Focus

Arms Acquisition Competitiveness: Relevant International Experiences

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Even though the Indian government has begun to encourage participation of private sector in defence systems production, it is not technologically competitive in the global market. The Chinese are giving importance to two factors: first, the civilian high technology market should increase sophisticated dual-use products that are readily available to the military. Developments of new C4ISR capabilities in the military have been a consequent result of improvements in the telecommunications sector. Second, technologies and skills developed in the civilian sector can be gradually transferred to defence production, thereby improving defence industrial process and production. This policy had been earlier followed by Japan and South Korea as well.

Introduction

Studies on arms acquisition competitiveness can either examine efficiencies of public accountability to prevent waste and fraud in the system or it could examine efficiencies of time, cost and technology competitiveness. Arms acquisition decision-making, in any country, is primarily a systems management problem which gets pronounced due to inadequate standards of security sector governance. Decision-making in complex systems have the following features:

Unexpected Outcomes

The smallest cause can have largest effect on outcomes. The largest causes may have little or no effect at all. Even though decision-making in complex systems is oriented towards achieving pre-specified goals, it should be configured to take maximum advantage of unexpected opportunities that may arise.

Meta-Planning and Meta-Management

Prescriptive planning cannot sustain efficient decision-making without self-correcting features. Therefore, good planning and management of complex systems is not traditional planning and management, it is meta-planning and

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meta-management.

Self-Sustaining Processes

Decision-making in complex systems requires processes for self-examination and correction rather than statements of objectives or setting goals. It means designing and creation of meta-system with processes for validation, verification, scrutiny and review to be applied by experts that are independent of project implementation authorities.

This seminar's concept note highlights a need to identify ways for making arms acquisition process competitive. Consequently, this paper examines factors that could sustain competitive arms acquisition processes through self-correcting features that are consistent with principles of security sector governance. It examines opportunities for sustaining military technological growth offered by technology convergence and building leadership capacities for technology innovation and participation in Revolution in Military Affairs (RMA)[1].

In view of the above, the first part of this paper examines security sector governance (SSG) reforms that reduce complexities of arms acquisition decision-making. SSG reforms aim at developing self-correcting processes of policy making, planning, and project monitoring and technology absorption. In the second part, the paper identifies policies to advance capacities required to sustain competitiveness and modernization in arms acquisition.

Part I

Principles and Criteria for Security Sector Governance

Good governance in public affairs include requirements such as: Voice and Accountability; Political Stability and Absence of Violence; Government Effectiveness; Regulatory Quality; Rule of Law; Control of Corruption[2]. Arms acquisition is unique public policy process involving security sector management which should factor elements of military confidentiality, public accountability, professional efficiency and probity. Consequently, the following criterion is considered essential in designing an ideal-type arms acquisition process:

- Checks and balances according to laws of natural justice and avoidance of conflict of interest in decision-making process;
- Decisions must consider value for money factors and economy in input-output ratios;
- Planning and implementation must be based on – competition, co-

operation, coherence, consistency and scientific objectivity;

- Accountability processes should distinguish between the methods to avoid waste, fraud and abuse from methods for sustaining time, cost and technical efficiencies.

- Professionalisation of executive and legislative oversight to balance military's recommendations with needs of social priorities and economic equity.

Self-Sustaining Features of Decision-Making Process

A self-correcting arms acquisition decision-making mechanism should be consistent with principles of security sector governance. It should include the following five elements:

- *Validation* of policy-making and decision making process. These must provide rational link between political aims with operational force designs and arms acquisition priorities. Such linkages must be validated by governance processes that are not dependent on the executive branch recommendations to avoid conflict of interest.

- *Verification* of linkages between policy/plans/budget/decision inputs should be done by independent professional bodies with legislated authority.

- *Monitoring* implementation of decisions and plans. These should be done by a technically proficient body. This could be set up within as well outside the executive branch, but should be independent of project development authorities

- *Scrutiny* of outputs should examine technological & financial input/output ratios by statutory authorities with multi-disciplinary resources to conduct performance audit; value for money audit and financial audit.

- *Review* of policy or decisions made should be conducted periodically and should be statutory requirement. This should be institutionalized at political levels higher than the decision-making process. And Re-calibration of policy or decisions.

Selected Experiences of Security Sector Governance Relating to Arms Acquisition

Validation Processes

It requires documentation of defence policy and clearly defined processes for implementation of polices such as for: arms acquisition; military R&D; and defence industrial development. These policy documents should be publicly available for professional scrutiny, verification and review.

Long-term and mid-term planning methods defence planning processes must define defence industrial and R&D plans in long and medium time frames. Japanese long term defence plans are validated by the parliament. Non-classified portions of the long term and medium term defence plans in South Korea and South Africa are also validated by their parliamentary defence committees.

Co-ordination between defence departments and different agencies within security sector decision-making are described through medium of white papers and documents approved by the legislatures. The white papers developed in Japan, Australia and South Africa provides sufficient details of specific responsibilities of different agencies involved in decision-making processes without compromising confidentiality.

Verification of Linkage Between Defence Policy, Defence Plans and Budget Approvals

In India annual budget allocations are made to service heads, which does not specifically identify either modernisation or acquisition budgets resulting in unpredictability and incoherence in R&D projects and arms procurement. It also results in underutilization of annual financial allocations in the annual budgets. Defence policy and plans must rationally link budget requirements with plans and processes for arms procurement (which take longer time frame for implementation). The Japanese defence sector plans are identify financial plans in terms of long-term allocations (in 20 years time frame), medium-term authorization (for 5 years) and annual appropriations. Taiwan's strategic planning process links defence plans with arms procurement budgets in long term, medium-term and annual plans. Israeli arms procurement budget allocations are designed for building up functional military capabilities in 5 year cycles. Israel allots 25 to 30% of its defence budget to locally produced arms procurement and makes additional allocations for imported weapons. The Chinese PLA's procurement budget is also based on five year budget plans and receives around a third of the total defence budget. In South Korea, arms procurement funding is provided on five years basis but reviewed on annual basis in planning, programming, budget and evaluation system (PPBES). South

Korea's Yul Gok project had made one time 25 year budgetary allocation for technology improvement, but lack of legislative oversight of this project resulted in lower professional accountability and corruption. South African arms procurement has a five year rolling budget, and a 10-20 years long term budget for long lead times required for acquisition[3]. The French Livre Blanc (White Paper) provides the general framework for the 30 years Perspective Plan to address operational issues in foreseeable time horizons. The Strategic Plan for Research & Technology is made by the Directorate General of Armament (DGA) aims to anticipate and control the development of new technologies required in future defense systems[4].

Scrutiny of Technological and Performance Outputs

The Ministry of Defence (MoD) in India as a single buyer and its Defence Research and Development Organisation (DRDO) as a single military R&D developer is not a competitive model for a national R&D system, as it neither allows scrutiny nor independent technical evaluation process. As the MoD does not have capacities to conduct technological oversight and quality control by Secretary R&D[5], this responsibility is passed on to the head of the DRDO, who is also the Scientific Advisor to Defence Minister. This triple-hat method impairs: independent checks and verification for: validation R&D plans; project monitoring, or technology evaluation. This double or triple hat method has become a norm in managing the DRDO projects, which does not augur well financial or technical efficiencies. Among the major problems facing indigenous R&D and defence production are: cost and time over-runs; overstated performance objectives and under-performing systems; understated or inadequately examined development costs[6] and inaccurate assessment of ownership (LCC) costs; higher rate for mean time between failure (MTBF) than assessed; a lower state of operability; a low emphasis on value engineering and value for money factors. These limitations are due to lack of technological knowledge that combines operational experience to develop new military capabilities.

It is evident that, executive oversight requires capacities for technology assessment and audit of R&D projects by technical experts who should also have deeper understanding of user's operational horizon. Unless the MoD build ups and organizes sufficient independent technical capacities in the country to scrutinize technological outputs of the DRDO projects, it cannot competitively develop advanced technology products. Advanced engineering fields where capacities are required independent of the DRDO include: aerospace, air breathing propulsion and avionics; advanced computers, photonics, machine intelligence and robotics; telecommunications, data fusion, information security; electronics, radars, sensors and lasers; advanced materials and materials processing; marine engineering and propulsion.

Examples of independent technology evaluation capacities that have been built up in the MoD's of different countries are: in France Director General Armaments (DGA) has its own engineering institutes; China's Science Technology Evaluation Committee (STEC) which reports to Central Military Commission (CMC) is independent of the technology developers. In Japan independent technology evaluation is carried out by Technology R&D Institute (TRDI). In South Korea, this is carried out by the Weapon Systems Examination Committee in the MoD and its Agency for Defence Development (ADD). Technical research centres in Israel such as: (Interdisciplinary Centre for Technology Assessment and Forecasting (ICTAF), Tel Aviv University; Technion in Haifa University and Ben Gurion University conduct independent technology assessment of the defence industrial contracts.[7] The Israeli State Comptroller has multi-disciplinary resources to conduct comprehensive financial, technological and performance audits.

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Monitoring of Plans

Monitoring of equipment induction plans is the responsibility of the armed services and the executive branch. Three kinds of limitations in higher order specializations are found to impair timely decision-making. These are: a) Operational and technology assessment skills; b) Decision assessment skills; and c) Contract assessment skills.[8] These skills are developed through research specializations for conducting efficient executive oversight, whereas, civil and military officials in the MoD learn-on-the-job. They need time and experience to acquire knowledge of unique requirements of the defence sector, however their career profiles require diverse experiences, which limit building up of expertise in arms procurement questions. Following essential steps are required in any military R&D System:

- *Concept definition* studies are required from User Service that incorporate both technological and operational requirements;

- *Technology Assessment* (at global, regional and national levels).

- *Project Feasibility* studies need to be conducted by military R&D laboratories in collaboration with technology developers. Before the R&D project is approved, the developers have to demonstrate technological feasibility of operational requirements leading to advanced technology demonstration model;

- *Oversight* by the Executive requires a competent evaluation for (technological, financial and performance) audit at every stage of product development to measure feasibility and technical standards of the R&D project. National technical capacities that are independent of the technology developers should match critical knowledge points to decide whether or not to progress funding the R&D project through its production stages.

Knowledge Point One
Knowledge is available that technology can be developed within the country or accessible from reliable international suppliers which can meet the stated qualitative requirements. Knowledge that this match will provide the envisaged operational advantages during the foreseeable period;

Knowledge Point Two
Knowledge and capabilities are producible and that the proposed design and systems will work to the expected levels of key technical parameters and operational performance;

Knowledge Point Three
Knowledge is available that the desired product can be produced within the targets of cost, quality, and production schedule.

Unless the armed services validate the above mentioned knowledge points and identify relative zones of "Unknown and Known", there is a likelihood that projects may falter at different stages of development due to some critical grey areas or the other. While technology developers and contractors have to provide evidence of these knowledge points, the scientific advisors to the MoD should technically verify capacities available to match the zones of "Unknown and Known." But as the scientific advisor in the Indian MoD is also an interested party as the technology developer, this verification process flounders due to conflict of interest. Evidently critical technology reviews are not being carried out before commencing the project or during its implementation stages.

The Swedish defence technology review process invites independent experts from specializations related to systems under development to examine sub-systems in their respective technology fields. Even though this seminar's concept paper suggests adapting the French DGA model for the MoDs arms acquisition process. It is believed that only those structures of the DGA are suitable to the Indian context which build coherence between operational, technological and financial considerations. DGA institutes training engineering graduates, masters and doctoral programmes in fields related to commercial and military technologies.[9] The DGA's engineering knowledge base, allows it to design and manage complex industrial systems and collaborative international projects.

For major projects, the MoD assembles integrated project monitoring team to include representatives from the armed forces, the DRDO, OFB, Defence Public Sector Undertakings and Defence Finance, to carry out detailed scrutiny as per stated milestones. But absence of technological capacities in these teams impair interrogation of the DRDO's projects and consequently, the project monitoring team merely leads to increasing time and financial allocations. The MoD and the Finance Ministry are presented with fait accompli to sustain projects which may not meet costs or operational standards that had been set at the time of project approval. The problem is acute in R&D joint ventures with international developers, since these are outside the purview of Indian audit authorities.

Review Process

Processes for policy review and re-calibration of defence or arms procurement plans have to be political. Reviews of defence perspective plans must be carried out at defined periods (say five years) either at the level of the prime minister or the defence minister. The defence review process in Norway is led by the former prime minister or the former defence minister as they already have the highest security clearance. These reviews examine security sector governance and defence policy-making; progress of major projects; decision-making efficiencies of subordinate organizations responsible for minor projects as defined by financial thresholds. Based on the recommendations of the review committee, the executive authority may be required to introduce policy re-calibration.

An important, yet underdeveloped element of meta-review is parliamentary oversight of arms procurement processes; policy validation; verification, scrutiny and monitoring of acquisition plans. Professional development of parliamentary oversight would go a long way to ensure that principles of public policy management are applied, and that the state is developing best practices required for accountability of arms procurement process.

Part II

As self-correcting processes enable self-sustaining technology development,[10] three essentials of competitive arms acquisition are: one, convergence policy for advanced commercial and military technologies, where both sectors cross-fertilize and supplement each other; and two, national potential in global advanced technologies market. And three, advanced technological knowledge required by any armed forces to participate in Revolution in Military Affairs (RMA).

Convergence of Military Technology Base (MTB) and Advanced Commercial Technology Base (ACTB); a Paradigm Shift

Convergence of military technology with advanced commercial technologies has three elements: technological, industrial and application of human resources and skills.

Convergence of advanced commercial and military technologies is a product of paradigm change which has been taking place after the World War II. Since 1950's, advanced civilian industrial sector had been growing both in terms of scale and diversity. After a couple of decades, it took a technological lead in developing new systems in shorter development time cycles. This change occurred because of increasing demands and competition of global market leading to greater investments in advanced commercial R&D. Examples: commercial applications of GPS based navigation systems, digital, advanced sensors, space-based communications and super computing power was developed for both commercial and military sectors.

- During the period 1950s to 1990s, computing power became 105 times faster, and 103 times cheaper.[11] From the 1980's onwards, globalisation created a more demanding market for the electronics systems in the commercial sector which enabled large scale R&D investments in advanced technologies and components which were also used by the military.

- During World War II, the expenditure on military electronics was 6% of the US defence budget, it became around 20% of the defence budget in 1970s and between 35 to 40 % in mid 1980s.[12] After the cold war, military systems are acquiring electronic components from commercial sector for weapon systems guidance; digital communications; data processing equipment; and surveillance radars. Despite military's insistence for equipment to be built to robust military specifications, commercial micro-electronics components were designed to withstand similar environment conditions, at lower costs.[13]

- Driven by competitive commercial technologies and the need to get the right system at right place and time, militaries in technologically advanced countries, instead of developing optimized components at very high costs, have begun to integrate their equipment with a broad array of commercial off-the-shelf systems and components.[14]

- An estimated 95% of day to day US defence communications is carried by commercial channels. Civilian R&D in mobile communications could be used in closely held defence applications; such as: missile guidance and electronic surveillance systems.

- In Israeli defence electronics markets, private sector firms had historically played a less significant role, but since the mid-1980s, their market share has increased. This includes major firms such as the Elbit, El-Op and Tadiran, as well as over 100 smaller firms.[16]

- In the US during the 1990s, around 30% of R&D expenditure on critical military technologies was spent on air breathing propulsion and semiconductor materials. Around 40 % of expenditure was spent on signal processing, sensors, simulation and modeling and composite materials. Around 18% of expenditure was on sensitive radars, software production, photonics, computational fluid dynamics, data fusion and robotics. All these fields of key advanced technologies have significant commercial applications as well.[17]

- There is a reversal of key relationship. The military is now increasingly finding itself as a technology follower rather than a developer of state-of-the-art systems.[18] The growing international competition in flat panel displays, electronics components and advanced materials would spur innovation in sub-components which could be used to develop electronic battlefield display systems.[19]

- This paradigm shift has reduced the exclusivity of defence industry to producing munitions, cryptographic and critical military-specific systems. Countries with defence industrial base that is segregated from developments in advanced commercial technologies, need to rethink in terms of sustaining its military technology R&D base.

Notwithstanding the above changes, a large number of technologies continue to be exclusively developed for military applications. Commercial-military convergence strategy is therefore, essential to sustain R&D investments required for unique military technologies.

India's Global Technological Competitiveness

A question is often asked: why Indian defence R&D and industries are still lagging in developing most of the basic military systems? A part answer to this question lies in the country's high technology infrastructure which is reflected in advanced technology R&D, production and export capabilities

> The top eleven countries ranked in terms of technological infrastructure: USA; Japan; Germany; China; U.K.; France; Switzerland; Israel; Canada; Netherlands; Australia; and Russia are also significant arms exporters. The exception is Japan, whose constitution prohibits arms exports.

of its private sector. Defence industrial capability is also indicated by a country's arms export ability. The top eleven countries ranked in terms of technological infrastructure: USA; Japan; Germany; China; U.K.; France; Switzerland; Israel; Canada; Netherlands; Australia; and Russia are also significant arms exporters.[20] The exception is Japan, whose constitution prohibits arms exports.

Indian arms acquisition decisions will have to continuously factor the Chinese growth in advanced technology manufacturing capability and infrastructure, as these have a direct bearing on its military technology capabilities. A comparison of Indian high technology development policies with Chinese priorities of building commercial high-technology sectors indicate that Indian exports are largely in low-technology areas. India's share of high technology exports has not grown since the mid-1990s:

	2000	2002	2004
China	18.58%	23.31%	29.81%
India	5.01%	4.76%	4.88%

The above comparison of Chinese and Indian share in global high technology exports,[21] is based on data in 11 technology fields: biotechnology; life sciences; opto-electronics; material design; aerospace; computer-integrated manufacturing; telecommunications; computers; electronics; weapons and nuclear.

Even though the Indian government has begun to encourage participation of private sector in defence systems production, but it is not technologically competitive in the global market. The Chinese are giving importance to two factors: first, the civilian high technology market should increase sophisticated dual-use products that are readily available to the military. Developments of new C4ISR capabilities in the military have been a consequent result of improvements in the telecommunications sector. Second, technologies and skills developed in the civilian sector can be gradually transferred to defence production, thereby improving defence industrial process and production. This policy had been earlier followed by Japan and South Korea as well.

The Chinese have begun dismantling barriers between civilian and defence R&D and creating new institutions to promote cooperation between the defence and civilian S&T establishments. (yujun yunmin). Priorities are given to development of critical technologies such as information technology, aerospace and lasers which straddle civilian and defence Technology sectors.[22]

Another study shows China's rapid climb in the global high technology export ladder. In 1980s, China was in 99th place. By 2005, China ranked second to the U.S., whose current market share of global high technology is 12.6 % while the Chinese share is 12.4 %. If share of Hong Kong is included to that of China, it becomes the world leader in global high technology market.[23]

A yet another study of high technology competitiveness of 33 countries indicates relative scores of China and India over the period 1993-2007.[24] It provides a comparison between the two countries in high technology capacities using the following four indicators:
Technological Infrastructure (TI) Institutions and resources that contribute to a nation's capacity to develop, produce, and market new technology. A prominent feature of technological infrastructure is the ascendancy of China standing at #4 ahead of UK, but follows US, Japan and Germany. India is at # 20 between Singapore and Czech Republic.

Technological Standing (TS) The current world market share in high technology products also reflects current technology development and manufacturing capability. Technological standing of China is at #1 position. India is at # 21 between Australia and New Zealand.

Productive Capacity (PC) The physical and human resources devoted to manufacturing products, and the efficiency with which those resources are used. In terms of technological productive capacity during 1996-2007, China leapt to second position behind Japan, whereas India is at # 10 between Switzerland and Netherlands.

Socioeconomic Infrastructure (SI) The social and economic institutions that maintain physical, human, organizational and economic resources essential to functioning of a modern, technology based nation. Despite China and India lagging in this indicator, at # 24 and # 27 positions respectively, the long-term trends depict policy changes in China that explain its meteoric rise.

The comparative scores of China and India (in brackets) based on the above four indicators are:

1993	1996	1999	2003	2005	2007	
38.6(33.0)	39.3(39.3)	46.5(48.3)	55.2(37.0)	64.7(43.2)	60.0(44.4)	TI
20.7(13.5)	22.5(18.3)	44.2(20.8)	49.3(17.9)	73.9(20.0)	82.8(20.7)	TS
33.2(38.6)	32.8(49.1)	41.0(52.4)	49.6(47.8)	72.4(59.9)	85.2(63.1)	PC
46.4(46.4)	44.8(46.0)	52.7(50.0)	55.0(49.3)	60.4(52.8)	61.2(55.1)	SI

In view of the above comparisons, a belief that India enjoys a better opportunity than China to access global technologies and therefore it has a better potential of acquiring advanced military technologies, are not supported by evidence.[25] To increase its global high technology market share, India has to implement policies that would improve its industrial competitiveness through joint ventures, investing in technologies and human resource infrastructure. If India has to close the military technology gap with

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its neighbour's, then it has to catch up with China's impressive strides in global exports in advanced technologies, despite both countries having similar levels of socio-economic infrastructure.

Insulating the defence R&D and production in India within exclusive domain of Defence R&D laboratories, defence public sector undertakings or ordnance factories restricts the country's strategic potential in advanced technology production. A Government Owned Company Operated (GOCO) model for converting the Indian defence entities could provide the necessary flexibility and incentives to compete and to promote exports of advanced technologies.[26]

The research conducted by the DRDO, in the most part, is systems integration of components and sub-systems to develop a military product. For application of emerging technologies to meet the military's needs, the MoD should set up centres of research excellence for developing key technologies.[27] These centres could also conduct exploratory and strategic research.[28] If provided with adequate investment infrastructure and technology incubators, these research centres could entrepreneurially contribute towards of advanced technology exports from the country. These enterprises could seek venture capital or offset benefits to sustain military technology innovation for building a virtuous cycle. Indian security sector governance reforms should aim to improve institutional environment of the military R&D in terms of improving accountability, autonomy, competition, incentives for innovation and efficiency.

India has not yet organized a defence industrial association to develop unique incentives and policies for its high risk industries. A consortium of defence related industries in public and private sectors, technology research institutes and the armed service training establishments could provide the necessary industry-technology-military synergy. Indian defence offset policy should be modified to facilitate access to global markets for advanced technology joint ventures.

In ultimate analyses, India's capabilities for self reliance in defence technologies will be influenced by its growth in global market share of advanced technologies.

Building Self-Sustaining Processes?

Two propositions are relevant in this regard: one, S&T self-reliance is achievable in sectors that have relatively matured technologies, than in sectors that undergo rapid technological changes. The military technology sector, on the other hand, has a higher rate of obsolescence. Two, expansion of engineering R&D ensures an adequate availability of qualified S&T personnel, which will sustain absorption of imported technology in the long run.
In India, the military technology users in the armed services are not equipped with higher technological education to leverage emerging technologies for innovating new systems. While the scientists in Indian DRDO do not have experience of military's operational environment for which they are developing weapons. This capability gap can have dangerous consequences, as technology changes dynamically and assumptions of technological advantages of the past may not be relevant in the future. Anecdotal information suggests that military leaders tend to prepare on the basis of experiences and the lessons learnt from the past conflicts rather than anticipate technology changes which they may face in the future.

The political challenge is in creating a technologically competitive military system to replace man-power intensive system. It should enable assessment and acquisition of emerging technologies (irrespective of its commercial or military origins) and interrogate the user's equipment requirements of robustness, maintainability and reliability for making balanced decisions based on costs and operability. "Integration of advanced engineering knowledge with combat experience is the key to technology innovation."

The Israeli experience of developing linkages between the R&D sector and military's operational requirements provides clear evidence of the above proposition.[29] A major factor in growth of Israeli defence R&D is innovation of new defence products by a pool of engineers with military experience, who are able to identify the unique technical requirements of the domestic military as well as that of the international defence markets.[30] This is evident from the Israeli venture capital investments in the defence sector that focus on force multipliers for domestic and international markets. For similar reasons, one finds that highly qualified engineers with military background are being employed to conduct military R&D in Japan, S. Korea and Taiwan.[31]

Minimal User Concept for educational standards of armed forces officers is an ability to use training manuals, interpret rules and laws; study maps and maintain accounts.

Maximal User Concept for educational standards of armed forces officers is an ability to use engineering knowledge to maximize operational advantages by exploring emerging technologies for leveraging opportunities and develop innovative solutions.

Military leaders in a 'maximal user concept' receive tertiary level training in science and engineering to understand and become developers of new products. Thereafter, new systems need to be innovated by investigating emerging technologies to meet military's changing needs of operational, logistical and battle space management. The military officers, instead of merely understanding 'know how' of operating a tank or an artillery equipment, need to understand 'know why' of scientific principles involved in that system's engineering development. This capability is essential to sustain R&D competitiveness of any military system.

As advanced engineering capability enables military organisations to efficiently use emerging technologies, education programmes of military leaders in Israel, Japan, S. Korea and Taiwan have become technology intensive.

Military organisations that fail to realize this fundamental fact and continue training its leaders in traditional education systems are unable to sustain acquisition of advanced technologies to meet new operational threats. Such military organizations will continue to remain technology followers, and remain mired as mere buyers of weapons. The current minimal user educational concept of armed forces leadership in India has remained unchanged over the past six decades.[32]

Should the maximal education concept be introduced in Indian armed forces, its leadership cadres will be staffed by highly trained engineers. That will enable the services to keep abreast of emerging technologies and respond to operational and technological threats. On completion of their armed service tenure, these engineers can make useful contribution in defence industries or in the national R&D system, which is currently experiencing severe staff shortages in R&D projects.[33] In pursuant of above goals, the MoD must set up of two or three engineering institutes modeled on the IITs for officers commissioned for the regular and short service tenures.

Some Policy challenges: Leadership Capacities for Revolution in Military Affairs (RMA)

What impairs arms acquisition competitiveness? One needs to examine capacities in a country's security sector for technology innovation and participation potential in Revolution in Military Affairs (RMA). Two essential requirements are: one, convergence between advanced commercial and military technologies to sustain R&D investments through demands of competitive commercial market. And two, technological expertise equipped to sustain laboratory-user-field interaction for testing outcomes and technical feedback on user's quality standards.[34]

Military technology innovation can take the forms of technologically new products (where functional characteristics differ significantly from those of previously produced products); and technologically improved products (where performance has been significantly enhanced or upgraded or costs lowered through use of higher-performance components or materials).

The technological capability of any organization or a military system is influenced by two conditions: one, technology diffusion to a broad range of individuals throughout the organization and the S&T standards to understand technologies of the future; and two, technological insight of the leadership for innovating new products or processes. In both these conditions, human learning are crucial to innovation facilitated by ease of technical communication within an organization,[35] and transmission or transfer of skills by individuals with enough knowledge and expertise.[36]

A recent study has found that the most creative and innovative period of one's life is around 32 years of age.[37] As the pace of technology life cycles get shorter and innovations become faster, the product development timelines in the defence market reduce, it forces fierce competition on technological super-highways. Unless the armed forces leadership receives technology intensive education, the services will not be able to absorb the rapid changes in state-of-the-art technologies to innovate new operational capabilities. It is therefore imperative that the military's education system has to change to maximal education concept.

Recommendations and Conclusion

Indian decision-makers need to examine three requirements: one understand and respond to the changing paradigm of technology convergence; two, understanding the policies and practices of technology acquisition that are successfully followed elsewhere; and three, building up of knowledge and capacities in critical technology R&D in both private and public sectors. Some of the essential policy initiatives that are urgently required are re-capitulated below.

- An Advanced Technology Convergence Strategy is needed to leverage and integrate advanced technology developments in both commercial and military spheres.[38] China started its convergence (it calls conversion) strategy in the early 1980s.[39] The focus of convergence strategy should be to develop generic technologies that could have both commercial and military applications such as: communications, information processing, guidance, navigation, reconnaissance, surveillance, and terrain analysis. It should also include applied technologies developed for defence or commercial sectors such as:[40] industrial (plant maintenance, quality control) environmental survey

(Earth and solar sciences, pollution control, energy conservation), health diagnostics, information and communications, and civil law enforcement, fire fighting and border surveillance.[41]

- Political initiatives should be taken up for membership of Wassenaar Arrangement[42] for accessing controlled technologies from technologically advanced countries. It will position the country in global advanced technology supply chain.

- Set up institutional capacities for studies and research on decision sciences; operational and technology assessment; financial and contract assessment sciences relating to public procurement by the armed forces, aviation, shipping and other major projects.

- Centres for Advance Technology Research must be set up in key military technologies of the 21st Century.[43] These R&D centres, if equipped with investment infrastructures and incubators for developing military and advanced commercial technology markets would make the process self-sustaining. These centres will also provide the executive and the military users with independent capacities for technology verification and assessment.

- The three armed services should be set up R&D laboratories to conduct operational and technological assessment studies[44] and proof of concept studies for developing future weapons and support systems.[45]

- Develop maximal education concept which requires building up of national capacity in advance technology education and research in the armed services.

The disarray in arms acquisition decision-making are often due to reasons of cost and time overruns and limitations in technology oversight processes. This results in inadequate application of technology verification and quality control methods. Leadership resource in any military, which has both advanced engineering training and operational experience, will spur creative thinking at different levels of operational, command and logistic systems in selecting emerging technologies to best advantage.[46]

•If India needs to increase its national security and technological capabilities, it's political leadership needs to decide on three elements: introduce reforms for security sector governance; develop advanced technology convergence paradigm; and last but not the least, decide if it wants the core competency of its armed forces leadership to be based on minimal user concept or invest in engineering education to develop their maximum technological potential?

Notes:

1. The idea 'revolution in military affairs' (RMA) argues that advances in technologies for information processing, target acquisition and precision weapons facilitate technologically developed military systems to operate more efficiently. Just as the Information Era has transformed how societies live and work, emerging technologies will transform their fighting methods. The two derivative concepts of the RMA, one, Information Warfare (IW) which views information as a potential weapon itself, and two: Network-Centric Warfare (NCW) which seeks to exploit data to make regular weapons more effective. These ideas of military transformation lead towards 'fourth-generation' warfare that requires specific force constructs to meet the unique demands of a new type of war, basis of which remains technological knowledge.
2. World Bank Indicators of good governance http://rankingslks.wordpress.com/2009/06/30/world-governance-indicators/
3. See Ravinder Pal Singh Arms Procurement Decision Making (APDM) Stockholm International Peace Research Institute, Oxford University Press, for China Vol. 1 p. 18; Steinberg, G. Israel, p. 100; M. Ikegami, M. pp 138-140; Choi, J.C. pp 179, 191 & Cawthra, G. South Africa, Vol. 2 p. 162.
4. For organization, roles and functions of Director General Armament, in the French MoD, see http://www.ixarm.com/Presentation,33471
5. Advanced research capacities in the following fields would need to be developed that provides the executive branch with multi-disciplinary examination of arms acquisition proposals. Operational and Technology Assessment studies: requires combat arms experience and advanced engineering knowledge of key technology developments. Decision Assessment sciences: Information Systems, Operations Research, Systems Analysis, Decision Sciences; and International Relations. Studies in Contract Assessment sciences should focus on arms acquisition methods and contracts. These specialisations would be needed to conduct inter-disciplinary analyses on aspects such as: Financial Risk Analysis; Actuarial Sciences, International Business Law, Corporate/Commercial Law and Intl Patent Law.
6. Steinberg, G. in Singh, R. SIPRI, APDM Vol. 1 p.111. Cost overruns because of design and technology changes during the R&D process on an average, in Israel, have been around 180%, and in the U.S. around 240%. The R&D developers routinely under-estimate costs and development time to obtain project approvals. Besides, initial estimates of costs and risks of developing new technology systems are conducted with inadequate attention to detail.
7. Estimated 2.3 % of Israel GNP goes to civilian R&D, of which, electronics sector gets 60 %, which includes defence systems, telecommunications, medical electronics and software. R&D focus is on digitization, transmitting / enhancing of images, speech and data. It is leading in fiber-optics, electro-optic inspection, printed circuit boards, thermal imaging night vision systems and electro-optics-based robotics manufacturing systems, computer graphics, computer-based imaging systems and educational programs. See Dan Izenberg, "S&T in Israel, Ministry of Foreign Affairs, July 1998, http://www.mfa.gov.il/MFA/History/Modern+History/Israel+at+50/Science+and+Technology+in+Israel.htm
8. South African arms acquisition bids are not assessed on the basis of lowest costs alone but on 'value for money' assessments made in terms of technical performance/risks/procurement costs/ownership costs. See Cawthra, G. Note 3 pp. 162-163 and for details see Griffiths, B. South Africa Working Paper No. 5.
9. DGA has highly reputable training for its military engineers at institutes such as École Nationale Supérieure de Techniques Avancées (ENSTA); Ecole Polytechnique; Higher Institute of Aeronautics and space (ISAE), National School of Engineers studies and technical armament (ENSIETA). http://www.defense.gouv.fr/dga/votre_espace/ formation/ ecoles_d_ingenieurs/ les_ecoles_d_ingenieurs_sous_tutelle_de_la_dga
10. CK Prahlad; "Self-sustaining processes are required for development." The Economic Times, Bangalore, 10 Nov 2009.
11. Jeffery Cooper, "Information Processing: Command Control and Communications", Gaspirini A. and Hoffman K. (ed.) "Transfer of Sensitive Technologies and Future of Control Regimes", UNIDIR, Geneva, 1997 p. 57. Walker, W and Gummett, P. "Britain and the European Armaments Market" International Affairs, Summer, 1989, pp. 419, 442
12. Moore M. "Electronics: the Linchpin of Modern Warfare" Armed Forces Journal, Sep 1986 pp. 76-86.
13. Gansler, J.S., "Improving Weapons Acquisition" Yale Law and Policy review, Vol5:73, 1986, pp. 93.
14. To integrate and exploit defence R&D and national R&D systems, South Africans are setting up a specialized National System of Innovation (NSI) for defence industry to leverage spin offs from and to advanced technology commercial sector. See Note 3, Cawthra, G. pp. 169-171.
15. Cooper, Note 12. p.55.
16. Steinberg G. in Singh, R. SIPRI, APDM Vol. 1 p. 97.
17. GAO Report GAO/NSIAD 92-4 " Defence Industrial Base: Industry Investment in Critical Technologies" p. 3

18. In the US, the military has already had difficulties in matching the pace of technological sophistication of commercial suppliers in areas such as simulation and electronics. Pages, E. 'the Future of US Defense Industry: Smaller Markets Bigger Companies, and Closed Doors' SAIS Review Winter-Spring vol. 1. XV. 1, 1995, p. 148.

19. In view of the rapid pace of developments in commercial technologies, the performance of Commercial off the Shelf (COTS) Information Processing (IP) technology is generally far superior to military standard counterparts. DoD Science and Technology List, Defense Threat Reduction Agency, Fort Belvoir, May 2000, p 10-27

20. Porter A.L., Newman N.C., Xiao-Yin Jin, Johnson D.M., Roessner, J.D ., "High Tech Indicators Technology-based Competitiveness of 33 Nations 2007," National Science Foundation Report by: Georgia Institute of Technology January 2008, p.14. and See SIPRI arms transfer data base 1990-2008.

21. India's exports in all high-technology fields to the US in 1991 was India $15.2 million and China $355.5 million; See, US National Science Foundation, Asia's New High Tech Competitors, NSF 95-309 (NSF: Arlington, Virginia., 1995), pp. 33, See Kowalski, P., China and India: A Tale of Two Trade Integration Approaches Indian Council for Research on International Economic Relations, (ICRIER) Working Paper No. 221 Aug 2008, pp 10 & 1332, 25.

22. The Civilian High-technology Economy: Where is it heading? Adam Segal Maurice R. Greenberg Senior Fellow for China Studies http://www.cfr.org/publication/10179/msnbc.html

23. Global high technology exports from 1980 to 2005, lists the top thirty countries for each year. See Gallagher, K.P. & Porzecanski, R. "Climbing Up the Technology Ladder? High-Technology Exports in China and Latin America January 2008 University of California Berkeley, Paper No. 20, P.11

24. For details of statistical indicators and Expert comments see Porter A.L., Newman N.C., Xiao-Yin Jin, Johnson D.M., Roessner, J.D ., op cit. Note 20. pp. 13,14,16, 20 & 22

25. Subrahmanyam, K. Keynote address at the IDSA Seminar 27 Oct. 2009. Russia has supplied China with $25 bn worth of weapons in the past 15 years. http://www.zimbio.com/F22+Raptor/ articles/7/Russian +arms+Made+in+China. Since the 1990's Chinese defence industry also had access to military equipment, systems and know-how from Israel, France, and Germany. See SIPRI arms transfer data base 1990-2008. These transfers have facilitated integration of advanced technologies into China's production lines. Chinese defence enterprises have improved their R&D and production capabilities through commercialization and exposure to international partnerships and competition over the past two decades. and Evan S. Medeiros, E.S., Cliff, R., Crane K., Mulvenon, J.C. A New Direction for China's Defense Industry RAND Corporation, Air Force Project Report, 2005, pp 23.

26. Major industrial houses in many countries conduct military R&D and production along with commercial production for managing their scarce R&D skills, and for technological and financial efficiencies. Among the examples are in Japan, where Mitsubishi makes tanks, heavy earth moving equipment and automobiles, Sumitomo shipyards make naval and commercial ships. South Korean chaebols, Samsung, Hyundai and Daewoo are involved in both defence and commercial production; In Sweden, Saab makes combat aircraft and commercial products. The Chinese defence industrial reforms has encouraged its shipyards and aerospace industrial corporations to make both commercial and military products.For discussions on China's integration of civil-military industrial production, see Evan S. Medeiros, E.S., Cliff, R., Crane K., and Mulvenon, J.C. ibid.

27. Centers for excellence to research key technologies need to be set up in fields, such as Semi-conductor materials and Micro electronic circuits; Air breathing Propulsion; Composite Materials; Passive Sensors; Signal Processing; Simulation and Modeling; Data Fusion; Software production capability; Machine Intelligence and Robotics; Photonics; Sensitive Radars; Signature Control; Parallel computer architecture; Weapon system Environment; Computational Fluid Dynamics; Pulsed Power; Hypervelocity Projectiles.

28. Exploratory R&D aims at investigating alternate technologies to find their natural limits. It is best carried out at advanced academic institutions. Strategic R&D investigates areas which are seen as promising in reaching the desired goals. See RP Shenoy, Defence Science Journal Vol. 46. No. 3 July 1996, pp 186 and p. 190.

29. Steinberg, G. in Singh, R. SIPRI, APDM Vol. 1 pp. 112, 115. A number of weapons and systems in Israel, such as Uzi personal weapon, Merkava tank or the UAVs have been developed by engineers with military background.

30. Steinberg, G. in Singh, R. SIPRI, APDM Vol. 1 pp. 121-122

31. Chi Cheng Lo, Taiwan, in Singh, R. SIPRI, APDM Vol. 2 p.205. Taiwan's Chung Shan Institute of Science and Technology conducts operational, technical and financial analyses. It has 6800 scientists and engineers, 90% of them have Ph d and 80% of these are from the armed forces. Steinberg G. in Israel has 13 % undergraduate students and 8 % graduate students specialize in engineering and architecture. APDM Vol. 1. P.110. M. Ikegami, APDM Vol.1, p.152, In Japan around 35% staff of TRDI is from the armed forces. Comparative output of engineering stock of engineering graduates in India is around 4.9% see Economic and Political Weekly 1999.

32. The minimal user concept was used for developing the educational standards at the time of founding of National Defence Academy, Kharakvasla.

33. A report on the education profile of one of the DRDO's laboratories, the Armament Research Development Establishment (ARDE) reveals that appropriate education profile of ARDE's research staff should have been

80% engineers and 20% natural scientists. Whereas, only 20% of its research staff had engineering background and 27% of staff had degrees in natural sciences. Estimated 48% of DRDO's research staff has undergraduate qualifications up to BSc or engineering Diploma holders in. See Comptroller and Auditor General Report No. 8 'Army and Ordnance Factories' New Delhi 1995. pp 219-220. The DRDO conducts a postgraduate Research and Training programme in electronics, mechanical engineering and allied disciplines to make up its deficiency of qualified engineers. Ministry of Defence Report 1996.

34. Presentations by Chaturvedi, I.S. 'Paper Evaluation of technical offers" and Sangra, Y. "A Roadmap for Trial Evaluation" discussions on limitations in technological experiences in the decision-making processes at the Arms Acquisition Seminar 27 October 2009.

35. OECD and European Commission Study, ' Measurement of Scientific and Technical Activities", pp. 20 and 23

36. Crucial and significant implications for policy are discussed in Dodgson, M. and J. Bessant "Effective Innovation Policy: A New Approach", International Thomson Business Press, London. 1996

37. Sing Lin, PhD Optimum Strategies for Creativity and Longevity, Taiwan National University Alumni Association, New York , 2002

38. Chinese Academy of Sciences has built a network of 900 factories, R&D institutes and engineering universities to develop nearly 80,000 military products from different industrial sectors, e.g.: machine building, electronics, advanced composites, chemicals, optical products, as well as weapons systems. Luo Fengbiao, APDM Vol. 1, pp. 15-16.

39. China's Sixth Five Years Plan 1981-1986 proposed defence industry to commercially produce 275 kinds of products. Singh, R. SIPRI, APDM Vol. 1 pp. 30; COSTIND's Critical Technologies Plan 1993 built up its high-technology defence industries as mainstay for its advanced technology in the commercial sector, which is also developing products for the military. Singh, R. SIPRI, APDM Vol. 1 pp. 32. The Chinese give R&D priorities to basic and applied research in dual-use high technology fields with domestic and foreign investors with a view to widen the spectrum of technology investments in both commercial and military enterprises. Singh, R. SIPRI, APDM Vol. 1. p.40.

40. Japanese advanced engineering capabilities in the commercial sector have a predominant role in defence systems. The production lines are shared flexibly between defence and civilian products. The focus of Japanese policy makers to gain technological competitiveness through rapid diffusion of imported technologies through the country's advanced engineering sector. M. Ikegami, in Singh, R. SIPRI, APDM Vol. 1 pp. 158, 159.

41. Satellite navigation and information systems can be applied in national security as well as development roles: e.g. surface and maritime transportation; management of fisheries, fresh water resources, livestock, energy, oil and gas production; combating drought and deforestation; management of toxic chemicals, hazardous and radioactive waste. Besides crucial role in defence communications, common social applications are in distance education and health services. See Yvette Stevens, "Space security: the need to safeguard outer space for the next generation" UNIDIR Conference Report "Security in Space, The Next Generation," United Nations, New York and Geneva 2008, pp 26-29.

42. Wassenaar Arrangement is a group of 40 states that control transfers of sensitive and very sensitive technologies listed as: Advanced Materials; Material Processing; Electronics; Computers; Telecommunications; Information Security; Sensors and Lasers; Navigation and Avionics; Marine and Propulsion

43. Ravinder Pal Singh, "Offsets How, Why and Why Not" paper at Seminar on Defence Finance and Economics, Vigyan Bhavan, New Delhi Nov 2007. See Annexure on Key Military Technologies with Commercial Applications.

44. A competent technical evaluation by user services is needed to prevent projects deviating from original cost, quality and timeline approvals. In the past decade, defence projects in Israel are estimated to have deviated by 70% from initial budget projections and 80% in terms of duration. Steinberg, G. Israel Singh, R. SIPRI, APDM Vol. 1 p. 127.

45. The three armed services laboratories must build capabilities to scrutinize and verify the following stages of R&D and production once the project has been approved by the executive branch: a) Final report on project definition; b) Exploratory or Experimental Development Model; c) Advanced Development Model; d) Full scale Engineering development Model; e) Qualification Development Models; f) Prototype and Industrial development models; g) Tooling, testing and production facilities; h) Industrial production. In countries where such skills are not available in the executive branch or in the military, teams of independent consultants are formed to review these stages.

46. Since the mid-1980s the Chinese have been aware of this need. As early as 1989, China had set up a Liaison Group for Civilian Applications of Military Industrial Technology (LGCAMIT). see Singh, R. SIPRI, APDM, Vol..1 pp. 31.