intelligence, Surveillance and Reconnaissance
ISRO	-	Indian Space Research Organisation

LEO	-	Low Earth Orbit
LM	-	Long March (Rocket)
LOD	-	Launch on Demand
LSG	-	Leading Small Group
MEO	-	Medium Earth Orbit
MIIT	-	Ministry of Industry Information Technology
MOST	-	Ministry of Science and Technology
NAOC	-	National Astronomical Observatories of China Academy of Sciences
NSSC	-	National Space Science Centre
PAN	-	Panchromatic
PLA	-	Peoples Liberation Army
PLAAF	-	Peoples Liberation Army Air Force
PLAN	-	Peoples Liberation Army Navy
PLARF	-	Peoples Liberation Army Rocket Force
PLASSF	-	Peoples Liberation Army Strategic Support Force
PNT	-	Position, Navigation and Time
PSLV	-	Polar Satellite Launch Vehicle
PRC	-	Peoples Republic of China

RADI	-	Institute of Remote Sensing and Digital Earth
R & D	-	Research and Development
RPO	-	Rendezvous and Proximity Operations
SAR	-	Synthetic Aperture Radar
SAST	-	Shanghai Academy of Space Technology
SASTIND	-	State Administration on Science, Technology and Industry for National Defence
SATCOM	-	Satellite Communication
SSA	-	Space Situational Awareness
SSN	-	Space Surveillance Network
ST	-	Shentong
TTC	-	Telemetry, Tracking and Control
UAV	-	Unmanned Aerial Vehicle
USSR	-	Union of Soviet Socialist Republics

Introduction

"Exploring the vast universe, developing space programmes and becoming an aerospace power have always been the dream we've been striving far."

– Xi Jinping, President of China, 24 April 2016

China's space programme can be described as a mystery within a maze. The visible elements of the programme include space launch vehicles, launch sites and satellite systems. However, various components of its organisational structure and architecture are shrouded in obscurity. Since the birth of China's space programme in 1956, its development has mirrored the progress of the nation as a whole. China's space industry[1], during the course of last fifty years has developed from being near non-existent to becoming highly advanced in the field of satellite recovery, multi satellite launches, cryogenic fueled rockets, strap-on boosters, geostationary and navigational satellites and micro gravity experiments.

The world at large is in favour of keeping space as a conflict free zone since it affects humanity and is a global common. Despite all the peace initiatives to control arms race in space, there are some countries that are working behind the curtains to militarise and probably even weaponise space.

India has ratified and is signatory to almost all major space treaties and agreements which entail the use of outer space for peaceful purposes only and is committed towards maintaining the sovereignty of space. However, there are very few legal restrictions on the uses of space for military purposes. There is as yet no

internationally accepted position for delimitation of outer space as to where the Earth's atmosphere ends and where the universe begins. By customary practice, outer space is considered upward of a hundred kilometers beyond the surface of the Earth. Below this, States exercise exclusive jurisdiction as sovereign airspace. The scope and applicability of space laws like sovereignty and appropriation is constrained on account of this lack of agreement on a precise boundary delimiting the atmosphere from space. However, the basic premise on which the existing space regime is established is that outer space is free for exploration and not subject to occupation by any one State.

The defining international legal instrument relating to Outer Space is the 'Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space including the Moon and Outer Celestial Bodies, 1967'. India ratified this treaty on 18 January 1982. It provides for freedom of exploration, access and use of outer space for the benefit of all countries on the basis of equality of opportunity. It ensures that all space activities are conducted in accordance with the principles of international law and the United Nations charter. It prohibits States from placing nuclear weapons or weapons of mass destruction in orbit, installing them on the moon or any other celestial body or otherwise stationing them in outer Space. It exclusively limits the use of the moon or other celestial bodies to peaceful purposes and expressly prohibits their use for testing weapons of any kind, conducting military manoeuvres or establishing military bases or installations.

In addition, there is the Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (Rescue and Return Agreement), 1968 (India acceded to it on 9 July 1979); the Convention on International Liability for Damage Caused by Space Objects (Liability Convention), 1972 (India acceded to it on 9 Jul 1979); the Convention on Registration of Objects Launched into Outer Space (Registration Convention), 1976 (India acceded to it on 18 January 1982); and the Agreement Governing the Activities of States on the Moon and other Celestial Bodies (Moon Agreement), 1979 (India signed this Agreement on 18 January 1982). International legal principles in these four documents provide for non-appropriation of outer space by any one country, arms control, the freedom of exploration, liability for damage

caused by space objects, the safety and rescue of spacecraft and astronauts, the prevention of harmful interference with space activities and the environment, the notification and registration for space activities, scientific investigation and exploration for natural resources in outer space and settlement of disputes.

The term 'peaceful purpose' in the 'Outer Space Treaty' is being construed by space powers to enable use of outer space for military purposes so long as they are non-aggressive. Therefore, there are loopholes in the existing legal framework on space, which are being exploited by countries like China for militarisation of space.

China's space policy goals focus on economic and developmental benefits, enhancing military capabilities and garnering influence in the international arena. Its space programme represents a major investment, aimed at enabling Beijing to utilise space in expanding its comprehensive national power. Experts estimate that China invested US$ 5.8 billion[2] on its annual space budget in 2018, compared to India's modest spending of US$ 1.5 billion[3]. China's space programme is essentially growth oriented with a military bias[4]. It integrates the civil and military aspects of space and does not have a clearly defined civilian space programme as a well thought out strategy. China is making substantial investments in the field of space technology. The inherent dual-use nature of such investments is bound to strengthen their military capabilities in space. The Chinese strategic thought envisions that the commanding height of strategic competition will be in space. Therefore, synergised development in all domains of space is being undertaken by them.

The PLA (People's Liberation Army) is rapidly improving its space and counter space capabilities[5]. Its space-based sensor development is focused on high resolution, dual-use Electro-Optical (EO), Synthetic Aperture Radar (SAR) and Electronic Intelligence (ELINT) satellites for surveillance and targeting. An expanding constellation of navigation satellite[6] further enhances China's operational prowess. China's space developments are an integral component of its military transformation effort, which aims to strike at the enemy's C4ISR (command, control, communication, computers and intelligence, surveillance and reconnaissance) system to guarantee success in war.

Unlike China, India's space programme has evolved entirely for acquiring capabilities in the civilian space domain[7]. It has been designed essentially to meet communication, remote sensing, television, meteorological and limited security requirements. In India, defence and space activities have been traditionally kept separate and the two departments function pretty much independently. However, this needs to change with space becoming an important dimension of defence and security now. Strategic long-term planning must integrate space capabilities with defence capabilities that need to bedeveloped for safeguarding national security interests. India should be in a position to take an independent stand on space defence and space control, commensurate with its own assessment of national security priorities.

It goes without saying that a new space order is emerging where strengths in outer space capabilities would heavily influence the international balance of power. Such strengths are derived from indigenous core competencies across the full spectrum of space technology both in civil and military applications. Suitable policy and organisational infrastructure are vital for bringing together all components of space power for deterrence, war-fighting or power projection purposes to support the national security objectives. It is very likely that in the years ahead, deterrence value of space capability may become as important as nuclear deterrence of today. Space will then become an important new dimension in the calculations for military and economic power of a sovereign nation. Therefore, it is imperative to analyse China's military space capabilities in order to identify the ramifications on India's security and propose a suitable response strategy.

China possesses the most rapidly maturing space programme in the world and is using its orbital and ground based assets to support its civil, economic, political, diplomatic and military goals with the objective of enhancing its comprehensive national power. China lays particular emphasis on Satellite Communications (SATCOM), Intelligence, Surveillance and Reconnaissance (ISR), Satellite Navigation (SATNAV) and Anti-Satellite (ASAT) weapons, as well as, manned, unmanned and interplanetary space exploration. In addition to its orbital assets, China has undertaken to build a vast ground infrastructure of Earth Stations, Satellite Launch Vehicles (SLV) and Command and Control links to facilitate the expansion of its space programme.

China has issued four White Papers related to development of space activities in 2000, 2006, 2011 and 2016. A perusal of these White Papers provides an understanding of the measure of State support towards building China into a space power. The Defence White Paper released by China in 2015 titled 'China's Military Strategy' also recognises the need to move from territorial air defence to aerospace domination as a pre-requisite for winning 'wars under informatized conditions'.

The multi-pronged nature of China's space programme demonstrates its military ambitions and is a matter of serious security concern for India. Therefore, it calls for a thorough analysis of China's military space capabilities to bring out the ramifications for India and suggest a suitable response strategy to meet this emerging challenge to India's national security.

Space based capabilities are today deeply embedded in the civil, commercial and military segments of all developed nations. Space systems have also become an integral component of the total combat potential of a nation. The military doctrines of most space faring nations emphasise the use of space systems to support national security. It is likely that in times to come, the deterrence value of military space capabilities may become as important as nuclear deterrence is today. In this backdrop, China has also been making rapid strides in the development of space technologies and capabilities, which may lead to huge asymmetries in combat potential with India and thereby impinge our national security.

On the other hand, India has a strong civilian space programme but the use of space technologies for military purposes has thus far been rather limited. For a nation with active borders and hostile neighbours, India cannot afford to adopt an ostrich-like approach. The ongoing developments in the military use of space by China are a pointer to the future threats to India's security. A strong impetus is urgently required if this asymmetry has to be addressed. Therefore, it is essential to study the military space capabilities and strategy of China, their ramifications on India's security and to suggest a suitable response strategy for safeguarding our vulnerabilities and building India into a credible space power.

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China's Space Programme : Evolution, Organisation and Architecture

"Space is a critical domain in international strategic competition."

– China's Defence White Paper, 2019

Evolution of China's Space Programme

The launch of mankind's first artificial satellite, Sputnik I, by Soviet Union in 1957, spurred China to develop its own space capabilities. As is the case with most space faring nations, the ballistic missile programme of China laid the foundation of its space ventures. Mao adopted 'Project 581' in 1958 with the intention of placing a satellite in space by 1959 to commemorate the 10th anniversary of PRC's founding[1].

A nation having emerged from the shackles of struggles and political turmoil, China's space journey has had distinct shades of political, economic and social influences in the last century. The subsequent paragraphs trace the evolution of China's space programme.

Initial Breakthrough, 1956-66

China's first missile and rocket technology institute was established in 1956. After a bilateral agreement signed in October 1957 between USSR and China, the Soviets provided substantial assistance to China in developing rocket

technology. Though, the Soviets withdrew the support in 1960, the Chinese were able to gather considerable knowledge about the Soviet R-1 and R-2 missiles[2]. Though mired with initial failures, the Chinese could manage to launch their first indigenous missile in 1966, thus proving their expertise in rocket technology. It was also the time when the 'Fifth Academy' for missile research was established[3]. Despite the famine years of 1959-61, missile programme continued to get state support at the highest level in the initial years.

China Sets Foot in Space, 1966-76

Though the cultural revolution strongly affected the socio-political fabric of the country, China continued to remain focused towards space. Zhou En Lai emerged as a major supporter of Chinese ventures in space and in 1967 he re-mustered the Chinese Academy of Sciences (CAS) under PLA control. This very step was a landmark in China's Space history as all its space missions now had a military flavour. With his continued patronage, China launched its first satellite Dong Fang Hong (East is Red) on 24 April 1970[4]. It was a communication satellite launched at an altitude of 2000 Km. By this time four other countries, Soviet Union, United States, France and Japan[5] had launched their own satellites making China fifth in this domain.

Space Recess, 1976-86

The focus of Deng Xiaoping was on building up China's economic and social infrastructure. While military space ventures receded due to lack of patronage, those accruing economic benefits continued. In August 1978, Deng Xiaoping had stated that as far as space technology was concerned, China was not taking part in a space race and that there was no need for them to go to the moon. However, Deng still continued to push for modernisation programmes. These programmes indirectly benefitted the space sector especially in telecommunications and remote sensing. In April 1984, China placed its first communication satellite into geo-synchronous orbit (GEO). Concurrently, China also commenced the development of LM-4 rocket in order to launch its meteorological satellites into sun synchronous orbits[6]. The setting up of China Great Wall Industrial Corporation (CGWIC) in 1985[7] enabled China to develop and market its

homemade satellites and launch vehicles overseas.

China's Golden Period in Space, 1986-2006

The next twenty years had in store some of the most remarkable achievements of China in Space. In 2000, China launched one of its most ambitious missions, Beidou-1, their first satellite navigation system consisting of a constellation of three satellites[8]. In 2003, under 'Project 921', China became the third country to undertake a manned mission to space. China's first manned mission was undertaken by employing Shenzhou-5 spacecraft in 2003.[9] The success of Chinese '*Taikonauts*' set the stage for undertaking the ambitious '863 Proposal'[10], which was a three pronged approach towards building a space station, developing a heavy launch vehicle and a space transportation system.

Strategic High Ground, 2006 Onwards

In 2006 China in its military pamphlet 'The Science of Campaigns' identified Space as the new strategic high ground. Accordingly, China commenced nurturing the development of dual use technologies and PLA's doctrines were aligned to the idea of '*local wars under informatized conditions*'. China tested its direct ascent Anti Satellite (ASAT) weapon in January 2007. Launched from Xichang Satellite Launch Centre, the ASAT missile destroyed a defunct Fengyun-1C weather satellite in Low Earth Orbit (LEO). The experimental test not only established China's Space prowess, it also brought to fore China's inclination towards militarisation of space. Despite worldwide condemnation, China did not put to rest its kinetic kill missions even after its defamed 2007 ASAT test[11]. In 2010, it carried out an in-orbit manoeuvre apparently bumping two of its own micro-satellites[12]. In 2012, the Chinese spacecraft Shenzhou-9 docked with Tiangong-1 space station setting the stage for sustained human presence in space in future[13]. With its ambitious space station project in mind, China continued to make giant leaps in launch vehicle technology. Currently, China has developed a wide array of launch vehicles to meet its requirements of launching satellites in LEO and GEO orbits.

China operationalised its Beidou-2 Satellite Navigation System with 10 satellites in 2012 and completed the Beidou-3 system with 35 satellites in 2020[14]. Beidou System and China's Belt and Road Initiative (BRI) are expected to be enmeshed into a composite package with transhipment and vehicle tracking along the proposed routes being enabled and controlled through space.

Some of the niche technologies in which China has achieved considerable breakthrough include the development of "*Kuaizhou*" (quick vessel) space launch vehicle, Launch on Demand (LOD) capability, laser-based radars for satellite tracking and space assisted ballistic missile defence capability[15]. Towards this effort, China in 2010, successfully intercepted a ballistic missile at mid-course using a ground-based missile. On 15 September 2016, the second space laboratory Tiangong-2, was placed into orbit[16]. Tiangong-2 is a precursor to the full fledged space station Tiangong-3, which is planned to be launched in 2022[17]. On 05 June 2019, China successfully carried out a ship based launch of its Long March - 11 (LM-11) space rocket from the Yellow sea[18].

China's Evolving Space Policy

China's space policy has gradually evolved over the years. Initially, China was not keen to take part in a space race and was focused towards peaceful utilisation of space. However, with the identification of space as the new strategic high ground and with the economic might to support its space ventures, China's space policy has gradually evolved over the decades.

In August 1978, Deng Xiaoping had stated that as far as space technology was concerned, China was not taking part in a space race and that there was no need for them to go to the moon. The White Paper '*China's National Defence in 2000*' had stated that activities like testing, deployment and use of weapons should be banned in outer space to prevent the militarisation of and an arms race in space. It further stated that there appear to be intentions, plans and actions to gain unilateral military superiority for controlling the use of space. These it said are not only real but growing. Therefore, it exhorts the international community to take effective steps to check such negative developments.

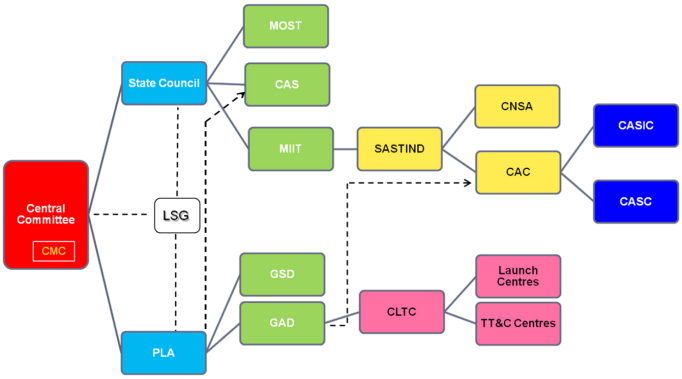
The Science of Campaigns[19], China's official military pamphlet published in 2001 had described 'space' as an essential part of fighting future wars. The 2002 Defense White Paper[20] of China stated that outer space was faced with the danger of weaponisation and its protection from weaponisation and arms race had become a very urgent and realistic issue. It further states that the international community should formulate necessary legal instruments to prohibit the deployment of weapons and use of force in outer space, in order to ensure peace. In 2004, Hu Jintao laid down the "*new historic missions*" for PLA, which included space security as one of its missions.[21] In 2006, just prior to the ASAT test, *The Science of Campaigns* in its new edition stated that the space domain was daily becoming a vital battle-space and that space had already become a new strategic high ground.

The White Paper 'Space Activities in 2006' identified that the aims of China's space activities were national security, protection of her rights and building up comprehensive national strength[22]. It further stated that China considered the development of its space prowess as a strategic way to enhance its scientific, economic, technological and national defence strengths as well as a cohesive force for the unity of its people and to rejuvenate China.[23] Even the Chinese ASAT test in 2007 was justified by China as a mere response to the US withdrawal from the ABM Treaty in 2001 with the aim of demonstrating its capability against US satellites[24]. The Defence White Paper of 2015 for the first time designated space as a military domain. In 2016, the White Paper 'China's Activities in Space'[25] stated that China's space vision was to build into a space power in all respects, with the capability to make scientific innovations, discoveries and research, to promote sustained economic growth and social development as well as to guarantee national security. The Defence White Paper of 2019[26] identifies space as a critical domain in the international strategic competition. Thus, China's policy has gradually evolved with the realisation that dominance in space shall prove vital to winning wars under informatized conditions.

China's Space Organisation

Strategic affairs are controlled by three major organs in China viz the Chinese Government, PLA and Chinese Communist Party (CCP). These three organs control a number of agencies related to space that have inter-linking functions.

In order to coordinate decision making on very sensitive issues, China usually forms a Leading Small Group (LSG) that harmonises a coherent view amongst the three organs and serves as an oversight body. It comprises key officials from Chinese Government, PLA and Chinese Communist Party (CCP). An LSG is likely to have been constituted for formulation of coherent policies on space also[27].



China has nurtured a successful civil-military interface for growth in space industries. While the strands of civilian control over the executive agencies involved in research, development and production are strong, there also exists a cross linkage with the PLA in domains related to strategic research. Therefore, it is prudent to mention that the running of space launch centres and Telemetry Tracking and Control (TT&C) Centres rests completely with the General Armaments Department (GAD) of PLA.

Civil Vertical of the Space Organisation

The civil organisation related to space in China includes the State Council, Ministry of Science and Technology (MOST), Ministry of Industry and Information Technology (MIIT), Chinese Academy of Science (CAS), State Administration on Science, Technology and Industry for National Defence (SASTIND), China National Space Agency (CNSA), China Aerospace Corporation (CAC), China Aerospace Science and Technology Corporation (CASC) and China Aerospace Science and Industry Corporation (CASIC).

The State Council, being the highest government body, has the final word on acceptance and funding of new space projects. It plays a major role in planning the National Long-Term Science and Technology Development Plan and Five Year Plans. It is involved in planning the research and development (R&D) of high-end technology, development programmes and formulation of white papers on space[28]. Under the State Council are the Ministry of Science and Technology (MOST), Ministry of Industry and Information Technology (MIIT) and the Chinese Academy of Sciences (CAS). Their roles are described below :-

- MOST works out the national R&D strategies in the field of science and technology. It sponsors projects with niche technologies, which may benefit both civil and defence industries. Currently, national science strategy for the period 2006-20 is in vogue.

- MIIT regulates industrial planning, policy and standards. Subordinate to MIIT is the State Administration on Science, Technology and Industry for National Defence (SASTIND), an administrative body for China's defence and aerospace industry.

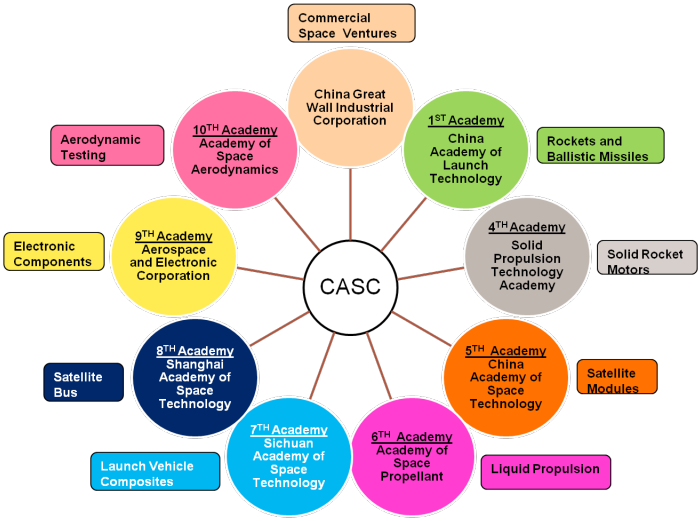
- CAS is the governing body of establishments related to space science and remote sensing. It has institutes under it like the Shanghai Institute of Optics and Fine Mechanics, Institute of High Energy Physics (lasers), Institute of Remote Sensing and Digital Earth (RADI), National Space Science Centre (NSSC), National Astronomical Observatories of CAS (NAOC) and Shanghai Institute of Micro-systems and Information Technology.

In 2008 the Chinese government had created SASTIND by dissolving the erstwhile Commission of Science, Technical and Industry for National Defence (COSTIND) which functioned under the State Council and used to oversee the administration of defence industry[29]. SASTIND the new body so created is an administrative body for China's defence and aerospace industry. It is engaged in policymaking and allocation of funds for research programmes[30]. It has two subordinate agencies viz the China National Space Agency (CNSA) and the China Aerospace Corporation (CAC). Their roles are described below:-

- CNSA is responsible for enforcement of policies and regulations related to China's space activities. It is also responsible for international collaboration and technology exchange programmes. However, it should not be considered as an umbrella organisation for all space activities in China. It should rather be viewed as an organisation created to meet China's international obligations[31].

- CAC is mandated to exercise control over China's aerospace industry. In 1999, the CAC was restructured and two new agencies were created. These are the China Aerospace Science and Technology Corporation (CASC)[32] and China Aerospace Science and Industry Corporation (CASIC).

- CASC is a conglomerate of nearly 130 companies[33]. These companies are engaged in research, design and development of space technologies and systems. This includes fabrication of satellites and launch vehicles. CASC is also involved in development of strategic ballistic missiles with technology co-opted in launch vehicles. It also produces air defence (AD) equipment, ship to air missiles, unmanned aerial vehicles (UAVs) and surface to air missiles[34]. CASC comprises the CGWIC and eight major complexes known as academies.



CASIC at its core is a defence development agency for conventional weapons. A conglomerate of 140 companies, the CASIC has factories and research institutes under it. It is state owned and funded and deals with short and medium range ballistic missiles, cruise missiles[35], aerospace electronics and aerospace equipment. While it primarily deals with defence equipment, its technologies and products, components and evaluation services for software are also used by space industry.

Military Vertical of the Space Organisation

Till recently, China's military space organisation included the Central Military Commission (CMC), General Armaments Department (GAD) and the General Staff Department (GSD).

The General Armament Department (GAD) of PLA functioned under the Central Military Commission (CMC). It carried out the management of R&D and production of defence equipment, which include spacecrafts and launch vehicles. Under GAD was the China Satellite Launch and Tracking Control (CLTC), which directly controlled China's four launch Centres at Jiuquan, Xichang, Taiyuan and Wenchang[36] and the TT&C network. With the exception of lunar exploration programme (managed by SASTIND, a civil body), GAD was in control of China's all major space ventures. This included patronage to China Manned Space Agency (CMSA) which manages China's human spaceflight programme. The other functions of GAD included the following:-

- Formulating defence and space procurement/ acquisition policies.
- Administering China's space programme.
- Exploring technical solutions and overseeing defence industrial R&D and manufacturing.

The General Staff Department (GSD) acted as the headquarters of PLA and is responsible for the military's day-to-day operations, planning, training and mobilisation. It was the consumer of space products and collates demands of PLA's field formations. The GSD's role in China's space enterprise was to provide operational tasking to China's remote sensing, meteorological and communication

satellites. Space related roles of various departments of GSD were as under:-

- First Department, responsible for obtaining meteorological data.
- Second Department, responsible for obtaining imagery intelligence from satellites. It is collected by the Technology Reconnaissance Bureau (TRB)[37].
- Third Department, responsible for signal intelligence.
- Fourth Department, responsible for the Electronic Counter Measures (ECM) and Radar management. Its space related tasks include jamming of adversary's satellite communications and GPS signals.
- The Satellite Navigation Office, which has a Surveying, Mapping and Navigation Bureau. It is responsible for the management of Beidou satellite navigation system.
- Informatisation Department, responsible for satellite communications[38].
- PLA Second Artillery was involved in direct ascent kinetic kill missions and operation of mobile satellite launchers. It has now been rechristened as PLA Rocket Force.

On 31 December 2015, PLA commenced its eleventh major reorganisation. This has resulted in transforming key military organisations which control China's space activities. It also led to the formation of PLA Strategic Support Force (PLASSF) and overhauling the organisational set up for undertaking space ventures in China. Major reforms being undertaken in the space organisation post creation of PLASSF are discussed in succeeding paragraphs.

Creation of PLASSF and Reforms in Space Organisation

Soon after the Defence White Paper of May 2015 designating space as a military domain, China announced major military reforms related to its organisations and structure in December 2015. These military reforms resulted in China creating

five services ie People's Liberation Army (PLA), People's Liberation Army Navy (PLAN), People's Liberation Army Air Force (PLAAF), People's Liberation Army Rocket Force (PLARF) and People's Liberation Army Strategic Support Force (PLASSF). These reforms envisage replacement of the General Staff Department (GSD), the General Political Department (GPD), the General Logistics Department (GLD) and the General Armaments Department (GAD) with 15 new functional departments placed directly under the CMC. PLASSF has been created in order to carry out the integration of strategic capabilities. Formed by the merger of three domains ie space[39], cyber and electronic warfare (EW), the PLASSF is thus the nodal agency for conduct of China's informatized and intelligentized wars. Commenting on the creation of PLASSF, Xi Jinping stated that it was a new type of combat force to maintain national security and enhance PLA's capabilities.

Overall, the role of PLASSF is likely to include technical reconnaissance, electronic warfare, space-based warfare, innovation and missile R&D. PLASSF is envisaged to have two major organisations i.e., the Space Systems Department (SSD) responsible for conducting space operations and the Network Systems Department (NSD) responsible for cyber and EW. The space related functions of GSD and GAD are likely to be transferred to SSD. No concrete evidence exists as to whether units in Second Artillery responsible for direct ascent kinetic kill missions and mobile satellite launchers have been subordinated to PLASSF.

Further, the CMSA has not been placed under PLASSF. China has rather raised a new department called Equipment Development Department (EDD) to meet the developmental needs of its armed forces and CMSA has been brought under EDD. It is however nearly certain that satellite launch and control centres have been brought under control of PLASSF[40]. Therefore, the purpose of PLASSF is to launch and manage China's space based Command, Control, Communication, Computer, Intelligence, Surveillance and Reconnaissance (C4ISR) sensors. It is possible that PLASSF also has counter space units of PLARF (erstwhile Second Artillery) under its command.

PLASSF is primarily staffed by army personnel but is expected to support operations of all three services. Further, President Xi Jinping on raising of

PLASSF urged for civil-military integration which points to the fact that PLA will be prepared to even integrate civil entities into its folds.

China's Space Architecture

The China Satellite Launch and Tracking Control (CLTC)[41] is responsible for satellite launch operations. It comprises launch centres, Telemetry, Tracking and Control (TT&C) centres and launch vehicles. Details have been discussed in the succeeding paragraphs.

Launch Centres

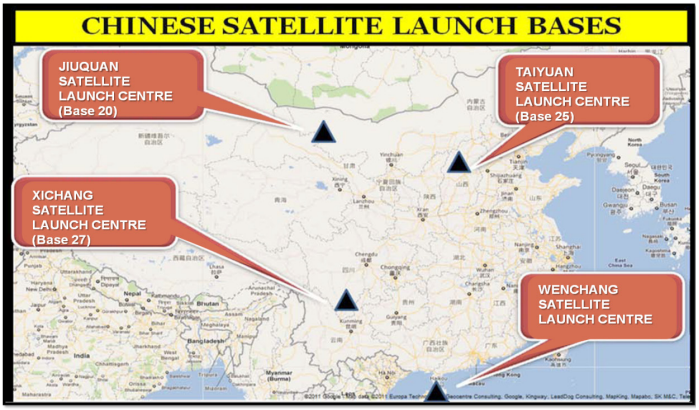
China has four launch centres[42]. Details of China's satellite launch centres are as under:-

- **Jiuquan Launch Centre.** Situated at the southern edge of Gobi desert in Kansu province, the Jiuquan satellite launch centre is also known as Base 20. The facility has three launch pads and can place satellites in LEO[43]. From Jiuquan, China launches most of its Intelligence, Surveillance and Reconnaissance (ISR) satellites and spacecraft involved in human space flight missions. It has also been developed for testing of surface to air and surface-to-surface ballistic missiles.

- **Taiyuan Launch Centre.** Also known as Base 25, this site is in Shanxi Province, Kelan county. From Taiyuan, China primarily launches meteorological, resource sensing and scientific satellites in LEO. The site has one launch pad. It has also been developed as a missile-testing site[44].

- **Xichang Launch Centre.** Also known as Base 27, the Xichang satellite launch centre is located in Sichuan province of southern territory of China. Used primarily for launching satellites in GEO[45], the centre has to its credit launch of some of the most prestigious missions like lunar orbiting probe and the DF-21 ASAT test conducted in 2007. From Xichang, China primarily launches commercial and communication satellites.

Wenchang Launch Centre. It is located on Hainan Island. It is used to launch heavy satellites and modules for the manned space programme. This launch centre's closer proximity to the equator enables launching of heavier payloads like the modules of space station project and bigger satellites.



Telemetry, Tracking and Control (TT&C) Centres

The TT&C Centres not only control and monitor China's satellites, but also enable China to track and target adversary's satellites. Such a capability can greatly augment China's ASAT operations in a conflict. TT&C operations are conducted primarily by two TT&C centres. Details are as under:-

- **Xian Satellite Monitoring and Control Centre (XSCC)**

  XSCC, also known as Base 26 is a satellite control facility located at Weinan near Xian[46]. It exercises command over geographically distributed stations which carry out TT&C tasks for satellites in LEO, GEO and experimental orbits.[47] It also controls three land based mobile TT&C stations.

- **Beijing Aerospace Command and Control Centre (BACC)**

  BACC acts as the nerve centre for space flight testing and manned space flight missions. It is also responsible for TT&C of the Shenzhou

spacecraft mission[48]. It exercises control over various TT&C stations located inland and abroad. BACC also controls the four Yuanwang TT&C ships located in the Sea of Japan (YW-1), at southern tip of South America (YW-2), Atlantic Ocean (YW-3) and Indian Ocean off Australia (YW-4).

Launch Vehicles

China has developed a wide array of launch vehicles to launch satellites in various orbits like LEO and GEO. Based on *Dong Feng*[49] intercontinental ballistic missile are the Long March (LM)-2C and LM-2D[50] rockets, which remain China's most commonly used launch vehicles for launches in LEO. The LM-2D and LM-2F are used to place light and medium satellites in GTO[51]. The LM-2F is also used to launch heavy satellites in LEO. It has been used to launch the Shenzhou spacecrafts. The LM-2G has been used to launch unmanned modules of Tiangong-1 and Tiangong-2 space laboratories. The LM-3 series[52] is used to launch medium and heavy satellites in Geostationary Transfer Orbit (GTO). The LM-4B and 4C provide for medium lift capability to China in LEO. In the LEO, China can lift 25 tons[53] of payload with LM-5B and 13 tons with LM-7.

In the GTO, the LM-5 can carry a payload of 14 tons. The LM-11, which made its maiden flight on 25 September 2015[54] is expected to be China's largest solid-

fuelled rocket and will enhance China's Launch on Demand (LoD) capability during conflicts. China has also been developing '*Kuaizhou*' (Quick Vessel) series of launch vehicles, based on DF-21[55] missile. Similar to LM-11, the Kuaizhou also provides China the LoD capability. To this effect, China launched Kuaizhou-1 (KZ-1) in September 2013.[56] China currently can launch a maximum payload of 25 tons in LEO and 14 tons in GTO. All launch vehicles of China are designated as 'Long March' and prefixed with the letters LM / CZ (in Mandarin). China's operational and developmental launch vehicles have been tabulated below:-

Launch Vehicle	Payload (Kg)		Remarks
	LEO	GTO	
LM/CZ-2C	2,400	-	
LM/CZ -2D	3,100	1,250	
LM/CZ -2F	8,600	3,500	Rated for human spaceflight
LM/CZ -2G	12,000	-	
LM/CZ -3A	6,000	2,650	
LM/CZ -3B	12,000	5,100	
LM/CZ -3C	-	3,800	
LM/CZ -3E	-	5,500	
LM/CZ -4B	2,500	-	
LM/CZ -4C	4,200	1,500	
LM/CZ -5	23,000	14,000	
LM/CZ -5B	25,000	-	Space station modules
LM/CZ -6	1,080	-	Sun Synchronous Orbit
LM/CZ -7	13,500	7,000	
LM/CZ -8	7,600	2,500	Not yet operational
LM/CZ -9	1,40,000	66,000	
LM/CZ -11	700	-	Ship launch variant successfully tested in
KZ-1	400 (SSO)	-	-
KZ-11	1,000 (SSO)	-	Planned 2021
Space Plane		-	Planned 2030

China's journey towards becoming a space power has been a constant struggle since its inception. But its rapid success is attributable to political patronage and national vision. From a modest beginning to its current pedestal, China has moved through the most awe inspiring journey in the domain of space. China is now moving steadily to meet all essential elements of its stated policies of winning *informatized and intelligentized wars*. It has also realised that harnessing the global space industry will bring not only commercial benefits but also accrue strategic gains. Having identified space as a strategic high ground, China is fast evolving into a space super power.

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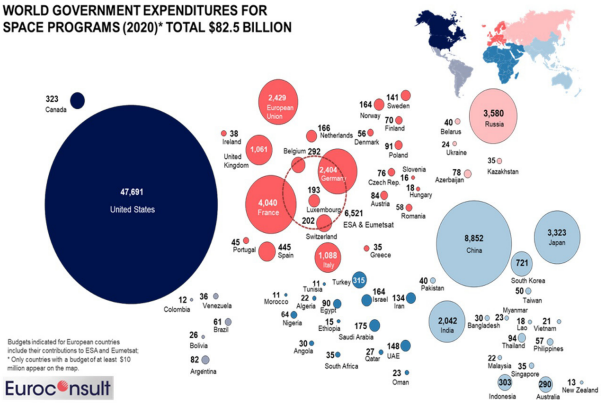
Dragon's Space Arsenal: Dominating the Strategic High Ground

"Beijing is clearly of the view that the country that leads in space may also be economically and militarily dominant on Earth."

- Congressional Report of US-China Economic and Security Review Commission, 2019.

Introduction

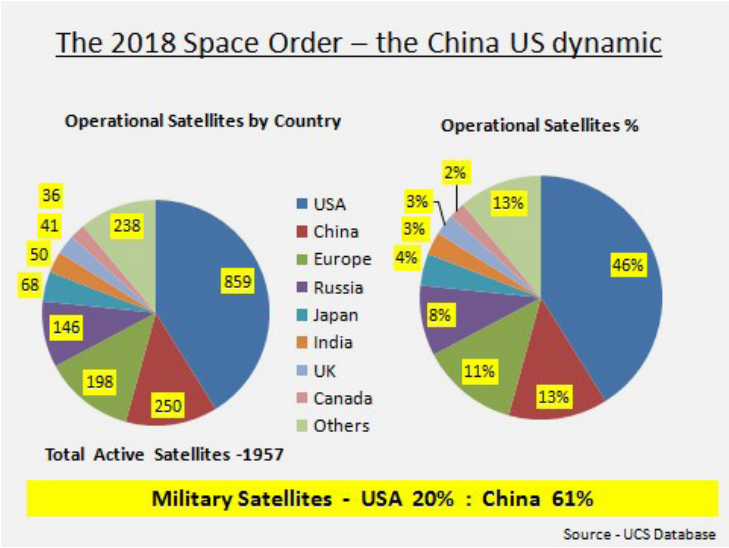
China launched its first satellite in 1970 and today it has become a major space power with a wide array of satellites and an advanced family of launch vehicles. It has a space laboratory and has successfully conducted human space flight missions. China's White Paper on space activities published in 2016 states that the country's space vision is "*to build China into a space power in all respects*"[1]. To accomplish this, China has increased its spending on space technologies and activities. China's expenditure on space projects is second highest in the world[2]. The world government expenditures on space in 2020 are depicted below:-



Source: www.euroconsult-ec.com

In the PLA's strategic thought reflected in their pamphlet '*The Science of Military Strategy*', the ability to control and exploit space, serves for both force enhancement and as a deterrent factor[3]. Therefore, establishing space dominance (*zhitianquan*) is an essential enabler for information dominance (*zhixinxiquan*) - a key pre-requisite for fighting wars under informatized conditions[4]. This alludes to China's intentions of using space as a new war fighting domain[5].

To realise its intent, China has been developing multiple types of space capabilities to include high resolution Electro Optical (EO) sensors, Synthetic Aperture Radars (SAR), Electronic Intelligence (ELINT) sensors and navigation satellites. China is also investing heavily in the development of quantum communication satellites[6]. China is second only to USA in the number of operational satellites. Although US has three times higher number of satellites than China, but if we compare only military satellites, then the difference is very narrow.



Apart from space based force enhancement applications, China is concurrently developing niche counter space capabilities, robust space situational awareness and quick launch capabilities. China realises that space dominance will be a vital factor in securing air, maritime and electromagnetic dominance and it will directly affect the course and outcome of future wars[7]. As per US Defence Intelligence Agency (DIA) report released in 2019, China is building space capabilities in

a way to deter other nations from interfering in military conflicts in the Asia-Pacific region[8]. China's Military Space capabilities can be discussed under ISR (Intelligence, Surveillance and Reconnaissance), Position, Navigation and Timing (PNT), Satellite Communication (SATCOM) and counter space capabilities. Apart from this, there are allied fields to support and augment military operations from space to include meteorology, Space Situational Awareness (SSA) and Quick Response Mechanism (QRM).

Space Based Intelligence, Surveillance and Reconnaissance (ISR)

China employs a robust space-based ISR capability designed to enhance its worldwide situational awareness. It is used for civil and military remote sensing and mapping as well as terrestrial and maritime surveillance. Space-based C4ISR figures prominently in Chinese writings and is often considered a critical component in extending China's power projection capabilities. As China's military is increasingly employed to conduct operations farther from its mainland, the utility of space becomes all the more important. China has been working persistently towards gaining a strong foothold in the space arena in order to use it as a strategic outpost. String of advanced satellites with wide spectrum of ISR capabilities serves PLA as "eyes and ears" to keep a tab on the adversaries and complements its strategy of informatized and intelligentized warfare.

China began working on satellite imagery in the mid-1960s, launching its first ISR satellite in 1975. Presently, China operates an extensive network of military ISR satellites. Prominent satellite constellations for ISR applications have been discussed in succeeding paragraphs.

Yaogan ISR Constellation

Yaogan satellites, launched by China from 2006 onwards, provide it global surveillance capability. These satellites are completely owned and controlled by PLA and form an important component of its Anti-Access Area Denial (A2AD) strategy. The Yaogan constellation comprises satellites, which are a mix of Electro Optical (EO), Synthetic Aperture Radar (SAR) and Electronic Intelligence (ELINT) satellites[9]. Details of Yaogan constellation are given below:-

- **Triplet Clusters of ELINT Satellites.** These triplet clusters of ELINT satellites enable coarse tracking of targets such as an Aircraft Carrier Group (ACG). These satellites pick up electronic transmissions and are able to locate the position of targets by triangulation method. Considering the mission life of these satellites to be 5-7 years, at least six clusters are likely to be currently operational viz Yaogan 20 (A,B,C), Yaogan 25 (A,B,C), Yaogan 31-1 (A,B,C), Yaogan 31-2 (D,E,F), Yaogan 31-3 (G,H,I), Yaogan 31-4 (J,K,L) and a pair of Yaogan 32 satellites.

- **Broad Area Coverage EO Satellite Cluster.** This cluster comprises EO satellites at an altitude of 1200 Km. They have a broad swath and a medium resolution of 3 to 10 meters. Three such satellites are likely to be currently operational viz Yaogan 22, 27 and 34[10].

- **High Resolution EO Satellite Cluster.** This cluster comprises satellites at an altitude of 500-600 Km and with a resolution of 1 to 3 meters. Five satellites are likely to be currently operational in this cluster viz Yaogan 21, 24, 26, 28 and 30.

- **SAR Cluster.** These satellites are at an altitude of 500-600 Km and they utilise a high resolution radar to capture images both during day and night. Three such satellites are likely to be currently operational viz Yaogan 23, 29 and 33R.

Ludikancha Weixing (LKW) Satellites

The LKW series of satellites comprises **four** military satellites launched by China between 2017 and 2018. These satellites have been placed at an altitude of 500 Km and are very similar to the Yaogan high resolution EO satellites.

New *Yaogan-30* Theatre ELINT Constellation

China has launched ten triplets of this ELINT constellation known as Yaogan-30 between 2017 to 2021. These triplets have been placed at an altitude of 600 Km and an inclination of 35 degrees. This constellation provides constant electronic

surveillance to China over land and sea covering Taiwan, Korean peninsula, Japan's southern waters, Guam, ASEAN countries and Indian Ocean[11].

Gaofen Satellites

The Gaofen series comprises both EO and SAR high resolution satellites, capable of providing imagery with sub-meter resolution. The Gaofen family of high-resolution Earth Observation satellites are part of the China High-definition Earth Observation System (CHEOS) meant for civilian purposes, with the first satellite launched in 2013. While these were developed for non-military usage but their payload and resolution render them dual applicability. Sixteen Gaofen satellites (EO-14, SAR-02) are currently operational.

Jilin Satellites

Jilin satellites are designed to be light weight commercial remote sensing satellites with HD video and EO sensors of approximately metric resolution and are being fabricated by Chang Guang Satellite Technology Company. Nineteen Jilin satellites are currently operational. The company had planned to launch 60 satellites by 2020 giving a revisit of 30 minutes and 138 by 2030 with a revisit of 10 minutes, but the project is running behind schedule. These satellites also have dual applicability, for both civil and military usage.

Shijian Satellites

Owned and operated by China's Academy of Space Technology (under CASC)[12], these satellites have a variety of configurations and missions. Although some have been used for civilian purposes, many appear to be having military ISR payloads due to their orbital characteristics and the secrecy surrounding their launches. Some Shijian satellites are also utilised to experiment contemporary technologies like ion and electric propulsion, Signal Intelligence (SIGINT), missile tracking payloads and counter space applications like Rendezvous and Proximity Operations (RPO). Based on mission life, seven Shijian satellites are currently operational.

Tongxin Jishu Shiyan (TJS) Early Warning Satellites

From 2016 onwards, China has launched five satellites of the TJS series in the Geo-Stationary Orbit. These satellites provide early warning of the launch of ballistic missiles. Thus, bridging the gap in China's early warning capability for their BMD programme[13].

Space Based Position, Navigation and Timing (PNT)

The 1991 Gulf War and subsequent US military operations illustrated the value of the Global Positioning System (GPS) for troop movements, force tracking and precision guidance. This prompted other countries to develop their own satellite navigation systems. Today, satellite navigation services are critical to military and civilian users worldwide, with applications in land, air and sea navigation, munition guidance, surveying and mapping, search and rescue, tracking and numerous other applications.

In 1994, Chinese government gave the go-ahead for the development and deployment of an experimental satellite navigation system called 'Beidou-1'. The first pair of satellites, known as Beidou-1A and Beidou-1B, were launched in 2000 and a third backup satellite Beidou-1C in 2003, making the system fully operational. The Beidou-1 services became available to civilian users in 2004. Thus, China became the third country in the world after USA and Russia to have deployed an operational Space-based navigation and positioning network. Subsequently, Beidou-2 was planned with ten satellites. By 2012, Beidou-2 started providing regional positioning services covering China and Asia Pacific region. It has two kinds of services, a civilian service with positional accuracy of 10 meters, velocity accuracy of 0.2m/s and timing accuracy of 50 nano seconds. Strategic users are provided better accuracies.

Beidou-3, China's next generation worldwide satellite navigation project commenced in 2017. Beidou-3 was conceptualised as a constellation of 35 satellites with the projected date of completion by end 2020[14]. China was successful in meeting this timeline with the launch of the last satellite of this constellation on 23 June 2020. The Beidou constellation also offers text messaging

and user tracking through its Short Message Service (SMS), to enable mass communications for specific Beidou users and provide additional command and control capabilities for PLA[15]. Director of China Satellite Navigation Office, had quoted that they are aiming for positional accuracy of 2.5m, which will further be improved to centimeter level with additional ground stations[16].

Beidou was originally designed exclusively for military purpose in order to reduce reliance on foreign PNT services. However, it has now turned into a commercial opportunity with its expanding reach. Chinese government has enunciated policy measures to ensure Beidou integration with current PNT based applications in civilian domain. It has coverage along the Belt and Road Initiative (BRI) countries, thereby incurring massive income for China by providing Beidou services to participating nations.

Satellite Communication (SATCOM)

China's initial Command, Control and Communication (C3) modernisation efforts were focused on developing a robust and secure terrestrial network of fiber optic cables, mobile radios and data-links. However, after realising the importance of space during the gulf war of 1991, China enhanced the scope of modernisation by including space applications in its modernisation plans. China has been investing in advanced space based communication capabilities, as nearly all of China's strategic goals and military plans rely on information dominance. The prosecution of Anti-Access Area-Denial (A2AD) strategy is impossible without an advanced space based and terrestrial C3 network. Development of China's communication satellites started at the beginning of 1970s and their first geo-stationary communication satellite was launched successfully in 1984. Initially, the technical threshold of Chinese communication satellite payloads was much lower than that of advanced countries, however they have gradually developed critical payload technologies like high power transponders, on-board processing, multi-beam antennas, controllable spot-beams, shaped-beam antennas and inter-satellite relay capabilities.

China is currently using a large number of communication satellites for both its civilian and military requirements. Civilian Chinese operators providing SATCOM

services are Asia Broadcast Satellites (ABS), Asia Satellite Telecommunication Company (Asia Sat), China Telecommunication Broadcast Satellite Corporation (China Sat) and also from Hong Kong based Asia Pacific Satellite Company (AP Star series). Fabrication of satellites is being done by Chinese agencies like China Great Wall Industrial Corporation (CGWIC), China Aerospace Science and Technology Corporation (CASC) and by foreign vendors like Hughes, Lockheed Martin etc. Altogether, China utilises hundreds of transponders in C, Ku and Ka band for servicing its enormous civil and military SATCOM requirements.

China's specific defence SATCOM requirements are also being met by PLA operated satellites[17]. CASC has developed the *Fenghuo* (FH) and *Shentong* (ST) series of military communication GEO satellites to provide secure voice and data communications for military users. Fenghuo is a family of tactical communications satellites. These satellites are used to support a theatre-level C3 network called '*Qudian*'[18]. Fenghuo satellites provide C and UHF band communications. Shentong is a family of strategic communication satellites, providing secure voice and data communications in the C and Ku band.

The mission life of a GEO satellite is normally planned for ten years. Accordingly, replacement satellites are launched. Going by the date of launch, it is evident that presently China has five dedicated satellites to meet its military communication requirements apart from utilising transponders from a vast array of civil communication satellites.

China launched its first data relay satellite, Tianlian (TL)-1, in April 2008. It was followed by TL-1A in 2008, TL-1B in 2011, TL-1C in 2012 and TL-1D in 2016, to complete global coverage for its data relay system. In March 2019, China launched its first satellite of the TL-2 series, a new family of bigger, more capable data relay satellites to link ground controllers with Chinese Shenzhou spacecraft capsule and China's planned space station[19].

China has been making a focussed effort to develop niche capabilities in the SATCOM domain in order to fill its present capability voids and further gain a technological edge in space over its adversaries. China's state-owned satellite

operator 'China Satcom' currently operates a fleet of 10 GEO communication satellites. It has been making huge investments in the development of high-throughput satellites (HTS) and LEO satellite constellation for communications. It had launched SJ-13 (Shijian-13) also known as ChinaSat-16 to test electric propulsion for future satellite buses. China faced a setback in the launch of ChinaSat-18, as this HTS encountered solar panel problems soon after its launch in August 2019. China Satcom is also part of a joint venture for development of the *Hongyan* constellation of 320 small satellites to provide LEO communication services. The first prototype satellite of the Hongyan constellation was launched in December 2018. With the present and future planned array of sophisticated satellites, China Satcom is gearing up to support the country's ambitious Belt and Road Initiative (BRI), thereby highlighting the strategic nature of the entire programme[20].

Importance of secure communication for the armed forces cannot be over emphasised. The recent developments in Quantum communications could potentially prove to be of immense significance for ultra-secure communication network and the Chinese have been researching in this field extensively. Quantum Cryptography can be used to transmit secret messages between two points by 'Quantum Key Distribution' method in which photons are used to transfer the data[21]. Chinese have adopted the twin approach of attempting quantum communications using both optical fibers (terrestrial) and outer space. They established a 712 Km Quantum communication link in November 2016 between Hefei and Shanghai[22] and to enhance the ranges, launched a 'Quantum Experiment at Space Scale' (QUESS) or 'Micius', a 500 Kg satellite into LEO on 16 Aug 2016[23]. Micius satellite is a technological demonstrator for hack-proof communication and China's National Science Center has announced the launch of additional quantum satellites to realise a secure network for both civilian and defence applications.

China is pursuing parallel programmes for military and civil communication satellites. China continues to launch new satellites to replace its aging satellites and increase its overall satellite communications bandwidth, capacity, availability and reliability. Adequate, robust and reliable satellite communication will enhance PLA's C3 capabilities especially while operating in remote and

inaccessible areas where terrestrial communications are difficult. Dedicated military communication satellites will also enhance the reach and footprint of PLA Navy in the Indian Ocean region.

China's Counter-Space Capabilities

China's counter space developments are coherently and asymmetrically designed to mainly counter a far more technologically advanced adversary's capability. China is pursuing an array of counter space projects, which include direct ascent anti-satellite missiles, co-orbital anti-satellite systems, directed energy weapons (DEW), cyber attack capabilities and ground based satellite jammers[24]. During a conflict, China would employ a combination of 'hard attacks', which use kinetic methods to cause permanent and irreversible destruction of a satellite or ground support infrastructure and 'soft attacks', which use non-kinetic methods to temporarily affect the functionality of a satellite or ground systems. These have been discussed in the succeeding paragraphs.

Direct Ascent Anti-Satellite (ASAT) Missiles

In January 2007, China tested a direct ascent kinetic-kill missile (SC-19) against a defunct FY-1C weather satellite[25]. The test demonstrated China's ability to strike satellites in LEO. Since then, China has conducted four anti-satellite tests for engaging targets in LEO (160-2000 Km altitude) in between 2010 to 2014. On May 13, 2013, China is reported to have tested a direct ascent ASAT weapon at an altitude of 10,000 Km. It was a cold test with no impact or debris. It is expected that this rocket could be made to reach 30,000 Km to threaten GEO satellites.

Co-orbital Anti-Satellite Systems

These systems consist of a satellite armed with a weapon such as an explosive charge, fragmentation device, kinetic energy weapon, laser, radio frequency weapon, jammer or robotic arm. Once a co-orbital satellite is close enough to a target satellite, the co-orbital satellite can deploy its weapon to interfere with, disable or destroy the target satellite. Co-orbital satellites also may intentionally

crash into the target. These systems provide several advantages over direct ascent anti-satellite weapons, including their ability to be used to target satellites in every orbital regime, generate less debris, conduct attacks without geographic limitations and limit escalation, as many co-orbital attack options are reversible and offer plausible deniability.

Chinese satellites have conducted co-orbital manoeuvres in 2008, 2010 and 2013. On July 20, 2013, China launched three satellites: the Shiyan-7 (SY-7), Chuangxin (CX-3) and Shijian-15 (SJ-15). SY-7 initially flew close to SJ-15, then it changed orbit, coming closer to CX-3. SY-7 also carried a robotic arm which the Chinese claimed was for proving in space manipulation technologies. However, in anti-satellite role, it could also be utilised to alter the orbit of target satellites or cause damage to them[26].

Directed Energy Weapons (DEW)

China has been committing substantial resources to research and development (R&D) for directed energy weapons, including those that could be used for anti-satellite missions, since the 1990s. DEWs can deliver concentrated energy along a line-of-sight trajectory at or near the speed of light to damage or destroy equipment, facilities and personnel. In 2006, China is suspected to have fired a laser at a US satellite, resulting in a temporary degradation of its functionality.

Cyber Attack

The Chinese are also developing systems to degrade or damage data links that connect satellites to ground stations[27]. Space dominance can be achieved if a key satellite is shut down, its mission payload is pointed in the wrong direction or it is unable to communicate at critical moments. Indeed, this may be a preferable option, since attribution may be difficult and such approaches are unlikely to generate space debris. PLA during a conflict would attempt to conduct cyber attacks against satellites and ground-based facilities that interact with satellites. These, cyber attack capabilities are an integral part of China's counter space capabilities.

Ground Based Satellite Jammers

Since the mid-2000s, China has acquired a number of foreign and indigenous ground based satellite jammers, which are designed to disrupt an adversary's communications with a satellite by overpowering the signals being sent to or from it. PLA may employ jammers to degrade or deny an adversary's satellite link during operations.

China's journey towards becoming a space power has been a constant struggle since its inception. But its rapid success is attributable to political patronage and national vision. From a modest beginning to its current pedestal, China has moved through the most awe-inspiring journey in the domain of space. The Chinese strategic thought envisions that the commanding height of strategic competition would be in space. China's rapid growth and success in space is attributable to political patronage and national vision. Chinese believe that as important as it is to possess advanced space based ISR capabilities, it is equally important to deny these capabilities to their opponents in a combat situation. This is of paramount importance for gaining superiority. Thus, China is developing systems and technologies that can interfere with or disable vital space-based navigation, communication and intelligence satellites of an adversary. Thus, the PLA is moving steadily to meet the essential elements of 'winning informatized wars'. The strides made by China in its space and counter-space capabilities pose a potential threat to India's space assets and national security.

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China's Military Space Strategy

Introduction

While the visible elements of China's space programme include its launch vehicles, launch sites, satellite systems and Anti-Satellite (ASAT) tests, its military space strategy has never been enunciated through any official document. Though China has not released any official document on the subject, steep rise in its military space capabilities which include Command, Control, Communication, Computer, Intelligence, Surveillance and Reconnaissance (C4ISR) capabilities, development of advanced launch vehicles, implementation of a successful satellite navigation programme (Beidou) and a structured counter space programme, raise suspicion about its appreciated military space strategy.

'Peoples' War' to 'Informatized War'

In the aftermath of World War II and Korean War, Mao felt that world was on the verge of another major war [1]. Riding on the success of 'Peoples' War' he felt that militia forces fighting guerrilla wars could be China's response to two military giants, i.e., Soviet Russia and the USA. The focus was thus on terrestrial conflict and lesser sophistication and not on a technology driven and capital intensive military space programme. In 1985, Deng Xiaoping in his assessment of

international situation observed that in future, conflicts were likely to be localised and intensive. This understanding of international scenario made Chinese planners focus on well defined smaller areas, generally on China's borders. This also helped them set limited goals and develop weapons specific to a localised conflict zone.

This was also the time when the world was analysing the Yom Kippur war, the Falklands war and also the Vietnam War. Lethality of weapons had grown multi folds and ways of fighting wars had modernized. Therefore, Chinese planners proposed the idea of 'local wars under modern conditions'[2]. This was followed by Deng Xiaoping's Plan 863 [3] also known as '*National High-Technology Research and Development Plan*'. Amongst other areas, Aerospace industry was also identified as one of the fields for key resource investment.

Post Gulf War-1991, the strategy of local wars under modern conditions, was upgraded to the concept of 'local wars under modern, high-tech conditions' in the Peoples Liberation Army (PLA) document of 1993 '*Military Strategic Guidelines for the New Period'*. It laid emphasis on joint operations, long-distance strikes and mobile operations. A very high degree of importance was also given to command, control, communications and intelligence (C3I). It was at this juncture that capabilities in space were identified as key players in modern wars under high-tech conditions. During Gulf War 1991, US is known to have used over 70 satellites for strategic intelligence and communications. It is in context of this US dominance in Space that a Chinese analyst observed, "before the troops and horses move, the satellites are already moving." [4]

In 2001, the PLA military pamphlet, '*The Science of Campaigns*' introduced the concept of '*integrated operations and key point strikes*' [5]. While 'integrated operations' were aimed at integrating all types of forces and operational domains, 'Key Point Strikes' was a concept related to employment of concentrated forces at a critical time against crucial targets with the aim of crippling the adversary's war waging potential [6].

In 2004, Hu Jintao[7] enunciated his '*new historic missions*' for PLA wherein he emphasised on the utilisation of space for national security. It was during this time that the Chinese Defence White Paper in 2004 [8] upgraded the concept of 'local wars under modern, high-tech conditions', to '*local wars under informatized conditions*'. It also identified that space is one of the essential elements for executing the technology driven informatized warfare which included communications, precision strikes, anti-access area denial (A2AD), C4ISR and jointness of all forces [9].

In the 2006 edition of the PLA's pamphlet, '*The Science of Campaigns*', the concept of 'integrated operations and key point strikes' was upgraded to "*integrated operations and precision strikes to control/constrain the enemy*[10]." This concept was aimed at gaining control of an area/zone of conflict. The pamphlet stated that space was becoming a vital battle-space and a new strategic high ground.

The Vice Chairman of CMC, General Xu Qiliang, in 2009 stated that space had emerged as the "new commanding height for international strategic competition[11]." He emphasised that gaining control over space was essential to gain strategic initiative. In 2015, the Chinese Defence White Paper further upgraded their military strategy from winning 'local wars under informatized conditions' to '*winning informatized local wars*' thus changing the war fighting canvas [12].

Informatization to Intelligentization

Informatization refers to exploitation of high-end technology for the planning and conduct of military operations. Its components include computers, networks, sensors and communications [13]. It not only supports conventional operations but has evolved into a new domain known as Information Warfare (IW). Major General Peng Guangqian and Major General Yao Youzhi are both retired major generals of PLA and authors of '*Science of Strategy*' published in 2001 and '*The Science of Military Strategy*' published in 2005. According to them, the strategy in IW should be focused towards seizing and maintaining information superiority.

The aim being to achieve strategic goals by way of information control and information attack including sabotage and destruction of infrastructure and information systems of the adversary. China's Defence White Paper of 2013 states that, reforms are being implemented in PLA to enable it to perform its missions and tasks as an informatized military.[14]

Major General Wang Pufeng, the architect of China's IW [15] opines that IW is the result of information age, which uses information technology in the battlefield. It comprises 'networkisation' (wangluohua) of the battlefield and a contest between time and space. It constitutes the struggle to control the informatized battlefield in order to influence the course of war. General Dai Qingmin published an article in '*China Military Science*' in 2002 [16] in which he proposed six forms of IW. These included deception, operational security, computer network attacks, intelligence, electronic warfare and physical destruction. Together with these forms of IW, General Dai also put forth the idea of Integrated Network Electronic Warfare (INEW) which is a concept similar to US' Network Centric Warfare (NCW) and aims to achieve superiority in information by integrating network warfare with electronic warfare (EW).

China views information superiority, which includes denying information to its enemies, as critical to success on the battlefield. President Xi Jinping gave the theory of 'Intelligentization'. In his report to the 19th Party Congress in October 2017, he urged the PLA to "accelerate the development of military intelligentization and improve all-domain joint operation capabilities based on network information systems." The information age had produced the concept of informatized warfare which was the basis for PLA's development since the early-2000s. Now Chinese military leaders believe that informatized war is evolving and 'intelligentized warfare' will become the prevailing form of war. That would be the guiding principle for the future of Chinese military modernization. As such, an '*Intelligentized Warfare*' campaign that goes beyond informationized to target and degrade systems with emerging technologies, such as artificial intelligence, is paramount for PLA.

China's Appreciated Military Space Strategy

Having envisioned space as one of the key contributing domains to informatized and intelligentized wars, China appears to have crafted its military space strategy to meet its geo-political and national security objectives of attaining pre-eminence on the world stage. The contours of China's appreciated military space strategy have been discussed in the succeeding paragraphs.

Regional Power Projection. In the realm of soft power, China has used its space assets to monitor and conduct humanitarian assistance and disaster relief programmes in Bangladesh, Nepal, Pakistan, Dominica, Antigua and Barbuda. It has also employed Gaofen [17] and Haiyang satellites for counter piracy operations and securing sea lanes of communication in the Gulf of Aden and South China Sea. Even China's Belt and Road Initiative (BRI) is expected to have a linkage to space, with vehicle tracking and trans-shipment being controlled through satellites. This soft power is often complemented with hard power when Chinese frigates frequent the disputed Senkaku Islands or blockade the approaches to Scarborough Shoal. In the disputed waters of South China Sea, China has bred a number of fishing militia. These militia are given free satellite communication sets and navigation devices and are enticed with higher payment if they volunteer to fish at distances far off from main land in the disputed waters claimed by China[18]. With the phenomenal growth in naval capabilities, PLA Navy (PLAN) assisted by space assets is increasing its maritime footprint in littoral South Asian countries like Bangladesh, Maldives, Myanmar, Pakistan and Sri Lanka.

Prosecution of Informatized and Intelligentized Warfare through Space. Space based assets have the capability to support key military functions like communication, navigation and surveillance. Therefore, space emerges as the backbone of informatized and intelligentized wars. In its report, the US-China Economic and Security Review Commission[19], while highlighting the role of space in PLA's concept of informatized war, observes that a reliable, space-based C4ISR system is a vital component of an informatized PLA. The need for PLA to develop space-based C4ISR systems is based on the requirement to achieve

precision strike and power projection capability. The development of anti-ship ballistic missiles and long range cruise missiles entails the acquisition of capability to locate, track and target adversary frigates at long ranges and the ability to coordinate these operations with the units of multiple services. In the conduct of operations, remote sensing satellites will provide intelligence on adversary dispositions and the requisite strategic intelligence before the commencement of war. Communication satellites will provide the required connectivity for effective command and control. Navigation satellites will provide indigenous and reliable capability to conduct the manoeuvre battle and precision strikes. Space should thus be viewed as a key player in the PLA's informatized and intelligentized warfare concept.

Anti-Access Area Denial (A2AD). China's A2AD refers to restricting the adversary's access to key locations identified as strategic in nature. It is executed with a design to ensure that the adversary is forced to engage Chinese forces from a stand-off distance in the waters claimed by China in the South and East China Sea. The execution of A2AD strategy calls for information superiority. While ground and sea based assets play a substantial role, space based C4ISR and navigation assets form the backbone of China's information superiority mechanism for prosecution of its A2AD strategy. The eight pillars of A2AD strategy enunciated by Anthony Cordesman are: cyber operations, information operations, long-range precision strikes, surface and undersea operations, ballistic missile defense (BMD), space and counter-space operations, air defense and the air operations[20]. These eight pillars of A2AD strategy have linkages with space for their successful conduct. In order to execute A2AD, China needs to engage targets in deep seas far from its mainland. China has developed various sea and land based Anti-Ship Ballistic Missiles (ASBM) like the DF-21D[21] to suit such operations. However, the success of these missiles would require precise target information and tracking which is being facilitated through space. China's ASAT programme is another facilitator to its A2AD strategy[22]. With a capability to disrupt or destroy the adversary satellites, PLA can reduce the effectiveness of adversary in this strategic area. Thus, China's ASAT programme would help China to attain information dominance over an adversary.

Ballistic Missile Defence (BMD). Another employment of China's space based assets is in the field of BMD. China has launched the Tongxin Jishu Shiyan (TJS) and Gaofen[23] satellites, some of which have infra-red payloads meant specifically for detecting the launch of ballistic missiles. Such satellites will prove to be the eyes and ears of China's BMD programme. The acquisition of satellite based ballistic missile early warning capability may lead to a change in China's nuclear doctrine from 'no first use' to 'launch on warning'. Presently, China's nuclear doctrine is based on retaliation only after the first nuclear strike from an opponent. However, a 'launch on warning' system would make China's nuclear arsenal more survivable, but there are possibilities of false warnings which could make it catastrophic.

China's Counter Space Strategy

Objectives. Capabilities in space have now begun to gain overbearing importance in the conduct of operations by modern militaries. A successful first strike launched without warning by a weaker party on the adversary's space assets can bring military advantages out of proportion. The attack so brought upon can bring crippling affect on the command and control architecture of the adversary. In this backdrop, the development of ASAT weapons by China can be viewed as part of its strategy to counter the military advantage accrued by the US forces relying heavily on satellites for their overseas operations. The objectives of China's counter-space strategy can be understood by two different concepts propounded by geo-strategic thinkers. These have been discussed below:-

- It is well known that the US military is heavily reliant on space based assets for its overseas deployment and conduct of operations. Its C4ISR architecture, long range precision strike missiles and aircraft career groups are dependent on satellite links for surveillance, navigation and communication. One school of thought feels that China has identified an 'Achilles Heel'[24] in the US over reliance on space assets for their overseas operations. These assets if targeted could cripple US war waging potential in key locations that are of interest to China like the South and

East China Seas.

- The other school of thought feels that space dependence of US should rather be viewed in terms its overwhelming space capability and not an 'Achilles Heel'. These space capabilities give US a definite military advantage[25], specially in South China Sea, and therefore, China needs to acquire capabilities to deter the adversary and protect its own space assets. The PLA textbook '*The Science of Second Artillery Operations*' identifies that the US ability to use its satellites in military operations is a military advantage and should not be viewed as its weak link. While the use of ASAT weapons may degrade or erode such advantage, it is not expected to cripple US war waging efforts [26]. The objectives of China's ASAT weapons should therefore be understood to be merely for safeguarding its own space assets and not for targeting a US' weak link. Bao Shixiu, a Chinese military scholar at PLA Academy of Military Science has observed that an active defence against a formidable space power entails that China should possess asymmetric capability. According to him, China will adopt the same principles for space militarisation as it did with nuclear weapons. That is, it will develop anti-satellite weapons for disrupting or degrading the adversary's space system, as a reliable and credible defence strategy[27].

Rationale. China's likely rationale for pursuing a counter space programme and working towards the development of various types of ASAT weapons has been discussed below[28]:-

- **Direct Ascent ASAT Weapons.** In 2007, China tested its ASAT weapon destroying its own FY-1C[29] weather satellite at an altitude of 800 km. It is believed that China is refining its interceptors to acquire the capability to engage satellites at much higher altitudes in Medium Earth Orbit (MEO) and Geostationary Earth Orbit (GEO). This would entail that China shall be able to engage communication and navigation satellites orbiting in MEO and GEO and thus bring a crippling affect

on the command and control structure of the adversary.

- **Co-Orbital Satellites.** China is known to be acquiring the capability to deploy satellites in the same orbit as that of a target satellite. These satellites may be armed with an explosive charge, kinetic energy weapon, jammer, robotic arm, fragmentation device, radio frequency device or a laser. Such co-orbital satellites may use these weapons or even crash into the target satellite of the adversary to achieve their objective.

- **Directed Energy Weapons (DEWs).** China's efforts in this field are well known. DEWs comprise laser, microwave, particle beam and radio frequency weapons of intensity which can destabilise or alter functionalities of the adversary's satellites in space. However, the affect of DEWs is normally temporary in nature. China realises that whilst direct ascent ASAT weapons could be detrimental to its own space assets owing to the consequent debris, DEWs provide the best offensive counter space option since these are neither collateral nor attributable.

- **Cyber Capabilities.** China already has a fair degree of expertise in cyber capabilities. Possibility of employing cyber attacks against adversary satellites cannot be negated. Such attacks would give the Chinese access to the command and control of an adversary satellite, thus allowing them to degrade, deny or alter the transmissions made by the satellite.

Chinese Concept of Conducting Military Space Operations

Concept Adopted in 2005. Maj Gen Chang, author of the PLA textbook *'Military Astronautics'* published in 2005 has covered three key concepts of space operations for achieving dominance in space. These include *Unified Forces, Unified Techniques* and *Unified Operational Activities*[30]. Details have been discussed below:-

- **Unified Forces.** It has two facets. Firstly, unification of military and civilian space efforts and secondly integrating space capabilities with PLA's forces on land, sea and air.

- **Unified Techniques.** It refers to acquiring both soft-kill and hard-kill techniques in space. Soft kill techniques include dazzle, cyber attacks etc and Hard kill techniques include ASAT attacks or destruction of ground based space infrastructure.

- **Unified Operational Activities.** This refers to achieving coordination between the offensive and defensive space operations.

- **Concept Adopted in 2013.** The concept of space operations was revised in 2013 in PLA pamphlet, "*Science of Space Operations Teaching Materials*". The concepts of 'active defence' and 'all aspects unified' were now introduced for achieving space dominance[31]. These have been discussed below:-

- **Active Defence.** It seeks to deter aggression and maintain national security interests. It involves PLA undertaking preparations for space combat in order to seize initiative in space operations.

- **All Aspects Unified.** It refers to the need to unify thinking for the conduct of space operations. It involves viewing all military activities including space in an integrated manner for successful conduct of joint operations.

Conduct of Military Space Operations by PLA

According to Dean Chang, the conduct of space operations by PLA can be divided into four categories, viz., Space Information Support, Space Offensive Operations, Space Defensive Operations and Space Deterrence. These have been discussed below:-

- **Space Information Support.** It includes providing information from sensors based in space to air, ground and naval forces. The key tasks performed here include space based ISR, satellite communication, space

based position, navigation and timing, weather sensing and early warning of ballistic missiles.

- **Defensive Space Operations.** These operations are intended to defend own space assets and ground based infrastructure from the attacks of an adversary. Such a defence would be based on both active and passive measures. While active measures include air defence measures for safeguarding ground infrastructure, passive measures are largely related to satellites and include electronic hardening and shielding from dazzling and electromagnetic interference. These also include deception measures applicable for launch centres and Telemetry, Tracking and Control (TT&C) stations, building up redundancy both in space and ground assets and incorporating mobility to TT&C facilities.

- **Offensive Space Operations.** These operations involve attacking the adversay's assets both in space and on ground. This includes use of both Hard Kill and Soft Kill techniques. Likely targets could be the adversary's satellites, space stations, launch vehicles, launch sites and TT&C stations.

- **Space Deterrence Operations**[32]**.** These are intended to dissuade an adversary from acting against own space assets. Since space based capabilities complement nuclear capabilities, space deterrence acts as a powerful intimidating tool.

China has rapidly enhanced its space capabilities and is increasingly using its space prowess for military purposes. The range of China's space activities is indicative of its intent to play a leading role as global space power. Space is an important module of China's Comprehensive National Power (CNP) and is an integral part their doctrine of winning informatized and intelligentized wars. China's space programme is endowed with all the capabilities and is completely integrated. The civil and military space programmes are centrally directed. The space enterprise is more in the nature of a strategic programme and the predominance of the

military factor pervade the space efforts.

China's aspirations are driven by its assessment that space power enables the country's military modernisation and would facilitate PLA to challenge US information superiority during a conflict. China has asserted sovereignty over much of the East and South China Seas, as well as Taiwan and is engaged in a course of aggressive conduct to enforce those claims. China's space and counter space programmes are designed to support its A2AD strategy to effectively tackle likely US intervention in a potential conflict in this region. The Chinese realise that space capabilities could make all the difference between success and failure in military operations. Hence, they are working not only to achieve space force enhancement but also to gain space control. Consequently, they have attained robust military space capabilities as well as counter space capabilities.

Chinese strategists recognise that space capabilities are crucial to PLA's transformation into an informatized and intelligentized force. They assess that space systems would provide effective battlefield communication, surveillance, meteorological predictions and precision guidance functions, rendering 'space dominance' an essential component of realising 'information dominance.' China's military space strategy is rooted both in its civil and military space domain and aims to integrate their space activities through a cohesive approach. Even its military modernisation programme is underscored by proactive steps in space organisations and enhanced space utilisation in the conduct of military operations by PLA. China has taken its place amongst the front runners of space faring nations. A well conceived military space strategy duly supported by strategic vision at the national level can be credited for this achievement.

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Ramifications of China's Military Utilisation of Space on India's Security and the Recommended Response Strategy for India

The Threat Landscape

China propagates the use of space for peaceful purposes in all international fora and in their White Papers on Defence, but their Space developments do not match this rhetoric. China carried out an ASAT test in 2007 [1]. Subsequently, it is reported to have carried out missile interceptor tests in 2010 and 2013 with an SC-19 missile as the kinetic kill vehicle. There are also reports of the launch of a rocket that reached an altitude of 10,000 Km from Xichang launch centre in May 2013 [2]. It is expected that this rocket could be made to reach 36,000 Km to threaten an adversary's GEO satellites. In July 2013, China conducted satellite manoeuvres[3], wherein one of the satellites lowered its orbit and made a rendezvous with another satellite. This manoeuvring satellite was also fitted with a robotic arm, which could be used to capture or damage adversary satellites. Such tests are indicative of China's covert counter-satellite programme.

Reports also indicate that in another demonstration of technological breakthrough in ASAT capability, China had destroyed the control chip of a Japanese spy satellite by using Electro-magnetic Pulse (EMP) energy. This indicates a fairly high level of competence in the electromagnetic field and China's prowess in attacking/degrading the adversary's space assets. China is also reported to be developing

laser and radio frequency (RF) based Directed Energy Weapons (DEW) [4] and Very High Frequency (VHF) satellite signal jamming devices capable of striking LEO satellites.

China has tested its capability to launch micro-satellites at short notice for replacement its defunct satellites, thereby ensuring redundancy in its space capabilities during hostilities. This Quick Response Mechanism (QRM) capability was tested with Kuaizhou-1 launch vehicle in September 2013 [5]. Kuaizhou-1 is a low cost satellite launch vehicle and can be assembled within a few hours. Kuaizhou programme, operated by the PLA Rocket Force, involves pre-positioning of launchers with specific satellite payloads at selected locations in China.

China is enhancing its electronic maritime surveillance capabilities for scanning the South China Sea and the Indian Ocean. The Yaogan series of satellites will provide China the ability to enhance its intelligence, surveillance and reconnaissance over a large ocean expanse to locate, track and attack ships and aircraft carriers with anti-ship ballistic missiles designed to attack moving targets on high seas.

Beidou-3 with 35 satellites became fully operational for global coverage with the launch of its final satellite on 23 June 2020 [6]. It is believed that China has begun equipping PLA, including the PLA Rocket Force, which handles China's strategic nuclear arsenal with the Beidou system, which is being utilised in the short range (DF-11 and DF-15 missiles with 600 Km range) and intermediate range Anti-Ship Ballistic Missile (DF-21 missile with 2000 Km range) as also in the CJ-10 cruise missiles.

India's Operational Imperatives

National security is a dynamic interplay of a variety of external and internal considerations. Increasing dependence on space assets mandate the need to focus on ensuring the security of these assets. We need to develop the means to deter and defend against hostile acts 'in, through and from' space. We should be able to achieve space capabilities to deter any hostile action targeting our space assets and

should deterrence fail, be able to execute appropriate counter measures. Future operations would be largely technology dependent. Accurate and real time ISR followed by speedy force application in a network centric environment would prove decisive. Cyber and space based operations would provide the cutting edge in any conflict. In view of the foregoing, the operational imperatives for national security related to space, emerge as under:-

- Near continuous surveillance of India's land and sea borders and the Indian Ocean.
- Counter the adversary's Ballistic Missile threats by developing Early Warning capability.
- Deter and defeat any attacks by joint operations, exploiting network enabled space based capabilities.
- Counter low intensity conflict and terrorist threats along the borders and within the country by space based Signal Intelligence (SIGINT) and Geographical Information Systems (GIS).
- Develop capabilities in Positioning, Navigation and Timing (PNT), communication, meteorology and Space Situational Awareness (SSA).
- Exploit space based tools for humanitarian support and aid to civil authorities, including crisis and disaster management.
- Maintain influence over the Indian Ocean region by space based surveillance.
- Foster neighbourly and good relations in South Asia by sharing of space based applications.

Ramifications for India's Security

India is ranked sixth in the world in terms of space budget and technological capabilities, behind US, Europe, Japan, Russia and China. Space has become an integral element of India's scientific and security architecture and it is likely to

grow significantly in the near future. The growth of Indian Space programme will also contribute significantly to the economic growth of the country. However, with our growing space assets, the challenge to protect these assets is equally daunting. The nation's security interests as well as economic development depends on the security of these assets and it is evident that space security is emerging as an important element in India's national security matrix. Besides, India cannot remain immune to the rapidly changing international security environment and the threat to its national security from the rapid growth in China's space and counter-space capabilities. The ramifications to India's security from China's rapid strides in space have been covered in the succeeding paragraphs.

China's Regional Power Projection. Advanced space capabilities facilitate China to project its power in the Indo-Pacific region. This includes projection of soft power by monitoring humanitarian assistance and disaster relief operations in the countries of South Asia and South East Asia. It also includes the projection of hard power by employing PLA Navy to patrol the sea lanes of communication in the Indian Ocean, anti-piracy operations in the Gulf of Aden and making port calls at the harbours of littoral states in India's neighbourhood. Thus, undermining India's influence in the region as a net security provider.

Enhancement of PLA Capabilities.

- **Strategic Level.** At the strategic level, space assets enhance PLA's capabilities to conduct joint operations by increasing situational awareness and boosting combat potential by synergised application of forces. Thereby, gaining a distinctive edge in any conflict.

- **Operational Level.** At the operational level, space systems provide PLA the early warning of launch of ballistic missiles, navigation of precision guidance weapons and redundancy of communications. In addition, China's superior space surveillance capabilities enable better planning, monitoring, control and risk assessment during hostilities.

- **Tactical Level.** At the tactical level, China's space systems provide PLA with near real time support to execute engagements in a non-

linear fashion. During operations, space systems provide PLA real time position and navigation data, persistent surveillance of the adversary's locations, activities and strength, real time weather information, terrain and hydrographic information and reliable communications to enhance the synchronisation of contact battle. Thereby, acting as a force multiplier to the troops in contact in the tactical battle area.

PLA's Battle Space Awareness. China's wide array of surveillance satellites with high resolution and revisit enable PLA to gain accurate information about the adversary's military mobilisation, concentration, location and movement. With the capability to observe both during day and night as well as bad weather, it renders surprise and deception measures by an adversary futile in battle. The increasing exploitation of space-based ISR with PAN, SAR and hyper-spectral payloads, has enhanced China's battle space awareness. It enables China to monitor the activities of Indian armed forces across the vast expanse of Indian landscape and Indian Ocean. This will enable PLA to know well in advance, the preparations for deployment of troops, air assets, air defence radars, naval fleet and ballistic missiles. This has major ramifications on our security.

Maritime Surveillance. China is fast progressing the development of maritime surveillance capabilities over the Indian Ocean. The Yaogan series of satellites provide ISR capability to China in the Indian Ocean region. Thus enhancing its capability to locate, track and attack aircraft carriers and ships of the adversary by employing its anti-ship ballistic missiles.

Suppression of Air Defence Systems. China's robust space based ELINT capability allows for locating and monitoring the adversary's air defence systems. This would enable PLA to target the adversary's air defence systems with electronic attack and anti-radiation cruise missiles.

Monitoring Communications. China's signal intelligence (SIGINT) satellites enable PLA to monitor tactical communications of the adversary. Hence, focused jamming and interference can then be calibrated on the adversary's communication networks.

Effect Based Operations. Enhanced battle space awareness enables PLA to acquire precise coordinates of the location of adversary's military assets, both in the tactical battle area and the hinterland, thus increasing its targeting capability. Exploitation of Beidou satellite navigation system enables PLA to carryout in-flight updation of target coordinates for its PGMs and thereby increases their efficacy and destructive potential. By virtue of having good battle space awareness and transparency, PLA can prioritise target selection and conduct effect based operations while prosecuting its air, land and maritime campaigns.

Redundancy. Development of Kuaizhou and LM-11 solid fuelled rockets provide China the capability to launch small satellites with varied payloads within actionable timeframe during hostilities if their main satellites are destroyed or degraded by ASAT actions of the adversary.

Prosecution of Informatized War. PLA's concept of space applications envisages exploitation of space based capabilities with a view to optimise operations at all levels. Integration of space applications with conventional capabilities assists PLA's commanders and staff to expedite the process of decision making. The exploitation of advanced space capabilities by PLA facilitates real time connectivity between sensors, decision makers and shooters at geographically separated locations. This integration of C4ISR systems with weapon platforms obtained through space assets facilitates battle field transparency leading to informed decision making, thus enabling China to prosecute informatized wars.

Vulnerability of India's Strategic Assets and Installations

Persistent surveillance and superior navigation render own strategic assets and installations vulnerable to attack by Chinese ballistic missiles. Such assets and installations include telemetry, tracking and control (TT&C) stations, airfields, satellite and missile launch sites, carrier battle groups etc. Guarding such vulnerabilities needs to be suitably prioritised in our security matrix.

Security of Own Space Assets. China's Space programme has grown significantly in the recent years and its ASAT test in January 2007 not only signaled its accomplishment but also created debris in orbits, posing serious threat to other

satellites. China is reported to have carried out a land-based missile interceptor test in January 2010 and again in May 2013 with an SC-19 missile used as a kinetic kill vehicle. China also destroyed the control chip of a Japanese spy satellite by using Electromagnetic Pulse (EMP) and is reported to be developing Directed Energy Weapons (DEW) and Very High Frequency (VHF) satellite signal jamming devices capable of striking LEO satellites. In 2006, China is reported to have used a ground based LASER to dazzle a US reconnaissance satellite. According to a report by US based China Aerospace Studies Institute (CASI), China had attacked Indian satellite communications in 2017 [7]. It is evident that China can destroy or disable the adversary satellites by employing its kinetic kill weapons, micro-satellites acting as space mines, pellet cloud attacks and DEWs like high powered lasers, microwaves and particle beams. Threats that emanate from China for the security of own space assets are as under :-

- **Attack on Ground Infrastructure.** Attacks on our space related ground infrastructure by conventional or unconventional means like ballistic missiles, sabotage etc.

- **Electronic Attack.** Use of radio frequency jamming equipment capable of interfering with our satellite links.

- **Laser Attack.** Laser attacks capable of temporarily or permanently degrading or destroying our satellite sub-systems could erode our satellite mission performance.

- **Electromagnetic Pulse (EMP) Attack.** EMP weapons capable of degrading or destroying satellites and ground system electronics.

- **Kinetic Anti-Satellite (ASAT) Weapon Attack.** ASAT weapons capable of destroying our satellites in LEO and GEO.

- **Cyber Attack.** Denial of information and its usage for own benefits will constitute a cyber attack on our satellites.

Disruption of Command and Control Networks. Space systems are dependent on communication links between satellites and terrestrial nodes. Satellites and

ground-based control stations send data up and down the link. In the up-link, tasks for satellite mission payloads and subsystems are sent. In the downlink, mission payload data and satellite state-of-health data are sent to a ground station for processing. China is rapidly developing its counter space capabilities, which include jamming/ interference of communication between satellites and ground stations and cyber attacks to render satellites non-functional. According to a report published in the Eurasian Times, China has deployed satellite jammers near the Indian border post the Galwan clashes [8]. This can severely cripple the command and control of our military commanders due to denial of surveillance, communication and navigation capabilities for our forces in war.

Pakistan as a Proxy Space Power. Pakistan as of now does not have any significant space assets but is likely to acquire space capability to meet its military requirements from China [9]. Pakistan has a long term (20 years) Space cooperation agreement with China. Karachi has a tracking station for China's Beidou navigation satellites. Pakistan has also signed an agreement with China to utilise the Beidou satellite navigation system. Its integration with Pakistan's guided missile systems would enhance their precision strike capabilities. By integrating this system, Pakistan Army will also be in a position to upgrade the non-guided missiles, rockets and Unmanned Aerial Vehicles (UAVs). Beidou system will also provide them redundancy to GPS.

Impact on Strategic Balance. Rapid technological advancements in space, its militarisation and increasing integration of space capabilities in national security and war fighting doctrines is changing the nature of warfare; signaling a new era of leveraging space superiority. The growing disparity in space capabilities between Indian and China will have a direct bearing on the strategic balance in the region.

Recommended Response Strategy for India

1. Development of Space Capabilities:

Space Based ISR Capabilities. The capability desired includes advanced Imagery Intelligence (IMINT), Electronic Intelligence (ELINT) and Communication

Intelligence (COMINT) covering our area of interest. For obtaining night time images, as well as under cloudy conditions, more satellites equipped with Synthetic Aperture Radar (SAR) are required. A constellation of SAR satellites at a suitable inclination can provide imagery with frequent re-visit capability. Data can be supplemented where required with higher resolution panchromatic (PAN) satellite imagery. A synergised picture could then be evolved by developing multi-sensor data fusion capability.

Persistent Surveillance. While persistent surveillance is required, we are no where near it. With our handfull of ISR satellites, our revisit capability is not in terms of hours but days which is inadequate to discern a tactical picture for conducting military operations. Therefore, there is a need to develop persistent surveillance capabilities.

SATCOM Capabilities. There exists a need for the armed forces to connect with space based systems to overcome the prevailing limitations of line-of-sight, attenuation losses and low-reliability of radio communications. SATCOM can be utilised to transfer enormous data and information provided by space based surveillance, navigation and meteorological systems to the users in near real-time. Acquisition of SATCOM capabilities includes requisite number of transponders, frequency bands and dedicated military communication satellites.

Space Based PNT Capabilities. There is a need to have encrypted, anti-spoofing PNT capability for the armed forces, especially in Northern and North-Eastern sectors which are characterised by inclement weather and inhospitable terrain as well as for effectively prosecuting mobile operations. It would also be useful for disaster relief operations and out of area contingencies. In order to achieve this capability, the development of IRNSS receivers needs to be expedited. Meanwhile, the utilisation of GAGAN could be factored in planning for applications that require higher location accuracy.

PNT Constellation with Global Coverage. The existing IRNSS system with seven satellites has a regional footprint. Its coverage is limited to India and her neighbouring countries. It also covers the Indian Ocean to a limited extent. However, with the rising stature of India at the global stage, there is

an ever increasing likelihood of Indian military to participate in out of area contingencies. The footprint of Indian Navy is also expected to expand with the planned acquisitions based on its modernisation plans. Therefore, it is prudent to simultaneously upgrade our space based PNT capabilities to a full fledged global constellation like the US owned GPS and the Chinese Beidou constellation.

Meteorology and Hazard Prediction of Chemical Agents. The applications related to real time environmental monitoring such as meteorology and hazard warning would pay great dividends in the battlefield. Capability related to hazard prediction of chemical agents by remote sensing from space also needs to be developed.

Launch on Demand (LoD). The capability to quickly restore minimum space-based facilities and capabilities by launching new satellites into orbit in a timely manner to replace destroyed or disabled satellites is a critical resilience measure. This is particularly important since satellites that have defence or strategic applications are in LEO where they are vulnerable to direct ascent ASAT weapons. Also referred to as Quick Response Mechanism (QRM) or Operationally Responsive Space (ORS), it seeks to augment satellite resources at short notice by launching mini / micro satellites from mobile / static launchers. This involves launch of mini/ micro/ nano satellites, on-demand to augment or replenish the existing LEO satellites. India has mastered the Polar Satellite Launch Vehicle (PSLV) technology and has the capacity to loft a number of small satellites on one PSLV at any given time. However, during conflict, small satellites with customised payloads and tailored orbits would have to be launched from mobile launchers to immediately restore a disabled capability for specific area surveillance. A number of satellites would need to be available for launch over a limited span of a few days. Launch vehicles may need to be configured for launch of multiple mini-satellites in a short timeframe and at a low cost. In this context, the fabrication of Small Satellite Launch Vehicle (SSLV) by ISRO is a significant development and needs to be operationalised at the earliest. However, this entails development of satellites with plug and play architecture for different payloads and control systems. Development of mobile launchers also needs to be accorded due priority. Advanced space faring nations like USA, Russia and China have already acquired this capability.

Dual Use Satellites. Keeping in mind the emerging counter space capabilities of China, it would be more prudent to share satellites between the civilian and military users. This will ensure that military functions are split over a large number of civil satellites rather than a handful of military satellites, which are easy to target. Dedicated military satellites should be few and only if splitting of military functions is not feasible over civil satellites. This will reduce vulnerability and ensure that complete disruption of functional capability does not take place.

Mega Constellation of Nano Satellites. Use of large satellites needs to be seen in the backdrop of growing counter space capabilities of our adversaries. Larger satellites make bigger targets, which are easier to locate, track and destroy. Emphasis should therefore be laid on the development of mega constellations of nano satellites to negate counter space threats. Dispersion through the use of a constellation would increase the number of targets and in turn increase the survivability of the system.

ELINT. Presently, India has only one ELINT satellite i.e. EMISAT, launched in April 2019. However, in order to locate non-communication emitters like enemy radars a constellation of satellites is required. Hence, there is a need to create a constellation of minimum three ELINT satellites, in order to accurately locate enemy radars.

COMINT. Currently, India does not possess any space based COMINT capability. COMINT is extremely important as it enables monitoring of adversary communications for initiating focused jamming and interference of his communication networks in battle. Development of this capability needs to be accorded due priority.

Counter EW/ Cyber Capability. The most vulnerable link of a space system is its command and control link. Communication satellites are inherently vulnerable to interference and jamming. Since China is developing advanced EW and Cyber capabilities, India needs to acquire military and space systems which are capable of withstanding or minimising these effects.

Diversity Mechanisms. Diversity mechanisms are to be developed both in space and ground based segments. This can be achieved by 'Redundancy through

Numbers' by developing additional and redundant capability in space assets as well as 'Dis-aggregation' by spreading the functional requirements over a number of satellites and ground stations to reduce the impact of loss of a few assets in case of hostilities.

Artificial Intelligence (AI) Based Change Detection and Fusion. Automated image processing, recognition and change detection is required to be developed for optimal exploitation of space applications. During any conflict the initial emphasis will be on 'Detection' followed by regular monitoring by 'Change Detection'. With limited trained manpower, availability of large number of sensors and voluminous data, it will be difficult to generate specific IMINTs to keep pace with the dynamic battle field scenarios. To overcome the same, it is essential that an Al based coherent change detection mechanism with event alerts be incorporated. Automated image processing, recognition and change detection is required to be developed for optimal exploitation of space applications. Also, at present there are a number of sensors providing a variety of inputs, all of which is being analysed in isolation. Imagery in PAN, SAR, multispectral and hyperspectral format is available from satellites and other platforms. Fusion techniques of integrating inputs from different sensors need to be acquired to enhance the value of intelligence. Utilising disruptive technologies like Al is the way ahead to overcome these challenges. Therefore, it is recommended that as part of future surveillance programme, AI based automatic change detection and imagery fusion technologies be developed by ISRO/ private industry for exploitation by the armed forces.

Counter Space Capabilities. Satellites are controlled through ground control centres. Commands from these ground control centres can be intercepted and spoofed to manipulate/ control an adversary's satellite operations or render them non-functional. Space based EW and cyber attack capability needs to be developed to intercept these commands from the ground stations of an adversary. Cyber intelligence technologies should be developed to decipher the codes and plan electronic signal manipulation. India has already conducted a direct ascent ASAT test in March 2019. Further research is required to acquire DEW and cyber attack capabilities to deter our adversaries and safeguard our rapidly growing space assets.

2. **Organisational and Conceptual Issues:**

Defence Space Agency (DSA) as Single Window Interface with ISRO. There is a need to synchronise the requirements of the three Services at DSA so as to economies the scare resources in space and avoid duplication. Thus, there is a necessity of having a single window system with ISRO for planning our military space capabilities. This would offset the chances of skewed individual service plans.

Joint Space Command. Indian space programme and capabilities developed so far have mostly been driven by civilian requirements. There is a need for a single agency to coordinate and manage the various aspects of India's ever-increasing defence space requirements. India's defence forces have only taken small steps by establishing joint organisations like the Defence Satellite Control Centre (DSCC), Defence Image Processing and Analysis Centre (DIPAC) and the recently created Defence Space Agency (DSA). These measures have been inadequate and there is a wide gap between the required and existing military space capabilities. This calls for developing the means to support military operations as well as to deter and defend against hostile acts 'in', 'through' and 'from' space. In this regard, the defence forces have to play a much more pro-active role in projecting, planning and implementing the development of space capabilities in close coordination with the civilian agencies. Therefore, in the interest of national security, there is an urgent and imperative need to give impetus to our military space capabilities. A dedicated organisation to centrally steer and control all military space activities is considered essential. The establishment of DSA is a step in the right direction but it is only an interim measure. DSA as it stands today is inadequate to address the emerging military space requirements. Therefore, DSA in due course, needs to be upgraded to a Joint Space Command, with enlarged scope, infrastructure and charter of duties to utilise more effectively the country's space based assets for military purposes and to look into threats to these assets. DSA can serve as a building block for the creation of a Joint Space Command. Establishing a Joint Space Command would be the next logical step towards the fulfillment of national security objectives. Thus, for the optimum utilisation of space for national security, there is a requirement to gradually transform DSA into a Joint Space Command [10].

Utilisation of Space Assets for Strategic Purposes. Space applications enable military activities both in peace time and conflict. C^4ISR is extensively dependent on space capabilities. The level of military preparedness of nations is judged by their availability of information in near real time, as also the capability of launching prompt offensives, with precision navigation, accurate weapons guidance inputs, weather information, target data and availability of secure communications. There is also a requirement of assured control over own nuclear and conventional forces through satellite based secure communications and capability to impinge on adversary's capability to communicate to his nuclear and conventional forces/ command structure.

Operationalising and Institutionalising Space in the Armed Forces. Operationalising space means using space based capabilities to provide force enhancement and space control in near real-time. To provide ground commanders with situational knowledge throughout the battle space requires responsive space systems to provide information in real time to influence operations. Operationalising space also requires educating commanders on space capabilities and limitations to allow them to successfully integrate space into planning, exercises, training and operations. Institutionalising space means making space part of the doctrinal way the armed forces plan and fight. It also involves having a vision and roadmap of how the armed forces can best exploit space now and in the future. The armed forces must include space when preparing any overarching war fighting vision, capstone concept or operational plan. Doctrine development and space training programmes and the infrastructure to administer them, increases the institutionalising of space in the armed forces.

Harnessing Space for Network Centric Warfare (NCW). NCW is an emerging concept of modern warfare that aims to transform information superiority into combat advantage through a highly responsive networking of geographically dispersed forces. NCW increases combat potential by networking sensors and weapons to get shared situational awareness, increased lethality, survivability and synchronisation. Space capabilities are integral to networking of modern militaries and are recognised as force multipliers that increase combat effectiveness by providing critical C4ISR capabilities. NCW operations have the potential to transform the entire gamut of military operations and bring them into one single

grid. Space based assets and technologies play a major role in the net centricity of operations. Hence, space applications should be harnessed as critical enablers for development of NCW capabilities of our armed forces.

Integration of Space in the Planning and Conduct of Military Operations. Role of space assets in enhancing the effectiveness of ground operations has been proven conclusively in Gulf wars, Kosovo and Afghanistan. India has an ambitious and dynamic space programme which has scored many successes in the past few years. Over a period of time India has built up a modest capability in remote sensing, communication, navigation and meteorological satellites which have a tremendous utility for the armed forces. Hence, it is necessary to integrate space assets into operational plans. Future military modernisation efforts will focus on NCW and honing the PGM capabilities. Concurrently, this requires doctrinal and organisational changes at tactical, operational and strategic levels to integrate space in the planning and conduct of military operations.

Continuous and Credible Integrated Surveillance. Current space based surveillance platforms are lacking in the amount of persistence they can provide to military users. This lack of persistence limits the times at which satellites can provide access to specific targets. Adversary denial and deception efforts due to the predictability of satellite orbits further limits, the utility of existing assets. There is a need for persistent real-time coverage of the areas of interest. The need therefore for the Indian defence planners is to architect an integrated surveillance plan by employing various platforms and sensors suiting a particular type of task to include satellites, Unmanned Aerial Vehicles (UAVs), radars and surveillance aircrafts. Losses or disruptions of satellite based services may be partly compensated or its effects mitigated by use of resources like UAVs and reconnaissance aircraft for collection of imagery, ELINT and COMINT data on strategic and tactical targets of the adversary. These platforms could be used for mapping the strategic and tactical targets during peacetime, particularly those close to the borders.

Active Defence Posture. India needs to adopt an active defence posture, beginning by expanding and invigorating the research and technical base needed to defend or replenish space assets. There is a need to invest in small

satellite development and rapid launch capabilities. The combination of the two, once achieved, will change the strategic calculations of prospective adversaries. Another important component of an active defensive posture is political rhetoric that fits the national narrative.

Ballistic Missile Defence (BMD). In order to safeguard our strategic installations and ground based space infrastructure, there is a need to develop the BMD capability. The operationalisation of BMD capability is intimately linked to advanced space capabilities that serve as strategic sensors to provide early warning of the launch of ballistic missiles by an adversary. Subsequent tracking and destruction of enemy's warheads is also a function of space capabilities. Hence, acquisition of advanced and robust space capabilities is a pre-requisite for the development of BMD capability.

Control of Space Assets. The three basic functions of satellite operations are telemetry, tracking and control (TT&C). All these activities are manpower intensive and the core competence of ISRO. With the growth in defence space assets and the enhanced scope of utilising space in the planning and conduct of military operations, there is a need to shift control of these assets to the defence services. Presently, the Defence Satellite Control Centre (DSCC) at Bhopal only controls defence EO satellites. In due course, other defence satellites related to SAR, ELINT and hyperspectral payloads, should also be transferred to the defence services.

Dedicated Defence Space Programme. Space has emerged as an important component of national power and an indicator of the status of a nation in the regional and international arena. Due to the inherent limitations of economy and technology, India's space programme, at the beginning, had a civil orientation and the results have been impressive. However, the lack of strategic forethought about the security aspects has resulted in China racing ahead in the military utilisation of space and is now posing a serious security threat to India. For India to be an effective space power, the military aspects of space have to be given due emphasis. Post Kargil war and the 2008 Mumbai attack, role of space assets in national security has been acknowledged. However, steps taken to ensure exploitation of this technology have been minimal. Even if we don't wish to publically

acknowledge, the nation must give priority to the military requirements in the space programme. A dedicated defence space programme [11], which works hand in glove with ISRO needs to be conceptualised keeping in mind the emerging threats impacting India's security.

Joint Space Doctrine. India, unlike most advanced countries lacks a joint approach within the services. An overarching joint space doctrine [12] of how the future joint force will operate across the entire range of military operations and the employment of space therein, needs to be evolved. It should become a unifying framework for developing subordinate joint operating concepts, joint functional concepts, enabling concepts and integrated capabilities in the space domain. Thus a joint space doctrine needs to be formulated by HQ IDS under the aegis of Chief of Defence Staff (CDS).

Architecting Space Assets Model. The Indian Army faces threats along the borders both on the Western and the Northern fronts. Due to new emerging threats from two fronts it becomes imperative that the satellite architecture be so created for the future so as to cater for simultaneous coverage. The advent of micro and nano satellites can be a great resource for filling the gaps in surveillance and as a redundancy. The overall satellite umbrella to cater for all time surveillance and enabling PGM strikes, should be suitably architectured.

Synergy in Research and Development (R&D). At present, in the domain of space, the three services are working on specific projects in isolation. The outcome of this approach is the existence of service specific satellites like GSAT-7 of Navy [13] and GSAT-7A of Air Force [14]. Similarly, Navy has gone ahead in conjunction with ISRO to sign an agreement with the French space agency CNES for jointly launching a constellation of satellites for maritime surveillance [15]. However, a synergised approach to any problem is the best way for optimal sharing of strategic resources like satellites. Hence, there is a need to synergies the efforts of all agencies and stakeholders to include DSA, Service Headquarters and intelligence agencies with ISRO to arrive at common solutions to meet our space security requirements. Further, it is also necessary to bring about synergy in the R&D effort of ISRO and DRDO, while simultaneously tapping the potential of private industry for

the development of encrypted satellite based communication and navigation equipment and high resolution surveillance sensors. The direction of R&D effort should be based on operational requirements of the armed forces. Towards this end, the creation of DSA under the CDS is a step in the right direction.

Cost Effective Model. The US experience needs to be minutely examined for a rational and cost effective model, which is joint in nature. For instance, a transponder or a satellite dedicated to a specific service only is wastage of effort, as there is enough capacity for utilisation by the other Services too. Hence, a cost effective model towards acquisition of defence space capabilities needs to be jointly worked out by the three services and DSA rather than separate service specific forays in the space domain.

3. **Policy Issues:**

National Space Security Policy. In order to clearly convey the focus of our space developments to the world and to give a direction to our defence space activities, it is essential to formulate a national space security policy [16]. The fundamental objective of the national space security policy should be the assurance of safety, security, stability and integrity of our space systems and of their uninterrupted services. This should be achieved essentially by reliance on defensive measures, utilising alternative platforms and developing options for deterrent counter-measures under the ambit of right to self-defence and advocating a non-discriminatory international legal regime that ensures equitable access to outer space resources by all nations. The space security policy needs to be sensitive to the possible threats to space assets by India's potential adversaries. The objective of a space security policy should be to impose on adversary high costs, denial of benefits and fostering restraint by developing not only credible counter space capabilities, but also by displaying the capability of the country to operate and prevail in any conflict, despite any degradation of space capabilities caused by an adversary. Such a credible capability could make it worthless for the adversary to consider an attack on our space assets.

Strategic Perspective of Space Policy Formulation. The policy formulation on space needs to be viewed from a security and strategic perspective. The national space security policy should be consistent with India's obligations under international treaties. India may continue to support efforts for a non-discriminatory legal regime ensuring equitable access of all nations to space resources and to prevent the militarisation of space including placing of nuclear weapons/ weapons of mass destruction in orbit or on celestial bodies. However, given the evolving nature of international jurisprudence relating to space and specifically the efforts undertaken by some countries to integrate offensive space operations in security doctrines, it is necessary to ensure that India retains the flexibility to develop options, including effective counter space capabilities, necessary to secure and safeguard its national interests till a non-discriminatory, comprehensive and binding agreement is reached on total ban on deployment of such systems in space and the weaponisation of space.

Cogent Counter Space Policy. There is a need to be sensitive to the possible threats to space assets that may emanate from our adversaries. The vulnerability of space assets and the need for safeguarding these assets entails putting suitable mechanisms in place that enable freedom to operate in space while denying the same to others. Space superiority can be gained and maintained through counter space operations, which have defensive and offensive elements, both of which are dependent on robust Space Situational Awareness (SSA). Counter space operations may be utilised throughout the spectrum of conflict and may be employed to achieve a variety of effects from temporary denial to complete destruction of the adversary's space capability. A cogent counter space policy that enables protection of our space assets and the capability to execute the desired space mission is essential. It must allow us to develop, operate and maintain space control capabilities to ensure freedom of action in space and if required, deny such freedom of action to our adversaries. While India works towards its long-standing cherished goal of peaceful use of space, there is simultaneous requirement to defend India's space assets and prevent our adversaries to see India's reliance on space as a susceptibility that they could exploit and inflict a crippling blow upon our military, social, political or economic strengths. To protect our space assets, there is a need to consider a long term proactive counter space policy.

4. **Diplomatic Issues:**

India's Position in International Fora. In 1958, India became a member of the adhoc committee constituted by UN on space and continues to play an active role in the UN Committee on the Peaceful Use of Outer Space (UNCOPUOS) and its sub-committees. India continues to maintain that the use of geostationary orbits should be rationally managed. At the UN General Assembly and at the Conference on Disarmament, India has supported proposals for prevention of arms race in space and for preserving space for peaceful purposes without weaponisation. India needs to continue emphasising these issues in the international fora.

A Responsible Space Power. Future wars will be characterised by operations that extend from land, sea and air to cyberspace and further to outer space. Operations will occur more rapidly and conflicts concluded more quickly. This realisation has prompted China to aggressively pursue new capabilities in space and today it is undeniably a reckonable military space power. However, as a matter of national policy, India has looked at space being used for peaceful purposes and as a responsible player in the global space community. Therefore, our actions towards development of defence space capabilities have to be so calibrated that India should continue to be viewed as a responsible space power.

Using Diplomacy to Curb the Trends towards Weaponisation of Space. Space is a global common characterised by a high degree of interconnectivity and interdependence. Enhanced diplomatic capacities can be used as a way of curbing increasing militarisation and consequently the likely weaponisation of space. International agreements and institutionalised procedures for conduct in space are essential to prevent conflict amongst space faring nations. India should vigorously pursue the case for non-weaponisation of outer space internationally and formalisation of treaties regarding non-targeting of space assets during hostilities.

Foreign Collaboration. While various indigenous space projects are being planned to meet the strategic requirements, these projects are time and cost prohibitive and cannot meet the operational requirements of the defence forces

in the short term. Cooperation with a dominant space power like USA is required to fill the voids and enhance our military space capabilities. Moreover, it should be viewed in light of our limited existing capabilities compared to China and also the fact that Pakistan is receiving full support from China under various space agreements signed between the two countries. Assistance in following areas/ applications be sought from an advanced space power like USA by leveraging our strategic partnership: -

- Augmenting our space surveillance capabilities and overcoming the existing voids until indigenous space assets start giving us a persistent surveillance capability.

- India's current progress in the field of space based ELINT and COMINT is nascent. Hence, strategic cooperation with USA can enhance our capabilities in these niche domains.

- Cooperation could also be sought in the development of hyperspectral library, access to military grade encrypted GPS and space training in US military establishments.

- Sharing of data related to Space Situational Awareness (SSA).

Augmenting Space Security through Partnerships. Augmenting and sharing space capabilities through collaborations with strategic allies would make it difficult for the adversary to deprive a targeted nation of its space capabilities. An adversary would then have to target not only a targeted country's space assets, but also those of the target country's partners. Such a partnership should also include Space Situational Awareness (SSA) where we are lagging behind at the moment. Other arenas where international partnerships can augment our defence space capabilities include the development of a hyperspectral library, ELINT and COMINT payloads, GEO high resolution PAN sensors and quantum communication technology. International partnerships in space security should be worked out keeping in mind the security sensitivity unique to India.

5. **Security of Space Assets:**

Protection of Ground Segment. Ground segment consists of facilities associated with satellite communications, data reception, command and control, launch and assembly of components. One of the easiest ways to disrupt, deny, degrade or destroy the utility of space systems is to attack or sabotage the associated ground facilities and their supporting infrastructure. It is necessary to ensure the security of ground stations in order to have uninterrupted communications between satellites and ground stations at all times. Current approach worldwide against possible attack on the ground stations is to have geographically redundant ground stations. These specialised facilities are critical to the continued operation and effective use of satellites. Therefore, it becomes crucial that these ground systems be defended and shielded from all possible threats.

Protection of Satellite Communication Links. Satellite communication links must have multi-level protection for command execution such as encoding, command repetition and confirmation of reception on-board before execution in order to protect the satellites from intentional or accidental interference in their functioning. Further, certain protection technologies associated with military satellites and ground terminals could be used for covering all communication between satellites and ground terminals, such as encryption, bit by bit processing, narrow band transmission, robust modulation techniques, burst transmission and frequency hopping. Interference and jamming can be mitigated by using multiple secure networks working on different frequency bands through a number of satellites and thus making it difficult for an attacker to target the critical link.

System Hardening. Hardening of space system links and nodes, allows them to survive direct attacks. Techniques such as filtering, shielding and spread spectrum help to protect own vulnerabilities from radiation and electromagnetic pulse. Physical hardening of structures reduces impact of kinetic effects and is applicable to ground based facilities rather than space based systems due to launch weight considerations. Robust networks and the ability to reroute enhances survivability and ensures uninterrupted operations.

Dispersal of Space Systems. As the satellite orbits are predictable, scattering them into various orbital altitudes and positions offers added protection. Dispersion also includes creating a grid of micro-satellites. These micro-satellites operate collectively to perform the function of larger and more vulnerable satellites and result in a more survivable system. For terrestrial assets, dispersal involves geographical dispersion or deploying mobile ground stations in a manner that they do not present a concentrated target.

Space Situational Awareness (SSA). Monitoring the status of one's own space assets is vital. So also is to monitor, identify and interpret the intent of adversary's space assets and space debris. India has limited ability to track space objects especially those belonging to foreign nations. Only a handful of nations like USA, EU, Russia and China possess their indigenous SSA capabilities. All other nations including India obtain the database on space objects from the open source website of US Strategic Command (STRATCOM), i.e., <www.space-track.org>, which shares only the basic information related to SSA. This open source data is prone to intentional and unintentional errors. In order to overcome this, we need to establish our own network of radars. India should develop indigenous capability to detect and catalogue space debris and inimical satellites to safeguard our space assets. Hence, there is a need for a comprehensive Space Surveillance Network (SSN) that can detect, track, catalogue and identify adversary satellites and debris in space to ensure the security of our space assets. The creation of an indigenous SSN, although essential, is a long term and expensive project. In the interim, the development of a customised software utilising open source data would be a cost effective solution, till such time an indigenous SSN is in place. Such a software will not only be able to track inimical activities in space but will also be useful to the defence forces for identifying blind periods of adversary satellites, thereby enabling them to execute critical deployments or deception measures.

Redundancy of Critical Defence Satellites. Presently, we are on the growing curve of developing military space capabilities. Therefore, redundancy is not being catered by ISRO. However, it needs to be understood that denial of service attacks by an adversary can be greatly reduced if redundant capabilities are available. Selective spare satellites could be developed and placed in 'cold' orbit to take on the functions of defunct satellites that are considered critical from a

strategic perspective. While the cost of creating such redundancies in space may be a limiting factor, in the interests of security of space assets and the broader national security, the creation of redundancy for critical defence satellites merits consideration.

Satellite Manoeuvre Capability. Defence satellites need to be imparted manoeuvre capability to move them from their fixed orbit in order to deny the opportunity to track and target them. At present, the manoeuvre capability of our satellites is limited by onboard fuel constraints and orbital mechanics. However, Chinese satellites have conducted co-orbital manoeuvres in 2008, 2010 and 2013. This capability would prove to be extremely beneficial for defence satellites as they could be repositioned to avoid directed energy attacks, electromagnetic jamming or kinetic attacks from ASAT weapons. Therefore, research in the development of satellite manoeuvre capability is recommended.

High Resolution GEO Sensors. The defence mechanism that needs to be developed to overcome the problem of ASAT weapons is by going into a higher orbit or preferably a geo-synchronous orbit. However, because of the increased distance from the Earth, the optics would have to be much larger in order to maintain sub-meter resolution at par with today's LEO sensors for the military. Basing a system in GEO gives some significant advantages. First, a satellite in GEO revolves around the Earth at the same rate as the Earth rotates on its axis. This allows such a satellite to remain over the same location on Earth. In addition, the altitude of GEO expands the field of view of a satellite because a satellite in GEO is at an altitude of 36,000 Km, where it is able to look at a much larger section of the Earth than a satellite in LEO like our CARTOSAT series of satellites, which are at an altitude of 500 Km. Another benefit of basing a sensor in GEO is that it would be less vulnerable to direct assent kinetic ASAT weapons and ground-based lasers. Hence, there is a need to focus our R&D efforts towards development of high resolution GEO sensors.

6. **Development of Human Resources in Space Domain:**

Space Training. In order to fully integrate space into the planning and conduct of military operations, there is a need for significant augmentation of expertise of

our human resources in various space applications and creation of a pool of trained manpower in the three services. Training for space applications is recommended to be included as a subject in selected courses for officers in the military training establishments. While the resources of ISRO can be tapped for conduct of technical training, focused training of general staff officers could be conducted initially at a suitable military establishment of an advanced space power like USA, followed by customised course being conducted by this core group of officers in an Indian military establishment. The conduct of space training should be centrally controlled by DSA since space is a tri-services function. A training pamphlet for space operations must also be published as a joint staff publication.

Creation of a Separate Space Cadre. Space being a niche domain, which requires exclusive and sustained expertise, the creation of a tri-services space cadre needs to be considered. Personnel for this cadre be drawn from the three services including direct induction from the civil sector with the flexibility to serve laterally in any service. The proposed space cadre should include armed forces personnel as well as civil scientists. Specialised training in various facets of space functioning needs to be organised for the personnel of this specialist cadre in India and abroad. Towards this, as a first step it is recommended that a space training centre be created as a tri-services establishment.

Recommended Offensive and Defensive Measures to Overcome Vulnerabilities of Our Space Infrastructure

There is a need to ensure the security of the entire gamut of space functions from launch of satellites to satellite mission control, ground segment, networks for relay of TT&C data and dissemination links. The following measures are recommended to be instituted to overcome the vulnerabilities and frustrate the enemy's designs to destroy/degrade our space infrastructure :-

1. **Offensive Measures:** Develop and showcase the following deterrent capabilities against enemy's space assets so as to deter our adversaries from interfering with the smooth functioning of our space assets:-

- Develop a basic space surveillance system for tracking the satellites of

our adversaries and debris in space.

- Develop Directed Energy Weapons (DEW), laser based weapons and weapons with kinetic warheads as credible ASAT weapon systems.

- Develop Electro Magnetic Pulse (EMP) weapon systems capable of degrading or destroying the electronics of adversary satellites and / or ground systems.

- Develop long range precision strike capability based on cruise missiles, combat UVAs and fighter aircrafts to target enemy's ground hub stations.

- Suitably equip and train a dedicated group of software professionals for focused cyber attacks on enemy's space related computing, networking and power supply segments.

- Capability to jam or interfere with enemy's satellite communication links.

2. Defensive Measures: The following defensive measures are recommended to be instituted :-

- EMP and electronic hardening of space and ground assets.

- Creation of redundancies as follows:-

    - Create large networked constellations of micro-satellites with a distributed architecture so that the system still continues to function even after destruction of one or more satellites in the constellation.

    - Have a reserve of satellites in 'cold orbits' which can be activated at the time of our choosing.

    - Create and stock a pool of ISR, communication and navigation satellites alongwith compatible launch vehicles for launch at short notice.

  - Activate at least one more satellite launch site in addition to the existing one at Sriharikota.
  - Develop and maintain a reserve of micro satellites for launch during critical stages of battle for coverage over specific area for a limited duration.
  - Create redundancies in computation and networking infrastructure.
  - Synergised usage of air-borne assets and Unmanned Aerial Vehicles (UAVs) for ISR and communication requirements to prevent single point of failure.
- Develop and install early warning sensors on our space assets for monitoring ASAT activities and providing real time information on suspicious space activities by our adversaries.
- Improve manoeuvrability of our satellite for evasive manoeuvres once a threat has been positively identified.
- Incorporate Electronic Counter Measures (ECM) like enhanced encryption of up and down links, agile frequency hopping and signal power boosting in our defence communication satellites.
- Operate from higher and lesser accessible altitude orbits, wherever feasible.
- Ensure security of ground assets by adopting the following measures:-
  - Organise multi-layered security system.
  - Ensuring strict access control based on biometric system for positive identification.
  - Install fail safe intrusion detection system.
  - Well trained and dedicated security personnel for warding off any

physical attack.

- Establish satellite ground hub stations near Army installations.

- Develop adequate protection against Cyber attacks through technologies and strict implementation of cyber security measures.

- Develop and field space weather sensor system to give advance warning of hazardous space weather conditions so that appropriate action can be initiated to protect our satellites.

- Expedite the operationalisation of IRNSS, to end our dependence on GPS.

Call of Times

The time has come to enhance space functions to force multiply our military capabilities. While doing so, the aspect of jointness amongst the three services is a fundamental issue for successful emergence of space as a centre of gravity for defence services and the nation. Our space programme has been primarily based on the civil and commercial requirements and the defence establishment has made the best use of the available resources. However, space being a potent dimension of warfare, space operations need to be fully integrated with land, sea and air operations to provide battlefield transparency to the field commanders to optimise their war-fighting resources and act as a major force multiplier against our adversaries.

Keeping in mind our existing and future space capabilities as well as alternative terrestrial methods to mitigate loss of space based services, there remains a need for a robust policy to ensure security of our space assets and coping mechanisms for continuance of operational capabilities. The capabilities destroyed by an attacker would need to be rapidly replaced and restored as part of a well thought out plan to ensure a credible defensive posture and to meet our national security requirements.

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Inferences and Implications of China's Space Power

Space Power and National Security

National security has become a key consideration in the space programme of most space-faring nations. The military space sector is an important driver behind the advancement of capabilities to access and use space. Satellites offer an ideal vantage point to monitor the Earth for providing strategic warning of signs of any nuclear attack, launch plumes of ballistic missiles or the light signature of a nuclear detonation. Satellites also offer the first credible means for arms control verification. It is thus imperative that we too build our space-based capabilities in order to protect our space assets as also our nation's interests in space.

A fully integrated space capability will provide depth, persistence and reach capability from the strategic to tactical levels that our present systems cannot provide. It is evident that space capability will be of immense value in remote theatres with insufficient or unreliable infrastructures. Tactical commanders (brigade and below) along active borders rely on radio communication which has limited range and capacity, especially in mountains. During war, border skirmishes or limited offensive operations this ability will further diminish. Near real time satellite imageries are accessible after 2-3 days. Therefore, Intelligence

Preparation of Battlefield (IPB) and decision making is based on redundant data, which renders our tactical commanders almost blind. Intelligence, surveillance and reconnaissance (ISR) for land operations needs no emphasis. Future wars will be fought in intense environment, which will require real time information and quick decision making by commanders and simultaneous dissemination of the same to sub-units.

China's pursuit of counter-space capabilities has in particular raised the spectre of increasing military contest in space. Security of our space and ground based assets and their communication links have therefore to be accorded the highest priority.

Military Implications of Space Power

It is evident that the importance and significance of the space domain for defence applications has gained prominence in the recent wars and this trend is likely to continue. Priority has been accorded by many countries towards progress in this arena. Accordingly, development of space capabilities and creation of suitable organisations are being given due impetus world over. Applications in the fields of Communications; Intelligence, Surveillance and Reconnaissance (ISR); Position, Navigation and Timing (PNT); Net-Centricity; Meteorology and other services make space a vital domain for the armed forces, towards battle situational awareness and conduct of military operations.

In future, wars will have pre-dominance of network centricity, cyber and space domains. The medium of space will be the key enabler for fighting Network Centric Warfare (NCW), which will be fluid, intense and short and will require quick reaction. Space dominance and the full exploitation for space systems are vital for achieving accurate navigation, combat situational awareness, information dominance, Post Strike Damage Assessment (PSDA) and C4ISR (Command, Control, Communication, Information, Surveillance and Reconnaissance) capability. These are essential for execution of responsive full spectrum, distributed operations in a NCW environment. Space based capability will enable implementation of these concepts particularly with respect to achieving

information superiority, creating situational awareness and non-contiguous operations with high tempo. Space based capabilities and services can provide assured and timely support all the way down to the tactical level commanders if they are fully integrated with other battlefield systems. This necessitates that Indian armed forces leverage such capabilities and ensure optimisation of space based capabilities.

Range of Military Applications

Military applications of space *per se* include SATCOM (satellite communication) enabled network centric operations, satellite-based surveillance, tracking and targeting, detection of strategic and tactical missiles, Electronic Intelligence (ELINT) for detection of air defence and weapon radars, radar finger printing and electro-optic and hyperspectral imaging for detection of camouflaged weapon storage sites, deployed weapon systems, caves and tunnels. Synthetic Aperture Radar (SAR) for day/ night mapping and detection of metallic objects/ targets and communication intelligence (COMINT) for monitoring adversary communication signals over our area of interest. Space-based ELINT/ COMINT is required to intercept signals from control centres that are beyond land borders. Strategic Space capabilities directly affect the credibility of nuclear missile deterrence. Precise Positioning, Navigation and Timing (PNT) data through satellites allows accurate navigation and precise application of firepower in the battlefield, thereby enhancing the ability to shape the battle according to the commander's operational plans.

Conventional warfare is increasingly dependent upon the cyber and space domains. Since space is the ultimate high ground, its utilisation for communication, intelligence, surveillance and reconnaissance by placing high quality sensors and building a robust communication network is crucial as it can provide a cutting-edge advantage over the adversaries. Further, the essence of network enabled warfare revolves around this core concept and space as a medium acts as a conduit for network enabled warfare. The development of space based military capabilities facilitate military commanders in the realisation of C41ISR capabilities, which

in turn can enhance mission effectiveness, survivability, lethality and quick deployment of forces as under:-

- Space assets contribute directly towards achievement of the commander's objectives. The commander must understand the capabilities and limitation of space support operations to determine how to best support the joint force. The appropriate joint headquarters must ensure that space applications support the geographic combat commander's objectives and are included in planning.

- Space assets assist in retaining and exploiting initiative through information dominance.

- Precision navigation capability enables the application of overwhelming force at key points of attack. Accurate navigation signals can improve weapon accuracy, thus increasing the probability of kill against fixed targets, minimising collateral damage and allowing use of advanced stand-off munitions to increase survivability. However, it is critical for commanders to integrate and synchronise supporting space assets so that the concentration of combat power at the proper time and place can be most effective.

- Space asset also provide a highly accurate time standard, permitting all units to synchronise their operations and allowing concentration of forces in time and space.

- Space systems and space based ISR assets can support attainment of dominant battle space awareness to a commander. This reduces uncertainty and permits a reduction in the number and type of forces needed for secondary efforts. Space systems can detect an adversary's movement and support an immediate engagement before its actions can affect own operations. Precision navigation and smart munitions permit the engagement of targets with the minimum number of weapons needed to achieve the desired effect while minimising collateral damage.

This allows a commander to concentrate forces and apply the combat power at critical points in the battlefield.

- Navigation, ISR, weather and communication applications provided by space allow units to perform precise, coordinated manoeuvres with speed and confidence, even in featureless terrain or under limited visibility. Thus, placing the adversary in a position of disadvantage through the flexible application of combat power. GPS and communications provided through space enhance not only the manoeuvrability of force but also command and control within the battlefield. Force tracking provides enhanced situational awareness and assists in reducing fratricide. ISR satellites provide additional capabilities to a force and place the adversary at a disadvantage through consistent observation.

- Coordination is necessary when planning and executing space operation. Space assets ensure unity of effort under one responsible commander for every objective. The commander must optimise resources and ensure that actions do not interfere with each other or with the overall campaign plan.

- The unique advantages of wide fields of view and the capability to revisit targets make observation of the Earth from space a powerful tool. Space assets can have access to large areas on Earth and proper management of satellite orbits and constellations offers flexibility. This enhances the supported commander's ability to observe the battlefield and increase battle space awareness, reducing the field commander's uncertainty. Commanders must understand the kind of technology at an adversary's disposal and how well it may be used by opponents. Observation and forecast through space is crucial to maintain battle space awareness. Thus, space assets do not permit the adversary to acquire an unexpected advantage.

- Space operations contribute to the element of surprise by providing

timely intelligence, enhanced information sharing and precise targeting, allowing the joint force to achieve success well out of proportion to the effort expended. Space control operations can foil the adversary's ability to determine own intentions through the use of space based ISR, allowing us to maintain the element of surprise. Thus, enabling us to strike the adversary at a time or place or manner in which he is unprepared. However, for achieving this, every effort should be made to ensure that the concept of space operations is clearly understood by field commanders in the operational area.

Growth of China's Space Militarisation

In its quest to become a major space power, China has taken a comprehensive, long-term approach in its space programme by providing firm political guidelines and adequate funding. China's space based remote sensing capabilities will enable it to engage targets over longer ranges in the Indian subcontinent and the Indian Ocean. Its significant imaging capabilities will enable acquisition of land and sea-based targets thus facilitating precision strikes by PLA Rocket Force. The space based ISR capabilities in the form of Yaogan ELINT satellite clusters in conjunction with Anti-Satellite Ballistic Missiles (ASBM) like DF 21D and DH-10, give China the capability to identify, locate, track and target an Aircraft Carrier Group (ACG) on the high seas. This has implications for Indian Naval operations at sea.

China's data relay satellites allow PLA to receive real time data from remote sensing satellites regardless of their position relative to the Earth's surface, thus providing timely battlefield intelligence. China's satellite navigation and positioning system also makes its military operations more secure. The *Beidou* system provides the PLA with self-sufficiency and enables it to jam and spoof GPS signals, while continuing to use its own constellation for navigation and precision strikes. The Kuaizhou and LM-11 solid-fueled rockets provide PLA with 'Launch on Demand' capability. China's growing counter space capabilities enable it to target critical sensors and communication capabilities of its adversaries.

China's directed-energy weapons, kinetic-kill projectiles, co-orbital satellites and cyber attack capabilities threaten adversary satellites. Their effectiveness is further enhanced by China's growing satellite tracking and control capabilities. China is in the process of developing high resolution remote sensing satellites, high bandwidth multi-band communication satellites, precision guided munitions, unmanned supersonic aerial vehicles, associated electronics and communication systems. These capabilities are not only force multipliers but also enable success in an electronically controlled modern battlefield.

China's space programme boasts of advanced satellites and an array of launch vehicles. The increasing exploitation of space has markedly improved PLA's intelligence gathering and targeting capability. The *Fenghuo* and *Shentong* series of communication satellites provide the necessary space based military communication networks to support PLA's military operations and for providing its ballistic missiles, cruise missiles, ships and aircraft a seamless strategic targeting capability. Beidou, an independent navigation system, provides the requisite navigation and targeting information to PLA. China is also on the course to putting the Jilin micro-satellite constellation in place in order to supplement the entire spectrum of space based C4ISR operations.

Inherent dual use nature of most space technologies, like the debris mitigation techniques, laser ranging and space robotics have counter-space applications. China's growing network of satellite tracking and control stations enhance the ability to control its satellites from around the globe and facilitate the tracking and targeting of adversary satellites. A space enabled PLA intends to increase the costs of war for a potential adversary.

Increasing build-up of conventional and nuclear arsenal and their delivery platforms has led to progression of space applications from strategic to operational and tactical employment. Due to this steady advancement in space applications, the security of space assets has also gained considerable importance among space faring nations. This concern of protection of space assets is particularly important for India in view of China's growing counter-space capabilities.

China Factor in India's Security Concerns

In the context of China's space militarisation, it is pertinent to note that China's rising power poses the greatest strategic challenge to India. Several developments in China, such as enhancement of military capabilities through its force modernisation programme, adoption of high end technology to develop space based weapons, Anti-Satellite Weapon (ASAT) capabilities, achieving self-sufficiency in defence production, development of infrastructure along the India-China border, especially inside Tibet, expansion of roads and railways opposite Arunachal Pradesh and sustained assistance to Pakistan in infrastructure projects, will affect the military balance in the region. China's plans will need to be monitored as it appears determined to challenge India's freedom to manoeuvre in the Indian Ocean also.

Growth in PLA's amphibious and submarine capabilities, carrier operations and space capabilities have thrown up security challenges for India that need to be suitably factored. Despite some positive movements in India-China relations, unresolved boundary issues and mutual distrust remain primarily due to China's aggressive actions along the Line of Actual Control (LAC). Our overall security construct needs to address the threat posed by PLA's rapid military modernisation and militarisation of space. China is seeking also to ramp up its presence in the Indian ocean. Space based assets can effectively assist us in detecting, tracking and countering PLA's movements on land and sea. We need to develop and deploy space-based assets so as to cumulate sensor inputs, data link it to the networked military command and control systems from where it can be fed to the field units and commanders. This will enhance the battlefield awareness through real time projection of the battlefield.

China's space programme is very comprehensive, combining both the civil and military applications and functioning under the patronage of a focused leadership to achieve strategic goals. Such a focused approach coupled with commensurate budgeting will enable China to achieve its objectives in the near future. Conversely, India's space programme has a civil orientation and needs a strategic

vision. Therefore, focused policy initiatives are required to ensure that both socio-economic development and national security objectives are attained through the utilisation of space.

India's Space Security Obligations

While India trails behind China in technical capabilities, it is catching up. India strongly opposes any attempt to place weapons in space as it would pose a perennial threat to the space systems of all countries. Given India's size, strategic location, developmental needs, trade interests and security environment, use of space-based systems is critical for the country's overall socio-economic development, scientific advancement as well as for both external and internal security. In the emerging information age, real time situational awareness has become the most critical aspect of defence preparedness.

In India, the application of space for military purposes has been restricted to support operations, in compliance with the Outer Space Treaty of 1967. This treaty prohibits location of weapons of mass destruction, claims of territorial sovereignty, establishment of military bases and testing of weapons in space. Consequently, facilities available to the Indian armed forces from space-based assets include surveillance, communications, meteorological and navigation. Facility for precision guidance of munitions has been acquired with the development of the Indian Regional Navigation Satellite System (IRNSS).

Indian armed forces will become increasingly reliant on space applications for communications, imagery intelligence, weather forecasting, early warning of ballistic missiles and satellite-based navigation. In peace, space and counter space systems are key elements of deterrence and during hostilities they provide a wide spectrum of options to the planners and commanders. In war, they enhance combat effectiveness, reduce causalities and minimise equipment losses. The integration of space support systems with other war fighting systems will be crucial for Indian armed forces in the future. India's nuclear doctrine of 'No First Use' requires a high degree of situational awareness based on early warning

capabilities. Information dominance through net-centricity coupled with space assets would become an important factor that could determine the outcome of a war.

Military space operations are an integral part of joint operations. Space capabilities are vital to overall military mission accomplishment and provide the advantages needed for success in all military operations. Military capabilities provided by space assets should be integrated and synchronised by military commanders into the overall concept of joint offensive and defensive operations.

India's space capabilities need to be developed with a command and control system capable of functioning in a joint operational environment, as these capabilities need to be operated and managed by the three services and the intelligence agencies. Space is a facilitator for acquisition of strategic capabilities and India needs to see it no differently. A well-conceived and planned development of space based military capabilities can integrate different aspects of space with war-fighting doctrines and can foster jointness in military operations.

Parameters of India's Space Security

The Indian armed forces stand on the threshold of entering a new phase of warfare capability, in which access to information is as lethal a weapon as possession of deliverable warheads. Military planners should focus on acquisition of space capabilities that will enable the armed forces to fulfill the country's security objectives. Requirements of effective space based ISR, PNT and SATCOM systems have to be addressed with dedicated efforts. The acquisition of these capabilities must deter or if required defend against an adversary's attack on our strategic space assets, enhance our operational effectiveness and ensure that our adversaries cannot prevent our use of space. This requires synchronisation with our operational philosophy and force capability development plans to ensure that attainment of military space capability is concurrent with the achievement of our operational goals.

There is a need to plan satellite constellations to establish a robust space based ISR network to meet our emerging security requirements. Availability of funds will be a major challenge. The armed forces also need to revamp their capabilities in terms of infrastructure, technology and human resource to be able to process, analyse and disseminate the satellite data.

Military Integration of Space

Though India is amongst the elite Space Club in the world, China's space programme is directly driven by PLA with required budgetary support and it is progressing at a very fast pace with the ambition to compete with USA. Chinese developments are also beneficial to Pakistan, being its strategic ally. Therefore, India too needs to give the required thrust towards development of indigenous military space capabilities. Therefore, a consortium of Department of Science (DoS), Defence Research & Development Organisation (DRDO), industry, military and academia are required to be formed to give impetus to the development of requisite defence space capabilities.

Till now, India's space programme has been largely driven by civil requirements, but now there is a need for defence forces to take the lead and steer the consortium through the newly sanctioned Defence Space Agency (DSA). Education, training and technology related to utilisation of space applications must be systematically adopted by the defence forces to harness the potential of space. Further, strategic and operational plans for integrating space in the next generation warfare must be jointly worked out.

With the threat to space systems from China, a robust counter-space programme and launch of dual use satellites is essential. As of now, there is no space security policy enunciated by the Government. Hence, there is a need to promulgate a national space security policy, which should lay down the planned usage and development of space and counter-space capabilities for national security. Importance of space applications will increase in Indian strategic environment due to the enabling capabilities that space assets provide to the battlefield.

Space capabilities should be integrated, coordinated and synchronised by the commanders into our offensive and defensive operational plans.

In the recent times, the strategy of Indian armed forces has transformed from reactive to pro-active operations. At the same time, it is also intended to achieve credible nuclear deterrence along with force accretion and embracing technological advancements in space domain so as to deny asymmetrical advantage to India's adversaries. Whereas, China has already carved a niche in the space domain, with its informatized warfare doctrine applied to enhance combat situational awareness and precision targeting by means of Beidou satellite navigation, ISR and counter-space capabilities. This entails building of Indian defence space capabilities in the areas of communication, navigation, ISR and Space Situational Awareness (SSA). The ultimate goal being to field a constellation of defence satellites for meeting these strategic requirements. The financial implications for fielding these defence satellites and the Space Situational Network (SSN) need to be factored by the Cabinet Committee on Security (CCS). Dedicated defence satellites and development of SSN capability also entails that the concept of jointness and integration be given paramount importance.

Network centricity has been recognised as the holy grail of military planning and operations worldwide in order to take precise decisions that could turn or maintain course of the battle owing to superior situational awareness. As of today, however, major portions of our network primarily rely on wired and terrestrial radio communication for voice and data transfer over longer ranges. Presently, the Indian military makes use of the limited satellite bandwidth allocated to it on Indian Space Research Organisation's (ISRO) civilian communication satellites. Such an arrangement imposes a range limitation up to which these networks can operate and amount of data transmitted. With the use of satellite based communication systems, this drawback can be satisfactory addressed.

With the thrust towards network centric operations, Indian armed forces have begun to rely upon space systems both for strategic and tactical purposes. However, the current level of space applications available to the armed forces are minimal

and more importantly, they are not specifically designed and developed to satisfy their operational needs. India's space program is still evolving as far as its military component is concerned. India needs to plan the induction of dedicated military satellites to facilitate the conduct of operations by armed forces. Geopolitical circumstances in the subcontinent could dictate India's future investments in this field. Till date, India has largely focused on using space assets for reconnaissance, navigation and communication needs of armed forces. However, China's growing military prowess in space and counter space capabilities is likely to influence India's policies in the field to safeguard her national security interests. India needs to plan specific space projects to achieve multiple objectives in navigation, communications, remote sensing and launch vehicles. The Indian government must realise the need for a proactive policy to adopt dual use technology and capacity building in space applications to meet the national security interests.

Approach to Military Integration of Space

So far, the Indian space programme has largely been driven by civil needs and only limited progress on defence space requirements could be achieved. In order to give impetus to military space requirements and channelise the existing resources for use during national crisis and emergency situations, a well coordinated approach towards development and integration of space capabilities is thus of vital importance. There is a need to identify the space capabilities required to be achieved for our armed forces. There is also a requirement to draw a comprehensive policy and timelines for space capabilities required to be developed and effectively integrated with the ongoing modernisation and transformation plans of the armed forces. It is imperative for planners to ensure that space applications are identified, voids are filled and the armed forces personnel are well trained to utilise these capabilities, thereby enhancing our combat potential in future conflicts.

ISRO has placed seven satellites of IRNSS system in orbit but the system is not yet operational due to non-availability of restricted service receivers. Development of these encrypted receivers in the required form factor should have been a simultaneous process. This delay is resulting in consumption of shelf life of

the satellites. This situation could have been avoided, if ISRO had incorporated the development agency of receivers at the initial stage itself. Development of receivers needs to be expedited. Post the development of receivers, the IRNSS constellation should be enlarged to provide global coverage for meeting our growing stake as a net security provider at the world stage.

A focused approach is imperative for transformation of space-based technologies into military operational capabilities to safeguard our national security interests. Our defence space applications need to focus on gaining information of military value areas as under:-

- Nuclear facilities and missiles sites in China and Pakistan.
- Troop movements and deployment.
- Military activities in Tibet Autonomous Region (TAR).
- Terrain and infrastructure improvement across the borders and creation of new airfields by adversaries.
- Deployment of PLA Navy in the vicinity of Andaman and Nicobar Islands, Lakshadweep, Minicoy Islands and monitoring of sea lanes of communications (SLOC) in the Indian ocean.
- Infrastructure development by China in the neighbouring countries like Pakistan, Nepal, Myanmar, Bangladesh and Bhutan.

Recommended Approach to Space Capabilities

The following approach is recommended to be pursued to optimally exploit the potential of space capabilities in the planning and conduct by military operations :-

- Jointness, commonality and interoperability of all space application projects undertaken by the defence forces.

- Progressive development of desired capabilities in a phased manner through short, medium and long term projections in the field of ISR, PNT, SATCOM, SIGINT and SSN.
- Integration of space based applications with existing and planned terrestrial C4ISR capabilities.
- Protection of strategic space assets and build-up of kinetic and non-kinetic counter space capabilities.
- Incorporation of requisite redundancies for critical defence space assets.
- Systematic approach towards joint space training for smooth integration of space resources in our existing and future war fighting concepts, thereby taking full advantage of space based capabilities in war and peace time operations.
- Incorporation of service inputs for R&D activities in space applications to enhance defence space capabilities.
- Cooperation and collaboration with advanced space powers to strengthen our defence space capabilities.

Imperative for Indian Space Programme

Implementation of roadmap related to acquisition of defence space capabilities related to communication, navigation and imagery needs to be vigorously pursued. Analysing imagery for change detection and correlation to extract intelligence should be a priority area. India also needs to reduce its dependence on GPS by operationalisation of IRNSS at the earliest. India also needs to look at the ASAT capabilities being developed by our adversaries and provide protection to own space assets and their corresponding ground segments. In addition, India also needs to develop comprehensive counter space capabilities. While a kinetic ASAT weapon has already been tested by India in 2019, there is a need to develop

soft kill technologies like Direct Energy Weapons (DEW), jammers and cyber attack capabilities for safeguarding our space assets. It is clear that in future, space power will play a major role in defining national security.

Presently, India lacks robust military space capabilities, resulting in gaps in gathering strategic intelligence and execution of punitive actions, which was evident during the recent stand-offs with China at Depsang, Chumar, Doklam and Galwan. Therefore, India needs to develop its defence space capabilities to secure her rightful place in the emerging world order.

Conclusion

Over the past decade, space has increasingly become an important arena to support military operations and information domination. This implies that the integration of space systems with other war fighting systems is crucial for the armed forces. Thus, protection of space assets and associated ground infrastructure is essential. There has been a steady increase in our space assets in the last decade and these are poised to increase further in the near future. Therefore, our space strategy should not only be focused on the ability of our space assets to operate and survive in a hostile space environment but also to protect our space infrastructure on ground, to achieve our strategic aims and objectives in war.

China has forged ahead in developing its space capabilities and is in the process of integrating these into its war fighting doctrines to challenge any adversary in a future conflict. In 2016, the White Paper 'China's Activities in Space' laid out China's space vision as, "*To build into a space power in all respects, with the capabilities to make innovations independently, to make scientific discovery and research at the cutting edge, to promote strong and sustained economic and social development, to effectively and reliably guarantee national security*." It emerges that China's ambitious space plans will not only give China the confirmed strategic advantage

but also alter the power dynamics in Asia and on the world stage. China's Space capability development has a direct bearing on India's security, its standing in the comity of nations and the security environment in Asia.

China has made rapid strides in space. Chinese military writings suggest that for efficient and effective joint operations, military must be able to exploit space. Only the high ground of space can provide the opportunity to gather information; transmit it rapidly, securely and reliable; and exploit it promptly. Space has been described as essential for reconnaissance and surveillance, communications, navigation, weather forecasting and battle damage assessment. PLA recognises the importance of controlling space as a means of achieving true information dominance. It advocates space warfare as an essential pre-requisite for joint campaigns and for maintaining the initiative on the battlefield. It also views the denial of an adversary's space systems as an essential component of information warfare and a pre-requisite for victory.

Till recently, Indian defence services had not evinced any serious interest in space applications. Therefore, integration of space technologies necessitates requisite changes in the operational philosophy of the armed forces.

The roadmap suggested in this thesis may not be the last word on the subject, but it can certainly be the stepping stone for policy formulation to address our national security interests. A long-term policy abiding by the international peace treaties and complemented with work on indigenous R&D on space systems to defend our space assets should be given priority, to make India self-reliant in this field.

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