SYNERGY

Journal of the

CENTRE FOR JOINT WARFARE STUDIES

CENJOWS
(Established : 2007)

Centre for Joint Warfare Studies (CENJOWS)
Kashmir House, Rajaji Marg, New Delhi 110011
Telephone Nos : 011-23792446,23006535,23006538/9
Fax : 011-23792444
Website : http://cenjows.in
e-mail : cenjows@yahoo.com

Synergy is a bi-annual Journal that is published in Jun & December every year. It is supplied to the members of CENJOWS. Articles, Book Reviews, abridged version of Research Papers and Dissertations may be sent to the Editor as per the guidelines contained in the Journal. Advertisment enquiries concerning space and charges may also be sent to the Editor.

The Centre for Joint Warfare Studies (CENJOWS) is an independent, professional research institute established in 2007, in pursuit of strengthening the concept of 'jointness' within the defence force, as well as with other agencies that jointly contribute towards a nation's war fighting capability. SYNERGY is the CENJOWS Journal that strives to expand and deepen the understanding of issues concerning defence, national security and civil-military interface which are so very essential for joint war fighting.

Price : ₹ 200/- INR or US $ 10

Contents

Foreword

Air Marshal PP Reddy, VM

CISC & Chairman CENJOWS

Director's Remarks

Technology – Civil and Military, A Two Way Traffic

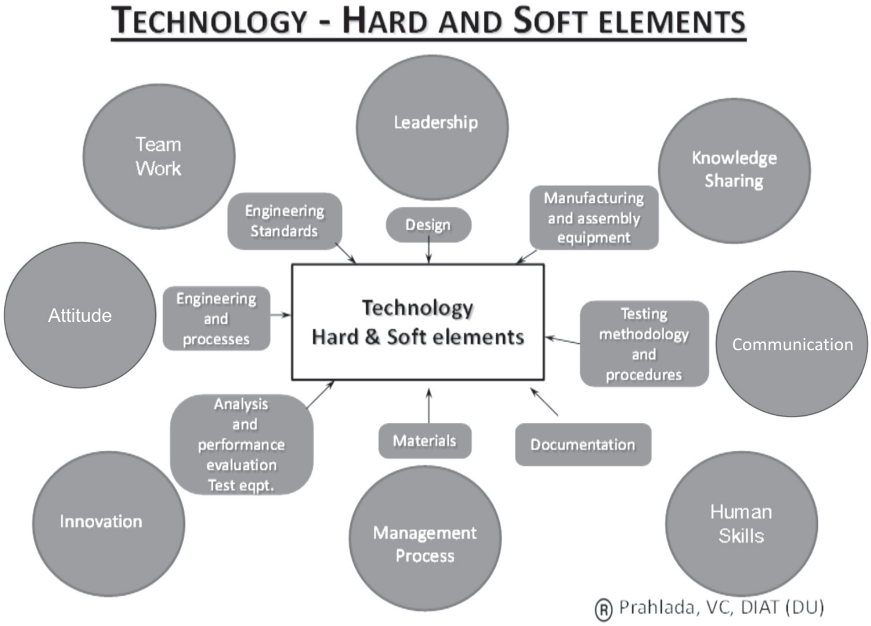
Dr Prahlada

All over the world heavy investments are done in generating new science and new technology for defence and security. Having spent enormous amount of money and effort and exploiting these outputs for defence and security applications, there is always a desire to harness the outcome of such an investment for civilian applications. This is a logical process and the benefits of heavy investment will reach the general public who have actually funded defence projects as a part of assuring national security.

It is to be understood that normally defence technologies are at high-end, very complex and most of the time quite expensive to develop and integrate. Harnessing for civilian application therefore requires either simplifying the defence technologies or restricting the application to the base version or stripping down the frills to make them affordable. Many a time military technology has to be reformatted and customized for civilian applications. In this paper some of the key technologies under development for national security and defence and possibilities of harnessing them for non military applications will be discussed. Similarly defence scientists are harnessing new science and technology that have been developed originally for civilian applications. This flow of knowledge and technologies is a 2 way traffic benefitting all.

Technology – Hard and Soft Elements

Whenever one talks of technology, there needs to be clarity on what really comprises of "Technology". Sometimes "technology" is used in a rather loose term as though it involves some fabrication and assembly. In fact “technology” comprises of a number of hard and soft elements which have to be seen together to realize a comprehensive picture of “technology”. The hard elements comprise of materials used, design documents, manufacturing and assembly equipment, test equipment, methodology and procedures, engineering standards, engineering processes, measuring and test equipment for performance evaluation and documentation covering quality assurance, quality control and production. But hard elements alone cannot complete “technology”.



There are a number of soft elements which are part of technology and whenever one talks about technology development or technology transfer or technology assimilation, one should include all the soft elements like human skills, attitude required to handle technology, team work required to make it success, knowledge sharing for error free absorption, communication skills for fast interaction of minds, leadership and management process for ensuring success. Therefore whenever technologies get developed either under civilian environment or military, the package should be complete having addressed all the soft and hard elements of that technology.

Key Features of Defence Technologies

Defence Technologies are unique and have some specific parameters and characteristics, some of which are listed below :-

(i) Defence Products are based on extreme technologies like lowest weight, highest strength, smallest in size, fastest in reaction, highest in lethality etc.

(ii) They are designed for highest rate of operations (per minute, per day etc.) or maximum number of operations before service or up to end of service. For example a gun will have a defined firing rate whereas a UAV has maximum number of launchings / landings allowed before a major refit.

(iii) They are engineered to be highly robust and environmentally rugged.

(iv) Sometimes they are meant for single use (Rockets, missiles, torpedos).

(v) As they are field deployed, minimum man power requirement to operate day and night and all weather is mandatory.

(vi) They are built for high reliability (should be usable after long storage and with no maintenance) and

(vii) As they are expensive, the military systems ought to have long life (several decades before decommissioning them).

It is seen that cost and affordability is not the primary goal here and stress is on performance. The production quantity of products for military applications are normally small sometimes in tens and hundreds and this also makes unit cost rather high. Normally military products are built for the armed forces of that country and are optimized accordingly to specifications and quality requirements of the concerned armed force. If some other country wants to acquire the same hardware or system, it would not be optimized for the recipient country and therefore requires re-engineering and development of new software. This again adds to additional cost.

Military systems being expensive and developed and perfected over long durations, sometimes over a few decades, their longevity needs to be necessarily high. Military aircraft, tanks, radars, frigates, missiles and guns are used over 4 decades. But technology being much more dynamic, military systems tend to end-up with rather obsolescent technologies early in their life. One way to tackle this is that that the R&D organization which developed the system, industry which produced the system and the user to constantly work together to upgrade technologies, subsystems and modules through product life to keep them as much technologically current as possible.

Another unique technological feature of military systems is lifetime maintenance equipment and tools. During their long life they need to be not only periodically maintained and checked but also need to be upgraded (both hardware and software) and obsolescent modules replaced.

Many a time OEM (Original Equipment Manufacturer) would have decommissioned the manufacturing, assembly and testing lines after producing ordered quantities. It becomes therefore mandatory for the user to own maintenance and test equipment and associated technologies to disassemble, reassemble, test and checkout the equipment during such periodic updates.

Common features of Technologies in products for Civilian Applications

Production quantities of civilian products are normally very large (sometimes in millions) and there is a continuous competition to bring down the cost per unit. Ergonomics, look, feel, color, attraction etc. normally dictate the saleability of a civilian product. Some of the other features of civilian products are the following:

(i) Easy and immediate availability at multiple locations.

(ii) Maintenance free or minimum maintenance requirement.

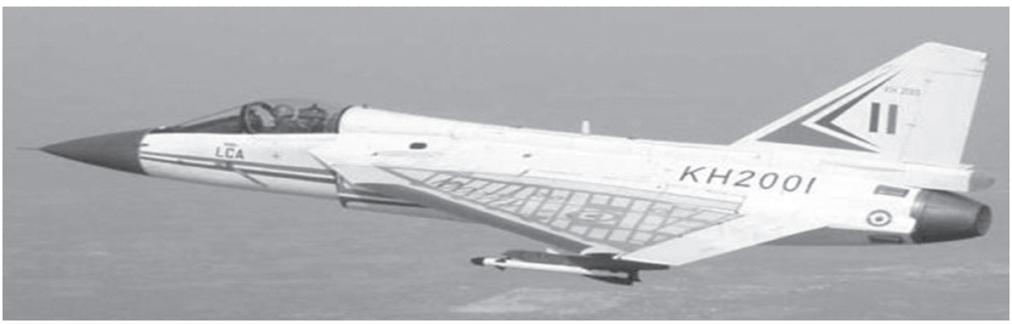
(iii) Short life and quick product up-gradation to catch up with the technology growth.

(iv) They are designed for global market (cars, white goods etc.) and therefore should be marketed in many countries around the globe.

Thus it is seen that to a large extent there are contradictory requirements in these two classes of products, though technology may be the same. This is the reason it takes a long time for technology developed for military application to reach a common man as a stripped down version. It is also seen that the cost of developing new technologies for military applications is increasing non linearly and many times becoming un-affordable even for the services. In fact, smart military R&D people are trying to harness the technologies developed for civilian applications into military products and reduce R&D cost and time. This is in a way reverse phenomenon and more and more of such attempts are being made all over the world. Some of the technologies have applications both in Civil and military. So, while some of them having developed for military are also being used for civilian applications, some of the technologies being developed predominantly for civilian applications are also being harnessed for military use. These are being addressed in this paper.

Aeronautical Technologies

There are many technologies common between civilian and military aircraft systems i.e. passenger aircraft and fighter / bomber aircraft. The technologies for Aerodynamics, Structures, Flight controls, Propulsion and Navigation are nearly the same for the two classes. In fact the technologies relevant in these domains have to be highly efficient and generally come out of civilian aircraft R&D where cost per mile for a given payload or pax will be a critical factor.



These technologies can be easily adopted for military aircraft systems like fighters, un-manned air vehicles and bombers. Some of these include Turbo fan engines, composite structural parts, radomes, high lift aerodynamics etc. On the other hand, the military aircraft systems require high tech systems like multi mode radars, synthetic aperture radars, ECM and ECCM systems, mission computer and capability to withstand high maneuvers for the air frame as well as onboard packages. The military aircraft will also have to carry weapons like rockets, bombs and missiles. The integration of these weapons into aircraft and releasing or launching them from aircraft will be totally a new technology to be exclusively developed for military applications.

The military aircraft will have to carry a large number of antennas for communication, ESM and navigation and therefore there is a lot of research going on in developing conformal, ultra bandwidth and multi band antennas and arrays. Sometimes same arrays are being used for radar and EW applications. The fighters will also got to be provided with ejectable seat and specially designed pilot support and helmet systems. There are special accessories like onboard oxygen generation system and weapon control console. Design of military aircraft is optimized for high speeds and high performance whereas civilian aircraft for cruise and fuel efficient flying and also for quiet operations. The flying quality requirements for military and civil aircraft will also be rather different whereas quality and reliability are treated at par.

As is noticed, unmanned Air vehicles have picked up in a big way for many military operations and this trend is expected to increase. In parallel, civilian use of small UAVs have also picked up for forest survey, surveillance of mines, paramilitary activities, surveillance of infrastructure, disaster management, crowd management and even home deliveries!. The technologies of automatic navigation, landing, takeoff and way point flying is therefore used in both types of applications. However, there is a new class of unmanned combat Aircraft being developed wherein weapons and weapon control consoles will also need to be integrated into unmanned aircraft.

Electronics Systems

Though this is a vast subject, discussions can be restricted to major ones like communication, radars, navigation and other avionic systems. Digital communication as a technology does not differentiate between civilian and military applications. However, the level of security and robustness against counter measures has to be specially designed and provided into military communication systems.

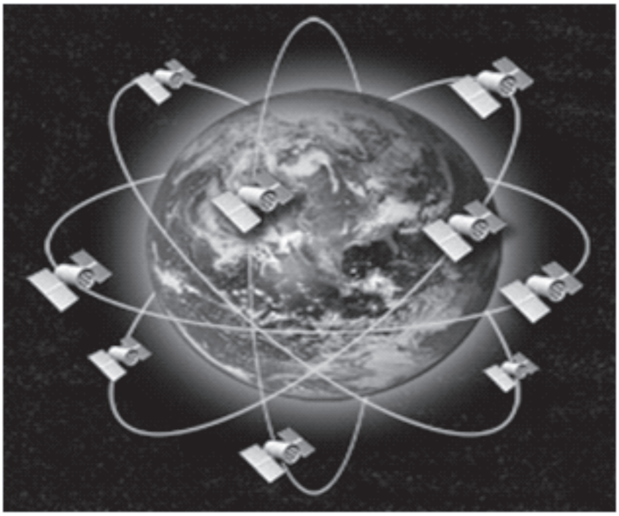
The physical ruggedness and hardening would also be much more seriously built into military hardware. The Microwave engineering, signal processing and data processing would of course be common for both applications. The communication equipment have been upgraded into software defined and cognitive radios for ensuring interoperability and survival. While civil communications seen to be mostly on voice, military communication is more with data and sometimes pictures and graphics.

All the air traffic control is aided by 2D radars in the world which provide range and azimuth data of all flying systems in the air space. On the other hand, in order to reduce the reaction time for engaging the target aircraft, military surveillance radars have to be 3D providing height information and even 4D providing speed information. The radars need to be electronically scanning so that multiple targets can be quickly acquired and tracked. Such high-end technologies are therefore developed for military radars and perfected for ground based, sea based and airborne applications.

While the civilian radars normally use only reflector based radar antennas, the military aircraft have switched over to electronic scanning radars based on passive phase shifters or transmitter - receiver module based active apertures. Once the technologies get fully matured and the cost of active apertures come down, they will also enter into civilian applications to provide the agility and flexibility. These radars then can of course be exploited by civilian authorities by producing these radars in larger numbers and amortizing the investment. Considering highly congested air traffic around megacities, the 3D and 4D radars will provide safer air traffic control and more efficient air traffic management.

Military navigation which is used in fighters and missiles were originally based on stabilized inertial platform which were also used in civilian passenger aircraft. But as the demand for reducing weight and space of navigation packages increased for fighter aircraft, lot of R&D was carried out by shifting navigation to SDINS (Strap Down Inertial Navigation System) and subsequently using ring laser based gyros and eventually fiber optic and now finally MEMs based gyros and accelerometers. These things have miniaturized the size of the navigation packages and also drastically brought down the power consumed. Having achieved such gains, it is only logical that these technologies will eventually enter into civilian passenger aircraft to harness the performance, size, weight and electrical power advantages.

Similarly, Global Positioning System (GPS) was developed entirely for military application at enormous cost so that one can locate himself anywhere on the earth.



This technology has now been totally adopted for civilian applications and now low cost ultra miniature sized GPS receivers are available almost in every smart phone and every moving vehicle on the earth and over the sea.

Cyber Security

In this digital world, security of data, messages, pictures and video is of paramount importance. Military information needs to be transmitted across the field, across the country and sometimes across the world and secrecy and security has to be ensured in such transactions. There are various measures of providing security (including cryptography) for such transactions in communication. In the commercial world it is astonishing that many a time the level of secrecy and security needs to be sometimes higher than that of military considering billions of dollars of online transactions taking place around the globe. E-banking, e-commerce, e-governance and integrated IT for critical infrastructure with cloud computing is becoming the order of the day and the level of data integrity required has also gone up. In fact the availability, speed and integrity of high volume digital communication is very much comparable between military operations and disaster management. Social networking and C4I networking would also become comparable and inter changeable. It is therefore seen that information and cyber security is a 100% two way technology traffic with both communities exploiting each others strength and capabilities. Parallel research is going on in malware detection, trusted platforms, cyber attack, cyber defence and emergency recovery for both applications.

Combat Vehicles

Army uses Combat Vehicles extensively in the form of battle tanks, armoured personnel carriers, armoured weapon carriers and weapon launchers (rockets and missile launchers). Army having to counter enemies in mobile formation, they need all the combat vehicles to be highly mobile, fast in plain terrain and with adequate mobility in deserts and on loose soils or on unprepared terrains and bad roads. The engine, transmission and suspension technologies though are common with civilian motor vehicles, military combat vehicles need high-end technologies to meet the requirements of military in general and army in particular.

The engines need to be rugged and with capability of operating at high altitudes (with turbo and super charging), high temperatures (designed up to 55^0C ambient) and high humidity environment (coastal and jungle environment). The materials and the mechanical design therefore have to be particularly attended to to ensure such rugged operations. The military vehicles also need to be more robust so that they can operate over long durations and distances without field maintenance. The civilian vehicles of course would be operating in more benign atmosphere and environment and would be more fuel efficient. The electronic integration and safety features of civilian vehicles are also much more sophisticated and friendly.

Similarly the suspension system needs to be designed for bad road and no road conditions while the tires have to be custom made for dessert operations. Sometimes the special military vehicles need to carry very heavy loads running up to 100 tons on multi axle platforms. The trend now a days is individual electric drives for every axle to ensure adequate mobility and controllability. Eventually the technology fallout from military to civilian will happen and civilian vehicles specially the big trucks carrying out heavy loads across the country will benefit from military technologies.

In case of protection, the armor protection would be exclusively for the army with a diluted version being made available for paramilitary to withstand attack by Terrorists, Maoists etc. Now a days there is additional requirement of military and paramilitary vehicles withstanding blast forces of buried mines and IEDs. Even VIP vehicles are provided with this technology for special protection. Therefore, again, one sees a two way traffic of high efficiency automotive systems entering into military combat vehicles and robustness and rugged operation technologies entering into civilian market.

Naval Systems

Navies are developing the following systems incorporating the latest technologies :

(i) Boats and Frigates

(ii) Submarines

(iii) Aircraft carriers

(iv) Torpedos

(v) Decoys

(vi) Unmanned underwater vehicles.

The technologies that go into these vehicles are the following:

(i) Efficient hydro dynamic designs

(ii) Propulsion engines ((a) Diesel (b) Gas turbine base (c) Chemical (d) Electric drive based on fuel cells or battery)

(iii) The structure (metals and composites)

(iv) Navigation (Inertial and GPS)

(v) Controls (electric, electrohydraulic)

(vi) Sensors (sonar based)

It can be seen from the above list that most of the technologies are common for civilian or military applications except for sensors, warheads and weapons. So there is a strong possibility of synergistic technology developments between civilian and military entities and the technologies can be freely exchanged.

However the sonars being the most important sensor for naval application, both for surface vessels and underwater vessels, these are predominantly military oriented. There are sonar arrays which are part of hull or they can be towed. These sensors are specially conceived, designed, developed, tested and perfected for naval applications. There will not be many civilian applications based on this high-end technology. Another important technological feature the military vessels need to have is that of "**stealth**". This technology will provide minimum signature of both sea surface platforms and underwater systems like submarine and Torpedos. The acoustic signature and also exposed cross section for radars and sonars need to be minimized using advanced technologies in materials and designs. Now a days even the thermal signatures and wake signatures of naval platforms are also becoming very important and new technologies are being employed to reduce their intensities. The propeller designs and wake created by the movement of ships and Torpedos are being modified to provide minimum opportunity for adversaries to detect the wakes and target the platforms. These are highly guarded military technologies and are normally not shared with civilian applications. Similarly thermal propulsion engines are high efficiency, compact propulsion systems for driving Torpedos at high speeds and are not cost effective for civilian applications. It is therefore seen that though there is a 2 way technology traffic in many areas between civil and military naval platforms, some of them are highly controlled, guarded and exclusivity reserved for military applications.

Healthcare

This is an area where military will benefit enormously by technologies developed in civil sector. The medical treatment, healthcare and wellness assurance is a big business for general public.

The amount of R&D that is being spent in the world is so high that military need not spend any funds for exclusive R&D in this sector for healthcare of officers and men. Military can simply borrow and harness the technologies developed in the civil market. The research going on in drug delivery, artificial organs, medical care, cell biology, nano biotechnology, diagnostics, biotherapeutics, biomaterials etc. needs to be continuously monitored by military experts to be harnessed for service personnel.

Summary

The issue of new science and technology taking a 2 way traffic between civilian and military applications have been addressed here. Some of the crucial areas in which dominant R&D has been done in the defence setup and certain other areas where the R&D is dominant in civilian setup have been discussed. There are a number of instances of 2 way traffic between civilian and military has been listed. Certain important observations can be made based on what is currently happening in Indian scenario:

(i) DRDO has a formal and institutionalized mechanism of trying to harness various new science and defence technologies into civilian applications.

(ii) Large amount of R&D is going on in other R&D organizations in the country like CSIR, ICMR, Department of IT, Department of Biotechnology, DST, DAE, etc. Efforts are being made to commercialize these technologies with the help of industries and find applications. But there is no formal or institutionalized mechanism to tap the new knowledge being generated for defence and military applications.

(iii) Similarly a lot of fundamental and basic research including development is also going on in various Academic Institutions and Universities in the country and again there is no formal mechanism of tapping this knowledge for military applications.

(iv) Therefore, it is time that Ministry of Defence institute a formal mechanism and an organized body to ensure that defene and military will benefit from the R&D going on in the civilian world to get benefits of new science and new technology at the lowest cost and earliest opportunity.

Exploiting Defence Technology

Lt Gen PC Katoch, PVSM, UYSM, AVSM, SC (Retd)

Chanakya had said, “Even if a snake is not poisonous, it should pretend to be one”. This is sane advice but then such pretensions are possible for a snake, not by a rope. India’s defence preparedness is like that rope and it would be fooling oneself if we attribute it merely to voids of arms and weapon systems and things like outdated batteries being used in submarines for lack of imports. The DRDO hierarchy admits they can only boast of ‘patches’ of excellence, which too are questionable. The public by large was alarmed by leakage of a Service Chief letter to the Prime Minister but by and large are content that the new government would make up these voids at the earliest within the constraints of economy and that is the reason the Defence and Finance portfolios are with the same Union Minister to ostensibly ensure there is no bickering for funds required for defence of the country.

But how would the public react to know the ground situation which many in the military too are unaware while the “rope pretends to be poisonous”, just some of the examples being: *one*, our scientists are ignorant what is ‘inside’ the BrahMos despite years of collaboration; *two*, Russia has stopped export of 2 metre resolution satellite imagery to us presently and we are operating on 15 metre resolution imagery – atrocious for targeting; *three*, current practice for BrahMos firing is that an IAF helicopter lands at the target with a GPS, takes and passes the coordinates at the firing to enable firing; four, in exercises involving airborne drops, an IAF team with a heavy vehicle is located at the point of the drop required (in Redland) to enable it; *five*, updating of maps by Survey of India (SoI) is more than 30 years behind; *six*, same is the case with Military Survey who are largely dependent on Google maps and have failed to establish Enterprise GIS for the military; *seven*, common standards and protocols have yet to be developed for the military for exchange of data, besides there is no commonality in radio equipment either; *eight*, twe did the underwater BrahMos test from a fixed platform but the submarine that can fire it is likely to be procures only around year 2030; *nine*, the Brahmos underwater test fired the missile in vertical position which the Navy does not want since it exposes the submarine – all foreign navies with such capability fire the missile in horizontal position without the submarine surfacing; ten, private sector participation in defence sector namesake.

A CAG report at the fag end of the previous government had pointed out: one, in several cases, crores spent on research despite COTS equipment available and finally DRDO bought COTS equipment, two, corruption in joint ventures including older, foreign technology; three, DRDO development and joint ventures (JVs) 'without' keeping the users (military) in the loop; four,chaoitic experiments in arms development and spending money on items like automatic idli-dosa makers making very existence of DRDO dubious; five,EW systems 'Samyukta' and 'Sangharsha' inducted in military were outdated and more expensive than latest technology available; six, An earlier CAG report (2011-12) pointed out that while DRDO spent crores on 55 high priority projects based on user-requirements, only 13 went into production: seven, Rs 2.28 crores sanctioned to a mathematics institute to develop a radar when DRDO scientists not even remotely connected with research related to the project; eight, DRDO annual budget has no audit verified document to show what value has been generated so far through its technologies and the like.

The narrative as above can go on endlessly. The bottom-line is that a country that imports above 80 percent of its defence needs can never be militarily strong. Our defence-industrial complex requires a major boost which cannot be done without major reforms in the government organizations like the DRDO, DPSUs, OFs and SoI. The previous government refused to even discuss the Rama Rao Committee Report recommending DRDO overhaul. The reasons were perhaps indicated from the letter written by Manibhai Naik, CEO of L&T to the Prime Minister in 2011 saying, "Defence Production (MoD) Joint Secretaries and Secretaries of Defence Ministry are on the Boards of all PSUs -- sickest of sick units you can think of who cannot take out one conventional submarine in 15 years now with the result that the gap is widening between us and China and bulk of the time we resort to imports out of no choice. The defence industry which could have really flowered around very high technological development and taken India to the next and next level of technological achievement and excellence is not happening." The new government therefore has a task cut out to stamp out this nexus but it is going to be a difficult nut to crack and almost impossible if the MoD itself does not undergo a total overhaul replacing generalist bureaucrats with professional serving military talent. As significantly, we need to be clear what technologies we need to develop / acquire in what time frame and how. In fact, India desperately needs an RMA headed by the Prime Minister himself and promulgated through an Act of Parliament, akin to the Goldwater-Nichols Act or the Berlin Decree that transformed the US and German militaries respectively.

Technology and Warfare

Presently we are witness to short, swift, hi-tech war with increased weapon ranges, accuracy and lethality. The space and time continuum are greatly compressed. Situational awareness and battlefield transparency is increasing. There is perceptible shift from Platform Centric to Network Centric and ssimultaneous handling of operations at strategic, operational and tactical levels is possible. There is increased importance of dispersion and deception and there has been advent of Effect Based Operations (EBOs), offensive cyber warfare and space wars. Electromagnetic weapons are under development. Besides, terrorists empowered to cause severe damage which is significant in the backdrop of enhanced strategic value of irregular forces and use of proxies even by powerful nations. The likely future technological transformation would include fully NCW capable forces, better PGMs including high-energy lasers, plasma, electro-magnetic, ultra-sonic directed energy weapons (DEWs), long-range strategic aero-space platforms, improved ISR and communications systems, stealth and smart technologies, improved compact nukes, artificial intelligence optimized, nano weapons and euipment, micro UAVs, ant robots, cyber warriors worms, viruses and cybugs, space and anti-space weapons, psychotropic technologies for mind control etc.

What We Need

Our technology roadmap should take into account that future conflict will be five dimensional; in domains of aero-space, land, sea, cyber and electro-magnetic. Information warfare will include NCW, C^4I^2 warfare, electronic warfare, cyber warfare and all other forms of operationalized cyber space. Space combat, cyber space combat, radiation combat, robotic combat, nano-technology combat will add to forms of combat. Operations will be increasingly inter-agency involving greater application of all elements of national power. States will continue to employ hi-tech irregular forces and asymmetric wars will be regular affair. Information superiority will be as important as land, sea and aero-space superiority. We need capacity building in: networked elements of national power; information dominance and information assurance; ability to paralyze enemy C^4I^2 infrastructure; credible deterrence against state sponsored terrorism; long range expeditionary strategic forces; stand-off and stealth weapons; adequate mix of DEW, PGMs, ASATs etc; ability to disrupt enemy logistics and sustenance; mix of hard kill and soft kill options; layered strategic air and theatre missile defence; ability to exploit space and cyber space; and, conventional forces capable of winning hi-tech wars

We need to exploit technologies like steerable beam, wide band SDRs, network security, fusion and analysis, data mining, alternate GPS, dynamic bandwidth management, engines, lasers, improved camouflage, detection and protection from CBRN terror strikes etc. it is critical for us to indigenize and achieve self sufficiency in of hardware, software, telecom equipment and chips HW, SW telecom equipment and chip production. In our defence technology acquisitions, the technology factor should be suitably discounted by technology adaptation, governed by ability of technological entities to integrate for synergized joint operations and the scope it provides for innovation and adaptability, for example drones. The LTIPP (15 Year time horizon) should be based on required 'Mission Capabilities' as deduced post defining the National Security Strategy an Comprehensive Strategic Defence Review. Comprehensive Joint Services 'Systems of Systems' approach must be ensured in all this.

The Indigenization Route

Reorganization. Aside from reorganizing the MoD as mentioned above, a thorough review of the functioning and capabilities of the DRDO, DPSUs and OFs is warranted, particularly what they should develop individually, what should be the Joint Ventures (JVs) and what defence products should be undertaken exclusively through indigenization, which in turn would permit cutting down some of these flabby government organizations running contrary to worthwhile costs benefit. In doing the demarcation of who does what including overlaps.

Road Map. A technology development roadmap is essential to be clear what technologies we need in what timeframe, including for bridging the asymmetry vis-à-vis our adversaries, particularly China. What we need has been described above. Considering the state of our R&D compared to advances world-wide, JVs are actually the route to leapfrog technology, aside from reverse engineering, latter being freely practiced by countries like China, Pakistan and North Korea.

R&D. Our investments in R&D are woefully inadequate. This needs to be boosted in line with the technology development roadmap. More importantly, utilization of such funds should be focused and judicious, not the manner they have been wasted by DRDO in the past.

Defence Offsets. Defence offsets too play an important part in the defence-industrial context. Opening of a Facilitation Cell by the Defence Offsets Management Wing (DOMW) in a civil area for easy access has been a good step. However, it needs to be remembered that the DOMW was preceded by the Defence Offset Facilitation Agency (DOFA) that was established in 2006 but had to be shut down as it could not deliver upon what was expected. At the same time, foreign companies which invest considerably in R&D may not be comfortable in sharing those high end critical technologies with India at a multiplier value level. There are no specific incentives to share high-end technologies and foreign OEMs can get the benefit of multipliers by sharing comparatively non-critical technologies for the same multiplier value. Perhaps there is need to provide higher multiplier values to extremely critical technologies required by DRDO in order to attract foreign vendors. It may be helpful if MoD assigns multiplier values on a case to case basis, based on criticality, importance, requirement and urgency; DOMW should ensure there is no ambiguity in the process including through a fully automated system that will monitor, account for, and audit offsets in real time, which should be preferably web based; and, DOMW must provide accurate and detailed information about the status of offset contracts and the technology/capability received from each contract to help stakeholders undertake cost-benefit analysis, facilitating mid-course corrections.

Defence Procurement Procedure (DPP). The DPP is complicated beyond imagination. Trefor Moss quoting the then Army Chief wrote in 'The Diplomat' on 25 March 2012 saying, "the procurement game is a version of snakes and ladders where there is no ladder but only snakes, and if the snakes bite you somewhere, the whole thing comes back to zero." Despite all the annual hoopla of simplifying the Defence Procurement procedure (DPP), the changes have been largely cosmetic, largely due to vested interests. Otherwise there is no reason why review of the DPP is done in-house by MoD. The fact that we have not been able to sufficiently attract our own private industry into the defence sector should lead us to focus why this is happening. The fact is that there are just too many disincentives: *first*, there is little monetary incentive for R&D; *second*, there is no change to the no-cost-no-commitment trial system; *third*, no assurance of subsequent phase even when undertaking current phase; *fourth*, complicated, costly and time consuming tendering, custom clearances (as applicable), multiple demonstrations in varied terrain and places etc; *fifth*, corruption – bribes at various levels; *sixth*, despite costs, time and efforts, possibility of termination and blacklisting even through anonymous letter; *seventh*, lack of transparency and the like. Logically, review of the DPP should be done by a panel fully integrating the private industry and the stake holders or still better, by an independent body represented by all concerned. To this end, establishment of such an independent and all encompassing expert body can solve the complicated jigsaw of not only the DPP, but establishment of JVs, optimizing defence offsets, roadmap and leapfrogging of technology, plus recommending division of responsibilities between the defence industrial complex; DRDO, DPSUs, OFs and private industry.

Absorbing Foreign Technology & Joint Ventures. Unlike China, India has the advantage of access to US and EU technologies. But, the hurdles in absorbing foreign technology are too many even if the foreign vendor is eager for the JV and ToT. Take the case of the US, where US technology and exports control areas are being looked at as in the case of closest allies of US; for the US system to operate on a timescale consistent with the needs of India. However, it is equally important for us to introspect especially since we failed to attract FDI in defence despite hiking the limit from 26 to 49 percent. FDI in defence now stands hiked to 100 percent but if the DPP remains the same and unless the procedures are not streamlined, results may not be very different. For example, for a JV with a US firm, issue of RFI with usual response time of three months for ‘Buy and Make’ projects would require concerned US firm to obtain permission from the US government every time for export. If the equipment or system is itself a JV within the US, then each of these firms too have to obtain US government approval for export of specific technology; something that may take up to 12 months or more. Additionally, before the JV is established with the Indian firm, what items and in what specific quantities have to be identified and applied to the US Government by GoI since the said items can only come through the FMS route on a Government-to-Government basis. On balance, if all these complications are not addressed, Indo-US JVs for a ‘Buy and Make’ project will remain misnomer.

Private Industry Participation. Little attention has been being given to why our own private industry does not find the defence sector attractive enough and why their participation is much less than desired. The main reasons are described above in the shortcomings of the DPP. A concerted effort is needed in this direction. For indigenization to succeed, we must optimize the potential of the private industry. Presently, the private sector is uncertain and unwilling to invest in a highly risky R&D and infrastructure environment in exchange for low returns even if the government is prepared to provide a level playing field.

Leapfrogging Technology. The world was astounded when Iran downed the CIA’s Stealth Drone RQ-170 in December 2011 ‘intact’ using its radio electronic warfare skills and vulnerabilities in the Sentinel’s GPS receiver, to trick it into landing on Iranian territory instead of its designated military base. But in early 2014, Iran surprised the world again by showcasing the replica of the RQ-170 showcasing the duplicate alongside the downed original at the IRGC’s Aerospace Exhibition. Even if the copycat RQ-170 stealth drone is somewhat lower in capability compared to the original, it is no mean feat and there may be no reason to suppose so in the first place. China and her protégés (Pakistan and North Korea) have similarly been resorting to leapfrogging technology particularly through reverse engineering. In May 2014, the US indicted five Chinese military officials with cyber espionage charges for allegedly hacking into US companies. US officials have long been concerned about hacking from abroad, especially China. Employing hundreds of Russian scientists’ post-breakup of Soviet Union, China used reverse engineering to fill technical gaps and improve upon Soviet designs. Spying, snooping, reverse engineering is institutionalized through a road map with blessings of the Chinese hierarchy and every opportunity is optimized. Unexploded US cruise missiles 'that Osama-bin-Laden eluded in Afghanistan was carted away by China. Remains of the MH- 60M Black Hawk stealth helicopter crashed during the US raid in Abbottabad were examined by the Chinese. Iran could have also given access to China of the downed US RQ-171. China has stolen US stealth technologies not only through cyber attacking US defence firms but also successfully penetrated FBI. Spying and cloning has given China designs of the US F-I6, B1 Bomber, US Navy's quiet electric drive, US W-88 miniaturized nuke used in Trident missiles, to name a few. China has begun capitalizing on her growing foreign policy reach into new markets offering low priced products like fighters (J-10 and J-17), missiles, radars, communication equipment, etc. For fiscal gains, EU firms are known to have provided new technologies to China through ToT and JVs in China, circumventing sanctions. Defence platforms like multipurpose helicopters are finding their way into China under commercial sector cover. China is leapfrogging technology regimes rapidly, employing every mean, disregarding international propriety and intellectual property rights. China aims parity with the US in science and technology in about three decades. The J-20 stealth fighter has been developed in record time. Stealth helicopters and vessels would follow. China has built up capability in aerospace and successfully flight tested a hypersonic platform in January 2014. All this will give China a tremendous boost in defence exports aside from a modernized PLA.

Swami Vivekananda had said, "We are responsible for what we are, and whatever we wish ourselves to be, we have the power to make ourselves. If what we are now has been the result of our own past actions, it certainly follows that whatever we wish to be in future can be produced by our present actions; so we have to know how to act." We cannot aspire to be a global or regional power without being substantively self-reliant in defence production. Our defence procurement must aim to transform our defence-industrial base to become an active hub for state-of-the-art defence exports besides making India self reliant in defence needs on an upward graduating scale. The DRDO must concentrate its efforts on developing critical cutting edge technologies that strategic partners are unlikely to share. The government needs to focus on all these issues.

Harnessing Military Technology in India–the case for Aerospace Technologies

Rajaram Nagappa

Introduction

Technology and strategy has always been a two-way process. Requirements stemming from basic needs of information, intelligence and early warning, for example, have forced technological outcomes; at the same time, technological findings and innovations have been harnessed for improving the efficiency, operational advantage and strategy-furthering processes. The arrow and the catapult in the ancient times, the artillery gun and aircraft delivered weapons –past and present - and the modern missiles underline the strategic advantage of 'standoff 'distance. The development of technology and its harnessing have brought about the immense advantage of the standoff distance being increased from a few tens of metres to intercontinental distances. The technology dependence in today's warfare scenarios is very high with many technologies of dual use nature as well as spin-offs from civilian technology being harnessed for military purposes. The pace of technological change and innovations today is rather fast and perhaps there is either no or limited exclusivity of today's technology for specific civilian or military application. The distinction has blurred.

Obviously, the advantage lies with how fast and how usefully can relevant, available and evolving technologies be adopted and employed for military applications. More important will be to forecast and identify critical technologies required for the future/emergent war scenario. The exercise is involved, as the technology development strategy has to take into account the adversarial technological strengths; assessment of the adversarial technology development and adaptation strengths; technology requirements to annul or neutralize adversary capabilities; and the availability of required resources. Additionally, factors like technology gestation times and technology obsolescence have to be kept in mind. These factors create conflicts of interest between indigenous development and purchase of readily available systems..

Today nearly 70% of India's military hardware is imported and for obvious reasons, imports at this level are neither desirable nor sustainable in the long run. It would be necessary to change this trend to translate to *more technology, less hardware import and more indigenous realization*. While there are many virtues of being self-reliant in critical technologies, it may not be possible for contemporary technologies on account of time schedule of requirement. However, for requirements of a later time as well as futuristic technologies, it is relevant to proceed on a self-reliance route. Such an approach will provide the platform for learning from the brass tacks; give superior capability for design and analysis; better assessment of technology issues and development problems; short-term fixes as well as solutions for long term remediation of technical problems. One has to provision for issues like a) delays in realization as all development issues are impossible to anticipate at the start of the design; b) conditional acceptance if full performance specifications are not met at the first instance; and c) backup if insurmountable technology issues with unacceptable time and cost overruns surface.

The aerospace sector forms an important component of military technology. However, India is dependent on imports and licenced production for practically all of its aircraft requirements. Indigenous capability in missile and space systems in comparison is quite high. Unmanned airborne platforms are obviously the oncoming trends and India needs to evolve a comprehensive development and production strategy.

Technology self-reliance

In the context of military technology in India, it must be borne in mind that we are some years behind in technological capability in relation to many countries. The United States is the technology leader and will continue to be so for some more years; Russia is another storehouse of advanced technologies and some years back offered intense technological competition to the United States; Western Europe has strength in a few important areas; Israel has very significant capability; China over the last 3-4 decades has built up remarkable capability by some very aggressive and innovative tactics and also has the money power; and India is not in the picture. India will be in the 'catch up' mode for quite some time. Even to be effective in 'catch up' one must evolve a catch up methodology and implement the same.

Some categories of equipment are governed by export control rules of the host country. Therefore selection of vendors, where critical technologies are involved must factor this as also continued availability of spares and services. Many technologies of today are software intensive and software maintenance and upgrades become equally important issues. Lifetime costs and availability of finance is the other relevant factor in addition to the delivery schedule and manpower training. Blending some elements of indigenous technology with the procurement, as has been done in the case of Brahmos cruise missile can prove to be useful step to self-reliance. The interdependence between the systems in such blending will provide good insight into interface requirements and integrated functioning. The level of technology acquisition should be atleast at a level from which further variants/modifications can come out indigenously. The block diagram in figure 1 on the next page depicts a possible approach.

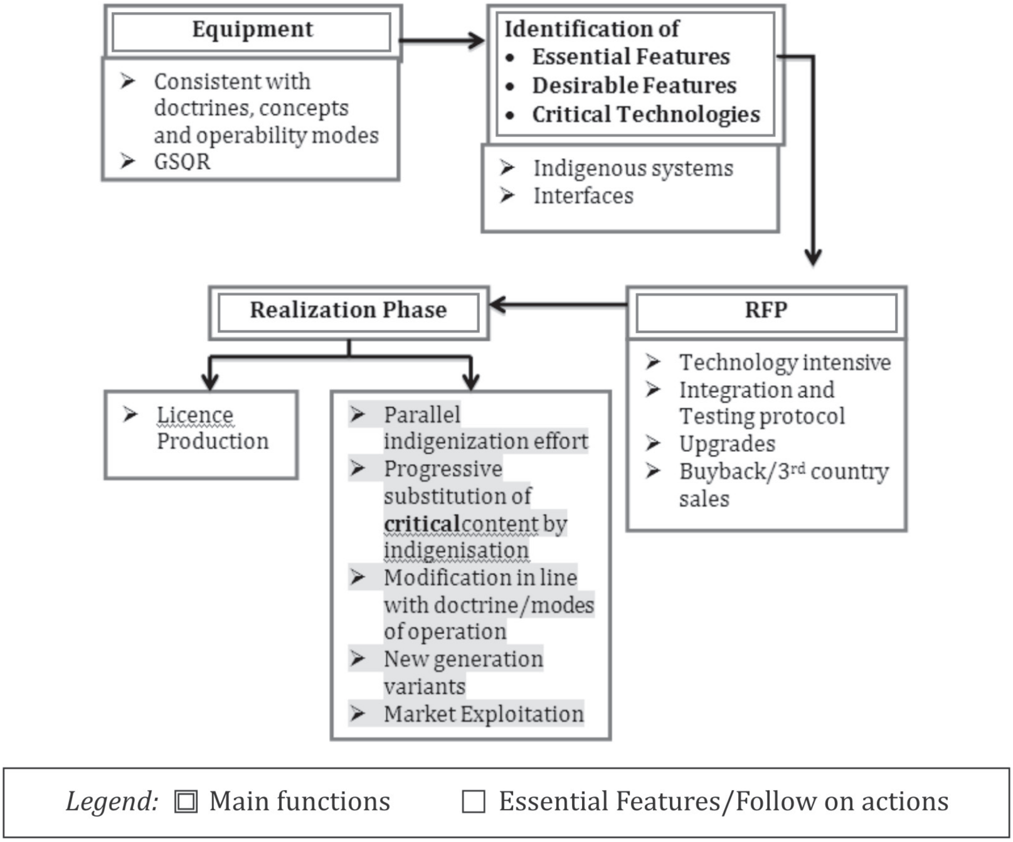


Figure 1: Technology acquisition requirement

The highlighted contents of the box under 'Realization Phase' list the most important functions essential for internalizing the technology acquisition and assimilation. The general absence of reverse engineered indigenous products out of major licenced production of military equipment reflects the absence of such an approach and needs to be corrected.

For the Indian Space Research Organisation self-reliance is an article of faith. It has adopted technology procurement in some instances essentially for leap-frogging. The hardware content in such arrangements has been minimal and technology content high. A backup team to the main technology assimilation team examines in depth, the documents, drawings, inspection and quality issues; clarifications are sought where required through the main team. The efforts of the main and backup team lead to the following outcomes:

- Understanding of the technology issues and development and realization process
- Source equipment and materials from domestic vendors to the extent possible to the required specification
- For development contracts, keep an element of indigenous development for integration
- Identification of external laboratories/institutions where technology development can be initiated.
- Involve academia to take up some technology development. Academia was consulted also to provide analytical and experimental support for better understanding of the development issues.
- Identify vendors/industry for supply of materials (e.g., hardware, chemicals, special seals, pumps to handle corrosive materials)
- Take up in house development of materials, subsystems and supporting technologies.
- Identify industry to scale up the in house developed technologies as well as to take up material supply and fabrication requirements.

Indian industry representatives often accompanied the ISRO teams abroad to get a first hand exposure to the manufacturing techniques. The industry reps have quite often come out with simpler and more elegant approach to a manufacturing requirement and have also been able to modify or adapt existing machinery to meet the fabrication needs.

With this background, it is proposed to examine the domains of aircraft, missiles and space towards harnessing military technology.

Aircraft

India had an early start in the aircraft industry when Seth Hirachand Walchand established Hindustan Aircraft Ltd (HAL, now known as Hindustan Aeronautics Ltd) at Bangalore in association with the Government of Mysore. HAL was established in 1940 and in the initial years produced under licence Harlow Trainer, Curtiss Hawk and the Vultee Bomber. The Curtiss Hawk fighter was a product of Curtiss Aeroplane Company, which had established the Central Aircraft Company in China to assemble the H75A-5 model of the aircraft. The plant was shifted to HAL to continue production of the H75A-5[1] rechristened as Mohawk Mk IV. After the war, HAL under the dynamic leadership of Dr VM Ghatge pioneered the development of a number of aircraft, culminating in the design and development of HF-24 Marut. During this time the research and development activities also picked up with the establishment of the National Aeronautical Laboratory (now National Aerospace Laboratories-NAL). The Aeronautical Engineering Department (now Aerospace Engineering) at the Indian Institute of Science (IISc) was already established and contributed to aeronautics research and catered to providing specialist manpower. Leadership matters to a large extent and the troika of Satish Dhawan at IISc, P Nilakantan at NAL and VM Ghatge at HAL played lead roles in the development of aeronautics in the country in its nascent years. The trendlines in fixed wing aircraft developments in the country are shown in figure 2.

The development of HF-24 Marut was a trendsetter despite the fact the aircraft could not fully meet the specifications mainly on account of an inadequate power plant (the decision of the Government of India not to underwrite the £ 13 million development cost of the Orpheus BOr-12 engine led to this sad situation). The aircraft design was initiated in 1957 and the first prototype assembly was readied in 1960. First flight of the aircraft was achieved in March 1961 and the aircraft entered squadron service in April 1967. The aircraft could touch transonic speeds, had good handling characteristics and was well suited for ground attack roles. The aircraft gave good account of itself in the 1971 hostilities against Pakistan[2]. The development of HF-24 took place at a time when only the US, Russia (then USSR), France, UK and Sweden had similar capabilities. The BAC Lightning F6, Dassault Mirage 3E, North American A5 Vigilante J35 Draken were supersonic fighter aircraft[3] operational during 1969-1965. This

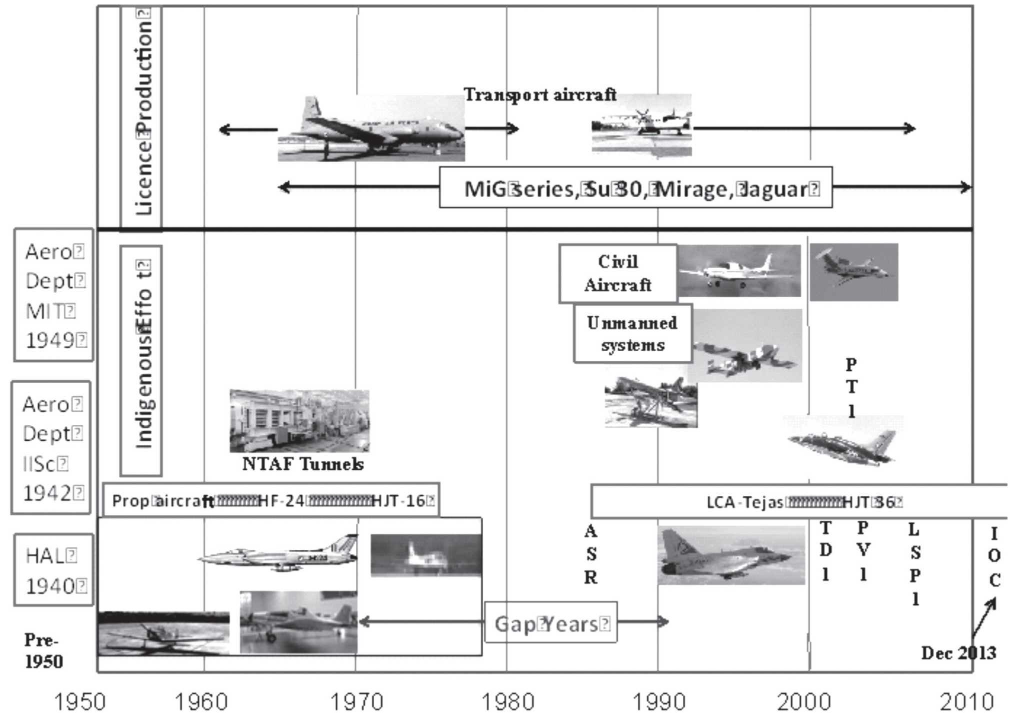


Figure 2: Timeline of aircraft technology development

amply demonstrates how contemporary was the HF-24 development. Save for the power plant this was indeed a good learning and development experience, which unfortunately was not nurtured and built upon for consolidating the early lead in indigenous capability.

The subsequent years saw the induction of aircraft from Russia, France and Britain into the Indian Air Force and the establishment of licenced production of these aircraft at HAL. The dependence on aircraft procured from abroad/built under licence has continued over the last four decades with one exception. The exception came out in the form of the Light Combat Aircraft (LCA), whose development was started in the mid 1980's and the first flight of the Technology Demonstrator Aircraft TD-1 happened in 2001. The aircraft has just entered limited series production and received the Initial Operation Clearance (IOC) in December 2013.

The aircraft types and technologies which came in, as part of the licenced production should have created the knowledge bank and capability leading to self-reliance. Obviously, the model indicated in figure 1 was not in practice; there was compartmentalization in the outlook; and more importantly stress was on procurement of hardware, hardware manufacturing and infrastructure and not on capability buildup. As shown in figure 3, the progress in the S curve of technology growth with time did progress in terms of new generations of aircraft being available to the Indian Air Force without much gain in technology.

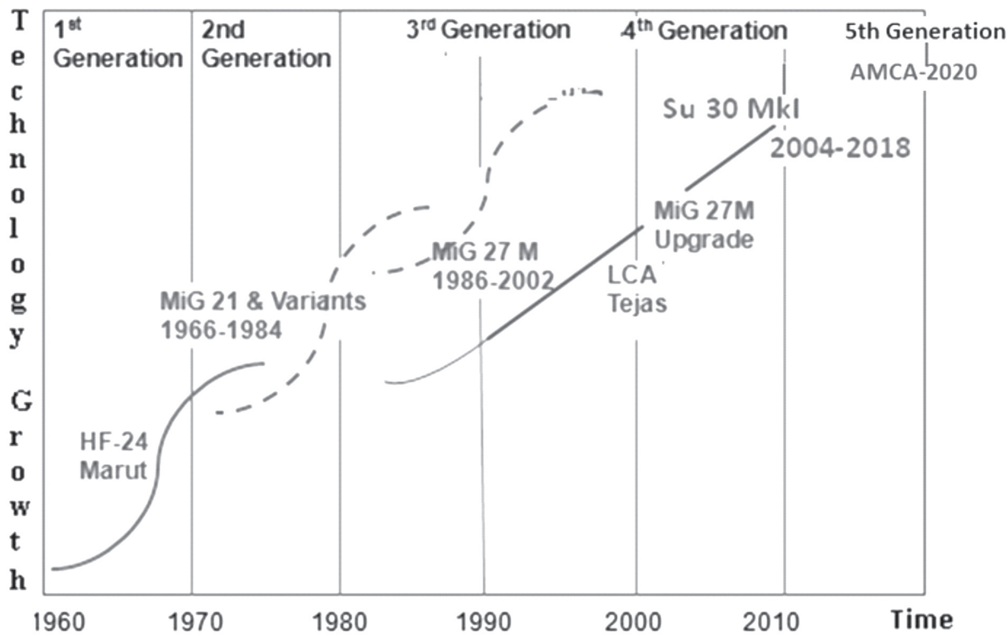


Figure 3: Military aircraft technology growth

The LCA-Tejas is in the technology growth and maturation stages, while the next generations of aircraft are already in service. The fifth generation aircraft are past the embryonic stage and in the growth part of the trajectory. The effort must be to harness the required technologies to catch up and progress the Advanced Medium Combat Aircraft (AMCA). A pattern outlined in figure 1 will be helpful for the envisaged technology procurement/joint venture.

One principal area where India has to mount extra effort pertains to aircraft power plant. This is a very critical system of the aircraft and it is absolutely essential to build indigenous capability in this. The requirement ranges from low thrust, low cost systems for use with UAV's/UCAV's to expendable systems for use with cruise missiles to high end engines to power aircraft of future generations. The question is not one of technology as the capability and experience in the country is not small[4]but more of organization and structure. A specialist working group with the participation of all stakeholders along with implementation of a rigourous review system and concurrently addressing the development and production needs should be able to bring the development to fruition. To start with an indigenous development of Su 30 MkI engine AL31FP could be one such task. The development should essentially be in the form of reverse engineering strengthened by the elements of technology transferred from Russia. It should necessarily incorporate design and process improvements over the Russian design based on shop floor suggestions and pilot feedback. Development of next generation engines incorporating super cruise features and low thermal signatures at the high end and low cost, low thrust engines for unmanned platforms should be the next target. Side by side, the capacity generation issue also merits serious consideration.

For aerospace quality of material India has demonstrated capability to develop critical class of alloys; related processes like rolling, forging, welding and heat treatment; and testing and characterization. They are competent to extend their expertise to any future requirement also. Here again the question of demand and capacity of the aerospace sector has to be considered and implemented.

One critical aerospace material relates to carbon fibre. On two occasions, India has tried unsuccessfully to establish a manufacturing line but the country still depends upon import for this crucial requirement. Here again, it is not a question of technology, but the willingness of industry to produce and supply material conforming to aerospace quality. To safeguard the industry investments, suitable buyback guarantees will need to be put in place as well as allow industry to cater to non-aerospace demands.

The Technology Perspective and Capability Roadmap (TPCR)[5] indicated other disciplines and technologies requiring attention. In harnessing military technology, the role of offsets cannot be understated. Along with co-development/ co-production offsets accord a faster method of technology assimilation. This in turn adds to the knowledge base and can be adopted/innovated for other indigenously designed products/applications. The offset clause in the Indian context came in rather late; defence offsets were first introduced in 2005[6], but the offset objectives were not stated; better clarity has emerged in the later enunciations made between 2006 and 2013. To take advantage of offsets there is need to a) identify elements of critical technology, b) create industrial capacity and c) simultaneously create the system required for technology absorption, indigenization and other applications. The absence of such an ecosystem which brings together the production agencies, MSME's and R&D labs has resulted in India under utilizing the offsets.

Ballistic Missiles

In retrospect, technology denial regimes are not all that bad as they promote self-reliance. The missile engineering community had realized the necessity of self-reliance in this discipline even before the MTCR came into being and had shaped their strategy accordingly. The Defence R&D Organisation (DRDO) had carried out detailed studies on the types of missiles needed by the Country, based on inputs from the services[7]. Consequently, the Integrated Guided Missile Development Programme (IGMDP) was formulated in 1983 to develop five missiles of different capabilities. These were:

- Prithvi: surface to surface missile with range of 150 km for the Army
- Trishul: multi-role tactical vehicle for Army, Navy and Air Force
- Akash: medium range surface to air missile
- Nag: third generation anti-tank missile
- Agni: re-entry vehicle

The development activities were projectised with appropriate decision-making and financial autonomy. Having achieved the project objectives, Prithvi, Akash, Nag and Agni missiles have entered service. In the case of Agni further developments and improvements have been carried out and new variants have also been developed. Agni has thus gone on to effectively enhance the Country's force projection and deterrence capability.

The Agni series of missiles represents a successful and successive harnessing of military technologies to enhance range and accuracy. Starting from the concept of technology demonstration and realization of a successful flight in May 1989, DRDO flight-tested the Agni 5 missile in April 2012 with a range in excess of 5000 km. The Agni 1 flight tested in May 1989 was a two-stage version with the second stage being a liquid propelled stage of Prithvi. At this time the merit of deriving a single stage missile with a shorter range became evident. The single stage Agni 1 was the result and was flight-tested in January 2001.Also employing solid propellant stage in place of the Prithvi in Agni TD was obvious from operational considerations.

The later series of Agni missiles employ bigger power plants, enabling longer ranges. In addition, significant performance improvement is due to adoption of improvements in the missile system. The steady improvement in the Agni missile system range[8] is shown in figure 4.

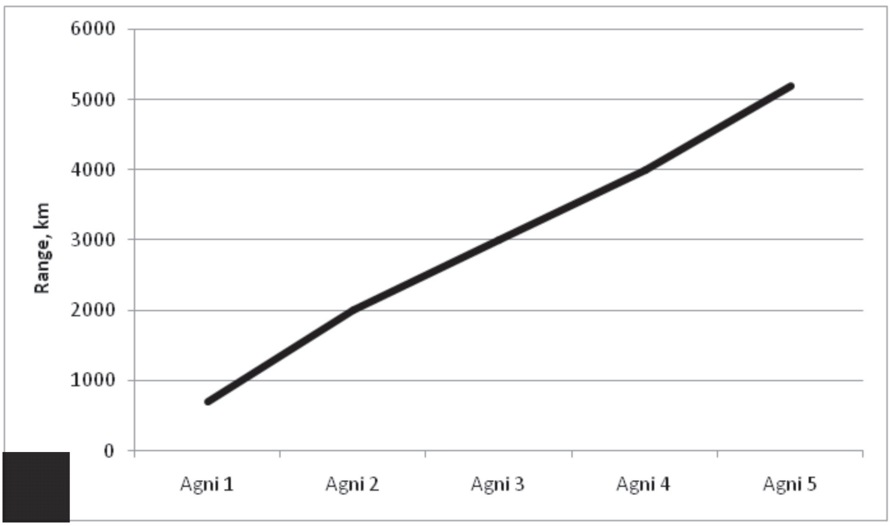


Figure 4: Agni missile series

The Agni 3, Agni 4 and Agni 5 missile systems compare very favourably with international contemporary systems. The enabling technologies that have contributed to this state of affairs are enumerated below:

Subsystem	Technology
Stage motors	• Development of high energy solid propellant systems with higher solids loading • Replacing liquid propellant systems with solid propellant systems in view of operational advantage • Gimbaled nozzle for pitch and yaw control • High strength steel and CFRP filament wound motor case • Motor chamber and nozzle thermal protection system
Control Systems	• Movable aerodynamic surfaces, jet vanes • Electro-mechanical actuators and hydraulic actuators • Reaction control systems • Digital flight control

Subsystem	Technology
Navigation and control	• Strap down inertial navigation system • Explicit guidance scheme • Gyros (Mechanical gyros initially, dry tuned gyros and now laser gyros on Agni 4) • Integrated INS, on board computer, sensors and actuators
Vehicle Systems	• Light alloy base shroud and interstage structures • Vehicle ordnance systems for stage separation • Composite structure with composite thermal protection system for the reentry vehicle • Carbon-carbon nose tip

Other features	• Road/rail mobility • Long storage life • Canister launch

The related technology extensions will involve a) maneuverable reentry warheads (MaRV) and b) multiple independently targetable reentry vehicles (MIRV). In respect of MaRV,some level of maneuverability is already available in the Agni reentry vehicle. The maneuverability is achieved using an attitude control system and aerodynamic fins. The system will have to be bolstered with on board synthetic aperture radar and terminal guidance for maneuvering to home on specific target[9].

The MIRV technology elements will involve miniaturization of the warhead and its associated subsystem, housing them in separate reentry vehicles, stacking the RV's as a cluster on top of a 3-axis stabilized liquid propellant rocket stage called the post-boost control vehicle (PBCV). An equipment bay comprising on board computer and INS system will be part of the post-boost vehicle. The number of MIRV's that can be carried therefore will depend upon the extent of miniaturization of the RV's and the mass of the PBCV.

Cruise Missiles

Cruise missiles with stealth features and following a low terrain-hugging flight path are difficult to detect. Further, they are amenable for launch from diverse platforms land; ship, submarine and aircraft and are therefore versatile weapon systems for both conventional and strategic missions.

In the supersonic area, India has made major headway with the Brahmos cruise missile. The missile has major advantage on account of its speed and multi-platform launch utility. In addition, the M-3 speed makes itlargely impervious to the air defence systems. Brahmos represents a powerful weapon system for its 290 km range. In terms of joint venture project many of the Brahmos subsystems are being made in the country. Some would have been indigenized also. And effort must be maintained to indigenize all components of the missile system.

One obvious improvement would be to extend the missile range. There are however, technological hurdles to increasing the range. Supersonic cruise missiles tend to be larger in size and heavier than their subsonic counterparts. For the same ratio of launch weight to fuel expended weight (W_i/W_f), the range of a low flying supersonic cruise missile will be about 25% of a subsonic cruise missile flying at 530 knots. The Russian SS-N-22[10] missile which has a maximum speed of M=3 is 9.74 m long and weighs 4500 kg to achieve a range of 250 km. Similarly, India's Brahmos supersonic cruise missile is 8.4 m long and weighs 3000 kg[11] to achieve a range of 290 km flying at M=2.5-3.By comparison, the BGM 109 Tomahawk subsonic cruise missile is 6.25 m in length, has a launch weight of 1588 kg and has a range of 1850 km.

It appears therefore, for longer ranges, of the order of 1000 km, it is advantageous to deploy subsonic cruise missile. The technology per se, except the power plant is well within India's capability and has been demonstrated in the development of the 1000 km range Nirbhay cruise missile by DRDO. The missile is undergoing flight test and qualification. One major element of technology that needs attention and as already mentioned is the small turbofan engine required to propel the aircraft. It would be worthwhile to address production issues involving industry in the public and private sector to meet the projected demand.

Hypersonic air breathing propulsion technology has been talked about since quite some years for missile and space access applications. This is an important area of technology, as speeds of M 7 will drastically cut down the travel time with attendant advantages. The principal propulsion system would be the dual mode ramjet/scramjet engine though a separate or combined power plant will be required to take the craft to supersonic speeds for the ramjet to become operational. If the craft is required to perform beyond the atmosphere, a rocket power plant will have to be combined. Scramjet operations in the Mach number range 7-12 would be of interest. Scramjet combustion has been demonstrated in the ground at labs in DRDO and ISRO. The demonstration involved kerosene fuel and limited in duration to a few seconds as no active cooling was employed. Designing for achieving positive thrust margins over drag, engine-airframe integration, management of transition from one mode of propulsion to the next, materials and thermal management pose serious design challenges. DRDO has identified hypersonic technology as one of the key areas of technology to be pursued for missile applications[12].

The development of hypersonic technology is very specialized, requires complex and expensive test facilities, needs special materials, is computation intensive, needs thermal management expertise and an array of sensors and instrumentation. The development task is best carried out departmentally with industry support for services.

Space

The Indian Space Research Organisation (ISRO) has pioneered the space effort in India. The Organisation has established capability in launch vehicles and application satellites with significant contributions towards communication and earth observation (EO) applications. ISRO being a civilian agency has concentrated on applications and products that contribute to social requirement, public good and nation building. However, dedicated military satellites are not part of ISRO mandate and this capability has to be separately developed. The military requirements for space utilization include:

- Communication
- High resolution imagery (satellite constellation to provide frequent revisit data over regions of interest in normal circumstances for intelligence gathering and rapid revisits; and over theatre of interest for operations planning during times of conflict)
- Navigation (target location and guiding weapon systems)
- Meteorological data over region of interest
- Signal intelligence (detecting communication, radar emissions and broadcasting signals)
- Early warning

Some military applications from ISRO satellites are available due to their dual-use nature. Thus military requirements relating to communication, high-resolution imagery, navigation and meteorological information are available through the ISRO satellite constellations. For example, ISRO's INSAT/GSAT communication satellites provide services in the C, extended C, Ku and Ka bands; IRS satellites provide imagery covering a broad spectrum of requirements and the best resolution is in the sub-metre range. Some INSAT satellites carry a

Very High Resolution Radiometer (VHRR) payload for providing meteorological services. Dedicated weather satellites like the Kalpana have also been flown by ISRO. One component of the Indian Regional Navigational Satellite System (IRNSS) is already in place and the whole system is planned to be in service by 2015-16.While ISRO capabilities are essential and useful, for dedicated military applications, new satellites have to be developed and launched.

The current constellation of EO satellites of ISRO is not deployed to provide frequent revisit coverage as required for military applications. For ISR purposes, a daily revisit is a requirement and this can be achieved using a constellation of small SAR/optical satellites. Keeping cost and operational considerations in mind use of small satellites for this purpose is advisable. Literature shows quite a few micro/small[13] application satellites within this weight budget have been realized[14]. Lightweight synthetic aperture radar (SAR) satellites for all weather and day/night observations are also possible within the ambit of small/ microsatellites. The Centre for Environmental Remote Sensing, Chiba University, Japan is developing the circularly polarized Synthetic Apperture Radar[15] satellite called CP-SAR. The satellite will be placed in 500-700 km orbit with 97.6 inclination. The satellite platform measures 1 $m^3$and weighs about 100 kg. The spatial resolution is 30 m with a swath of 50 km. Small satellites can also handle intelligence-gathering missions. The US ELINT Grab operational in the 1960's was 500 mm wide and weighed 123 kg.

The current space capabilities when complimented with small satellites can go a long way to meet the military satellite requirements. One way to manage the satellite number requirement would be to standardize the satellite bus either based on one of the existing ISRO satellites or a new one. The ISRO small spacecraft bus (SSB) fits the bill very well. SSB is 3-axis stabilized, measures 600mm x 600 mm x 600 mm and weighs about 70 kg. The deployable solar panels can generate 220 W with 30 W available for payload. Data transmission is in S Band at 8 Mbps. Combination of star sensor, sun sensor, and GPS based satellite positioning system are used to provide an accuracy of 0.1 in all three axes. 1-N monopropellant thruster is available on board for orbit correction.

For launching microsatellites into orbit, ISRO's polar satellite launch vehicle is a well-proven and reliable platform. In the standard configuration PSLV can accommodate two piggyback satellites of nominal mass 100 kg each along with the main satellite. The PSLV payload bay can be reengineered to accommodate multiple small satellites within a total mass of 1500 kg. The standard payload bay configuration for two piggyback satellites and the modified configuration for housing upto four small satellites is shown in figure 5.

In meeting the military satellite and launch requirements also no technology shortfall is seen. Like in other aerospace systems, there is a capacity shortfall. With proper documentation and training, industry can meet the satellite bus requirement. Payloads can be separately prepared and tested before integrating with the bus.

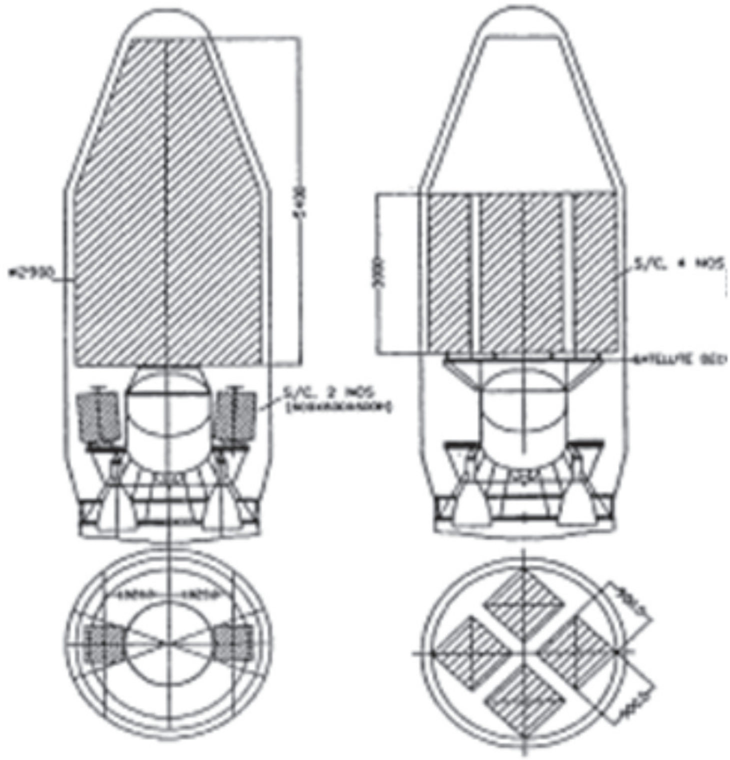


Figure 5: PSLV deck configuration for a) piggy back and b) multiple satellites

(Figure sourced from: S. Ramakrishnan et.al. *Small Satellite Launch Opportunities on PSLV*, ESA SP 430, Feb 1999, pp. 547-556)

Currently, ISRO carries out 3-4 launches of the PSLV/GSLV essentially to meet its planned missions. It should be possible to increase the launch frequency based on satellite orbiting demand and the same has to be worked out with ISRO. At the same time, it would be economical to have a launch vehicle just suitable for small satellites. Such a vehicle can be engineered from among the available components stage systems and will enable higher launch frequency.

Conclusion

The military technologies that need to be harnessed in some aspects of the aerospace sector have been examined. Unmanned Air Systems form another major component in evolving technologies. In general, while technology per se is within the capability of the professionals engaged in these disciplines, there is a major issue of capacity. The capacity shortfall is felt in all domains and is one reason for delayed realization of deliverables. Adequate funding, infrastructure and timely demand by the users need to be created. Aircraft engines for both manned systems and cruise missiles are technology critical and a coordinated approach consolidating the development experience, identification of the technology gaps and the approach to bridge them along with the appropriate managerial approach needs to be evolved. Reverse engineering is a useful way of technology consolidation and enhancing self-reliance. It is worthwhile to progress parallel indigenous development using such an approach, side-by-side with licence production. An appropriate ecosystem needs to be evolved to take full advantage of offsets.

Endnotes

1 From http://www.pilotfriend.com/photo_albums/timeline/ww2/2/Curtiss%20P%2036A%20 Hawk.htmaccessed 10 June 2014

2 See http://www.bharat-rakshak.com/IAF/History/Aircraft/Marut1.html accessed 13 June 2014

3 See http://www.fighter-planes.com/data6070.htm accessed 13 June 2014

4 HAL has been producing under licence improved Orpheus 70105 engine (for Kiran Mk II), Adour Mk 811 engines (for Jaguar aircraft) and AL31FP engines (for Su 30MkI). In addition,

the Kaveri engine development has provided GTRE with background and rich experience in design, development, analysis, integration and testing.

5 The document issued by Headquarters Integrated Defence Staff, Ministry of Defence in April 2013 can be viewed at https://mod.gov.in/writereaddata/TPCR13.pdf (last accessed 26 June 2014)

6 Nirdosh Tyagi, Offsets: Provisions for Transfer of Technology, Offset Review, Volume 2-3, Oct-Nov. 2013.

7 Rajaram Nagappa, Evolution of Solid Propellant Rockets in India, DRDO Monographs/ Special Publications Series, DESIDOC, 2014, pp 125

8 Range values taken from: http://economictimes.indiatimes.com/slideshows/science-technology/agni-series-indias-ballistic-missiles/agni-iv-sophisticated-missile/slideshow/23288514.cms accessed 29 June 2014.

9 For a detailed explanation of the MaRV functioning, NIAS study report titled, "China's Anti-Ship Ballistic Missile: A Game Changer in the Pacific Ocean" authored by S Chandrashekar et al may be referred. A pdf version of the report can be accessed at http://isssp.in/publication/reports/

10 Input taken from: http://fas.org/man/dod-101/sys/missile/row/moskit.htm accessed 30 June 2014.

11 Missile weight taken from: http://aviationweek.com/awin/brahmos-prepares-reduced-weight-missile-export accessed 01 July 2014

12 DRDO-Coherent Directed Research Areas-Hypersonics listed at http://www.drdo.gov.in/drdo/English/index.jsp?pg=moredetails_thrustareas.jsp#hyper accessed 01 July 2014

13 Satellites weighing less than 500 kg can be classified as small satellites; and those in the 100 kg category are termed microsatellites.

14 See *The role of small satellites in NASA and NOAA earth observation programs;* see http://www.nap.educatalog/9819.html accessed on 17 January 2014

15 J T Sri Sumantyo, *Development of Circularly Polarised Synthetic Aperture Radar (CP-SAR) onboard Small Satellite*, PIERS Proceedings, pp 334-335, Marrakesh, Morocco, March 20-23, 2011

Technology, RMA and India

Air Marshal Dhiraj Kukreja (Retd)

No civilisation was so little equipped to cope with the outside world,
no country was so easily raided and plundered,
and learned so little from its disasters.

VS Naipaul
'India- A Wounded Civilisation'

Understanding Military Power

Wherever and whenever, men have gathered, there has been greed, ambition and a tussle for power. Consequently, rivalries arose. When people got together to form groups, societies and nations, the need for security, survival and well-being has been protected and furthered by the group. Conflicts, thus, became unavoidable, as there was always a competition for security and relative prosperity. Human history, from the Stone Age, has been a long tale of such conflicts, wars and the rise and fall of nations and empires. All major markers of human history have one commonality, namely, nations and empires prospered when they were militarily strong; history has repeatedly confirmed the validity of this observation.

Civilisations have prospered when they possessed military might and their decline generally commenced with the diminishing of their military power. Such was the case with the mighty Roman Empire and also in ancient India. The people of ancient India were prosperous, and culturally and scientifically far ahead of the others, under great kings of the likes of Chandragupta Maurya. The Kings possessed powerful armies to keep the outside marauders at bay, but the decline began when the military dissipated into small kingdoms, which could not unite in the face of external aggressions.

Military might, however, is not the only means of exerting influence over others. As man evolved socially, economic power, diplomacy and moral persuasion, as other means of influence evolved to hold the sway. While these were effective in some cases, military power continued to be the ultimate arbiter of resolving disputes, giving rise to the maxim that a state can prosper only if it possesses a strong military. Most powerful nations maintain military forces far beyond their legitimate needs of self-defence. Such strength is then used to facilitate economic and political dominance. This has been amply demonstrated through the passage of history and by events in recent times. Modern militaries are not necessarily large in numbers, but are technologically sound to have the desired effect through what is known as Revolution in Military Affairs – a term largely unknown and not widely used till the early 1990s.

Revolution in Military Affairs (RMA)

In the normal course, improvements in the capabilities of the platforms and weapons are considered evolutionary. Technology has helped in increasing the aircraft performance and aerial weapons, the accuracy of artillery guns, the size and speed of ships. These improvements were slow and countered by improvements in other spheres. The effect of a true RMA goes beyond the normal by the introduction of totally new and novel methods of warfare. As mentioned, the term was hardly used until the early nineties, except for a related term 'Military Technical Revolution', used by the Soviets in their strategic writings. Being essentially Marxists, the Soviets maintained the idea that normal evolution is interspersed with sharp discontinuities, which were referred to as 'revolution'.[1] The Soviets refer to two periods of revolutionary changes in the military in the past; the inter-war period of the 1920s, till about the 1930s, and the introduction of nuclear weapons. Their strategic writings foretold a revolution led by new technology, towards the end of the 20th century, which could be the 1991 Gulf War, as it also coincides with the entry of the term, RMA, in Western lexicon. The Americans consider RMA to be a combination of technological innovations, evolving doctrine and organisation. Since the 1990s, the term has attained high visibility in militaries the world over, and is a topic of discussion whenever changes are sought.

Military is a part of a society, maintained by the society to mitigate its fears, protect it, and fulfil its aspirations. It, therefore, stands to reason, that any major changes in the military should also be useful to society and the State; changes, if any, hence, have to occur in the backdrop of broader political, economic, social and scientific changes. It is well known that upheavals in international affairs, led by the end of the Cold War and the break-up of the Soviet Union caused a change in the security environment, the effects of which can be felt till date. The absence of another superpower, led USA and its allies to face ill-defined threats from lesser-known adversaries. Such a situation, coupled with rapid technological advances in all fields and not just for the military, has necessitated major changes in the militaries world over, starting with USA. The Gulf War of 1991 buried the ghosts of past failures in Vietnam and Somalia for the US military and showed to the world the historic changes in the military and the art of warfare that were underway in USA.[2] The War also suggested ways that USA may have been thinking of, for retaining military preponderance in international affairs in the 21st century.

A doubt arises – can the RMA, witnessed during the Gulf War, affect all nations equally, to alter their way of thinking? Is it necessary for all to acquire similar capabilities? It is obvious that RMA was initiated by emerging innovative technologies, but do all States have the necessary resources to acquire and possess such technologies? The US and its allies possessed the resources to have initiated the revolution, but for other nations, adequate financial and infrastructural support is required towards Research and Development (R&D). It, therefore, appears doubtful that similar capabilities created by the initial RMA in the US military would be seen in the militaries across the globe. At the same time, nations will have to procure the latest technology to ensure power denial to adversaries, depending upon individual nation's unique requirements.

India and the RMA

The successful transformation in the US military, as was expected, had an impact on international and regional affairs in the last two decades or so with the region of South Asia also coming under its influence. The question arises that how should a nation like India react or respond to the revolutionary changes that have come about in the other militaries of the world, more so in USA?

States have historically pursued innovative approaches to warfare in an attempt to either capitalise upon the available advanced technology or overcome strategic or operational challenges that defy a conventional solution. It, therefore, follows that those States with problems that cannot be solved using existing means, will be the ones with the highest motivation to innovate. This, however, is not the end-all for successful transformation. A nation must have the desire and knowledge to pursue new ways of conducting warfare with a capacity to compete. Political, social, economic and technological barriers often prevent States from innovating or place a constraint on their efforts.

The historical record of military innovation and harnessing evolving technologies in India, is scarce. Notwithstanding, there are mentions of transformation in some journals, mentioning changes starting from 3rd century BC onwards when Chandragupta Maurya raised a salaried army.[3] Similarly, there are other mentions of rockets being used by Tipu Sultan against the British, but the instances of Indian militaries concentrating on innovative changes are but a few. India missed out on the Industrial Revolution, being under British rule and hence, inherited the remnants of what the British left for the country in 1947.

Today, however, a resurgent India is slowly gaining its earlier prosperity and importance in the comity of nations. It is in the fitness of things that India remembers the lessons from its past on the need for a strong and balanced military that keeps abreast of the changes occurring the world over. This requirement needs to be uppermost in the minds of the political and military leadership, which must identify the barriers to innovation and then put forth the means to overcome them. India's efforts to develop cutting-edge technology and military capabilities are hampered by its strategic culture, economic limitations, tortuously complicated bureaucracy, outdated military industrial base and a disinterested political setup.

India represents a significant force in regional and global stability and security. The tone of public discourse on military and foreign policy has changed lately. Indian military leaders, though retired from service, some junior officers, intellectuals, and civilian researchers at think-tanks, have lately been quite vocal in expressing a variety of perspectives on international security and military innovations in other parts of the world. The books, journal articles, seminars and studies are, however, restricted to circulation amongst the strategists and the analysts and do not reach the ears of the policy makers. The discussions do not just centre on the Western concepts. Indian military analysts and civilian researchers, study Chinese concepts too for exploiting the emerging RMA, considering the emergence of China as a regional power with aspirations for global influence, and the continuing possibility of a war between China and India.[4]

The seeds of innovation need to fall on fertile soil for them to sprout and grow into experimentation with organisations and doctrine to execute. The US Army, Air Force, Navy and the Marines have established 'battle-labs' for developing innovative approaches to war. In India, the Air Force, as it would be for the other two Services, has established experimental organisations which conduct exercises to examine new concepts, first as a war-game on computers and then on ground. The Services approach for new military formations, promulgation of doctrines, demonstrates their commitment towards pursuing new combat methods, for which support by the appropriate agencies, and sections of the Government is essential.

As mentioned earlier, many barriers stand between India and the effective implementation of a US-style RMA. Factors within the Indian political system, include strategic, culture, and economic limitations, and what Ashley Tellis has called the "otiose" nature of India's national security process[5]. Perhaps, however, the foremost consideration is the absence of a threat, which requires or justifies significant innovation, notwithstanding the continuing modernisation of the Indian Armed Forces for two-front war.

As a whole, a broad range of security threats challenges the entire force modernisation, leading to a competition between the Services for getting a bigger share of the budget pie. India faces security challenges at three different levels.

- The first, and immediate, if not the most threatening, is the continuing challenge to national unity. Traditionally it has been concentrated on the NE and NW frontiers, almost ever since the country gained independence. Continuing insurgencies, terrorist attacks, and secessionist activities have required a constant presence and involvement of the Indian Army and para-military forces in these areas. In the recent past, the 'Maoist' insurgency in the Eastern and South-Eastern parts of the country, and spreading to the South and South-Central regions, has been termed by the erstwhile Prime Minister, Dr Manmohan Singh, on many an occasion, as the gravest security threat that the country faces today. While hardly a threat to the political establishment, the continuing unrest is a drain on India's resources that could well be utilised elsewhere. Patrolling long borders and carrying out counter-insurgency operations is manpower-intensive; certain modern technologies, especially in the fields of surveillance, communications and information processing are required and are being utilised, for these operations, but they have hardly provided the impetus for a technology-related revolution.

- The continual rivalry between India and its aggressive neighbour, Pakistan, constitutes the second threat. While the Indian military has always held a conventional edge over the Pakistan military, as well as superior demographic and economic trends, ever since the two countries gained their independence, nevertheless, the two nations have fought as many as five wars in the last 60+ years. Pakistan continues to spend a major portion of its GDP on defence, along with some generous funding by USA and some Muslim nations, in an effort to maintain parity with India. Increased aggression across the Line of Control (LoC) and tacit support to fundamentalist groups has led India to revisit its doctrine as far as conflict with Pakistan is concerned.
- India also faces a constant threat from China. Many intellectuals in India call the humiliating defeat of 1962 as a betrayal by China and term it as a particularly difficult and menacing military threat. China's nuclear forces, proliferation of its delivery systems, development of its infrastructure in close proximity of the Indian frontiers, assistance to Pakistan in whatever it asks for, the aggressive posturing by China against its neighbours in the South China Sea, the 'String of Pearls' around India, provide the justification for India's security infrastructure and force modernisation.

India, with such threats, faces the dilemma of prioritisation. While the Army has believed in numbers in the past, it now wants to combine the numbers with technology. The Navy seeks sea and air capabilities, which will extend the security perimeter and, if the need arises, allow it to show its muscle in areas of interest in the Indian Ocean. The Air Force, on the other hand, wanting to maintain the edge over the adversaries, wants state-of-the-art technology, both in the air and on the ground. Whether India places its priority on tackling the problem of internal security, or decides to go extra-regional, will be prompted by how the situation develops. While the former will be manpower-intensive, the latter will demand high funding for modernisation and R&D, through manpower reductions.

Much has been written and spoken about India's strategic culture, or the lack of it. India, is perhaps one of the few nations in the world which does not have a written security policy or directive for its military. After the 1962 debacle, it was presumed that India would be more pragmatic and *realpolitik* to address its security concerns; sadly, it did not happen. The change in the political set-up has once again given rise to hopes. Despite the Government's initial display of concern towards security of the nation, one has to wait and watch for it to display its resolve and provide the necessary direction to the military, R&D, military industrial base and provide the much-needed resources. (The annual budget is not too far away, it will be known by the time this Article goes to print, if it does).

Budget priorities face serious limitations. After the boom years of the economy, India has been struggling to make ends meet. What with the high deficit, rampant inflation, and other economic factors, the defence budget, though increasing in numbers, is actually reducing in real terms and hovering around 2% of the GDP. The Indian Armed Forces are 'hollow' and need a tremendous boost in the budget to replace or modernise the obsolescent inventory and build up critical stocks of munitions and spares.

Bureaucracy has been discussed *ad nauseam.* The maze of the bureaucracy is considered another barrier to development, not just in the defence department, but in other departments too. Reforms in the Ministry of Defence (MoD) were recommended immediately after the Kargil War, by the Subrahmanyam Review Committee of 1999 and the Group of Ministers (GoM) Report of 2001, and subsequently by the Naresh Chandra Committee in 2010; apart from a few cosmetic changes, other major recommendations have been conveniently brushed aside by a disinterested bureaucrat-politician combine.

Ever since gaining independence, the India polity has been trying to convince itself that the country did not need a strong military, as India was a believer in *ahinsa* (non-violence) having inherited the teachings of Gautam Buddha and Mahatma Gandhi. Two critical facts, however, were conveniently ignored in this telling; the intervening period of about 2500 years in Indian history, between Buddha and Gandhi, have been marked by great violence, between Hindus themselves, and later with the many invaders; almost all the Hindu Gods and Goddesses bear arms for self-protection and destruction of evil.[6] One must be grateful to the Chinese for having woken up the policy makers to the realty of power, or else 1965 too would have been a disaster. The Indian defence industrial base has remained only in the public sector, the private sector being kept out totally, barring the manufacture of a few minor items. Efforts in defence manufacturing, be it by the Ordnance Factories inherited from the British, or the DPSUs, have varied from total self-reliance to assembly under licence; efforts have varied between the high-end to the lowest technology of the graph.

In an era of rapid technological changes, a future oriented military has to invest heavily in R&D. Efforts in R&D, however, have been meagre by the military. A recent audit of the Defence Research and Development Organisation (DRDO), by the Comptroller General of Defence Audit (CGDA), ordered by the outgoing Defence Minister, Shri AK Antony in 2011-12, has revealed alarming figures. Despite a network of about 52 laboratories with over 5000 scientists and 25000 support staff, only about 30 per cent of the products developed during the last 17 years have been used by the Armed Forces.

For all the criticism that is heaped, quite often justly, on the DRDO and the DPSUs, the fact remains that with proper reorganisation, restructuring and collaborating with the private sector, these national institutions, with the vast infrastructure and resources at their disposal, coupled with accountability to the Armed Forces, can rescue India from the mire of arms-dependency and ill-affordable purchases.

The Way Ahead

From the brief coverage above, it emerges that contradicting security perceptions, combined with organisational and cultural obstacles, will not only slow India’s pursuit and definition of innovation and RMA, but will also inhibit its implementation. It may be possible to achieve success in the future, despite competition from other grandiose schemes, if India decides in utilising its space and information technology-related private industries as a guiding light.

The first step in transformation is innovation, which then leads to participation in RMA. Any organisation which operates in a competitive environment and whose survival or well-being is dependent on remaining ahead of the adversaries requires being innovative. Often, the military is called to acquit itself in a life and death struggle; there may be times when the destiny of the nation depends upon the outcome of this struggle. It, therefore, is incumbent upon the military and political elite to provide an environment conducive to continuous innovation. Generation of new ideas requires knowledgeable members – knowledge in terms of current capabilities, plans and organisational functioning and goals. For the military and other related agencies, this translates to acquiring specific technical knowledge, skills and an understanding of their application towards the achievement of organisational targets. Encouragement and support for incremental innovations would make the organisation amenable to breakthrough with radical ideas and concepts, which challenge current approaches or thinking. Such ideas cannot be expected to emerge in normal course in hierarchical and tradition bound organisations like the military. Separate teams or institutions need to be nurtured to generate such ideas. It is not that the Indian military has ignored this aspect; many training institutes have developed separate sections for this task, however, being part of a larger institution, these tend to get sucked into meeting routine training tasks. Separate institutes or project teams are the answer.

Recent years have seen some major changes being introduced in the Indian military; the process is being called 'modernisation' and 'restructuring'. Higher defence management was reviewed at the highest level; while some recommendations were implemented, other, equally major changes have been hanging fire. Increased allocations in the last few years have held the hope of overcoming critical deficiencies through big-budget purchases; the Indian defence industrial base needs an impetus to achieve self-reliance, rather than continuing to rely on 'licence manufacture' or 'transfer of technology' from other nations. Induction of new platforms or technology does not necessarily bring about new approaches to warfare. Acquisitions through indigenisation would not only improve firepower and lethality, but also encourage innovation.

The constraints should not impair Indian military's attempt of exploiting the RMA. At a minimum, India is aware of the RMA, and this awareness has led to some level of institutionalisation and implementation. Changes in the current political and economic structures may accelerate the implementation, and affect the definition and security focus of RMA-related developments. A caution - even in a period of dramatic political changes, one should not be overly optimistic to assume overnight transformation and adoption of RMA-related capabilities.

The internal barriers, mentioned in this writing, remain significant; resistance to change would continue; a unifying vision, however, needs to emerge to develop some capabilities in RMA-related sectors.

Only then can India claim to have begun to harness technology to reap the benefits in emerging warfare.

Endnotes

1 Steven Metz, 'The Next Twist of the RMA', Parameters, Autumn 2000, p 40-53.

2 Jeffrey McKitrick, ' The Revolution in Military Affairs', p1, http://www.airpower.maxwell.af.mil/airchronicles/battle/bftoc.html

3 AK Tiwari, 'Indian Experience in RMA', Indian Defence Review, Vol 18(1), Jan-Mar 2003, p 65-71.

4 Akshay Joshi, 'A holistic View of the Revolution in Military Affairs (RMA)', Strategic Analysis (Internet Edition) February 1999.

5 Ashley J. Tellis, 'Stability in South Asia', RAND 1997.

6 KR Singh, 'India: Self-Imposed Arms Control (Part-I)', Defence Watch, Vol XII No2, October 2012.

Revitalising India's Defence Sector

Dhruv C Katoch

At the time of independence, India had a vibrant defence industrial base. This was a legacy of the British, which at the time of the East India Company, in 1775, established the first Army Ordnance Factory in India to manufacture military weapons, gain economic interest and strengthen their political power. The fledging start to the establishment of a defence industrial base in India grew with time and peaked in the first half of the twentieth century, to sustain the forces in World Wars I and II. Post-independence, a large number of defence ordnance factories (OFs)came up. Thirty nine of these are functioning today, and two more have been added, though these are yet to operationalise. All these function under the Ordnance Factory Board (OFB).India also has nine Defence Public Sector Undertakings (DPSUs) producing a variety of defence armaments and equipment and has a vibrant Defence Research and Development Organisation (DRDO). With such a setup, and with the head start India had, the country should have been a major arms exporter. However, the situation on the ground remains sadly remiss, forcing India to meet about 70 percent of its defence requirements from abroad. In 1995, the government introduced an ambitious plan to reduce our requirement on imports to a more reasonable 30 percent. Two decades down the line, the situation has not changed. Besides the import content being astronomically high, even the process of acquiring much needed armaments and equipment is infirm and plagued with delays and procrastination. As an example, since the purchase of the Bofors gun for the Indian artillery in the eighties, we have not yet been able to make up our voids in artillery, through purchase either from foreign vendors or through local manufacture. The same situation applies to helicopters, fighter aircraft for the Air force, ships for the Navy and a host of equipment for the Army. Delays in procurement have led to huge cost over runs, indicating yet again the heavy price the nation pays for indecision and procrastination.

Not that India lacks capability. In the Defence Expo 2014 held at Pragati Maidan, New Delhi, many Indian companies displayed their products, amply demonstrating that despite stifling red tape and difficult market conditions, the private sector in India has the potential, capacity and capability to manufacture sophisticated equipment. In the public sector too, the success of DRDO stands testament to Indian capability. Why then have we not been able to manufacture even basic equipment like a world-class assault rifle for the Indian Army? What we need today are not incremental changes but a major overhaul in our thought processes and the way we function. We need to ask ourselves the question – 'What can we do to alter the structure of the defence industry in India on a global scale'? For this, key personnel representing the users, the decision makers and the manufacturers of defence equipment need to get together on a common platform to chart out a bold new course for India's defence Industrial sector.

There are three major players in the system. Foremost among them is the users, which comprise of the Armed forces, the para-military (Assam Rifles) and the Central Armed Police Forces (BSF, CRPF, ITBP). Then is the manufacturer, which comprises of public sector enterprises and research organisations (DPSUs, OFs, DRDO and the private sector). Lastly, is the decision maker. (The political authority and the bureaucracy in the Defence Ministry). While all three remain focused on achieving a similar desired end state, there is no real cooperation between them, nor is there an understanding of the manner in which each functions, the challenges they face and the restrictions under which they operate. The relationship for the most part is plagued with suspicion, with the decision maker sadly out of sync with the other two players and the user rarely coopted in the decision making process, in research or in the manufacture of products. In addition, the Indian Armed Forces have the ownership of a vast array of weapons and equipment. The inventory consists of a mix of vintage equipment as well as state-of-the-art systems, incorporating the current generation of technologies. Such a diverse range demands ingenuity and foresight to address operational sustainment issues. Technological obsolescence has affected our sustainment efforts adversely influencing mission reliability, particularly of legacy weapon systems. Operational sustainment of these weapon systems throws up a great challenge in the face of rapidly diminishing product support from the original equipment manufacturer (OEM).A focused approach towards maximising indigenisation is the only way to achieve our aim of total self-reliance in defence technology.

Establishing a Technology Base

The Indian private sector today, as highlighted by their display of equipment in Defence Expo 2014, possesses the requisite skills and infrastructure for undertaking defence production. All it needs is for the industry to be encouraged to make suitable investments with guaranteed buy-backs as an incentive. Firms of national repute that are willing to participate in the development model must be encouraged to come forward and take on system and sub-systems development, testing and evaluation, sustenance and re-set of systems through its entire lifecycle. In the case of high technology complex systems, high levels of investments are required to be made in research and development (R&D) to yield results in the future. This investment must be made now. Projects can progress in conjunction with the DRDO and other R&D establishment. As of now, DPSUs have been instrumental in developing ancillaries on major and minor aggregates in sufficiently large orders, thereby incentivising participation of small and medium enterprises (SMEs) and micro, small and medium enterprises (MSMEs). Disaggregating systems into sub-systems and components can facilitate manufacturing by companies having the requisite expertise within the country. This way, indigenisation can be achieved much more easily. BrahMos is a case in point. The way ahead now is to identify self-reliance goals through pragmatic perspective planning and by establishing technology transfer paradigms and unambiguous policy directives with time bound goals to be achieved as a national focus to achieve self- reliance.

A technology base is the need of the hour. While selective government funding would be useful, of greater import is creating an environment to facilitate a collaborative process between the academia, research institutes, the defence industry and the armed forces. If defence indigenisation is pursued as a long-term goal, it could well lead to a self-reinforcing title of national development and technology security, creating in the process, a strategic surprise for our adversaries. Towards this end, in recent years, the Defence Procurement Procedures (DPP) mandate offset obligations, even in inter-governmental purchases. India's domestic demand in this segment is likely to grow for reasons such as geopolitical scenarios, replacement of obsolete equipment, internal security requirements, economic growth that India is bound to witness in the coming years and increased innovation in this sector. The basic intent of the offset policy is to build a domestic manufacturing base. The most recent amendment to DPP offers opportunity to large private enterprises, SMEs and MSMEs to work closely with defence. While much more needs to be done in this regard, the beginning made is positive and need to be capitalised upon. It must be noted that Indian industry is positioned to cater to domestic defence needs for reasons that are very evident such as cost efficiency, availability of engineering talent in India, shorter lead times, improved productivity and the increased focus on R&D, which is now taking place within the country.

Defence imports are costly and have the additional double whammy of outflow of foreign exchange thus increasing the balance of payment liabilities, thereby having an adverse effect on national economy. We have to make sure our indigenisation efforts include their sustenance requirements in terms of spare parts cover over the life of the equipment. This must be included in the initial purchase agreement and costing done accordingly to ensure availability at all times. Transfer of technology (TOT) should be looked into with respect to maintenance, as imports of spare parts are prohibitively costly. There is also the concern that continued import of technologies will make us addicted to them and indeed prevent indigenisation. In addition, foreign origin manufacturers, who have spent a great deal of time and money on research, would be loath to part with critical technologies. The hurdle of circumventing technology denial regimes also needs consideration. Here, we could look into the DARPA model. SMEs and MSMEs need to be co-opted in a big way in India's defence industrial base, especially in the design and manufacture of sub-assemblies, component and systems. More often than not, it is the small players that tend to be a lot more innovative than the larger enterprises.

India has a vast array of talent in its academia, which unfortunately is not coopted into facilitating the development of a vibrant defence industrial base. It is important to facilitate academia-industry interactions through innovative interfaces for 'Pre-competitive Applied Research' and through 'Directed Basic Research', for Industrial Development. For example, C-MAT is the core advisory group for research and development in the machine tools sector. It was established because of Indian Machine Tools Manufacturers Association (IMTMA) interaction with the Principal Scientific Advisor (PSA) to the Government of India and academic institutions like IISc, IITM, VIT, PSGCT and others. The Programme Advisory Committee (PAC) constituted by the PSA for R&D in the machine tool sector has representation from academia, industry, R&D institutions and the Government. Another example is CAREL (Core Advisory Group for R&D in the Electronics Hardware Sector). This was established by the PSA,in consultation with the Department of Electronics and Information Technology and the various industry associations, to provide a remedy and to give a fillip to academia-industry participation in Electronics Hardware. The aim was to develop a Technology Road Map for the country's Electronics Hardware Sector, identifyingthe technology gaps in that sector and other related sectors and the thrust areas for pre-competitive applied research and directed basic research. Establishing University Research Parks, which are a "cluster of technology-based organisations that are located on or near a university campus in order to benefit from the university's knowledge base and ongoing research", are a great way to facilitate such interaction. Effective parks can aid in the transfer of technology and business skills between universities and industry teams, encourage the creation of start-ups, and promote technology-led economic development.

Charting a Road Ahead

To harness new technologies, there is a need to produce them. Herein lies the problem. If we only ask for tried and tested technologies, then we can never be leaders in the field. By the time said technology is available to us, the cost would be prohibitive and worse, a newer technology would be on the cusp of development. In any case, the General Staff Qualitative Requirements (GSQR) for any weapon system or equipment issued by the Services is based on what is available across the world. We therefore need to change the way we think and consciously delve into futuristic research in an attempt to be the first to introduce new technologies. Therein lies the path to a knowledge-driven economy. This obviously would inform some element of risk taking, which the scientists and the political, military and bureaucratic leadership must be prepared to accept. We should get accustomed to occasional failures when developing new advanced technologies. Only then can we hope to be world leaders. It is also sobering to remember that the so-called proven technologies, unless subjected to continuous evolutionary improvements are often a synonym for obsolete technologies.

While looking at futuristic product acquisitions, the Services are conspicuous by their absence in the research and development of most ranges of products. This needs to change. While this issue pertains more to policy than technology, it affects the latter if the end user is not associated with the development of the product from the conceptual stage itself. As of now, the relationship between the DRDO and the Services as also the relationship between the Services and the OF and DPSUs is a vendor customer relationship, with the additional drawback of the customer in this case being captive to the vendor and being forced to take what is offered. This relationship must change to a partnership, wherein the Services, the research establishments and the manufactures (both public and private sector) function as a team for the development of a product. The Service component of such a team must have long tenures to see the product through to fruition.

Another aspect which need consideration is the desire of the Services to have what is the best available across the globe. While this is understandable, it stands in the way of India ever hoping to be a long-term player and leader in specified fields. The users therefore, should be willing to live with somewhat lower specifications in the short term,to enable in-house manufacture. Even if indigenous products do not match up to what established global vendors could provide, it does not matter as long as the critical requirements of the Services are met. Unless we do this, our defence industrial base would perpetually remain weak, putting paid to Indian hopes of being global leaders in the long term. We have a window of opportunity as of now to tread on this path as at least for the next decade or so, Pakistan lacks the capacity and capability to pose a credible conventional military threat to India. By seizing this opportunity, we could hope to fully indigenise the mechanised forces and the field and air defence artillery within a laid down timespanand be in a position to produce a range of other sophisticated equipment. Allied with this, there should be continuity in technology development. For example, we should follow up now for a more advanced version of LCA Tejas, otherwise knowledge tends to attenuate. User agencies need to be part of the long-term vision propagated here, so that there is continuity in policy to see through the execution of long-term capability development plans. This would also put paid to 'stop-and-start' ordering of advanced systems by user agencies, which greatly retard the indigenisation process.

Too many of India's DPSUs are simply assembling units. As an example, Bharat Earth Movers Limited (BEML) claims to manufacture the Tatra vehicle for the Army, when all it does is to assemble the vehicle that it has procured in a knocked down condition from the Czech Republic. Screwdriver technology is not what India needs. Most DPSUs need to close down and reorient towards cutting-edge technologies. The same goes for the ordnance factories. We still have some of these factories producing general stores and clothing, which in any case the private sector produces, that too of superior quality and at cheaper rates. Downsizing of both the DPSUs and the OFs, and focusing on critical technologies with the remainder will lead to enhancement in India's defence production capabilities. The private sector should be asked to step in and take over all low to medium technology activities being undertaken by them.

As part of India's Defence Procurement Procedure (DPP), offsets are gaining increasing salience. The advantage from offset (when importing) should be maximised at RFP stage itself. The highest possible level of technologies, if introduced in the contract,can help indigenisation in the long term. This would provide an opportunity to Indian vendors to produce equipment for internal use and for the global market in collaboration with the foreign supplier.Over time, it would lead to the strengthening of India's defence industrial base.

A major weakness observed in the acquisition process, is lack of trained personnel in making of contracts. Too often, persons entrusted with this task have limited knowledge of the subject and learn the procedures while on the job. Personnel posted to such assignments need to be put through at least a two year course to enable them to master the subject. These people must have extended tenures so that full benefit accrues from their expertise. This also applies to laying down the GSQR for an imported defence system. Here, the Armed Forces group involved could be given a short crash course in Defence Institute of Advance Technology, Pune, with additional faculty drawn from academic institutions so that the scientific and technological significance of every specification is fully grasped. In addition, when going for visits to the factories of foreign vendors before signing the contract to examine the system or for inspections before accepting the system, DRDO scientists (or scientists from academic institutions) working on similar systems, should form part of the delegation. This will help knowledge to flow into the country.

We could also consider the establishment of a common management information grid raising all individual MIS domains in defence technology. The road to self-reliance starts from interdependence and collaboration between the services, public sector units,private sector and the various government agencies. Disaggregating systems into sub-systems and components can facilitate manufacturing by companies having the requisite knowledge and expertise within the country.Allied with this, we need to move away from the L1 system and shift to a ranking system as an incentive for better quality products. Also, the Technology Perspective and Capability Roadmap (TPCR), in its present format, does not assist the industry in making any strategic partnerships or investments. It needs to be redrafted into an action-oriented plan with some level of commitment for industry to pursue strategic partnerships and joint ventures with global OEMs. In order to harness the emerging dynamism of the private sector as well as the increasing opportunities to obtain advanced technologies from foreign sources, there is a need to bring about a synergised approach that furthers the objective of achieving self-reliance. Partnerships, both with Indian as well as foreign vendors must be considered to harness new opportunities. These could relate to outsourcing, subcontracting, formation of consortium, projects specific joint ventures etc.

Finally, it would be worthwhile to establish a 'National Technological Council' (NTC) to identify essential technologies, which we should concentrate on or invest in. This should have national level testing facilities, since the industry may not be able to undertake this from within its own resources. Following a DARPA like model for the NTC could be beneficial. A focused approach towards maximising indigenisation is perhaps the need of the hour to revitalise India's defence Sector.

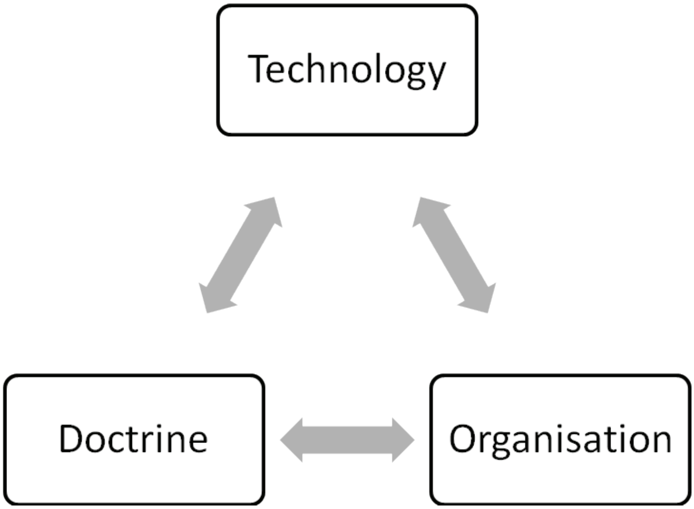
Harnessing Military Technology: Strategising Technology Innovation

Brig Rahul K Bhonsle (Retd)

This Paper argues that harnessing military technology requires holistic approach to include soft and hard components with multiple pathways following key vectors of innovation. This will lead to simultaneity in progression on diverse time lines, short, medium and long term successively expanding India's strategic leverages achieving a degree of technology autonomy while at the same provide the war fighter tools for expanding vistas of operational art.

Significance of Military Technology- Expanding Military Strategic Options

Military strategy is a component of grand strategy providing the leadership optimal approaches to achieve national goals and objectives through, "hard power". In the contemporary world of competitive security with a full spectrum threat dimension, nuclear, conventional, sub conventional and asymmetric innovation is essential in each vector to stay ahead of the power curve. Military innovation has three key dimensions, doctrine, organization and technology together making the basic triad of Revolution in Military Affairs (RMA).[1] Relative importance of each has been the subject of debate over the years.



The American military claims that the evolution of doctrine of Air Land Battle drove technology innovation. Development of blitzkrieg in the period between the two Great Wars of the 20th Century could be attributed to superior organization of the German panzer and the stuka dive bomber. In more recent years, Anti Access and Area Denial (A2AD) strategy by China could be attributed to development of a superior array of ballistic missiles which has made intervention for the opponent exponentially expensive.[2] In each case outlined above harnessing indigenous technology through innovation has remained pivotal. Correspondingly it could be argued that military strategic options of the Indian armed forces have been constrained due to lack of effective harnessing of technology.

Thus Indian military has had to, "fight with whatever we have," or rely on organizational factors or mass, rather than technology to pose deterrence to the adversary. Raising of the mountain strike corps is a salient example where lack of alternative technologies that could be effectively employed for deterrence and war fighting in the mountains has led to the linear approach relying on mass of men and material. Technologies in terms of Reconnaissance, Surveillance and Target Acquisition (RSTA), mobility and precision fire power may have provided suitable alternatives to doctrinal and organisational development to meet the challenge far more economically. The importance of technology to provide greater options for force application with optimal resources is thus evident. This may be as much an important factor as need for strategic autonomy by reduction of imports which receives more frequent mention.

Harnessing Military Technology – The Basics of Innovation

Over the years many reasons have been cited for lack of absorption of military technology by India. These could be summed up as absence of culture of innovation, thus identifying basic factors that would contribute to creation of the same may provide us the necessary answers.

Technology innovation comprises of, "soft" and "hard" factors. Soft factors can be classified as overall governance of the sector to include directions by the political leadership, legal and regulatory structures, promotion of research and development in the government as well as private sectors, entrepreneurial and managerial skills and so on. The Indian Information Technology (IT) sector is an appropriate example of how excellence in soft factors has driven IT industry in the country in a leading position globally even though it is based on process oriented applications and not core software development.

In the field of defence technology, Defence Procurement Procedure (DPP) that outlines the process of acquisition in India over the past decade or so could be identified as setting out soft factors of technology absorption. Over the years the DPPs have outlined the process of acquisitions. This is a linear bureaucratic approach that is averse to disruptive enhancements. Defence Offsets and Joint Ventures are some of the latest additions to the DPP in an attempt to create an environment for technology absorption. Restructuring of the Defence Research and Development Organisation (DRDO) undertaken through the Rama Rao Committee is part of the process in a different dimension.[3] Publication of the Technology Perspective and Capability Road Map (TPCR) is another measure which adds to soft factors providing transparency to developers and the industry for investing in future technologies.

The hard factors on the other hand include technology innovation and product development which will comprise of development of scientific talent in schools, universities and academia, research and development laboratories in the government and private sector, funding of research, access to foreign technology and an industrial base for absorption of the outputs so generated. A survey of these in the Indian context would reveal that there is a deficiency in each of these factors thus preventing technology absorption and innovation. A case in point is the budget for the DRDO. From 2009-10 to 2012-13 this has fallen from 0.13 percent to 0.09 percent of the GDP. It may well be argued that inefficiency, cost and time overruns are a contributory factor to the same, yet underfunding of the premier defence research organization reflects on the inefficiency of management of the technology development culture in the country involving soft factors outlined above. Other issues such as academia base and interface and soon have been well documented and are thus not been covered herein.

Suffice to say a holistic approach to invest in soft and hard factors that will contribute to technology innovation which has multiple dimensions is necessary. The first step is to understand that the two dimensions of innovation, soft and hard are distinct and focus on these through a concerted National Military Technology Development Strategy (NMTDS). This should stitch in the developments evident today such as publication of the TPCR or emphasis on indigenization of technology by the leadership to develop a culture of modernism. The NMTDS will be a national strategy focused on innovation in defence science and technology. The approach has to be inclusive with parallel and intersecting pathways to include all stake holders. There has been sufficient articulation of various dimensions of such a strategy in separate forums, thus this is not being addressed separately and the Paper will concentrate on, “hard,” technology innovation hereafter.

Technology Innovation Pathways

Solving the puzzle of technology absorption by the military would require identifying appropriate pathways for the purpose. There are many routes which nations and defence scientific communities adopt. Generally speaking the hierarchy of technology innovation pathways is as follows:-

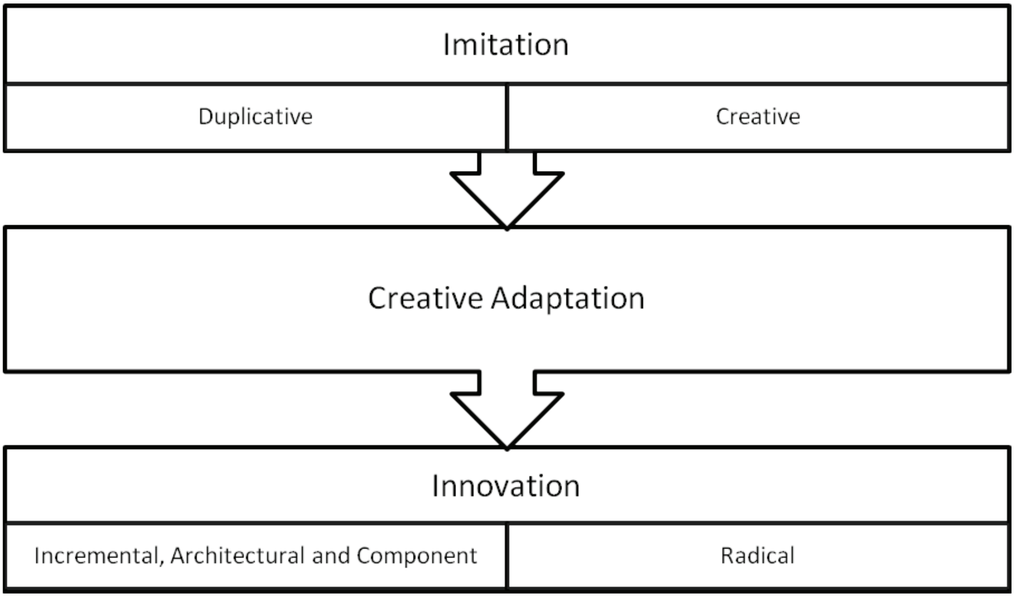
(a) Imitation – Duplicative and Creative.

(b) Creative Adaptation.

(c) Incremental Innovation – Architectural, disruptive, incremental and component.

(d) Radical Innovation – Developing the, “Assassin’s Mace.”

Under normal course nations and militaries progress from one step to another though there is a distinct possibility for simultaneous adoption. These pathways including simultaneity in the Indian context for high technology absorption is being discussed in subsequent paragraphs



Imitation

Duplicative Imitation. Imitation is said to be in two forms, duplicative and creative.[4] Duplicative imitation could be seen as technology transfer the much preferred model adopted by the Indian defence sector. Here products are copied without any contribution to technological innovation based on the drawings and designs that are provided by the manufacturer. Some key components on the other hand are directly imported without any substitution. Most of the high technology platforms be it the Su 20 MKI combat fighter, the Scorpene submarine or the T 90 S armoured fighting vehicle all of which are manufactured/assembled could be said to be through process of duplicative imitation where low level technology parts are manufactured in the country. The process of technology transfer is expected to generate spin offs through absorption of manufacturing techniques leading to possible next level of imitation, creative.

Creative Imitation. Creative imitation involves developing new systems with improvement in performance. [5] Production of 155mm artillery gun by the Ordnance Factory Board (OFB) is an example of creative imitation. Named as the, “Dhanush”, the howitzer is of 45 calibre as against the original Bofors design which is of 39 calibre and has a maximum range of 38 km. Dhanush is presently under extensive trials and could be introduced after successful completion of the same in the months to come. Creative imitation based on designs provided by Bofors along with the original contract has facilitated improving the caliber and also range of the gun. The case shows that creative imitation may provide answers to technology absorption in the near time. Availability of design parameters by the Original Equipment Manufacturer (OEM) without Intellectual Property Rights (IPR) restrictions is important. The Government of India had entered into License Agreement with M/s AB Bofors, Sweden for indigenous manufacture of 155mm/39 calibre FH 77 B02 Gun and Ammunition along with the procurement of 155mm/39 calibre FH77 B02 for the Indian Army.[6] This option was not exploited in 2012 indicating that availability of designs and possibility of this approach for procurement of guns was not evident to stake holders, an inexcusable knowledge gap.

Creative Adaptation

Creative adaptation entails a level of inspiration from foreign technology even though the product itself may differ from the derived one considerably.[7] The Joint Venture model which is part of the DPP could be reflective of this model. While in the initial stage a joint venture as say the BrahMos supersonic curies missile is based on the Russian P-800 Oniks, there are many variations that have been developed which could be categorized as creative, “imitation,” but the development of a hypersonic cruise missile which is the advanced stage fall in the more distinct category of creative, “adaptation”. Similarly other joint venture development that are planned with Russia such as the Fifth Generation Fighter Aircraft (FGFA) and Multirole Transport Aircraft (MTA) are expected to generate spin offs through creative adaptation by taking the country to next level of development in technologies in this sphere. Much will depend on how much is actually shared by the technology partner in the joint venture, what can be practically absorbed by the junior associate and level of supervision in this dimension. There are inherent challenges in this approach which include both sharing and cost. While the final design contract for the FGFA was to be signed in 2012, this has still not fructified due to factors of cost and work share. At present India's work share is only 15 percent whereas it is bearing 50 percent of the cost. The Indian Air Force is looking for a higher level of work share so as to build a future capacity for creative adaptation if not imitation.[8]

Given the emphasis on Joint Ventures in the DPP 2013 a number of such proposals are on the table. The United States has adapted this for expanding defence sales to India through the Defence Technology and Trade Initiative (DTTI) framework. [9] Substantial investments are likely in case present limit of Foreign Direct Investment (FDI) through the automatic route is expanded beyond 26 percent. There is a need to ensure that the benefits accrued in Joint Ventures create a capacity for creative adaptation and do not end up as products of duplicative imitation. Agreements when inked should ensure the same taking a cue from the Bofors case.

Innovation

Incremental Innovation. Incremental Innovation entails upgrading military systems developed within the country based on experience and exposure in operating the same and feedback from the user.[10] This is a familiar approach of developing systems from the first Mark 1 version to the Mark 2 and so on. The Arjun Tank is a significant example of incremental innovation. While the Indian Army much reluctantly accepted to induct Arjun Mark 1 it also demanded a number of improvements. The DRDO carried out modifications which were rigorously tested.[11] Comparative trials were carried out with T 90 S and the Mark 2 developed 124 more of which are now being inducted in the Army.[12] Yet possibly a poor General Staff Qualitative Requirement (GSQR) has led to design constraints which are not likely to be overcome through incremental innovation. The Light Combat Aircraft Tejas and Pinaka MBRL are also going through the process of incremental innovation.

Architectural Innovation. Architectural innovation purely from the technology point of view entails improvement in system integration to achieve efficiency in synergy which adds to improvement in performance.[13] This may be incremental or could even be exponential depending on the original and improved product. This is also a result of progressive build up of experience and exposure to equipment in the field. In some cases it may overcome faulty design at the initial stage. The Indian Air Force hybrid AWACS with Russian IL 76 platform and Israeli RSTA and C4I2 equipment is an apt example of architectural innovation.

Component Innovation. Component innovation involves improvement of technology of parts of a system thereby enhancing efficiency.[14] Component innovation requires high degree of technological inputs essentially based on a strong scientific and knowledge base, human resource competence and well placed research establishment. Upgrades of various equipment such as the Mirage 2000 would also fall in this category.[15] Some countries as Israel are specializing in component innovation which has been exploited in a number of projects in India. Capability for component innovation will have to be build in the country in the long term. At the same time some niche areas in which India has high level of expertise, which has been harnessed by foreign IT firms in particular could be exploited even in the short term.

Radical Innovation. Radical innovation entails major breakthroughs in technology such as components and architecture improvement to bring about generational change.[16] India should focus on developing radical innovation capability based on sixth generation technologies. Some of the technologies which are likely to contribute to radical innovation are miniaturization, variable lethality, hypersonic speed, low observables, robotics, all weather sensing, holography and virtual reality and prosthetics.

Hybrid Approach. Technology harnessing in many cases is undertaken by a hybrid approach with a mix and match between adaptation and innovation. Given that military systems are complex fits of diverse technologies some elements could well be developed indigenously while others absorbed through duplicative imitation. The DPP tends to suggest such an approach, thus in categories as, “Buy India,” where the systems are to be bought exclusively from an Indian firm, the components produced indigenously on a cost basis are only 30 percent.[17]

Stitching Innovation Models in Strategy for Harnessing Technology

Stitching in models for innovation outlined above in the National Military Technology Development Strategy (NMTDS) is essential to exploit benefits of each while overcoming deficiencies and building a strong defence R & D capability. Correspondingly principal policy and procedures such as the Defence Production Policy and DPP would have to be restructured to reflect objectives of the NMTDS. Suggestions for adopting models of innovation are being examined in the reverse order to the discussion above as follows:-

Radical Innovation. Areas for radical innovation that can be achieved in the next 20 to 30 years providing India a unique advantage by say 2030-35 by which time sixth generation technologies are likely to manifest should commence now. A multi layered R & D base should be build up by identifying various technology inflection points many of which would be derived from basic sciences. Sufficient commitment of budget for this purpose would have to be catered for and projects undertaken on a mission mode approach. Assistance from foreign agencies is inevitable; this can be tweaked in the FDI policy wherein companies willing to co-develop next generation technologies could be permitted 100% FDI with sharing of proprietary rights.

Creative Adaptation, Incremental, Architectural and Component Innovation. This will form the main framework of R & D for expanding technology efficiency of current systems as well as programmes by focusing on improving components or systems integration. Companies providing key technology innovations could be provided incentives through high level of FDI even up to 100 percent.

Duplicative and Creative Imitation. The current format of technology transfer is based on this paradigm. Systems which can be innovated through creative imitation should be identified for focused investments indigenous or FDI as the case may be. However mere transfer of technology without IPR of critical components should not provide any advantage.

Conclusion

India is singularly advantaged in that there are very few restrictions on technology sharing or exchange by foreign countries, while adequate budgetary resources can be provided if the political leadership so determines. Thus it does not suffer from denial of technology or resources; however these have been key factors that have led to innovation in China and Pakistan respectively. China's defence research and technology and production complex is expanding rapidly through a hybrid approach while Pakistan is adopting creative adaptation to make up for paucity of budgetary resources. In India while the need for harnessing military technology is well established, there has been limited debate on pathways for innovation. An attempt has been made herein to outline models in this field.

Endnotes

1 Andrew L Ross. Framing Chinese Military Innovation. In Tai Ming Cheung. Ed. China's Emergence as a Defence Technological Power. Routledge. London. 2013. P 192.

2 Thomas G Mahnken. China's Anti Access Strategy in Historical and Theoretical Perspective. In Tai Ming Cheung. Ed. China's Emergence as a Defence Technological Power. Routledge. London. 2013. P 7

3 Press Information Bureau. Government of India. Recommendations p Rama Rao committee on DRDO. http://pib.nic.in/newsite/erelease.aspx?relid=37794. Accessed on 15 June 2014

4 Linsu Kim and Richard R Nelson (Eds). Technology, Learning and Innovation. Cambridge UP 2000. Pp 305. In Tai Ming Cheung The Chinese Defence Economy's Long March from Imitation to Innovation. In Tai Ming Cheung. Ed. China's Emergence as a Defence Technological Power. Routledge. London. 2013. P 34.

5 Ibid.

6 Press Information Bureau. Government of India. http://pib.nic.in/newsite/erelease.aspx?relid=83930. Accessed on 16 June 2014.

7 Tai Ming Cheung The Chinese Defence Economy's Long March from Imitation to Innovation. In Tai Ming Cheung. Ed. China's Emergence as a Defence Technological Power. Routledge. London. 2013. P 34.

8 Jay Menon. India Concerned About FGFA Work Share With Russia. Oct 21, 2013. http://aviationweek.com/awin/india-concerned-about-fgfa-work-share-russia. Accessed on 15 June 2014.

9 Rahul Bhonsle. Indo US Defence Cooperation: High Point of Prime Minister's US Visit. Sep 30, 2013. http://www.security-risks.com/security-trends-south-asia/india-defence/indo-

us-defence-cooperation-high-point-of-prime-ministers-us-visit-2124.html. Accessed on 15 June 2014.

10 Tai Ming Cheung. P 35

11 Press Information Bureau. Government of India. Production of Howitzers by Ordnance Factory. http://pib.nic.in/newsite/erelease.aspx?relid=75191. Accessed on 16 June 2014

12 Press Information Bureau. Government of India. http://pib.nic.in/newsite/erelease.aspx?relid=10623. Accessed on 16 June 2014

13 Tai Ming Cheung P 36

14 Tai Ming Cheung. P 37.

15 Press Information Bureau. Government of India. http://pib.nic.in/newsite/erelease.aspx?relid=81647. Accessed on 16 June 2014

16 Tai Ming Cheung. P 38.

17 Press Information Bureau. Government of India. http://pib.nic.in/newsite/erelease.aspx?relid=96361. Accessed on 16 June 2014

Articles For Synergy Journal

Articles, Research Papers, Book Reviews pertaining to issues related to defence, national security, international relation and other matters professionale; in original may be forwarded to the Editor SYNERGY, Centre for Joint Warfare Studies (CENJOWS), Kashmir House, Rajaji Marg, New Delhi - 110 011 as per following guidelines:-

- Printed in double space on A-4 Size paper
- Printed on one side of the paper
- Preferably less than 3000 words
- Arial Font with Font Size 12 in Word Document
- Forwarded alongwith a CD.
- Copy should also be sent on e-mail to cenjows@yahoo.com
- Abbreviations may please be avoided
- No classified content should form part of the article
- End Notes and Bibliography, if applicable, should be attached
- Contribution should not have been offered to other journals
- A brief CV of the author should accompany the article.

A certificate from the author certifying that the article has neither been published in any other journal / magazine / book nor has been offered for publication should also be sent alongwith the article. Serving officers should enclose a "No Objection Certificate" from their immediate superior wrt publication of the articles.

The author will also receive a complimentary copy of the Journal in which his/her article appears.

Suitable honorarium will be paid to the contributors for their articles.

- Editor

CENJOWS Publications

Seminars

		Price (Rs)	Year
1.	Indian Way of War Fighting Proceedings of the Seminar compiled In the form of a Book.	395/-	2008
2.	Indian Experience in Force Projection Proceedings of the Seminar detailing First hand account by those who commanded/ Participated in IPKF Operations in Sri Lanka And Maldives.	300/-	2008
3.	War Against Global Terror Proceedings of the Seminar compiled In the form of a Book.	495/-	2008

Study Reports

1.	India's Comprehensive National Power: Synergy through Joint Decision Making - Study Report.	800/-	2009
2.	Uniform Code of Military Justice	100/-	2009
3.	India's Strategic Stakes in Afghanistan	295/-	2010
4.	The Armed Forces Tribunal Act	100/-	2010

5.	Defence Industrial Base - 2025*	850/-	2010
6.	Integrated Force Projection by India*	750/-	2011
7.	Space Security: Indian Perspective*	550/-	2011
8.	Employment of Special Forces: Challenges and Opportunities*	795/-	2012
9.	Indo- US Defence Cooperation*	225/-	2012
10.	Water: A Source for Future Conflicts*	995/-	2013
11.	Implementation of RTI Act 2005 in the Armed Forces and its Implications*	450/-	2013
12.	Rise of Islamists in Bangladesh*	295/-	2014

Issue Briefs

1.	Role of Pakistan in India's Energy Security* Vol I. No. I. 2013	450/-	2013
2.	India's Defence Procurement: Issues and Prospects* Vol I. No. II. 2013	150/-	2013
3.	India's Quest for Defence Equipment Policy* Vol I. No. III. 2013)	150/-	2013
4.	Chinese Chequers in the Indian Ocean Region* Vol II. No. I. 2014	195/-	2014
5.	Understanding Iran* Vol II. No. II. 2014	150/-	2014
6.	Training and Technology Requirements for Anti-Maoist Operations* Vol II. No. III. 2014	125/-	2014

* *Available from Vij Books India Pvt Ltd*)

6. India's Foreign Policy: Time for a Rethink* Vol II. No. IV. 2014	125/-	2014

Synodos Papers

1. LTTE & Sri Lanka : A Way Ahead	50/-	2009
2. India's Option in the Emerging Political Scenario of Bangladesh.	50/-	2009
3. Myanmar India Relations: An Appraisal	50/-	2009
4. Situation in Nepal Implications & Policy Options for India	50/-	2009
5. Developments in Pakistan	50/-	2110
6. Afghanistan: Past, Present and Way Ahead	50/-	2010
7. Indo-US Relations: A Perspective	50/-	2011
8. South Asia: Our Foreign Policy Priority	50/-	2011
9. Review of India's Civil Nuclear Energy Programme: Post Fukushima Disaster	50/-	2011
10. Asia Pacific Region Ballistic Missile Defence Scenario 2020: Recommended Approach for India	50/-	2012
11. Democratisation of Myanmar: Implications for India	50/-	2012
12. Demilitarisation of Siachen Glaciar	50/-	2012
13. Peoples Liberation Army Air Force (PLAAF)	50/-	2012
14. Emerging Trends in BMD	50/-	2013
15. Is India Prepared to Exploit the Opportunities offered by Space- An Assessment	50/-	2013
16. Sino Pak Economic Corridor An Appraisal	50/-	2013
17. Deciphering Uighur Unrest in China	50/-	2014