ISSN: 0974-5823 Vol. 7 No. 5 May, 2022

International Journal of Mechanical Engineering

Introspection of Global ‘Transfer of Technology (ToT)’ to India for Defence Electronics

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We have no conflicts of interest to disclose. We acknowledge the information and experience shared by top level Government officials, Armed Forces leaders, Industry stalwarts and foreign OEM representatives to enrich this paper. We are thankful for their voluntary contributions, without which it would not have been possible to complete this research paper. We would also like to thank University of Petroleum and Energy Studies (UPES) for providing us the library facility and access to literature.

Abstract

Purpose: Introspection of global transfer of technology (ToT) to India for defence electronics. This paper is research of available literature and case studies on global ToT to Indian defence services for their degree of success in electronics intensive programs. The resultant impeding factors have been further subjected to primary research through questionnaire-based survey. Hypotheses formulated and statistically tested to derive concrete results, which were further corroborated through core group opinions and reviews.

Scenario Brief: Global ‘Transfer of Technology (ToT)’ to India appears to be a win-win situation to both parties; ie. the ToT provider for amortization of their development expenses and ToT recipient for acquiring quick proven technology. This paper brings research findings of both successful and failed case studies supported by dependable publications and facts. This paper is a much-wanted original work, beneficial for the stake holders. The paper starts from the techno-economic situation of Indian industry, technology absorption reality, to the level of success of Government funded Defence Research and Development Organization (DRDO), similar technology centric organizations. The successful cases have been analysed and secrets of success identified. The findings of the Government formed investigative committees and their recommendations also have been analysed and suitably included. This paper has valuable lessons for global companies as well as Indian industry power houses regarding impediments and required corrective measures for future endeavours.

The Research Outline:

Business Problem: Global Transfer of Technology (ToT) to India in defence electronics has not been as successful as anticipated.

Research Problem:

(1) Study the published literature on global ToT to India for Defence Electronics to identify and analyse the impeding factors.
(2) Obtain primary data on the afore impeding factors for hypothesis-based test/ analysis.

Research Objective: Identify the impeding factors, if any, for global ToT to Indian defence electronics segment through literature review, primary research/ analysis and ratification by core group review.

Research Questions: A set of research questions were formulated and served to 51 persons from the target MSME industry segment to respond in a 5-level Likert Scale. The uncorrelated stratified random sample responses were quantitatively analysed for their acceptance/ rejection.

Statistical Method: Z-test was applied to test our hypothesis-based test statistic with an acceptance threshold or confidence level of 95% (1-α) i.e. significance level (α) of 5%.

Factors: The factors impacting success of Global ToT to India for defence electronics, are assessed from literature review as:

(a) Degree of Complexity of ToT

(b) Availability of adequate technology base and skilled manpower

(c) Extent of support from domestic technology intensive / R&D organizations

(d) MSMEs' contribution to innovation and technology absorption

(e) Cost of global ToT

Originality/ Value: There are over 200 publications on the subject. Most of them give isolated and disjointed expert views and opinions. This study gathered views of a wide range of stake holders across policy makers, industry stalwarts, research agencies, government officials, investors etc., through a stratified random market survey and analysis to highlight some of the salient impediments to global ToT to India for defence electronics. Population survey based primary research established the facts,

followed by expert group ratification. The results are expected to be of interest to the global defence majors, the Indian lead participants, the members of the eco-system and enthusiast defence analysts.

Findings:

(1) The reasons for unsatisfactory global ToT to India for defence electronics are assessed as:
(a) Global Transfer of Technology (ToT) in defence electronics is complex
(b) Cost of global transfer of technology is high.

(2) Other encouraging facts established:
(a) Adequate technology base and skilled manpower is available
(b) Adequate support from domestic R&D organizations is available
(c) MSMEs capability for innovation and technology absorption is adequate

Key Words

Transfer of technology (ToT), Self-Reliance, Technology absorption, MSME, DRDO

Abbreviations

CSIR	Council of Scientific and Industrial Research
DAE	Department of Atomic Energy
DARPA	Defence Advanced Research Projects Agency
DGA	Directorate General of Armaments
DPrP	Defence Production Policy
DPSU	Defence Public Sector Undertaking
DRDO	Defence Research & Development Organization
FDI	Foreign Direct Investment
FMS	Foreign Military Sales
GoM	Group of Ministers
HAL	Hindustan Aeroneutics Limited
ISRO	Indian Space Research Organisation
LCA	Light Combat Aircraft
MDL	Mazagon Dock & Shipbuilders Limited
MoD	Ministry of Defense
MSME	Micro, Small and Medium Enterprises
MTCR	Missile Technology Control Regime
NPT	Nuclear Non-Proliferation Treaty
ODC	Offshore Development Center
OEM	Original Equipment Manufacturer
OFB	Ordnance Factory Board
PPP	Public Private Partnership
RIAC	Russian International Affairs Council
SME	Small and Medium Enterprises
ToT	Transfer of Technology
UNCTAD	United Nations Conference on Trade and Development

Introduction: Technology Self Reliance in Defence

India's dream of achieving self-reliance in defence has been in the offing for a long time (Karanpreet Kaur, 2013, p.2). 'Achieving self-reliance in defence technology has been a national goal pursued by India from the mid-1960s' Kevin (2017). India has been continuously striving to maintain stability internally as well as in its strategic neighbourhood, conduct military modernisation, induct and absorb world class defence technologies by the establishment of a robust defence industrial base. Despite efforts being made by all stakeholders, and the good policies of the Government of India, the desires of the armed forces and expectations of the domestic industry are yet to be fulfilled. Even though the intent of policy-makers is forward looking and positive, the desired results have not been achieved (Karanpreet Kaur, 2013, p.2).

Self-Reliance Index (SRI)

The importance of developing critical technologies in the defence sector was first highlighted by the committee headed by Dr APJ Abdul Kalam, the then Scientific Advisor (SA) to Government of India on 27 October 1993. The report stated that this would act as a safeguard against technology denials by developed countries and that 'technology power will raise the nation to a position of greater strength, militarily and economically'. The committee, underscored the need to improve India's self-reliance index (SRI) from 30% in 1992 to 70% by 2005 (Kevin A. Desouza, 2017, p.1).

Vigorous efforts were made to 'indigenise' a larger number of foreign parts of the various systems being manufactured. It has only given little success (Kevin A. Desouza, 2017, p.2). Though we are far from achieving this SRI goal, as a result this today there are 6000 Medium, Small and Micro Enterprises MSMEs and growing, 60 private firms, 9 DPSUs and 41 Ordnance factories, regrouped to a dozen plus, manufacturing defence equipment. Their comprehensive competency map of the Indian industry is still being collated as a progressive continual measure since the databases available in DRDO laboratories cover manufacturing technology available for their systems which are being developed by the respective Labs and not country-wide capabilities (Kevin A. Desouza, 2017, p.3).

India has adopted numerous methodologies like licensed production, Transfer of Technology (ToT), Joint Ventures (JVs) and indigenous Research and Development (R&D) to acquire and absorb critical defence technologies. However, the current state of affairs is lagging behind the envisaged goals of realising a sustainable indigenous defence manufacturing industry (Karanpreet Kaur, 2013, p.1).

Despite this and many other positive thrusts, however, progress towards self-reliance in defence technology has not reached the milestones that were set apparently because global developments in defence technology outstripped the pace at which DRDO was able to advance. The Indian defence forces thus continue, as in the past, to depend on imported, globally competitive, defence systems (Kevin A. Desouza, 2017, p.2).

Prime Minister Narendra Modi in his address to the Combined Commanders Conference on December 15, 2015 stated that 'at a time when major powers are reducing their forces and rely more on technology, we are still constantly seeking to expand the size of our forces. Modernisation and expansion of forces at the same time is a difficult and unnecessary goal. We need forces that are agile, mobile and driven by technology, not just human valour (Gurmeet Kanwal, Neha Kohli, 2018, p.99).

The Impediments

In order to achieve higher operational preparedness, the bottlenecks at the policy and implementation levels need to be addressed. Several factors like inordinate delays in modernisation projects, cost overruns, lack of strategic vision and synergy among stakeholders have posed challenges for the indigenisation drive. There seems to be serious disconnect between the planning and execution of programmes meant to achieve the ultimate objective of self-reliance and indigenisation in defence (Karanpreet Kaur, 2013, p.2).

Lack of technology absorption capability in India has been the main reason for non/ under-utilisation of technology transferred from foreign sources. The need of the hour is absorbing technology, but more crucially, taking the endeavour forward through rigorous indigenous R&D. The foreign OEMs believe that India is not yet capable of absorbing the heavy flow of offsets through the ToT mode in high end technology. Though the ToT provision seems promising, there is no guarantee that India will be able to make full use of it, considering its inability to do so in the past (Karanpreet Kaur, 2013, p.12).

Government Initiatives

The government has taken several steps to promote the participation of private sector in defence production. These measures include opening up of the defence industry (since May 2001) for private sector participation (Karanpreet Kaur, 2013, p.5).

The government formulated a Defence Production Policy (DPrP) in order to reduce dependence on the import of defence equipment from foreign countries. The Defence Production Policy came into effect from January, 2011. The objectives of the policy are to achieve substantive self-reliance in the design, development and production of military equipment/ weapon systems/ platforms in the shortest timeframe possible; to create conditions conducive for the private industry to play an active role; to enhance the potential of Small and Medium Enterprises (SMEs) in indigenisation and to broaden the defence R&D base of the country. In order to synergise and enhance the national competence in producing state-of-the-art defence products and services within the government approved framework of budget and timelines, all viable approaches such as formation of consortia, joint ventures and public private partnerships, etc. will be undertaken. The academia, R&D institutions as well as technical and scientific organisations of repute will be made a part of the holistic defence production environment. The government has further simplified the procedures under the 'Make' category of the DPP in such a manner that it enables the indigenous design and development of the required equipment/ weapon systems/ platforms by both public and private industry in a faster timeframe (Karanpreet Kaur, 2013, p.6).

Transfer of Technology (ToT)

The provision of ToT as part of offsets is expected to immensely benefit the Indian defence industry. There have been such provisions for ToT in earlier defence procurement programmes and the experiences of indigenous industry in absorbing and utilising the technology received from foreign Original Equipment Manufacturers (OEMs) have fallen short of expectations in the past (Karanpreet Kaur, 2013, p.11-12).

The foreign vendors complain about bureaucratic hassles and the complex business environment of India resulting from long and rigid government procedures, thus, making it difficult for them to operate and conduct business in a conducive manner. The Japanese believe that there cannot be real security unless the country is independent with regard to technological knowledge and competence as well as self-sufficient in the production of armaments (Karanpreet Kaur, 2013, p.20-21).

Hurdles in Technology Absorption

Thus, there are so many vexing issues plaguing the acquisition of 'critical' technology. The primary function of the acquisition process is to procure equipment and systems which meets the needs of the defence forces. By 'leveraging' the procurement process to obtain 'critical technologies', one wonders if we are losing the primary focus of procurement and bogging it down with the secondary, i.e. the complex process of technology acquisition? (Kevin A. Desouza, 2017, p.5).

The magnitude of indigenous production which is practically implementable is a matter of serious concern considering our limited manufacturing capabilities, infrastructure and human skill sets (Karanpreet Kaur, 2013, p. 21-22). The participation of the domestic private industry has been thwarted by issues related to taxes and licensing. The innumerable taxes like service tax, customs duty, VAT, exchange rate variations, and the delays in obtaining industrial licences are major impediments that discourage the private sector from investing resources, capital and time in an uncertain environment. Limited incentives and public sector bias in defence restricts the realisation of the immense potential and expertise of the private sector which has been identified as a crucial partner by the DPP for its success. Lack of relevant experience and subject matter expertise renders the decision-making process ineffective. In addition, lack of accountability and transparency leads to a lackadaisical attitude on the part of the bureaucrats. To add to the woes, there is a problem of vested political and personal interests of various actors involved in the process. Inconsistencies among the various departmental policies and their interpretation results in uncertainty and misunderstanding of policy literature. As a result, there is lack of coordination among the stakeholders because of which consensus-based issue resolution is a challenge.

Lead Role of Defence Research & Development Organization (DRDO)

If the Indian defence industry has not performed well, the DRDO, which has a monopoly over technology and product development, must assume the lion's share of the blame. It is widely known that the DRDO has not performed optimally. Time and cost overruns in key projects undertaken by the organisation coupled with failures in developing key technologies in a time-bound manner are among the reasons why the organisation has been subjected to widespread criticism in the past. Some of the problems facing the organisation are lack of organisational reforms, poor accountability, meagre resources and poor human resource management (Gurmeet Kanwal, Neha Kohli, 2018, p.186).

For India to establish a credible defence industrial base, improved R&D will play a vital role. Unfortunately, its role so far has been marginal due to the inefficiency of the DRDO, its lack of synergy with production centres and the industry's miserly attitude towards R&D as a whole. This needs to be corrected by making the DRDO accountable, bringing the R&D labs and the industry together as a team and encouraging the industry to spend far greater resources on in-house technology development (Gurmeet Kanwal, Neha Kohli, 2018, p.195).

Offsets

As regards complexity of transfer of technology (ToT), Air Marshal Anil Chopra (2015) states that no nation would like to part with painfully hard-earned technology even at substantial cost. To evolve a defence Offset contract is a complex exercise. It involves local partner identification, offset certificates, penalties and confidentiality clauses. Nearly 122 open defence offset contracts signed around the world between 1997 and 2010 have only partially been executed due to various imponderables. Sometimes, there are conflicting views on levels of transfers of sensitive technologies. The US, being one of the largest exporters of high technology weapons, has been most vocally moderating the Offset policies around the world. (Air Marshal Anil Chopra, 2015, p.2)

Through a US Presidential Decree of 1990, no Offset clause can be applied to a FMS agreement. The US government considers Offsets to be 'market distorting and inefficient'. It has been made clear that 'the decision whether to engage in offsets resides with the companies involved' and that 'no agency of the US government shall encourage, enter directly into or commit US firms to any offset arrangement in connection with the sale of defence goods or services for foreign governments', effectively sounding a death knell for the instrument of Offsets (Air Marshal Anil Chopra, 2015, p.3).

Technology Obsolescence

The pace with which technology is becoming obsolete is a real problem. Defence preparedness calls not just for military modernisation but also reforms, which are capable of accelerating the R& D processes in the field of security. Moreover, it should be kept in mind that no one player or OEM can fully manufacture critical equipment. Several components are now procured from various producers, making the procurement procedure lengthy and complicated. These can cause unnecessary delays too. Another point of view currently attracting a lot of attention is that opening the doors of the security sector to foreign players will jeopardise India's position as a strong defence power (IDN, 2016, p.2).

Absorption of ToT would require promoting indigenous capability to imbibe technology (Air Marshal Anil Chopra, 2015, p.5).

Self-reliance trends in defence acquisition present a dismal picture. The principal reason for this state of affairs is our poor design capability in critical technologies, inadequate investment in R&D and our inability to manufacture major sub-systems and components. The Transfer of Technology route has provided India with the know-how without providing the clue for 'know-why' (SN Misra, 2015, p.2).

Make In India

For several experts in the field of National Defence and Security, 'Make in India' has been more than just a mere slogan, and an amalgamation of all the ongoing projects, procurements and forward planning in India's security sector (IDN, 2016, p.1-3). For a strong indigenous defence industry both outside support and internal political commitments are very crucial. Integral to any development program, is the need to provide a conducive socio-economic and political environment where any proposed idea can take roots. That foreign players are still not fully convinced with the idea of 'Make in India' especially shifting their production bases to India, a market which has inherent haphazard supply chain structures. Positive market trends have indeed widened the horizons of defence manufacturing in India but India still needs a little more political and financial push to achieve a higher degree of self-reliance in defence technology.

Historically, India has been availing of technology through licence agreements from Russia and a smattering of Western countries. The exceptions are some of the missile systems, small arms and their ammunition and tanks where technology has been indigenously developed by the Defence Research and Development Organisation (DRDO). The Light Combat Aircraft (LCA) Tejas with Final Operational Clearance (FOC) will hopefully be a major 'Make in India' platform. It must be mentioned that indigenisation has effected a substantial reduction in cost of the systems due to India's labour arbitrage, good facilities and fairly well-trained labour force (SN Misra, 2015, p.1).

It needs to be sensitive to skill requirements in order to absorb high technology which comes as part of ToT. One of the predominant reasons for Japan's phenomenal growth since the 1950s has been their highly skilled labour force which could absorb front-end technology from the US quickly and adopt it to harness commercial success through dual use technology. Japan's success in electronics and automobile is testimony to this. In India, on the other hand, the ToT experience reveals that the technology absorption has been inordinately slow leading to continued dependence for our foreign collaborators well beyond the originally contracted period. Experience of HAL in terms of production of the MiG series of aircraft and SU-30 and for MDL for producing Scorpene submarines are grim reminders of our poor high-skill absorbing capability (SN Misra, 2015, p.5).

India is witnessing a significant stickiness in its manufacturing sector which is bedeviled by the huge presence of small scale and informal sector that are bereft of requisite skill levels and economy of scale. Their access to capital is also seriously impeded. However, the manufacturing sector provides a wonderful opportunity for India to be part of the global supply chain and generate high levels of employment opportunity to absorb around ten million young Indians who will come in to the market in search of employment every year. They also need to be properly skilled and trained and networked with their global peers. The defence industry, be it public sector or private, has to be part of the national manufacturing policy mosaic. Unfortunately, the defence sector often chooses to distance itself in its interface with other civilian sectors. There is opportunity aplenty in areas such as aerospace and ship building where there is considerable civilian and military market. Lack of design capability to manufacture critical subsystems remains a major handicap. The DRDO remains mired in inordinate delay, huge cost overruns and deficient in critical technology areas like 'seekers' and 'stealth'. Tokenism like Rs. 100 crore allocations towards Technology Acquisition Fund or lip service to FDI policy by increasing to 49 per cent are not the way forward. Public Private Partnership, Joint Venture with foreign OEMs and design houses will require bolder policies such as FDI ceiling higher than 50 per cent and the political will to mentor and hold together the different stakeholders who are often at cross purposes. The new Prime Minister has set his foot in the right place. The Ministry of Defence, however, has to match his steps, shed its ghetto mentality and strive for better synergy with other manufacturing sectors to make 'Make in India' the mantra for the days ahead (SN Misra, 2015, p.5).

Role of Public Sector Units (PSUs)

Prof. Bharat Karnad (2015) in a perceptive article in the Economic Times, while paying fulsome tributes to Dr. APJ Abdul Kalam for his contribution to long range delivery systems like Agni series of ballistic missiles, has bemoaned the fact that the Defence PSUs have never progressed beyond the ‘Screw Driver’ technology. He has specifically brought out, how the aeronautic behemoth HAL has alarming import content (70%) in its Value of Production during 2014. Prof. Karnad has suggested that there is a need to stop ‘mollycoddling the DPSUs’, avoid wasting sophisticated built-up capacity in the private sector and contain our humongous import drain (SN Misra, 2015, p.1).

Defence Procurement Modes

The ‘Buy’ option viz importing weapons platforms and systems from OEMs has been the first priority of the services, as they dread the interminable delay and capability of indigenous initiatives. The **technology transfer route**, ‘Buy & Make’ is the second option, where the imported parts are assembled and integrated with a fair degree of dexterity by the DPSUs. However, value addition is a serious concern in this route, as major platforms such as the Su-30 MKI aircraft have clearly demonstrated. In the ‘know-how’ route, building design capability is a huge casualty. It is because of our lack of depth and commitment to indigenous Research and Development (R&D). As a result, the ‘Make in India’ initiative has taken a serious beating with our Self-Reliance Index as low as 30 percent. The Self-Reliance Index is particularly poor in sub-systems such as propulsion, weapons and sensors where our dependence on imports is abnormally high (SN Misra, 2018, p.2).

The critical technology gaps linger in India, without any perceptible improvements. The Committee had recommended improvement of our Self-Reliance level to 70 per cent by 2005 by developing work centres at the national level and bringing together PSUs, DRDO, ISRO, CSIR, DAE, private sector and academia on one platform (SN Misra, 2018, p.2).

ToT availability from Global Partners

The Government of India (GoI) wants leading global weapons manufacturers to make their weapons in India and sell those to the world. The requirement of the Indian armed forces is being used as an incentive to make the offer more lucrative. Still, USA (Lockheed Martin) is less likely to share key technical components and Transfer of Technology (ToT) (Sumit Walia, 2017, p.26).

US companies offering to produce defence equipment in India want stronger assurances that they won’t have to part with proprietary technology, according to a letter from the business lobby group US-India Business Council (USIBC) addressed to India’s defence minister. The American companies which are bidding to supply equipment to India’s armed forces are also demanding that should not be held liable for defects in the products they manufacture in collaboration with Indian strategic partners. The USIBC’s letter seeks a guarantee that US firms would retain control over sensitive technology. ‘Control of proprietary technologies is a major consideration for all companies exploring public and private defense partnerships’, said the letter by the business lobby, which represents 400 firms. (D Raghunandan, 2017, p.1).

Indo-Israel relationship is booming like never before. Prime Minister Modi’s recent visit to Israel was termed historic by many observers and was much talked about in the global media. After all, this was the first visit by a serving Indian Prime Minister to the Jewish stronghold after 70 years of Indian independence. During the visit, India signed several agreements with Israel on science, agriculture and technology. The agreements also included the decision to create a bilateral technology innovation fund worth $40 million for research in industrial development, among other deals (Ketan Salhotra, 2017, p.81)

Joint Development with Global Partners

Israel has become a prominent defence partner for India in recent times. A string of defence deals between the two countries have benefitted Indian companies seeking advanced manufacturing technologies and Israeli companies looking at new defence markets. Israel has also been able to provide the Indian armed forces with weapons which it could not directly buy from its usual defence partners - Russia and US. Future defence cooperation between India and Israel is expected to focus on the joint development of military products that includes Transfer of Technology (ToT) and R&D from Israel, emphasising Modi’s ‘Make in India’ initiative. In fact, Israeli and Indian companies can also explore joint production of arms and ammunition for other countries. Indian companies looking for high-end defence technologies could also look at acquisitions in Israel. Wipro Infrastructure Engineering (WIN) acquired Israel based HR Givon, supplier of metallic parts and assemblies to the aerospace industry. More such acquisitions may take place over short to medium term (Ketan Salhotra, 2017, p.85).

As a small country, export is what makes Israel unique. Unlike its competitors, that consider export secondary to their domestic and regional activities, Israel’s defense companies are all export oriented, with share of export ranging from 75% to 50% of their annual sales. On the other hand, research and development (R&D) is often oriented to address local needs. Leveraging joint research and development programs Israel could benefit from R&D cost sharing, with industries leveraging the follow-on sales and support of such products through their JVs with Indian companies. Israel’s defense establishment has recognized this opportunity and Israel’s Ministry of Defense (MOD) named the cooperation with India in the highest priority, by streamlining the activities of Defense R&D Agency (Mafat), Defense Export Control Regulator (API), Security and Defense Export and International Cooperation Directorates. All these stakeholders are brought together to speed up permissions and processes and minimize bureaucracy to promote Israeli-Indian cooperation. As an important and trustable ally, India has access to most of the technologies, systems and capabilities Israel can export and is now sharing research and development of future systems and capabilities that will gain their military forces an overmatch over future adversaries (Tamir Eshel, 2017, p.87)

ToT Limits

Without a doubt, there are some limitations on the extent to which a country would transfer its military technology, experts believe. According to Alexander Ermakov, expert at the Russian International Affairs Council (RIAC), this especially concerns critical types of technology that influence the ability of a country to ensure its security: most importantly missile technology, communications and electronic warfare systems. The limitations always vary depending on the client. Trading technologies is also much easier for a country like Russia when a partner shares the same geostrategic and military interests and there is a history of past fruitful cooperation. India is in the best position here, unlike Pakistan, which Makienko calls 'unstable and unpredictable and to an extent, an analogue of Ukraine in South Asia.' While India is enjoying a privileged status among Russian partners, there are obstacles that hamper it from producing Russian defence technology using its own industrial capabilities. 'Moscow puts no limitations whatsoever on military technology transfer to Delhi,' Vasily Kashin, senior research fellow at the Moscow Based Institute for Far Eastern Studies and at the Higher School of Economics, told RIR. He says it is the ability of India to pay for a certain technology and localize it that determines the scale and effectiveness of such cooperation. The problem with the Su-30MKI case is that the progress is not happening as fast as planned due to difficulties in local industrial production capacity, lack of skilled manpower and low adherence to technological requirements. Kanwal Sibal, former Indian Foreign Secretary and Ambassador to Russia (2004-2007), acknowledges that this problem does exist (Ksenia Zubacheva, 2017, p.2-3).

The second route to acquire competitive defence technology is their import. Executed under the rubric of 'Transfer of Technology' (ToT), this comprises of arrangements wherein foreign supplier firms provide 'technology' for enabling the buyer to manufacture defence systems. Since indigenous capability was limited, India has been using ToT to shore up its defence production capabilities from as far back as the 1960s and 1970s (Kevin A. Desouza, 2016, p.1).

Intricacies in ToT Implementation

'Transfer of Technology' gives the impression, to the average person not acquainted with the details of such matters, that it will magically elevate defence production capabilities to cutting-edge levels. After which, India would attain self-reliance in that particular domain of technology for all the years to come. If that had been the case, India would have become self-reliant decades ago in fighter aircraft, helicopters, armoured tanks, artillery guns and numerous other defence materiel. India has been the recipient of these technologies since the 1960s and has full-fledged Ordnance Factories and Defence PSUs dedicated to their production. That these factories have not been able to absorb and build on the received technologies is viewed by many as a failing, for reasons of incompetence, poor management and short-sightedness. While these may have been contributory factors, digging a little deeper reveals a whole plethora of factors linked mainly to the legal clauses protecting the rights to industrial/intellectual property (IPR) of technology sellers. While protection of these rights is justifiable considering the substantial investment made by the seller, the generally prevalent oligopolistic environment in defence technology has been exploited by many through the adoption of measures which could, arguably, fall under unreasonable restrictive trade practices (Kevin A. Desouza, 2016, p.2).

UNCTAD on ToT

Firms in the developed world have been selling both defence and civil technology to less developed countries as a means to increase the returns on their investment over a wide range of products. Sellers have used numerous ways of excessively milking technology transfer arrangements, till growing resentment prompted the technology buying, less developed, countries to introduce regulations to protect themselves. In 1970, the matter was formally recognised by the United Nations Conference on Trade and Development (UNCTAD) with the setting up of the Inter-Governmental Group on ToT for drawing up a Code of Conduct. 8 Today, the UNCTAD document on Transfer of Technology provides an exhaustive coverage of the various issues of regulatory measures, market competition, protection of IPR, Foreign Direct Investment (FDI) and encouragement of ToT (Kevin A. Desouza, 2016, p.2).

Restrictive Trade Practices

Defence trade and technology, being highly controlled by a powerful few, is significantly more vulnerable to restrictive trade practices. Foreign firms, which would, in the case of civil technology, be expected to follow the code of conduct, have, in the case of defence systems, a convenient justification for indulging in these restrictive trade practices. A quick look at these practices is illuminating. Technology seller firms have been known to: impose restrictions on field of use, volume and territory; ask for prolonged periods of validity (thus precluding its further development by the buyer); restrict any research and development in the field; impose non-competition clauses on the buyers; tie down the buyer to purchase material and parts from the seller; fix their own prices; impose restrictions in the event of the expiry or loss of secret technical knowhow; prevent challenges to the validity of the rights of the seller; impose grant-back provisions which force the buyer to transfer back to the seller, any improvements, inventions, etc.; and lastly, restrict exports. In addition to these, numerous export control arrangements and non-proliferation treaties such as the Wassenaar arrangement, Nuclear Non-Proliferation Treaty (NPT), Missile Technology Control Regime

(MTCR), the Australia Group, etc. impose additional restrictions on export and transfers. While these, no doubt, hold universal acceptance for the righteous cause of preventing technology from falling into the wrong hands, they nevertheless impose heavy restrictions and are accused by some of being propagated by technology denial regimes (Kevin A. Desouza, 2016, p.2-3).

Exorbitant ToT Costs

ToTs enabling indigenous manufacture of defence systems appear, prima facie, to be cheaper than outright purchase of the system, given, as is the case for less developed countries like India, the availability of cheaper labour and use of existing infrastructure. Paradoxically, however, it is, in many instances, the other way around. In the 1970s and ‘80s, this aspect was hotly debated when it was noticed that the cost of making the Jaguar aircraft in India would be twice that of buying finished planes from Britain. Reasons for higher costs have been attributed to the costs imposed by the seller firms on patents, licenses, know-how, trademarks, over-pricing of capital goods and equipment supplied, and many others (Kevin A. Desouza, 2016, p.3).

So is ToT an undesirable route for India? Would it be better just to keep buying defence systems outright until indigenous development catches up? These are questions which need to be answered keeping in mind the negatives discussed above, while at the same time taking into account the positives in the form of saved foreign exchange, employment generated, modernisation of production facilities, economic and industrial growth, possible spinoffs to commercial use and export. A lot will depend on how well these contracts are negotiated for the long-term goal of self-reliance. Therefore, Indian agencies would do well to deploy competent negotiators who are well trained and acquainted on connected matters of patents, licenses, pricing of technology, etc. by a special agency nominated for the purpose. A strong advantage that India has at this point of time is the economic slump prevalent worldwide, which has prompted a surge of competition among the foreign seller firms to partner with India in defence manufacturing. With detailed, well thought out, and executed negotiations, India may possibly be able to leverage the situation to turn ToTs into more effective means of building self-reliance in competitive defence technology (Kevin A. Desouza, 2016, p.3).

India’s Strengths

India has a vast pool of engineers and a genius for adaptability. The innovative skills are recognised world over. In the recent Forbes list, five Indian companies were in the first 50 for innovativeness. Indian entrepreneurship skills are respected the world over. Our manufacturing costs are low. Many Fortune 500 companies and major aerospace players have set up shop in India using Indian IT and engineering services. They have established captive R&D units and are also collaborating with our centres of learning (Air Marshal Anil Chopra, 2015, p.5).

Capital acquisition for various platforms, weapon systems has significantly increased over the years, i.e. seven fold from the level in 2000-2001. It constitutes broadly 40% of our defence budget. As per the Defence Services Estimates, the import content is nearly one third in recent years. However, a major defence PSU like HAL, imports nearly 70% of its requirements, drawing criticism that it is predominantly an ‘assembler’, ‘systems integrator’ rather than a ‘value adder’ (SN Misra, 2015, p.1).

India is gearing up well for innovation and related activities. It is emerging more & more as a R&D hub for foreign firms mainly owing to the availability of skilled manpower produced in world-class elite institutions and cost advantages (low wage and operational costs). The process of turning from low-cost provider of routine, standardised tasks into a high-tech center of qualified R&D work has been slow but steady and impressive. It is true that today there are hardly any major multinationals not engaged in some sort of R&D work or Offshore Development Center (ODC) in India (Cornelius Herstatt, Rajnish Tiwari, Dieter Ernst, Stephan Buse, 2008, p.51).

Public Private Partnership (PPP) Model

The Public Private Partnership (PPP) model is an excellent way to synergise the core competencies of both the public and private sectors. The private defence industrial hub of SMEs that has sprung up around the cities of Bangalore, Hyderabad, Pune and Chennai has the capability to absorb and develop critical technologies given the right impetus in the desired direction. The potential of bigger private companies can be substantially harnessed if they are provided with incentives and a level playing field vis-à-vis government enterprises (Karanpreet Kaur, 2013, p. 26).

India's Government has played a major role in promotion of innovation system in India ever since its independence from British rule, has invested much time, money and efforts in creating knowledge society and building institutions of research and higher institutions. It has consciously and consistently promoted the spread of science and technology in the country. Moreover, it has created and sustained an institutional infrastructure that ensures functioning of a market economy and allows its citizens to invent creative ideas and implement them. Since it began the process of economic liberalisation in 1991 it has also supported selected high-tech industries to reach international standards. The Government has constituted fiscal incentives and support funds for spreading R&D in the industry (Cornelius Herstatt, Rajnish Tiwari, Dieter Ernst, Stephan Buse, 2008, p.51). Industrial firms in India have recognized their chances and are investing progressively in R&D. India is also a beneficiary of global exchange of talents, technology and resources as the world, especially the developed western countries have profited from India's export of brains.

Lessons to Learn from other Countries

Lessons from DGA & DARPA: In this backdrop, India can take a leaf out of the experiences of the DGA in France and DARPA of USA to rev up our defence manufacturing and research. The Directorate General of Armaments in France is the procurement and technology agency responsible for programme management, design and development and procurement of weapons system for the French military. It coordinates the armament programme with local industries in France and other European countries besides customers for exports. It has also entered into cooperative armament programmes such as Combat Tiger Helicopter, Surface-to-Air missiles and Anti-aircraft systems. The entire gamut of design, development, acquisition, collaborative arrangements and exports are thus handled by one overreaching organisation. It would make eminent sense to consider replicating such an institutional model in India. This was strongly advocated by the Sisodia Committee (2009), who had observed with concern the lack of professional expertise in handling such issues in the Acquisition Wing of the MoD (SN Misra, 2018, p.3). Furthermore, in countries such as the USA, the private sector is treated as a partner from the design and development stage to manufacturing and maintenance of weapon systems. DARPA, which was created by President Eisenhower in 1958, in response to the technological surprise thrown by Sputnik of USSR (1957), is a frontline research organisation which collaborates with academia, industry and the government for developing of emerging technology required by the military. The DRDO of India needs to draw lessons from the functioning of DARPA.

Synergy

We need to encourage similar synergy between academia, industry and the government (SN Misra, 2018, p.3-4). If India wants to become a global manufacturing hub in defence production, the DGA model of France and collaborative R&D model of DARPA should be seriously considered for galvanising indigenous research and manufacturing capability of critical sub-systems.

Transfers of technology (ToT) have been an important contributing factor to the building of capability in India's defence industrial base (Kevin A. Desouza, 2017, p.2).

Committees and their Recommendations

The Subramanian Committee (1963), after the 1962 war debacle: With JRD Tata as member this report had brought out that our knowledge base in design was inadequate compared to the requirements in the fast-changing aerospace sector. They had accordingly suggested that joint design and development of aircraft engine should be pursued with reputed engine manufacturers like GE, Rolls Royce and Snecma. India's misadventure to do it alone by GTRE and the failure of the Kaveri engine program for LCA should provide adequate lesson how we need to be pragmatic in such strategic programmes. Incidentally it may be pointed out that the investment by DRDO, Defence PSUs and the Private Sector in R&D is pathetically low compared to global levels as the following table would show. However, it's not the quantum of investment but the quality of synergy that we build with academia, private sector and DRDO that would be the key to improving our design capability in key technologies (SN Misra, 2015, p.3).

After the Kargil experience, the GoM (2002) recommended creation of an acquisition wing, integration of SHQs with MoD. FDI up to 26% was brought in 2001 which now stands at 49% (2015). Increase in private sector participation, providing level playing field, creation of RURs (Raksha Udyog Ratnas) out of the private sector was recommended by Kelkar (2005). The Sisodia Committee (2009) has called for Integrated Acquisition structure as in DGA France. The Rama Rao Committee (2008) called for replicating DARPA like structure of USA for DRDO and greater involvement of the Services in project implementation. The subsequent Committees like the Naresh Chandra Committee (2012) and NMCC Committee (2011) have highlighted the need to integrate defence manufacturing sector with the overall manufacturing initiatives in the country. Needless to say, there are many dual use items, particularly in the aerospace and ship building sector, where a synergy between the defence manufactures and National Manufacturing Zones can really bring in significant economy of scale, cost effectiveness and excellent export potential (SN Misra, 2015, p.2).

In a turbulent world where equilibrium is the key and technology denial the norm, improving our knowledge base and all stakeholders putting their heads together into the programme instead of fighting turf war, accepting failure as the mother board of success is how Dr. Kalam would envision India's tomorrow. To quote him 'The whole universe conspires to give the best to those who dream and work'. We need to seize them with both hands (SN Misra, 2015, p.4).

India's march towards the acquisition of competitive defence technology and thus gain assured capability against the military threats it confronts has essentially two routes. The first is indigenous development and the second, import. The first route was adopted in the 1950s when the Defence Research and Development Organisation (DRDO), Defence Public Sector Undertakings (DPSUs) and additional Ordnance Factories (OFs) were established. Despite considerable thrust in that direction, albeit with an understandably limited budget, progress towards self-reliance in defence technology has not reached the milestones that were set. While overall indigenous development and production has significantly increased in technology levels and volumes over the decades, it has been offset by a faster evolution of defence technology in the world. Consequently, the defence forces continue, as in the past, to depend on imports of competitive defence technology systems. Today, India holds the embarrassing distinction of being the largest importer of defence systems in the world (Kevin A. Desouza, 2016, p.1).

ToT Challenges

The degree of willingness to engage in transfer of technology (ToT) will be the main criteria in deciding whether a foreign defence company can qualify to partner an Indian company to manufacture military equipment under the long-awaited strategic partnership (SP) model, the government has said in a presentation made to Indian defence industry honchos. 'ToT remains the main factor in selection of the OEM,' says the presentation on the planned guidelines to select strategic partners, comprising Indian military equipment making companies and foreign OEMs (Sanjib Kr Baruah, 2017, p.1). The foreign defence company will then be the designated original equipment manufacturer (OEM) to pair the Indian strategic partner. The presentation, titled 'Revitalising Defence Industrial Ecosystem', was part of an interaction between the government team led by defence minister Arun Jaitley and Indian defence industry officials. In evaluating ToT, the considerations will include 'range, depth and scope of technology transfer offered in identified areas, extent of indigenous content proposed, extent of ecosystem of Indian vendors/ manufacturers proposed, measures to support SP in establishing system for integration of platforms, plans to train skilled manpower, and extent of future research and development planned in India,' the presentation deliberated. (Sanjib Kr Baruah, 2017, p.1).

Robert H Meyer (2012) has made a thorough review and analysis of a selection of India's Innovation, Entrepreneurship, Knowledge Management and Technology Policy literature and summarised that: better dynamic finance mechanisms for MSMEs, growing more dynamic university-industry collaborations, building reliable networks of mentors and trusted service providers, promoting technical entrepreneurship curriculum and internships, providing for appropriate intellectual property protection, higher academic institutional involvement, streamlining nonessential bureaucratic government regulations, higher public-private partnership financed by government-backed funding leveraged by private investment could raise the standard for entrepreneurship capabilities, lower start-up company risk through value-add activities, and, properly protect the knowledge assets entrepreneurial ventures are founded upon (Robert H Meyer, 2012, p.9).

Nevertheless, India still being a developing country is faced with major problems of infrastructure, power supply, transportation, and synergy. In many instances bureaucracy, corruption, time-delays and callous attitudes of people in power have impeded processes. The quality of mass-education system has not reached the standards required for cutting edge R&D (Cornelius Herstatt, Rajnish Tiwari, Dieter Ernst, Stephan Buse, 2008, p.51).

India's National Innovation System is unique in the sense that probably no other poor country, starting from a low literacy base of less than 20% in 1947, has ever since its political birth, so consistently a systematically tried to create, nurture and enhance its scientific capabilities and has achieved impressively positive results within such short span of time (Cornelius Herstatt, Rajnish Tiwari, Dieter Ernst, Stephan Buse, 2008, p.52).

The Research Outline:

Business Problem: Global Transfer of Technology (ToT) to India in defence electronics has not been as successful as anticipated.

Research Problem:

(1) Study the published literature on global ToT to India for Defence Electronics to identify and analyse the impeding factors.
(2) Obtain primary data on the afore impeding factors for hypothesis-based test/ analysis.

Research Objective: Identify the impeding factors, if any, for global ToT to Indian defence electronics segment through literature review, primary research/ analysis and ratification by core group review.

Research Questions: A set of research questions were formulated and served to 51 persons from the target MSME industry segment to respond in a 5-level Likert Scale. The uncorrelated stratified random sample responses were quantitatively analysed for their acceptance/ rejection.

Statistical Method: Z-test was applied to test our hypothesis-based test statistic with an acceptance threshold or confidence level of 95% (1-α) i.e. significance level (α) of 5%.

Factors**:** The factors impacting success of Global ToT to India for defence electronics, are assessed from literature review as:

(f) Degree of Complexity of ToT

(g) Availability of adequate technology base and skilled manpower

(h) Extent of support from domestic technology intensive / R&D organizations

(i) MSMEs' contribution to innovation and technology absorption

(j) Cost of global ToT

Hypotheses Formulation

From the literature review, the key factors / attributes coming in the way of successful global ToT to India for defence electronics were identified and hypotheses formulated for test. The null hypotheses and alternate hypotheses (to test) are stated below:

Hypothesis 1

$H1_0$(null hypothesis): Transfer of Technology (ToT) in defence electronics is not very complex

$H1_a$(alternate hypothesis): Transfer of Technology (ToT) in defence electronics is complex

Hypothesis 2

$H2_0$: Adequate technology base and skilled manpower is not available

$H2_a$: Adequate technology base and skilled manpower is available

Hypothesis 3

$H3_0$: Adequate support from domestic R&D organizations is not available

$H3_a$: Adequate support from domestic R&D organizations is available

Hypothesis 4

$H4_0$: MSMEs capability for innovation and technology absorption is inadequate

$H4_a$: MSMEs capability for innovation and technology absorption is adequate

Hypothesis 5

$H5_0$: Cost of global transfer of technology is not a concern.

$H5_a$: Cost of global transfer of technology is a concern

Hypotheses Test Procedure

Research methodology adopted is based on 'method of survey questionnaire'. Survey data is collected from relevant stake holders through G-docs, e-mail, and personal meetings.

Sources of Data: MSMEs, engaged in Defence Electronics, relevant Government departments, Services personnel, DRDO officials, academia, industry stalwarts, MSMEs etc. In order to ensure the best representation of the population in the sample, care is taken to include samples from widest distribution patterns such as

(a) Geographical strata for a well distributed representation.

(b) Representation of Micro, Small and Medium enterprises as per turn over, closer to their proportions.

(c) Vertical specialization coverage as per type of work within defence electronics such as Design, B2P, Prototyping and Testing specialised Companies.

(d) Urban. Semi-urban and SEZ mix etc.

Secondary data from literature and publications formed the benchmark only to formulate the hypotheses of relevance.

Data have been collected in Likert scale: Refer Table 1: Sample survey question format.

Statistical Method:

Z-Test with Level of Significance (α) = 5% has been chosen. This corresponds to 95% level of confidence (C).

If z ≤1.645 (as per table of area under normal curve for the given confidence level of 95%, α = 5%, level of significance); accept null hypothesis. For, z >1.645; reject null and accept alternate hypothesis.

Calculation: Refer Table 2: Test situation and test statistics used for Hypotheses testing.

Xbar computed

$\sum (Xi-X_{bar})^2$ computed

Ϭs computed

During statistical treatment, permissible assumptions have been made that Ϭp=Ϭs.

$\mu H_0 = 3$ Population mean, by Likert design

$$z = \frac{\overline{X} - \mu_{H_0}}{\sigma_p / \sqrt{n}}$$

$$\sigma_s = \sqrt{\frac{\Sigma (X_i - \overline{X})^2}{n-1}}$$

Refer to Figure 1: Z-Test, Acceptance and rejection regions

Based on a large amount of survey samples (51: i.e. >30 for Z-test) from related stake holders, a test statistic for testing the alternate hypothesis has been developed and tested.

Hypotheses and Computation Summary

Refer to Table 3: Hypotheses statements and results of Z-test

Analysis: Refer to Figure 2: Z-test results on graph.

H1: The null hypothesis that ' Transfer of Technology (ToT) in defence electronics is not very complex' has been contested by the alternate hypothesis that ' Transfer of Technology (ToT) in defence electronics is complex '.

Based on a large amount of survey samples (51: i.e. >30 for Z-test) from related stake holders, a test statistic for testing the alternate hypothesis has been developed and tested.

The obtained value of Z=4.499 is significantly large than the decision criteria Z>1.645, meaning that the null hypothesis is rejected in favour of alternate hypothesis with resounding level of reliability and confidence.

Similar Inference for all other hypotheses has been made and presented (refer to Figure 2)

Hypotheses H1: Theme - Complex ToT Process: The alternate hypotheses have been found true with a very high degree of confidence. H1 indicates overwhelming responses supporting the view that 'ToT process is complex' in defence electronics. The sample standard deviation is lowest in these hypotheses, highlights least variation of opinion.

Hypotheses H2: Theme - Technology base and skilled manpower: The alternate hypotheses have been found true with a very high degree of confidence. H2 indicates overwhelming responses supporting the view that 'technology base and skilled manpower' for defence electronics are available. The sample standard deviation indicates fair variation of population opinion.

Hypotheses H3: Theme - R&D Support: The alternate hypotheses have been found true with a high degree of confidence. H3 indicates very good responses supporting the view that 'adequate support from domestic R&D organizations' for defence electronics are available. The sample standard deviation indicates larger variation of population opinion.

Hypotheses H4: Theme - MSME Innovation and Technology Absorption: The alternate hypotheses have been found true with a high degree of confidence. H4 indicates good responses supporting the view that 'MSMEs are capable of innovation and their technology absorption potential is adequate'. The sample standard deviation indicates a larger variation of opinion.

Hypotheses H5: Theme - Cost of global ToT: The alternate hypotheses have been found true with a fair degree of confidence. H4 indicates good survey responses supporting the view that 'cost of global ToT is high'. The sample standard deviation indicates the largest variation of survey population opinion.

Summary of Research Framework: Refer Figure 3

The research publications provided a good overview of Govt initiatives and growth impetus in various forms in a right direction as well as the impediments (see Box 1). We also noted the innovation potential of rapidly growing MSMEs, start-up companies and fast emerging of private industries in ToT implementation in defence electronics is immense (box 2). Hypotheses were framed out for the salient impeding factors (box 3) so that they could be put to test using survey of opinion from a stratified random population of stake holders. Using statistical techniques, the survey data could be quantified and analysed for acceptance / rejection of hypotheses with certain degree of confidence. The opinion variance was also analysed. The results of all five hypotheses testing correlate and complement each other reasonably well.

We believe that these inferences, can further be correlated in subsequent work with established theoretical framework (box 4) such as 'Technology Acceptance Model (TAM)' or, 'Unified Theory of Acceptance and Use of Technology (UTAUT)'. TAM and UTAUT are well known theoretical framework and models, which deal with impact measurement of external factors on usefulness, ease of use, user intention, and usage behaviour.

Theoretical Premises

Technology Acceptance Model (TAM) is one of the most frequently employed models for research into new technology acceptance. The TAM suggests that when users are presented with a new technology, a number of factors determine their decision about how and when they will use it.

The TAM model deals with two specific beliefs: Perceived Usefulness (PU) and Perceived Ease of Use (PEU). Perceived Usefulness is the potential user's subjective likelihood that the use of a certain system (*i.e. the digital India initiatives to access and use available resources in this case*) will improve his/her/its action (*i.e. MSME action here*) and Perceived Ease of Use refers to the degree to which the potential user (*i.e. MSME*) expects the target system to be effortless.

Refer to Figure 4: Technology Acceptance Model (TAM) by Venkatesh and Davis, 1996

<u>External Variables</u>: In this case of MSMEs in defence electronics, some of these variables are as follows. These variables have been categorised with respect to their relevance:

(i) <u>Relevant to 'Perceived Ease of Use'</u>

(a) Computer anxiety, computer playfulness, comfort with the application programs

(b) Fear of exposing own information, fear of hacking

(c) Reluctance and inertia of transition from traditional mindset to digital India schemes.

(d) Learning, accepting and adopting various digital India initiatives

(e) Schemes of registrations and empanelment for getting access to Govt. resources

(ii) Relevant to 'Perceived Usefulness'

(a) Past experience, voluntariness, inhibition

(b) Result demonstratability

(c) Other MSMEs behaviour and their expression of usefulness (neighbour effect)

(d) Degree of relevance and quality of output (benefit)

(e) Effort versus benefit

Extensions of TAM theory: TAM has become so popular that it has been cited in many of the research that deals with users' acceptance of technology (Lee, Kozar and Larsen, 2013). TAM attempts to help researchers and practitioners to distinguish why a particular technology or system may be acceptable or unacceptable and take up suitable measures by explanation besides providing prediction. Even though TAM has been tested widely with different samples in different situations and proved to be valid and reliable model explaining information system acceptance and use, many extensions to the TAM have been proposed and tested. They are as follows:

(i) Technology Acceptance Model (TAM) was introduced by Fred Davis in 1986 for his doctorate proposal.

(ii) The TAM theory was formalised by Davis, Bogozzi and Warshaw, in 1989.

(iii) The final version of Technology Acceptance Model (TAM) was published by Venkatesh and Davis (1996),

(iv) Technology Acceptance Model 2 (TAM2), a amplified version of TAM was introduced Venkatesh and Davis (2000) and Technology Acceptance Model 3 (TAM3) by Venkatesh and Bala (2008).

(v) The Unified Theory of Acceptance and Use of Technology (UTAUT), was published by Venkatesh, Morris, Gordon and Davis (2003)

Some of the most prolific TAM authors include Viswanath Venkatesh, Fred D. Davis, Detmar W. Straub, Elena Karahanna, David Gefen, Patrick Y. K. Chau, Lee, Morris, Kozar and Larsen.

Further Work: Factors and Variables for further research work

From the literature study and observations, many other impeding factors to the Make in India programs came to light. We have only researched and collected survey data on the most prevalent three set of factors. However, other factors also could be researched in a similar way. The list of themes / factors and possibilities of formulating hypotheses around the variables are shown in Table 4.

Third Level Ratification: Global ToT to India for Defence Electronics

Refer Table 5: Expert Group Review and Opinion.

Research Findings

[1] Degree of Complexity of ToT is high.

[2] Cost of global ToT is high.

[3] Adequate technology base and skilled manpower is available in India.

[4] Support from domestic technology intensive, R&D organizations is available.

[5] MSMEs' are capable of innovation and technology absorption

Conclusion: Amplification of Research Findings and Additional Findings

(1) The process of global transfer of technology (ToT) to India is complex, and needs to be steered with involvement and support of professional technology-oriented organizations with full participation of the Government and the supporting eco-system. Some ToT cases with DRDO support has seen to succeed and few other cases without association of technology savvy organizations have failed. Systems Integrators alone in India may not be able to drive a global ToT case.

(2) ToT can sometimes be exorbitant, and unaffordable. Needs to be evaluated and negotiated well.

(3) India has not met its own Self-Reliance Index target. Contributions from DRDO and DPSUs for technology self-reliance could have been better. There is a need to emulate relevant lessons from the models adopted in developed counties such as DGA in France and DARPA in USA.

(4) There is a need for detailed articulation of global ToT contracts along with detailed work break-down structure, review processes and mid-course correction measures.

(5) The Indian start-up companies and MSMEs need to be encouraged and associated in the ToT processes for technology absorption and innovation. They are known as 'innovation power house' and have good agility.

(6) India has the requisite technological base, skilled man-power. The synergy, organization processes, infrastructure and facilitation need improvement. Funding and consistency of task assignment to MSMEs and start-up companies is also needed.

(7) Make-in-India movement is conducive for global ToT. Some early initiatives with Israel, and Russia have shown good results.

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Table 1: Sample survey question format.

Survey Question: Global Transfer of Technology (ToT) in defence electronics is complex						
Sl.	Survey Input	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	Name of Respondent	1	2	3	4	5
1	Respondent 1					
2	Respondent n (n=51)					

Table 2: Test situation and test statistics used for Hypotheses testing

Table 9.3:
Names of Some Parametric Tests along with Test Situations and Test Statistics used in Context of Hypothesis Testing

Unknown parameter	*Test situation (Population characteristics and other conditions. Random sampling is assumed in all situations along with infinite population*	*One sample*
1	*2*	*3*
Mean (μ)	Population(s) normal *or* Sample size large (i.e., $n > 30$) *or* population variance(s) known	z-test and the test statistic $z = \frac{X - \mu_{H_0}}{\sigma_p / \sqrt{n}}$ In case σ_p is not known, we use σ_s in its place calculating $\sigma_s = \sqrt{\frac{\Sigma(X_i - \bar{X})^2}{n-1}}$

Table 3: Hypotheses statements and results of Z-test

H	Null Hypothesis, H_0	Alternate Hypothesis, H_a	$Z_{computed}$	$Z_{threshold}$	Decision Criteria	Decision
H1	Transfer of Technology (ToT) in defence electronics is not very complex	Transfer of Technology (ToT) in defence electronics is complex	4.499	1.645	Reject null if Z>1.645	H_0 rejected, H_a accepted
H2	Adequate technology base and skilled manpower is not available	Adequate technology base and skilled manpower is available	4.397	1.645	Reject null if Z>1.645	H_0 rejected, H_a accepted
H3	Adequate support from domestic R&D organizations is not available	Adequate support from domestic R&D organizations is available	3.303	1.645	Reject null if Z>1.645	H_0 rejected, H_a accepted
H4	MSMEs capability for innovation and technology absorption is inadequate	MSMEs capability for innovation and technology absorption is adequate	2.943	1.645	Reject null if Z>1.645	H_0 rejected, H_a accepted
H5	Cost of global transfer of technology is not a concern.	Cost of global transfer of technology is a concern	2.902	1.645	Reject null if Z>1.645	H_0 rejected, H_a accepted

Table 4: Further Work: Factors and variables for further research work

Sl.	Theme (Factors)	Number of Publications Studied	Major Variables, around which test hypotheses can be formulated
1	Regulatory	35	1. Rules, 2. Laws, 3. Policies, 4. Framework, 5. Guidelines
2	Market	28	1. Size, 2. Spread, 3. Opportunity landscape, 4. Statistics 5. Offset, 6. Export potential
3	Technology/ Indigenization	51	1. R&D, 2. Innovation, 3. Technology, 4. ToT, 5. IPR, 6. Patent 7. Build to Print/ Spec (B2P/B2S)

Sl.	Theme (Factors)	Number of Publications Studied	Major Variables, around which test hypotheses can be formulated
			8. Obsolescence Management 9. Reverse Engineering
4	Promotion	38	1. Incentives, 2. Benefits, 3. Concessions for example on finance, tax, training, skill development 4. Concessional policies
5	Production/ Manufacturing	15	1. Licensing 2. Infrastructure, 3. Capacity, 4. Testing, 5. QA, 6. Process Certification 7. Accreditation
6	Challenges	36	1. Unresolved hurdles 2. Ineffective areas 3. Known but, lingering problems 4. Identified areas of focus 5. Future plans not yet implemented 6. Conflicts

Table 5: Expert Group Review and Opinion

Expert Group Member	Opinion Summary
[1] Expert 1 (Leading Industry champion)	(i) In most cases the global ToT is solicited through the system integrator, which is often a defence PSU, a Govt agency like OFB or, a shipyard. Whereas actual ToT can happen by involving the innovation power house, that is MSMEs. (ii) There is a lack of synergy, in organising the ToT implementation and absorption involving the Indian industry and MSMEs.
[2] Expert 2 (Representative of a Technology Incubation Centre)	(i) Global ToT infusion is a multi-disciplinary complex task, which needs to be broken down to implementable parts and appropriate teams need to be engaged in it. (ii) The ToT lead (systems integrator, SI), mostly being Govt agency, lacks insight to understand the technology segments and devoid of a process to systematically implement them involving the tier-1 and tier-2 companies, those are registered with them. (iii) The ToT lead (SI) is generally disconnected from the academia and R&D organizations. (iv) Whereas India has significant talent in unorganised pockets and unfortunately lacks a system or, process to channelise them and integrate them.
[3] Expert 3 (Board Member of a Project participant Company)	(i) The global ToT recipient, mostly being a large Industry house, is more organised to implement the project and deliver to the end-user, the armed forces. (ii) A system for absorption of ToT, is not in their DNA. Which, they try to evolve but, more often it lags behind and eventually remains half-baked and progressively fades out after project delivery. (iii) The ToT absorption aspects are reviewed several years later during the follow-on

Expert Group Member	Opinion Summary
	projects. By then the old leadership team would have either superannuated or, transferred out resulting lack of ability to remake the project without fresh help from the foreign OEM. (iv) Reinventing of the wheel unfortunately begins. The SSK submarine ToT case from Germany to Mazagon Dock & Shipbuilders Ltd., India and Sukhoi-30 ToT case from Russia to Hindustan Aeronautics Limited (HAL) are the live examples of incomplete ToT infusion.
[4] Expert 4 (Representative of a Tier-I Participating Company)	(i) Participation in a Project in India is based on 'vendor registration for a purpose' and 'lowest cost (L1)' approach. (ii) A tier-1 company needs to register with every Systems Integrator (SI) or Govt agency separately for a purpose. In defence, everything is 'need to know' basis. (iii) A system to build Synergy is still evolving. As a result, despite having ability, the opportunity does not flow down to us. (iv) Talent is available in India. But, retaining the talent without continuously engaging task is not viable in the Lowest Cost (L1) system.
[5] Expert 5 (An Army Officer dealing with Technology Transfer)	(i) As end-user, a reliable, well-tested and robust product is preferred. Hence, we get inclined for a seasoned product directly from the global Best. (ii) During product life cycle support, we feel the pain, due to lack of support from the global OEM. At that time, a domestic solution to maintain the equipment becomes paramount. (iii) Now-a-days, the Make-in-India policy, compels the procurement system to first look for an indigenous solution. Only when not available, global import option is permitted, with a life-cycle support package or a ToT or an offset plan. (iv) It is the same progressive path every developing country has to go through, to reach self-reliance.
[6] Expert 6 (A Legal Counsel associated with global ToT)	(i) Global ToT is often not-so-well defined from legal perspective. (ii) It is often qualitative and subjective, between the giver & the taker, where proving or disproving the ToT implementation steps become blurred and a legal course of action becomes clumsy and indeterminant. (iii) Therefore, legal options are seldom a choice, unless it is a blatant refusal from one side.
[7] Expert 7 (CEO of a MSME Co., working for developing a niche technology)	(i) We have tremendous potential for technology creation, incubation, innovation, prototyping and product realization. (ii) All we need is the opportunity, and tasking with clear boundaries, funding, development infrastructure, test facilities, and well-defined dependencies with related developers to realize a complex product. (iii) Though systems and procedures are evolving to address these, many of the start-up companies and MSMEs don't have the required endurance and can't wait long for cash-flow and survival compulsions.
[8] Expert 8 (Senior DRDO scientist)	(i) We are proud to state that Global ToT has succeeded in most of the major programs where DRDO is associated from the beginning, such as BrahMos missiles project with Russia, Long Range Surface to Air Missiles (LRSAM) project with Israel, Advance Technology Vessel Project (ATVP) with Russia etc. In fact, the ToT took the course of joint collaborative development. (ii) Whereas SSK submarine ToT from Germany, Sukhoi-30 fighter jet ToT from Russia etc. did not involve DRDO and lost out from bridging the gap in technology absorption process. (iii) These are learnings from the past, which the authorities should take cognisance in future.
[9] Expert 9 (Member of Institute for Defence Studies and Analyses, New Delhi)	(i) Transfer of Technology (ToT) is a complex subject ranging from intentions of the giver to the capability of the recipient and its eco-system. It includes, the way the ToT agreement is articulated, its scope defined and understood by the parties. (ii) The implementation of ToT with a Good Work Breakdown Structure and well-

Expert Group Member	Opinion Summary
	defined activity flow chart could facilitate time bound implementation. (iii) Most important is the work flow-down from the Project Implementer down the line through its tier-1, tier-2 companies to the actual development team, which may be a start-up or a MSME with good knowledge base but, limited support infrastructure. (iv) The small companies are often struggling with cash flow constraints, consistency of order inflow, tools and test equipment, development and test infrastructure, and overall awareness of available opportunities.
[10] Expert 10 (Marketing Head of a participating Company)	(i) Acquiring global technology and self-reliance is good for the Nation, but it is more often not a viable business proposition. Since the ToT cost is often very exorbitant and not always justifiable. (ii) Advanced countries offer those technology, which has either matured and, on its decline, or, its advanced version is already developed and about to get launched. In such situations, if ToT cost is high, one is not always sure to recover the hefty ToT cost. (iii) Therefore, from marketing perspective, ToT is to be examined with utmost care in terms of its viability.

Figure 1: Z-Test, Acceptance and rejection regions

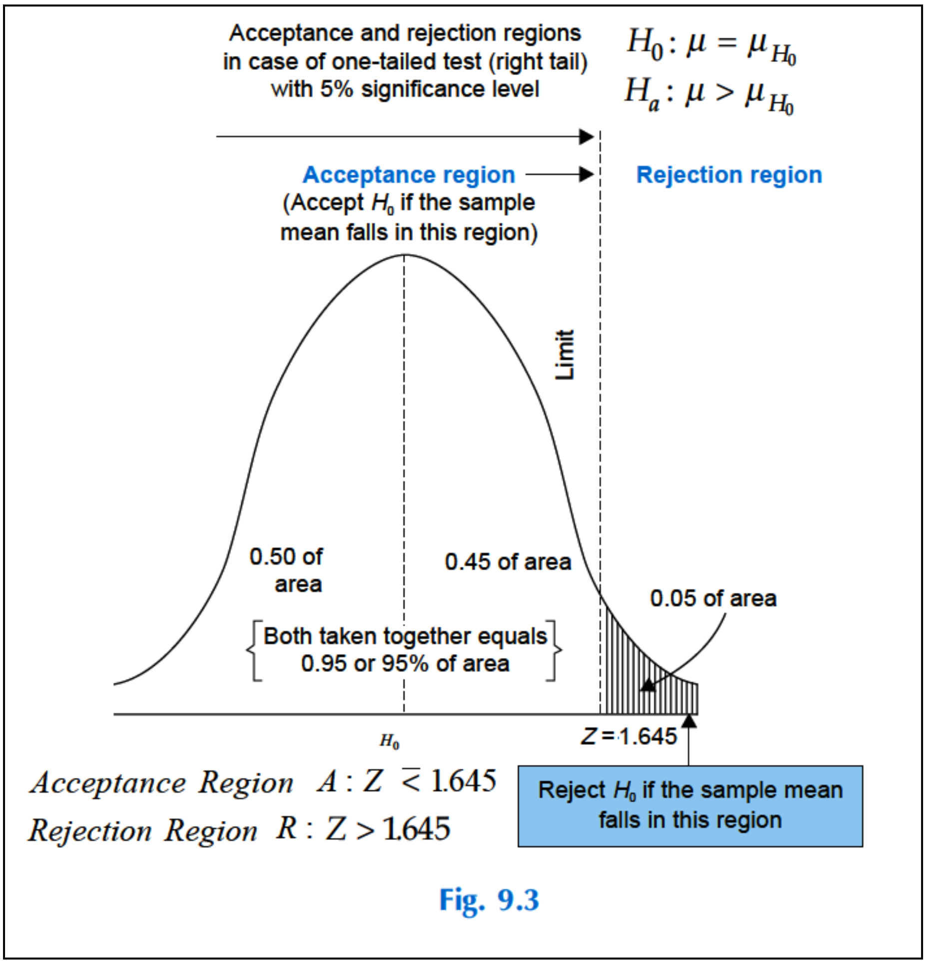

Figure 2: Z-test results on graph

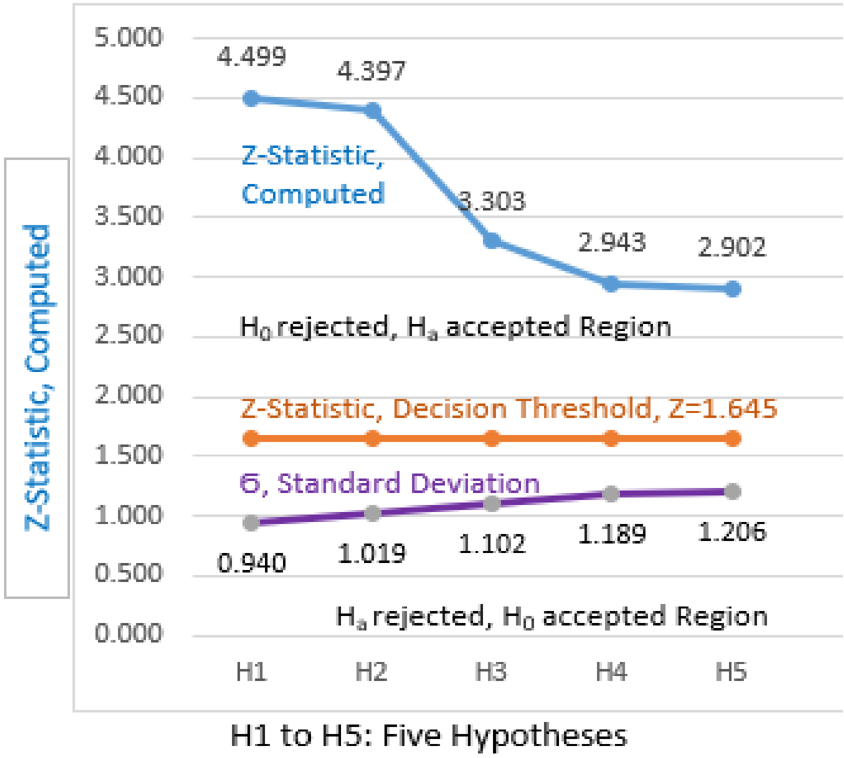

Figure 3: Basis of Research Framework

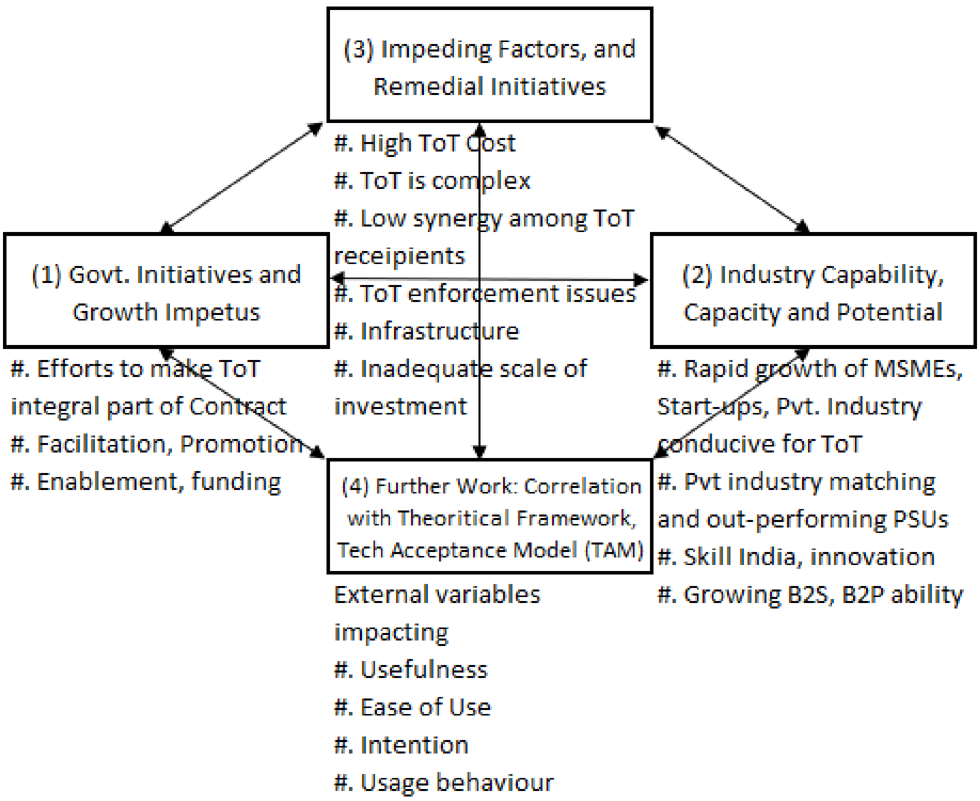

Figure 4: Technology Acceptance Model (TAM) by Venkatesh and Davis, 1996