

# LEVERAGING SPACE CAPABILITIES FOR INDIA'S DEFENCE

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Space capabilities are becoming absolutely essential for national development, economic well-being, commerce, and everyday life, besides becoming a crucial component of successful military operations. It is generally well-known and accepted that space has emerged as an essential component in furthering a nation's comprehensive national power. India has a robust civil space programme which is essentially geared towards scientific and development goals. As we move towards greater development, utilisation of space for economic and developmental purposes is likely to increase, and as dependence on space assets and systems increases, the concurrent vulnerability of our country to hostile action seeking to deny, degrade or destroy our space capabilities would increase. India's dependence on space for vital economic purposes has been growing rapidly and, hence, any serious disruption or degradation would have a major negative impact for the nation's economy.

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protect national interests and investments. This generates the rationale for military involvement in space apart from the fact that space enabled capabilities are fundamental to the core of the revolution in military affairs (RMA) aimed at enhancing military capabilities. The effectiveness of modern precision warfare witnessed during the Gulf War is largely a by-product of the RMA which is aimed at combining the cumulative potential of air and space forces in terms of

intelligence, surveillance, reconnaissance (ISR), communications, navigation, etc for providing information dominance, essential for application of force, which, in turn enables decisive war-winning effects. Hence, as part of the Indian Air Force's (IAF's) modernisation drive as also to attend to the compulsions of national security, it would be essential to utilise the space-based options available for national defence. Before a comprehensive assessment of the options available, it would be essential to broadly examine the utility of space for the armed forces.

### **MILITARY USES OF SPACE**

The use of space has expanded with every passing conflict as emerging technologies afford greater exploitability of the environment for pursuance of military activities. Until the last decade, however, the uses were largely of a "non-weapon" nature. Space-based assets were mainly aimed at "force-enhancement" missions like observation, communications, navigation, meteorology, etc which allowed terrestrial military forces to conduct military affairs more efficiently. Thus, most military space missions were auxiliary to other more direct military activities. In fact, the capacity to deliberately cause damage to another asset in space is not the main criterion for attributing a military character to satellites. Most present-day satellites (excluding anti-satellites—ASATs) affording military capabilities or performing military functions are incapable of directly destroying or damaging another country's

property. Apart from “early warning” satellites, which have a clear military role, most of the other military activities can also be performed by civilian satellites and vice-versa. For example, civilian earth-observation satellites can be used for military surveillance, civilian (even commercial) communication satellites have been known to carry military transponders, military navigation satellites have overwhelming civilian users—there is, hence, no clear demarcation between civil and military users.

However, as military as well as commercial reliance on satellites grows, so too has the awareness that space-based assets are centres of gravity which are likely to be targeted in war. This in turn has fuelled the quest for development of techniques for protecting one’s assets in space as well as denying an adversary the use of space. Thus, space-based systems earlier focussed on force-enhancement missions, and the new focus has shifted to controlling the realm of space for one’s own benefit while denying it to the adversary. The accent on military utilisation of space is gradually shifting beyond enhancement of military force capabilities to control of the environment and actual application of military force “in, from and through space.” The above trend is evidenced in the quest of space superpowers like the US embarking on programmes aimed at space control and space force projection. Some of these include programmes like the experimental satellite series (XSS) which seeks to use small satellites to manoeuvre around other satellites in order to inspect, service or attack. They also include kinetic energy anti-satellite (KEASAT) systems, directed energy programmes as well as “counter-space” initiatives like the counter-communications system (CCS)<sup>1</sup> aimed at disrupting satellite-based communication used by an enemy for military purposes. The first of such CCS systems was delivered to the US 76th Space Control Squadron in the year 2004.

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1. Jeffery Lewis, *Arms Control Today*, November 2004, p. 12; Nicole Gandino (USAF) “Weapon for Counter-Space Capabilities,” *Defence News*, July 2005.

A space-based interceptor test-bed programme is also underway to develop and test space-based miniature missile defence interceptors. The Pentagon's Missile Defence Agency has already provisioned budgetary allocations for the same. The concept broadly envisages a constellation of space-based interceptors of 50 to 100 interceptor satellites offering a thin boost/ascent defence against intercontinental ballistic missiles (ICBMs) and a multi-shot mid-course defence against medium to intercontinental range missiles.

The agency's plans call for the first contract to be let out in 2008, the first intercept tests by 2012 and "a constellation production decision" by 2014. From the foregoing, it is evident that space-based systems are presently in the process of transition from an era of militarisation to weaponisation.

### *Military Applicability for Nascent Space Powers*

However, it needs to be borne in mind that the above transition is applicable only to nations like the US. The next rung of "space powers," the Russians and the Chinese are yet to embark on any serious weaponisation programme. This is mainly on account of the prohibitive costs and technological challenges involved. The Russians inherited the entire range of capabilities for force enhancement missions from the erstwhile Soviet Union. However, since the 1990s, Russia's capabilities have been severely degraded due to funding problems. With regard to the Chinese, though they are the undisputed leaders in Asia, in relative terms vis-à-vis the US, their capabilities are nascent. However, the Chinese seem to be pursuing the ASAT programme as a priority area. Other countries with known space-based force enhancement assets in operation include France (Helios imagery intelligence satellite and Telecomm-2 communications satellite), Italy (Sicral communications satellite), Spain (Hispatat communications satellite), Britain (Skynet-4 communications satellite), Israel (Eros and Ofeq imagery intelligence satellites), India (TES photo-reconnaissance satellite); Japan (commercial Superbird communications satellite system and information gathering satellites); and South Korea (Komsat-1 remote sensing satellite).

Thus, it is apparent that besides the US, most nations are yet to progress beyond rudimentary military space capabilities aimed at force enhancement missions.

## USE OF SPACE FOR FORCE ENHANCEMENT

A brief description of the capabilities afforded by space systems for force enhancement are as follows:

### *(a) Intelligence, Surveillance and Reconnaissance (ISR)*

Their primary contribution is to enable situational awareness by providing high resolution images of the area of interest, monitoring changes, strength and location of forces. ISR satellites could be of the following types:

- (i) **Imaging Satellites.** These are low earth orbit (LEO) satellites that orbit the earth at a height of approximately 300-450 km. Their payload comprises optical as well as radar sensors to provide day/night coverage. To identify troops, a resolution of less than 25 cm would be required. However, for larger sized target identification, a one metre resolution would suffice. Presently, this capability is provided by the technology experimental satellite (TES), which was launched in October 2001. In the future, the CARTOSAT-2 would provide an enhanced capability with the space-based surveillance (SBS) programme.
- (ii) **Early Warning (EW) Satellites.** These are used to monitor the launch of ballistic missiles, rockets for launching satellites as well as nuclear detonations. Space-based sensors are capable of giving warning almost immediately after launch or when the missile breaks through the cloud cover. Hence, they provide maximum warning time for counter-action. Geo-stationery satellites are suitable for the EW role. Sensors include scanning infra-red telescopes having a resolution of 3 m or less to pick up the hot plumes of missiles.

### *(b) Communication Satellites*

These are typically geo-stationery satellites at altitudes around 36,000 km. These enable military commanders to exercise command and control over their forces and to receive real-time information about the progress of the campaign. Space and terrestrial sensors involved in ISR, navigation, etc generate an enormous amount of data. The transmission of this data requires reliable and secure

communication which is provided by communication satellites. Satcom is particularly useful for connecting geographically separated units. Networks could also be established at remote locations in a short period using these.

The Indian communication satellites are as follows:

- (i) INSAT-2 E
- (ii) INSAT-3 A,B,C & E
- (iii) GSAT-2\*(ADGES back-up & IMMOLS)
- (iv) GSAT-3\* (Tele medicine)
- (v) INSAT-4A

\* Presently used by the Indian Air Force (IAF)

In the future, GSAT-4 will provide Ka band transponders on an Indian satellite for the first time, and GSAT-7, a dedicated navy satellite, would provide an enhanced coverage in the Indian Ocean region.

#### ***(c) Navigation Satellites***

Navigation satellites such as the Navstar GPS, and GLONASS have helped military forces to precisely manoeuvre, synchronise actions, locate and attack targets as well as locate and recover stranded personnel. They have profoundly improved the accuracy of weapon delivery. With a hand-held global positioning system (GPS) receiver, a ground soldier can precisely locate his position. Using a laser range finder, he can obtain the range and bearing of the target. This could be relayed to an airborne platform to attack the target site. We currently use the American GPS array of satellites in a 20,000 km orbit. Of the entire constellation, at any time, at least four satellites are simultaneously in view to provide precise time, position and velocity data. In the future, the projects GAGAN and Indian Regional Navigation System (IRNS) would provide an indigenous wide area augmentation system (WAAS) and navigational platform.

#### ***(d) Meteorological Satellites***

These satellites provide information about atmospheric water vapour, temperature and other weather phenomena. They could be used to determine the most appropriate time for attack. They monitor meteorological conditions

over the target area, and provide data about cloud cover so that satellite reconnaissance missions can be planned effectively. The satellites maintain altitudes around 800 km, inclined at 98 degrees, and are sun synchronous. The geometry of this orbit is such that each satellite views the whole surface of the earth twice a day. These can also be geo-stationary satellites, typically giving cloud cover every hour. Kalpana-1 and Oceansat-1 are satellites dedicated for meteorological purposes. In the future, the Oceansat-2 is envisaged for providing continuity to Oceansat-1

#### *(e) Geodetic Satellites*

These are used to produce maps of the earth by using photographic and radar techniques. They also provide data about the earth's gravitational and magnetic fields which enable trajectories of ballistic missiles to be predicted accurately. These are essential for the guidance system of cruise missiles.

### **IMPERATIVES FOR OUR DEFENCE NEEDS**

It is apparent that space-based systems provide vital capabilities to successfully execute national military strategy, and have the potential to be used across the full range of military operations at the strategic, operational and tactical levels of war in order to accomplish national security objectives.

Secondly, information derived from air space platforms would be vital for success in conflicts. Hence, it would be imperative to attain a certain medium of "information dominance" in order to complement our conventional capabilities.

Thirdly, targeting would assume increasing importance and would be aimed at the heart of the enemy through effect-based operations (EBO), which would, through a few, carefully selected and executed time critical operations (TCO),

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significantly affect the course of the campaign. Such a winning combination of information dominance, real-time command and control and judicious force application would be possible only through the aerospace medium. Aerospace operations, extending from the ground up to space will render obsolete the traditional dividing line between strategic and tactical operations, and enable hitherto distinct levels of war to be merged into simultaneous, precise and carefully orchestrated operations which would aim for the nerve centres of leadership as well as command and control at the very outset of hostilities.

Many emerging realities of IAF air power like the integrated air command and control system (IACCS), airborne warning and control system (AWACS), operational data link, etc are different aspects of an emerging network-centric environment in which the space medium would be a vital, though largely invisible component. However, there exists an emergent need for examining the options afforded by space in order to address the following aspects:

- (a) Securing of our space and terrestrial assets and, thereby, ensuring uninterrupted national development.
- (b) Coordination of military requirements and development of military space capabilities.
- (c) Integration of space and conventional military capabilities.

From the foregoing, it is clear that there is a need to amalgamate space assets with conventional capabilities to bolster prevailing capabilities, resulting in the conduct of traditional tasks more efficiently. Existing space assets would need to be exploited and future projects should take into account national

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security requirements along with economic, scientific, social and other requirements. The military uses of space have evolved from early, tentative attempts at enhancing conventional military force capabilities to actually enabling the decisive outcome of battle in the present times. The reliance, rather over-reliance on space-based systems like in the

US basically stems from the fact that space-based systems can accomplish or enable accomplishment of military missions more efficiently, more economically and in a technologically superior manner than could be achieved by any other means. No surprise then that acquisition of space-based military capabilities globally has become the norm rather than the exception.

At the same time, it also needs to be understood that space is not a substitute for conventional military capabilities, or a panacea for information voids or military inadequacies. Uses of space-based systems are constrained by exorbitant costs because of the high levels of technology involved. Satellites themselves are constrained by technological factors like predictable over-pass timings and orbital patterns, width of coverage, attenuation due to inclement weather, etc. Their utility and limitations in the information loop, applicability at the strategic, operational, tactical levels, etc must be understood in the correct perspective for optimal exploitation. It also needs to be borne in mind that arriving at present levels of military space utilisation has taken even an advanced nation like the US the better of over four and a half decades. Hence, we would need to be cautious in emulating the capabilities of such advanced nations, and in superimposing their advanced doctrines and strategies on our relatively nascent needs and capabilities. Defence strategy on space should be dictated by rational security needs and not the outer limits of what appears to be technically possible as in the case of superpowers like the US.

### **DEVELOPING SPACE CAPABILITIES FOR DEFENCE**

Nonetheless, it is crucial that we incorporate existing space capabilities, resources and operations in our security policies and strategy. Our unique circumstances and practical considerations would demand a deeply cooperative and integrated approach to capacity building and resource utilisation by various departments of the government. It would be counter-productive to duplicate assets or to reinvent the wheel; affordability and optimisation would demand a cooperative evolutionary

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approach. India already has fairly advanced programmes for economic and social development purposes. These programmes could be modified to include space capabilities needed for security purposes. In other niche areas, space capabilities for defence could be built upon as an extension of these programmes, thereby, enabling affordability and optimal utilisation of resources.

Space capabilities for defence would primarily need to be built upon two considerations. One, a balanced assessment of the military requirements vis-à-vis capabilities afforded by space; and, second, the coordination and integration of space into our conventional security apparatus. Prioritisation of requirements, technologies and capabilities would need to be objectively charted and pursued for development and deployment of capabilities. This would be essential for evolving a robust, credible and affordable programme which would be mutually beneficial, cohesive and cost-effective. It could fulfil national defence needs, and at the same time, not drain or compete with the civilian developmental programmes. The structure could be designed to ensure that the civil and military aspects of the national space programme complement and draw strength from each other rather than compete with each other.

### **EXTRACTING MILITARY APPLICATIONS FROM CIVIL CAPABILITIES**

We have significant experience and expertise in space and space-related technologies. Many of them would have dual-use applications while some of them would have to be further developed to support defence forces. Civil, and military space activities are complementary and no "budget-intensive" effort is envisaged for technology transfer from civil to military space endeavours. For example, launch vehicles are the same for civil and military payloads. Similarly communications, navigation, imagery, meteorology and geodesic satellites have both military and civil applications. In fact, space-based imagery, communications and permission guidance are available off-the-shelf as commercial products. It is accepted that economic (and perhaps political) considerations may limit some civil-to-military spin-offs. However, it is a matter of national interest that capabilities for defence should benefit from

economic and commercial uses of space. These are challenges to be overcome jointly in the larger national security interests, while developing our military space capabilities. While certain dual-use capabilities could be harnessed right away,

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other capabilities would demand dedicated efforts. Certain defence-specific technologies would need to be developed and progressed. Defence research and development (R&D) would have to concentrate on defence-specific technologies that cannot be developed by civilian R&D agencies. Joint efforts by a central defence coordinating agency, space agencies and defence technological agencies like the Defence Research and Development Organisation (DRDO) could undertake development, planning and execution of such programmes.

Thus, keeping in mind the "availability and affordability" criteria, presently available space technologies would need to be dovetailed to meet present national security and defence requirements. Future requirements should be projected with due attention to costs, legalities and treaties in vogue, technical feasibility, etc. For future applications, doctrine, requirement, technology and capability could be evolved synergistically, keeping pace with each other for optimal military exploitation and utility of space-based systems.

### *Challenges to Civil-Military Modifications*

In the near term, the main differences perceived for modification of our prevailing (civilian) space programme to meet security requirements relate to:

- (a) Greater robustness and manoeuvrability, essential to secure space assets against degradation, disruption and destruction by enemy counter-measures like jamming, ASAT weaponry, etc.
- (b) Increased resolution capabilities coupled with more frequent revisit capabilities to meet intelligence, targeting and other requirements.
- (c) Independent, secure, dedicated and redundant communication and navigation links to ensure uninterrupted access even during times of crisis,

wars, etc. Reliance cannot be placed on systems like the American Navstar GPS, whose use may be denied, restricted or degraded by the service provider itself.

(d) Sharing of technological, operational and related knowhow for building up aerospace surveillance capabilities.

### AGENCY FOR COORDINATING SPACE-BASED MILITARY AFFAIRS

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communications, continuous surveillance and highly accurate positioning. These capabilities provide a decisive advantage to the military. India has considerable civilian space capabilities, but dismal military space capabilities. We have, over the years, built up adequate capability in space technology and our space assets are being exploited efficiently by the civil sector for a number of applications but the military use of space by India has been minimal. Indian military use of space is limited to procuring imagery

from a single military satellite, the TES. India is yet to integrate its civilian capabilities into its war-fighting machinery or at least take steps to protect its assets in space. This lack of coherent direction in military space application has resulted in the significant gains being underutilised in a military context. India ranks at fourth position in the world with regards to both national air power and space capabilities; however, the absence of foresight and coordination has led to a situation wherein joint exploitation of the media of air and space is among the lowest in the world, as highlighted by Table 1.

As part of a focussed, integrated approach, the Integrated Space Cell (ISC) at Headquarters Integrated Defence Staff (HQ IDS) has been designated as a nodal agency to coordinate all space related issues for the three Services. Some of the tasks that the ISC would fulfil are as follows:

**Table 1: Composite Aerospace Exploitation  
Across The Globe<sup>2</sup>**

Country	Air Power (No of Aircraft)- year 2003	No of Military Satellites-year 2003	Degree of Integration
USA	16,038	105	Highest
Russia	9,211	144	High
China	9,812	09 Dedicated, dual-use 42-use not known	Medium
India	1,813	01	Nil
Japan	1,754	02 launched (in orbit) 02 failed	Medium
Israel	1,038	02 in orbit 01 dual-use 02 failed	High

- (a) It would serve as a single point of contact for all space applications and support, responsive to all security agencies.
- (b) It would serve as a nodal agency for space system/capability demand, acquisition, procurement, etc from external agencies (both civil and commercial).
- (c) It could be entrusted with the responsibility of coordinating the requirements of various users, consolidating all existing and proposed space support applications, recommending compatibilities and feasibilities of such applications and scrutinising support requirements, etc.
- (d) It could be tasked to examine and recommend suitable defence oriented systems/sub-systems, deployment of such systems, and, subject to approval, pursue implementation of such projects.

2. The number of aircraft has been sourced from "World Military Aircraft Inventory," *Aviation Week and Space Technology*, January 13, 2003, pp.257-76 and generally corresponds to equal figures in SIPRI's and *Military Balance*. However, military satellite estimates with respect to the US and Russia differ in publications ranging from SIPRI's, the Teal Group, etc to the US Air Force Association's *Space Almanac*, etc. Nevertheless, most publications are in common agreement regarding the estimates of Asian military spacecraft.

### *From Theory to Practice*

The present choice of military space applications, hence, could be a subtle mix of applications which need not be exclusive to military needs, but would be a natural adjunct of civilian applications, with a greater degree of autonomy, redundancy and security. Thus, while present military requirements may be included into the Indian Space Research Organisation's (ISRO's) decade plan (1997-2007), future military requirements, after due consideration, could be projected well in advance to allow their inclusion and integration into the subsequent decade plans. The above would enable synergistic evolution of national military space capabilities without disturbing the pace of our civilian space capabilities. Towards this, the Defence Space Vision (DSV)-2020 has been produced by HQ IDS with the participation of the representatives of the three Services and the Department of Space (DoS). The document is presently being converted into two technical reports pertaining to ISR and communications. The reports will contain the roadmap of the specific space-based capabilities required by the three Services and the commitment, with time-frames by the DoS to achieve the same.

### *Roadmap for Military Utilisation*

The assets and capabilities required for a credible space programme aimed at national security in addition to civilian development would need to be carefully built up taking both the operational needs as well as the critical issues of affordability, political correctness, cost, etc into account. A significant amount of capability and assets would need to be built up, with many of them created on a priority basis and/ or strengthened even after they have already been initiated. The needs and developments would have to be kept under constant review and monitoring.

### *Roadmap Ahead*

The list of technological advances and applications afforded by our extant civilian capabilities is long and impressive and there is an equally long list of the potential paths and options for exploiting these capabilities.

Fundamentally, the roadmap in the near term would focus on force enhancement missions and protecting our assets in space. The first aspect could be addressed by inducting space systems in areas such as communications, navigation, observation

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which would be within the scope of technologies available to us and affordable to the exchequer. The emphasis would be on utilising the enormous scope provided by space systems to conduct military affairs more efficiently. This would demand significant participation and cross-exchange of ideas and information between the military and civilian space agencies. The cross-flow of information would primarily be in terms of technological inputs and feasibilities from the civilian space agencies corresponding to operational requirements put forth by the armed forces. The second aspect would be of protection and security of our space-based assets built so painstakingly over the decades which would also demand cross-exchange of inputs and participation by both civilian and security agencies.

## DESIRABLE CAPABILITIES

### *Reliable Communication Capabilities*

In view of factors ranging from immediate responsive communicability required for the defence forces deployed across the length and breadth of the subcontinent, the variety of terrain, and the inherent limitations of ground-based communication systems, there is a need for the armed forces to be provided connectivity by space-based systems. The inherent virtues and efficiency of space-based communications would overcome prevailing problems of line-of-sight links, attenuation losses, low reliability, etc. Secondly, apart from enhancing command control, communication, computers, intelligence (C<sup>4</sup>I), it would also serve to efficiently transfer the enormous amount of data and information provided by space-based observation, navigation and other systems to the users in real-time or near real-time.

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A military communication system in our Indian context would basically indicate military-unique system(s) owned, leased or dedicated to military purposes. These would encompass operations, control and employment of system(s) by the military. The system(s) could include the requisite number of transponders, frequency bands or even leased capabilities on civil or

commercial satellites rather than dedicated military communication satellites. Dedicated efforts would be prohibitively expensive and may amount to underutilisation in an era of multi-tasking. The essential factor distinguishing civil and military systems is that civil applications are aimed at reliable connectivity at most economical rates whereas defence applications would demand reliable connectivity even in the face of deliberate degradation, interference, etc which are characteristic to combat operations. It is desirable to have the required bandwidth on more than one satellite to obviate disruption of services and in case of failure/sabotage of a particular satellite, requisite modification could be undertaken to balance and meet both the requirements.

### *Space-Based Capabilities*

The term space-based observation has been used to broadly include missions of imagery intelligence (IMINT), electronic intelligence (ELINT), signals intelligence (SIGINT), etc which primarily deal with space-based observation aimed at providing significant ISR capabilities. ISR requirements would entail integration and exploitation of prevailing and forthcoming advances in space-based sensors inclusive of capabilities on civilian application satellites like the IRS series, dedicated military assets like the TES, and even commercial satellites like IKONOS . The integration would not be limited to just space-based ISR systems but also to corresponding air and surface-based systems because pursuing independent ISR capabilities would amount to defeating the purpose of such potent capabilities. Overall integration of capabilities would be essential

to obtain a synergistic strategic, operational and tactical observation capability. The broad requirements to be fulfilled for ISR capabilities would be as follows:

**(a) IMINT**

- (i) Systems providing one metre resolution are presently available and would suffice for the near term, though repetivity and revisit factors need to be improved. In specific areas, sub-metric imagery would have to be obtained for effective targeting.
- (ii) Area of coverage contiguously needs to be extended to include locations where known threats exist.
- (iii) Availability of a judicious mix of sensor payloads like hyper spectral imaging (HSI) and synthetic aperture radar (SAR), etc.
- (iv) Availability of better data processing and transmission capabilities.

**(b) ELINT/SIGINT**

- (i) While dedicated efforts for the above capabilities would be most suitable, in the interim, requisite payloads could be placed as “piggyback options” on satellites to cover areas of interest.
- (ii) Opportunities afforded by micro and nano satellites in fulfilling the requirements also need to be explored.
- (iii) Integrate space-based effort with conventional capabilities.

**(c) Ocean Reconnaissance**

- (i) This would be an investment in the near term, which would be dedicated to purely military affairs; however, this is considered inescapable on account of our expanding area of interests and reach of the navy.
- (ii) In view of the enormity of the investment involved, the project may have to be undertaken phase-wise.

***Space-Based Positioning and Navigational Capabilities***

Financial propriety in investing in expensive indigenous navigational capabilities would *prima-facie* appear questionable. However, it needs to be borne

in mind that apart from our own satellite-based augmentation system GAGAN (GPS and geo-augmented navigation), which is devoted to civilian uses, India has already invested in every existing navigational system ranging from the American NAVSTAR GPS, Russian GLONASS to the European GALILEO with no reciprocal guarantee of assured access. The requirements and costs of an indigenous navigational capability need to be assessed vis-à-vis our strategic relationship with parent countries i.e. the US, Russia and the European Union (EU). In addition, the following measures could be undertaken:

- (a) Acquire navigation receiver systems compatible with multiple transmitters since receivers would need to be compatible with American, Russian and European systems.
- (b) Take advantage of the existing GPS, using differential GPS for greater accuracy.
- (c) Develop a system analogous to the wide area augmentation system (WAAS) of the USA for military uses. The system is a network of precisely surveyed ground reference stations which receive GPS signals and determine errors and compute corrections. These corrections are then transmitted from a geostationary communications satellite on the same frequency as GPS. This would enable continuous use of GPS even in the eventuality of the service provider attempting to deny or degrade GPS facilities. Incidentally, until the maturing of their indigenous space-based navigational system "Beidou", the Chinese were known to be following this option.
- (d) Install GPS integrity monitors at air traffic control centres or air defence direction centres to monitor GPS, and enable corrective action in case of systems degradation or denial.

### *Early Warning*

The requirement of early warning (EW) against ballistic missile (BM) launches would require an enormous investment since neither would the satellites be dual-use nor would the requirement be sufficed by a single satellite, two satellites or a part constellation. An enormous effort and investment into a constellation covering the entire subcontinent, including the island territories,

would be required. Such an enormous investment in the near term is not considered prudent and it would be wiser at present to invest in capabilities like communications, navigation, observation, etc which are of a more emergent nature in the near term and the foreseeable future. Dispensing with an elaborate ballistic missile early warning (BMEW) system in the near term is being suggested primarily on the following grounds:

- (a) BMEW systems are largely a sub-set of ballistic missile defence (BMD) which itself is a controversial endeavour. The technology is yet to mature, the operational utility and concepts are unproven, and the cost intensive. Once the experimentation stage ends, depending on the failure or success of the endeavour, efforts could be initiated.
- (b) Unlike in the case of Cold War where BM rivals, the US and USSR, were separated by intercontinental distances and, hence, needed an elaborate investment in BMEW systems, our threat is characterised by proximate, contiguous neighbours. The prevailing conventional radars are capable of detecting and tracking missile trajectories within the atmosphere (to a certain extent). Therefore, whether an enormous investment needs to be undertaken for tracking and detection beyond the atmosphere is a moot issue. Particularly, in view of the fact that even after detection and identification, the more important issues of interception and destruction are yet to be addressed.
- (c) Lastly, other delivery options are available to both the BM and nuclear powers in our neighbourhood, hence, concentrating on BMEWs is not recommended.

### *Protecting and Securing Assets in Space*

As of now, no known protection measures have been undertaken to secure our assets in space. Assuming that some of these would have joint civil-military applications, a hard kill (e.g. ASAT attack) or soft kill (jamming, interference) by a hostile entity would cause a significant dent in our military capabilities and an enormous dent in our economic capability. Increased

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use and exploitation of space capabilities for economic and other development would call for enhanced protection of space assets and capabilities; hence, steps to protect and secure assets in space need to be undertaken in the near term.

### *Threats Envisaged*

Presently, the threats to space-based systems are perceived from the following:

(a) Ground, airborne and space-based energy weapons like directed energy weaponry (DEW), electro magnetic pulse (EMP), high power microwave (HPM), etc.

(b) Kinetic kill by (non-nuclear) ASATs and other interceptors.

(c) Degradation by jamming and other forms of interference.

Effective threat levels of the above three would, however, vary. Technology in the first case is yet to mature completely and is extremely costly. The other two are more problematic due to the prevalence of established technologies, which are capable of jamming or degrading space systems by targeting signals, uplink/downlink, etc or actually destroying satellites. It also needs to be borne in mind that latent ASAT capabilities already exist with many space powers. Conflicts and disputes are already on-going as also is interference with signals, etc. The situation is already alarming and is only likely to worsen further.

### *Protection and Security of Space Assets*

The above would demand parallel defensive measures, which comprise a studied, deliberate, institutionalised effort rather than knee-jerk responses to adverse situations. Our space systems would need to be equipped with proper shielding, frequency agility, manoeuvrability and encryption to be invulnerable and more importantly, survivable even with degraded capability in a worst-case scenario. Protection of space systems would largely revolve around the following:

(a) Orbital monitoring and protection.

(b) Link (uplink/downlink) control and protection.

(c) Allied receiver system (terrestrial) protection.

*Protection Measures*

Broadly, the following measures would need to be undertaken to ensure protection of space assets:

- (a) Monitoring of space for continuous information on the location of satellites, space debris, asteroids and other harmful matter. This would necessitate the formation of aerospace surveillance centre(s), which would monitor the entire vertical expanse inclusive of the atmosphere, near earth orbit and even beyond. This task may require collaboration with other space powers.
- (b) Incorporation of survivability measures for both satellites and their payloads like hardening, shielding, etc to shield against soft-kill energy weaponry like (DEW), lasers, HPM, etc. Electronic counter-measures (ECM) like frequency hopping, antenna nulling, etc would need to be incorporated. The ability to pin-point and enable counter-response against jamming, interference, etc would also need to be factored in.
- (c) Incorporation of additional energy (fuel) to provide manoeuvrability to defeat physical attack (hard-kill). Payload penalties would have to be designed within acceptable limits so as to compensate for hardening, manoeuvrability, etc.
- (d) Encryption of satellite links (uplink/downlink/crosslink) to protect and prevent intelligence leaks from transponders, transmitters, receivers, etc.
- (e) Multi-sensor data fusion to provide for redundancy and integration of satellite imagery and other data derived from airborne sensors like aircraft, unmanned aerial vehicles (UAVs), etc to defeat camouflage, concealment, deception and also compensate for degradation.
- (f) While a wide variety of survivability and protection options is available, a judicious mix of efforts in response to the nature and probability of threat as well as the value of satellites would need to be undertaken for balancing

**Monitoring of space for continuous information on the location of satellites, space debris, asteroids and other harmful matter. This would necessitate the formation of aerospace surveillance centre(s).**

**While a wide variety of survivability and protection options is available, a judicious mix of efforts in response to the nature and probability of threat as well as the value of satellites would need to be undertaken for balancing conflicting requirements of security and cost.**

conflicting requirements of security and cost. Towards mid-term, the technological maturing of micro and nano satellites would herald a revolution in the uses and cost of satellites and consequent cheaper options would have to be explored.

#### *Roadmap Categories*

The list of technological advances and applications afforded by our extant civilian capabilities is long and impressive and there is an equally long list of the potential paths and options for exploiting these capabilities

but fundamentally, the roadmap to be followed could be grouped into the following three categories:

#### **(a) Near-Term (2007-2017)**

- (i) Application of available space capabilities for military force enhancement, i.e. using space for enabling more efficient use of conventional military capability.
- (ii) Institutionalising protection measures for securing space-based assets by measures like hardening, manoeuvrability, etc.
- (iii) Establishing organisational and infrastructural facilities to fulfil the above requirements.

#### **(b) Mid-Term (2017-2027)**

- (i) Integrate space and conventional military capabilities to possess a comprehensive instrument of national power capable of delivering the collective might of military and space power for furtherance of national objectives.
- (ii) Institutionalise measures for defending national territory and assets against military force application from space.

#### **(c) Long-Term (2027- 2037)**

- (i) Synergise operations and technology to go beyond incremental capability

development and pursue better strategies for accomplishing national objectives.

*Near-Term (2007-2017)*

The list of technological advances and applications afforded by our extant civilian capabilities is long and impressive and there

is an equally long list of the potential paths and options for exploiting these capabilities. Fundamentally, the roadmap in the near-term would focus on force enhancement missions and protecting our assets in space. The first aspect could be addressed by inducting space systems in areas such as communications, navigation, observation which would be within the scope of technologies available to us and affordable to the exchequer. The emphasis would be on utilising the enormous scope provided by space systems to conduct military affairs more efficiently. This would demand significant participation and cross-exchange of ideas and information between the military and civilian space agencies. The cross-flow of information would primarily be in terms of technological inputs and feasibilities from the civilian space agencies corresponding to operational requirements put forth by the armed forces. The second aspect would be of protection and security of our space-based assets built so painstakingly over the decades which would also demand cross-exchange of inputs and participation by both civilian and security agencies.

**Fundamentally, the roadmap in the near-term would focus on force enhancement missions and protecting our assets in space.**

*Middle-Term (2017-2027)*

It would be too ambitious to expect total fulfilment of all near-term goals, therefore, it would be prudent to expect spillover of incomplete programmes onto the subsequent phase. The pace of technological and geo-political change would dictate intense inherent dynamism and adaptability in our plans and capabilities. Nevertheless, by mid-term, it would be reasonable to expect a certain level of mission fulfilment in the roles of communication, navigation, ocean reconnaissance, etc. A certain level of maturity in the technology,

**By mid-term, the emphasis should shift to completion of pending projects and better integration of space into conventional military capabilities. This would dictate a review of changed capabilities and focus on doctrine, strategies and procedures for optimal exercise of military power in pursuit of national objectives.**

operational concepts, human resources, organisation and infrastructure may also be expected. Hence, by mid-term, the emphasis should shift to completion of pending projects and better integration of space into conventional military capabilities. This would dictate a review of changed capabilities and focus on doctrine, strategies and procedures for optimal exercise of military power in pursuit of national objectives.

#### *Long-Term (2027-2037)*

Long-term predictions and visions are fraught with difficulties on account of the pace of change. Extended long-term visions generally dissipate into mirages and, hence, for the present it would suffice to have a broad long-term concept which would deal largely with going beyond incremental capabilities and developing new strategies based upon capabilities foreseen in the future. Such an endeavour could be undertaken towards the end of the middle term and, hence, is dispensed with at present.

## CONCLUSION

The security demands of the future on any nation are no longer restricted to physical security. The future security starts with physical security in one's own territory, and extends to security of its population worldwide, to economic security, to energy security, not only its own, but also of friendly states. In the future, armed forces would increasingly be involved, more so in peace-time activities like disaster management and out-of-area contingencies, etc.

Use of air power in various parts of the world during the last decade has shown that air power is the most effective instrument of power projection for a nation. Air power is also the most effective instrument for providing for any

commitment of the nation to its population.

In recognition of this, to keep pace with the growing needs of the nation, the IAF's strategies and its operational concepts have been reviewed constantly to meet all kinds of contingencies and the need for

unremitting vigilance. Professional training and development of air warrior qualities have been strengthened to meet all future challenges.

It is keeping in mind such a futuristic scenario that the IAF is planning to integrate space-based applications extensively into its conventional strategies and operations. The IAF vision is linked with the vision of the country, and the IAF's capabilities would grow as the country grows. The new dimension of warfare is moving into space, the ultimate high ground, and this is where the IAF would also move to. We are already using space for telecommunications, reconnaissance, navigation targeting and many other operations. The IAF is adopting a focussed and fast tracked approach to harness space effectively to provide synergy with all the facets of its operational roles.

**Air power is also the most effective instrument for providing for any commitment of the nation to its population.**