International Journal of Research in Engineering, Science and Management
Volume-2, Issue-1, January-2019
www.ijresm.com | ISSN (Online): 2581-5792

A framework for Building Technological Capability in India-Strategic Electronics Perspective

Kishore Balbadra[1], K. Kalidas[2]
[1]*Research Scholar, Department of Commerce & Business Management, Osmania University, Hyderabad, India*
[2]*Professor (Retd.), Department of Commerce & Business Management, Osmania University, Hyderabad, India*

***Abstract*: The role of the technology exemplifies in leapfrogging the technology development in strategic electronics area in developing countries like India. Despite many denials from the advanced countries, the technological growth in India has been remarkable and innovation system in the country had contributed to various milestones earmarked for achieving excellence in mastery of high technology areas. This paper focuses on the various elements of technology management in developing the high technology in the process of building competitive edge for achieving the self-reliance in strategic electronics in India. A framework has been proposed for building the technological capability in the field of high technology areas of strategic electronics industry in India.**

***Keywords*: Technology, Technology Absorption, Technology Development, Technology Diffusion, Technology Transfer, Technological Capability.**

1. Introduction

Technology has been considered as the main tool for achieving the competitive advantage for an organization which in turn gives competitive edge to the country when it is managed to its full potential. Management of Technology determines the future of the country as the technological progress depends on the technological trajectory maintained over a period of time, managing several critical technologies, embedded into products and systems. In strategic technology areas, the components of technology determine the technological leadership that the firm maintains in the chosen technological domain.

2. Technological capability and it's influencing factors

A. Definition

Technological Capability [1],[2] can be stated that " a set of functional abilities, reflected in the firm's performance through various technological activities and whose ultimate purpose is firm level value management by developing difficult-to-copy organizational abilities." The strength ofn technological capability depends on how effective those resource combinations of the capability have been bundled. The effective technology management will lead to a successful absorption of technology by the recipient or local company and strengthens the technological capability of the country.

B. Factors for consideration

Technological capability of the country mainly depends upon various contributing factors like technological learning, technological empowerment, technology transfer, technology assimilation (absorption) and further diffusion of the technology, cultural barriers in the given Technological Innovation System.

At the organizational level, the technological learning manifests itself in increase of existing technology base and further improved products and services. In development of high technologies, many sub-technology areas will become complimentary to one another due to high development cost and long lead times. In India, high technology areas are restricted to strategic needs of the country and various R&D labs viz., Defence Research and Development Organization (DRDO)/Indian Space Research Organization (ISRO)/ Department of Atomic Energy(DAE) / Department of Scientific and Industrial Research(DSIR), Council of Scientific & Industrial Research(CSIR) and Institutions like (Technology Information Forecasting and Assessment Council-TIFAC, Tata Institute of Fundamental Research-TIFR, Software Technology Parks of India-STPIs, Incubation Centers at IITs etc)/Industries(Defence Public Sector Undertakings-DPSUs, Ordnance Factories-OFs, Central Electronics Laboratory-CEL, Electronics Corporation of India Limited-ECIL, Raksha Udyog Ratnas-RURs etc.) and Academia (Indian Institute of Technology-IITs, Indian Institute of Science-IISc, Indian Institute of Science Education and Research-IISER, National Institute of Technology-NITs etc.) are trying to integrate to produce a niche technology.

The various steps involved in realization of the technology are depicted in the Fig. 1.

Fig. 1. Steps in realization of high technology

As above, various facets of high level risks pertaining to Technology, Investment and Economic to be managed properly in order to enhance the technological capability of the country in the area of strategic electronics.

1) Technology development

Technology development [3] in case of high technology areas involve the participation of all the members from scientists, engineers and technicians for solving the problems in a dynamic environment, resolving many cultural barriers among the agencies from Design, Production, Inspection, User Groups. The typical process of productionisation of a high technology system is depicted in Fig. 2.

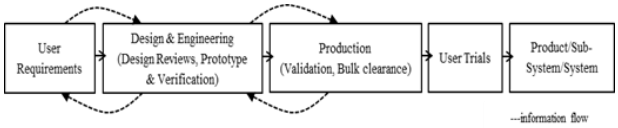

Fig. 2. Technology Development Process

2) Technology empowerment

The main purpose of Technology Empowerment [6] is to excel in the area of intended technology through collaborating with many partners with varied core competencies beyond organizational boundaries. This is useful when there is core competency to develop a mission critical technology. Technology empowering enhances the contribution as well as the core competency due to inputs from multi-institutions/multi-organizations like R&D labs, basic/applied research institutions, production agencies from both public and private sectors.

3) Technology Transfer

Technology Transfer [6], [8] is a term used to describe the processes by which technological knowledge, in its various forms, moves within or between organizations. Technology flows from the source to the receiver which in turn transformed into commercial products. The transfer of technology and its enrichment plays a vital role in management of high technology and the flow of information include documents, training, concepts, hardware, software, expertise. In reality, the technology transfer can be managed through Design Records, Contracts, Project Reviews, Production Reports, Technology Transfer Groups, and User Groups etc.

4) Technology absorption

This indicates the process of exploitation of technology and conversion into useful technology suitable for local environment. This process envisages know-why, product/process/system improvements with systematic investigations into the process in order to avoid the dependence on advanced countries/technology providers in case of specific raw material, new product technology and further optimization of system[6] through minor modifications to suit to the high technology system requirements. This often results in optimization and up gradation of the product or system for superior quality and performance.

5) Technology diffusion

According to Roger (2003), diffusion [5] is the process by which an innovation is communicated over time among the participants in a social system. Technology diffusion can be defined as the process by which innovations are adopted by a population. The typical process is shown in Fig. 3.

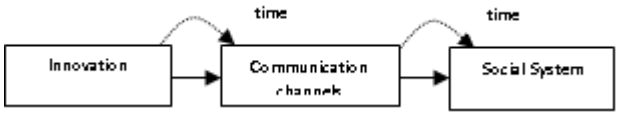

Fig. 3. Technology Diffusion Process

3. Strategic electronics in India

This area has been a boon to develop the high technology systems in the area of Aerospace, Defense, Space and Nuclear Research programs in India. The development of critical technologies in this area demands support from all key players viz., R&D, Academia and Industry due to involvement of high uncertainty and complexity in managing technology know-how as most of the projects come under the category of build-to-specifications (B2S), build-to-design (B2D) category, where in meeting time and cost baselines is very much critical to the success of the realization of the technology. Electronics systems form an integral part of almost all defense equipment's and are embedded into every hardware held by the defense Forces. At higher level, Avionics, Airborne Systems, Tactical Communication Systems, Unmanned Aerial Vehicles (UAVs), Land System Electronics, Naval System Electronics, Electronic Warfare Systems, Weapon and Missile system electronics and Command, Control, Communications, Computer, Intelligence, Surveillance, and Reconnaissance- (C4ISR) are emerging as key focus areas for the defense electronics industry. In order to maintain the technological leadership in the strategic field, an eco-system is envisaged to give an impetus for the growth of technological capability in mission critical components, line replacement units (LRU)s through indigenous R&D, Reverse Engineering, Joint/Co-Development with foreign OEMs encompassing the available Innovation System in the country.

A. Technological capability gaps in strategic electronics

The key technology capability gaps for the domestic players in defense electronics systems lie in the areas of Internet Protocol(IP) Radios/Software Defined Radio(SDR)s, Military Grade Geographical Positioning System(MGPS), Encryption and Secrecy Modules, 3D Tactical Control Radars(3D TCRs), Target Acquisition Systems, Electro-Optics, Battery Backup Systems, Field Wireless Systems, and support of Long Term Evolution(LTE) while adhering to the defense services security protocols and core electronics technologies. Unlike commercial electronics, strategic electronics Industry in India is still in the nascent sage of developing the technological systems around know-how, by managing SKDs (Semi-Knocked Down)/CKDs (Completely Knocked Down)kits due to non-availability of core competency or home grown technologies in the critical

areas like Chips, Sensors, Field Programmable Gated Array (FPGA) technology, Artificial Intelligence(AI), Micro Electro Mechanical Systems (MEMS) design and manufacturing, Miniaturization, Ruggedization of displays, and Design Changes(technology up-gradation) of existing equipment. In terms of software engineering, cyber and network security solutions, algorithms and data security and software protocol stacks emerge as technology gaps. Many areas of the supply chain need to be strengthened and in order to advance in supply of high technology areas. A cluster of System Integrators/OEMs along with DRDO labs with other research centers in India should take part in the supply chain to develop an eco-system at every level of manufacturing.

B. Strategic electronics production scenario

The various levels of manufacturing set ups in strategic electronics and expected capabilities are shown in Table 1.

Table 1
Technology Providers with Capabilities Sought

Player	Product/System	Required Capabilities
OEMs/Foreign Players	System of Systems with advanced technologies	Design, Better Supply Chain, Finance, Project Management etc.
Tier I & Tier II Manufacturers	TierI: System Integrator with major production share Tier-II: Sub-System/Module Integrator	Design, Production capability, Testing & evaluation with Cost effectiveness.
Tier III-Component Manufacturers	Specialized in particular technology, Component level supplier	Design, Development, Production, Testing, Supply Chain, economies of scale, cost effectiveness in case of limited series production.

4. A framework for developing technological capability for strategic electronics in India

In managing the high technology domain, requirements tend to change dynamically in many folds from its origin to finalization due to various reasons like Revolution in Military Affairs (RMA), Mission Critical, Security Aspects, Confidentiality, Long Gestation Periods, Technological Obsolescence etc. and this requires lot of iterations to converge into technical demonstration on the concept. Most of the experiences from the past indicate that involvement of many partners in the form of design agency, production agency, inspection agency and finally the users makes the developmental activity a projecticised technology development programme with good track of technological learning out of each stage of technology development (i.e., component level, assay level, sub-system level and system level).

Most of the technologies are managed through licensing and as well as purchase route from advanced countries, which are of outdated or second rated technologies and thus there has been a little focus on development of indigenous technologies resulted in low technological capability in the areas of critical technologies. This has been observed in many instances of delays observed in program or project execution of national importance like Light Combat Aircraft (LCA) Program, Integrated Guided Missile Development Program (IGMDP), Akash Missile System Program and Supercomputing etc.

A. Issues in developing the high technology-strategic electronics

In this, the various inputs from the stages of development of technology are depicted referring to different stages of technology development starting from requirements to product realization.

1) Requirement Stage

The development process itself is very complex activity with uncertainties, demands lot of iterations and involvement of user/customer in the very start of the project/program. The requirements in case of high technology evolve over a period of time as most of the critical technologies are coming from advanced countries amidst regimes/sanctions especially in the strategic electronics area.

2) Technology development stage

Matrix organization is envisaged for achieving the results with collective effort form both functional and project organizations by way of consortium/technology empowerment while collaborating with many stakeholders, viz., Research labs, Academia and Industry. Technology Development traverses from lab model to technical demonstrator and to further final prototype.

3) Technology transfer stage

Technology Transfer must be planned with lot of iterations to get the best out of many strategies lie outsourcing, JVs, Technology substitutions, Collaborative Development, Licensing through MoUs, Co-Research & Development etc. for reaping the benefit out of each core technology area. The cultural barriers of the different agencies hinder the process of transfer of technology as most of the process is concurrent in nature and support and participation of all stakeholders is very much necessary for effective transfer and assimilation of the technology. In this case, technology facilitators play a significant role to bring all the partners onto a common platform forcreating technological innovations.

4) Technology absorption

Technology Absorption is expected through stage gate/project reviews at all levels of Prototype Development (Conceptual Design review (CDR), Preliminary design Review (PDR), Critical Design Review (CrDR) and Final Design Review (FDR) which will pave a way for final bulk clearance. A systematic walk through the reports from different stages viz., Design, Production, Testing, Inspection (Verification/validation) will give the confidence for design agency, which eventually decides the success factor for development of high technology product/system.

5) Technology diffusion stage

As the different core technologies coming from diverse fields of development, there is a thrust on communication

among all the interested parties of the supply chain so as to increase the knowledge base of each partner. The excellence in diffusion process lies in empowering the partner from design stage to mastering the technology in productionisation stage and further to grow to the next level of absorbing the technology with more complexities or addition of advanced features.

6) Managing the product realization

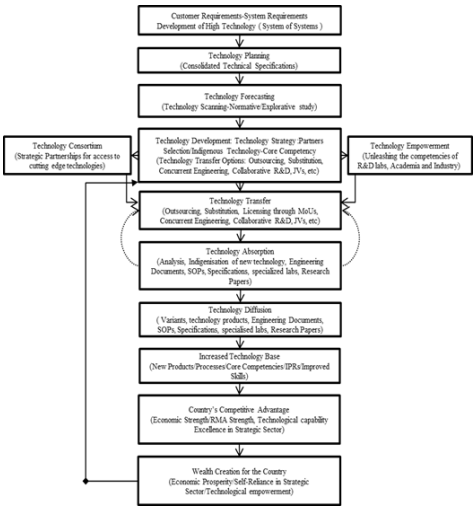

Fig. 4. Framework for building technological capability in strategic electronics

At the end, product realization comes from integration of different technologies into a single product/system/platform for a specific purpose is a challenge in front of the knowledge community. This requires systematic follow-ups using project management tools, knowledge management portals, team management for archiving the information on core technology areas, specific technology domains like Intellectual Property Rights(IPRs) in the form of patents, standard operating procedures(SOPs), industrial designs etc. for achieving technological leadership with superior organizational performance in the given area of strategic electronics. Inquest of the complex technologies in developing system of systems, wherein, managing a supply chain plays a vital role, comprises of public and private players with different cultural barriers and expectations towards meeting strategic needs of the country. The clear understanding of the various stages of development of technology beginning with requirements elicitation, technology demonstration, model/prototype building, and bulk production while managing a gamut of agencies contributing to the success of the project is utmost important in order to build an eco-system in India in the field of strategic electronics. A framework has been proposed taking into consideration of various factors for the developing nation like India, as depicted in Fig. 4.

5. Conclusion

The key elements of high technology focuses on Technology Management keeping in view of schedules, cost effectiveness and technological performance that creates competitive advantage characterized by high quality products and services. As the high technology development involve the continuous inputs from the customer, managed through concurrent engineering approach with dynamic decision making aiming at sharing of ideas, experience, risks, and review mechanisms at different stages of technological development. The very essence of Technological capability comes from the nature of R&D eco-system, leveraging Time, Cost & Quality for achieving global competitiveness [4] by providing world class products & services with the global market share in the field of strategic electronics leads to creation of wealth for the country.

References

[1] Bell, M. and Pavitt, K. (1995), "The development of technological capabilities," In: HAQUE, I.U. (1995) Trade, Technology and International Competitiveness. Economic Development Institute of the World Bank, Washington. pp. 69-100.

[2] Panda, H, and Ramanathan, K. (2006), "Technological capability assessment of a firm in the electricity sector," Technovation, 16(10), 561-588.

[3] Lall, S. (1992), "Technological capabilities and industrialization. World Development, 20 (2), pp. 165-186. .

[4] Kim, L. (1999), "Building technological capability for industrialization: analytical frameworks and Korea's experience," in Industrial and Corporate Change, 8(1), pp. 11-136.

[5] Rogers, E.M. (2003), "Diffusion of Innovations (5th ed.), New York: Free Press.

[6] Pillai, A. Sivathanu, "Management of High Technology Projects-Some Experiences," in Indian Project Management Journal, vol. 1, 2002.

[7] Thomas, A. Salomone, "Concurrent Engineering," Marcel Dekker, New York, 1985.

[8] Kevin, A. Desouza, "Transfer of Defense Technology: Moving beyond Self-Reliance towards Technological superiority."