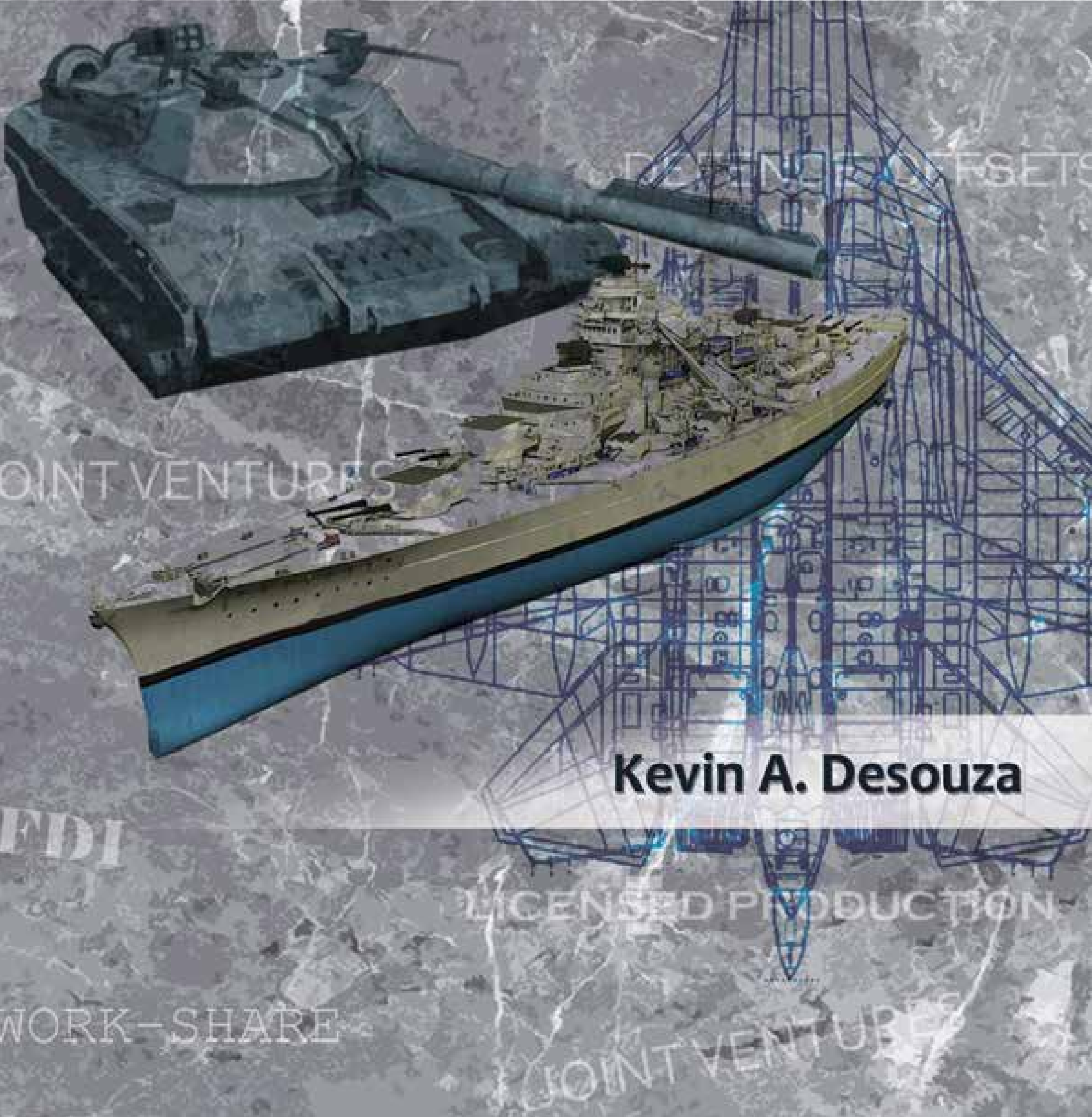
Transfer of Defence Technology

Understanding the Nuances and Making it Work for India



Kevin A. Desouza

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KNOWLEDGE WORLD
KW Publishers Pvt Ltd
New Delhi

INSTITUTE FOR DEFENCE STUDIES & ANALYSES
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Website: www.idsa.in

ISBN 978-93-89137-17-0 Hardback

Published in India by Kalpana Shukla

KW Publishers Pvt Ltd
4676/21, First Floor, Ansari Road
Daryaganj, New Delhi 110002
Phone: +91 11 23263498/43528107
Marketing: kw@kwpub.com
Editorial: production@kwpub.com
Website: www.kwpub.com

Printed and bound in India

To my wife,

Veena

For helping me to be critical and forthright.

Contents

Abbreviations

ALH	Advanced Light Helicopter
AMRC	Advanced Manufacturing Research Centre (UK)
AoN	Acceptance of Necessity
AoT	Absorption of Technology
APCTT	The Asian and Pacific Centre for Transfer of Technology
ASSOCHAM	The Associated Chambers of Commerce and Industry of India
B&M	Buy and Make (route in the DPP)
B&M(I)	Buy and Make (Indigenous) (route in the DPP)
B2D	Build to Design
B2P	Build to Print
B2S	Build to Specifications
CII	Confederation of Indian Industries
CKD	Completely Knocked Down (kits)
CLA	Component Level Assembly (stage)
CNC	Contract Negotiation Committee
COTS	Commercial Off-The-Shelf (equipment)
CSIR	Council of Scientific and Industrial Research
CToT	Complete Transfer of Technology
CVD	Core Value Determinants
D&DToT	ToT required to Design and Develop a system
DAA	Defence Acquisition Agency
DDP	Department of Defence production
DG	Director General

DGAQA	Directorate General of Air Quality Assurance
DGQA	Directorate General of Quality Assurance
DIB	Defence Industrial Base
DoI	Department of Indigenisation
DOMW	Defence Offsets Management Wing
DPP	Defence Procurement Procedure (Indian)
DPrP	Defence Production Policy (Indian)
DPSUs	Defence Public Sector Undertakings (Indian)
DRDO	Defence Research and Development Organisation (Indian)
DTIC	Defence Technology Information Centre
DTOC	Defence Technology Oversight Committee
DToT (Limited)	ToT required to carry out minor design deviations while manufacturing a system
DTTAC	Defence Technology Transfer and Absorption Centre
DTTI	Defence Trade and Technology Initiative (with the US)
EOI	Expression of Interest (by the Indian government on the acquisition of a system)
FDI	Foreign Direct Investment
FF	Fully Formed (systems)
FICCI	Federation of Indian Chambers of Commerce and Industry
FM	Fast Moving (spare parts)
FMS	Foreign Military Sales (US)
G2G	Government to government (agreements or negotiations)
GIPC	Global Intellectual Property Center (U.S. Chamber of Commerce's)
GITA	Global Innovation and Technology Alliance (Indian)
GoI	Government of India
HAL	Hindustan Aeronautics Limited

HQ IDS	Headquarters of the (Indian) Integrated Defence Staff
IACs	Information Analysis Centres (US)
IC	Indigenous Content
ICT	Information and Communications Technology
IDDM	Indigenous Designed, Developed and Manufactured (systems)
IGMDP	Integrated Guided Missile Development Programme
IISER	Indian Institute of Science, Education and Research
IIT	Indian Institute of Technology
IM	Indigenous manufacture (kits)
IP	Intellectual Property
IPL	Itemised Price List
IPO	Initial Public Offerings
IPR	Intellectual Property Rights
ITAR	International Traffic in Arms Regulations (United States)
JV	Joint Venture (between two agencies or firms)
JV CP	Joint Venture for Co-production
JV-CD-CP	Joint Venture for Co-development and Co-Production
LCA	Light Combat Aircraft
LLTR	Light-weight Long-range Transportable Radar
LM	Licensed Manufacture
LP	Licensed Production
LRSAM	Long Range Surface to Air Missiles
MBT	Main Battle tank
MDP	Major Defence Partner
MEMS	Micro Electro-Mechanical Systems
MoD	Ministry of Defence (Indian)
MOTS	Military Off-The-Shelf (equipment)
MRL	Manufacturing Readiness level
MRLS	Manufacturer's Recommended List of Spares

MSME	Medium, Small and Micro Enterprises
MToT(M)	ToT required to maintain a system
MToT(MRO)	ToT required to overhaul a system
MToT(R)	ToT required to repair a system
OEM	Original Equipment Manufacturer
OF	Ordnance Factory (Indian)
OToT	ToT required to operate a system
P2P	Private (firm) to Private (firm)
P2S	Private (firm) to State-run (agency)
PA	Production Agency (which could be an OF, DPSU or private firm) (Indian)
PIO	Person of Indian Origin
PToT	ToT required to produce (or manufacture) a system
R&D	Research and Development
RFI	Request For Information (on a system or its technology)
RFP	Request For Proposal (for supply of a system or its technology)
RoI	Return on Investment
S&T	Science and technology
SCOMET	Special Chemicals, Organisms, Materials, Equipment and Technologies (list) (Indian)
SHQ	Service Headquarters (of the Indian Army/Navy/Air Force)
SKD	Semi-Knocked Down (kits)
SODET	Society of Defence Technologists (Indian)
SP	Strategic Partner (Indian defence firm entrusted with strategic responsibilities by the Indian government)
SQR	Services Qualitative Requirements (of defence systems)
SRI	Self-Reliance Index
STI	Science, technology and Innovation (strategy)
TAI	Turkish Air Industries

TEC	Technical Evaluation Committee (of systems being considered for acquisition)
TMPP	Technology Maturity and Productionisation Path
ToT	Transfer of Technology
TRIPS	Trade Related aspects of Intellectual Property Rights, an international agreement administered by the WTO
TRL	Technology Readiness Level
TT	Technology Transfer
TTLC	Technology Transfer Life Cycle
TTSC	Technology Transfer Steering Committee
UNCTAD	The United Nations Conference on Trade and Development
USML	United States Munitions List
VA	Value Addition (in systems produced through ToT in India)
VC	Venture Capitalists
WA	Wassenaar Arrangement
WE directorate	Weapons and Equipment Directorate (of the Indian Army)
WTO	World Trade Organisation

List of Figures, Tables and Annexures

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Acknowledgements

I am grateful to the Almighty, for providing me the opportunity and capability of serving my country through this research work. The Indian Army, for sponsoring me for a two-year research fellowship and the Institute for Defence Studies and Analyses, New Delhi for welcoming and supporting me through it. In the IDSA, I owe my gratitude to Brig Rumel Dahiya (retd), Shri Vinod Misra, Shri Amit Cowshish, Gp Capt Vinay Kaushal (retd), Dr. Laxman Kumar Behera, Maj Gen Ranjit Ghosh, Maj Gen Alok Deb (retd) and the Director General, Shri Jayant Prasad for their helpful support. I am also grateful to Dr. G. Balachandran, Col P.K. Gautam (retd) and Gp Capt (Dr.) Ajey Lele (retd), who provided me with additional insights and guidance in my work.

I am grateful to many members of the Indian defence technology community as well for sharing their insights and experience. I would like to extend my thanks to Dr. S. Guruprasad, Dr. Parimal Kumar and Shri A.D. Rane of the DRDO, and Shri Umesh Singh of OFB and officers of HVF and EF Avadi, GCF Jabalpur and their supporting DGQA agencies. I would also like to acknowledge the support I received from the DPSUs, officers of BEL Ghaziabad and BEL Chennai. And among the private industry, I would like to extend my thanks to AVM Pradeep Singh (retd), Rear Adm Pritam Lal (retd), Dr. S.V. Kannan, Cmde Sujeet Samaddar (retd) and many others, both foreign and Indian.

I am especially grateful to Smt Smita Nagaraj (IAS), former Director General (Acquisition) of the MoD, who recognised my initial work and brought to my notice, critical issues faced in transfer of technology (ToT). And to officers of the three military services, the DDP and DGQA, who provided me relevant inputs.

Lastly, but most importantly, my gratitude goes out to the two anonymous reviewers, editors Neha Kohli and Vivek Kaushik and their teams at IDSA, for helping me complete this challenging task.

New Delhi
September 2019

Kevin A. Desouza

Prologue

Dear Reader,
No doubt, you have picked up this book expecting an exhaustive exploration and a textbook solution to making transfers of defence technology work in India. This indeed was my initial objective when I started out on the subject's research. Many months into my research work, however, I began to realise the deep levels of complexity involved. It took me over a year to fully comprehend its nuances and another to make sense of how these are to be addressed fruitfully. My work was also hampered by insufficient data, a result of the understandably protective ethos in Indian defence agencies. In places where concrete data was not available, I have attempted to provide indicative figures, more in order to assist you in understanding the nuance than to assert a finding. The inputs drawn from Wikipedia are of a static nature and were inserted after finding them to be the most suitable among a number of websites. I shall not dwell on the structure and flow of this book, which I am certain, you will find quite simple to comprehend. I have included the content of all six of my articles that were published by IDSA, New Delhi for comprehensiveness and your convenience. In the last chapter, I have attempted to provide as many remedies and solutions as were thrown up by my research, and I sincerely hope that they will generate enough debate within those protective walls of our defence agencies to truly make it work for India.

India took concrete steps as early as the 1950s to build its defence industrial base by setting up the Defence Research and

Development Organisation (DRDO) as well as a few Defence Public Sector Undertakings (DPSUs). These DPSUs added capacity to the already existing Ordnance Factories (OFs) for manufacturing defence equipment within the country, and both have been the recipients of foreign technology in the form of licensed manufacture contracts all through the subsequent decades. In the past decade or so, a few major indigenous systems such as the Main Battle Tank (MBT) Arjun and the Light Combat Aircraft (LCA) have materialized but despite that, a significant proportion of the needs of the Indian armed forces continue to be imported. This has generated a widely held impression that efforts at indigenous development and developing on imported technology have not been successful.[1] While the very limited budget that India could allocate through the decades and the start from scratch have been accepted as cogent reasons for the limited success in indigenous defence Research and Development (R&D), the reasons for not being able to build up on imported technology are not so easily explained.

The Indian Government's recent emphasis on achieving the country's long-held goal of self-reliance through indigenous design, development and manufacture (IDDM), indicates a belief among the leadership that this route will generate greater returns than technology transfers from abroad. However, there are a few realities which need to be accepted here. The first is the reality that India's economic capacity to spend on expensive, long gestation-period and risky R&D projects, aimed at developing state-of-the-art technology, is small as compared to that of advanced countries.[2] The second is the reality that fundamental and applied research output, which comprises the fodder for development of future technology, is miniscule in India.[3] Without this research input, the Indian DRDO and prospective private R&D entities will always need to turn to foreign sources at some stage of the value chain. The third reality is the extremely weak national innovation system and semi-developed defence industrial base (DIB), which together, preclude the development of competitive defence technology.[4] And, the fourth is the shortage of competent, innovative and creative recruits for the R&D community, a result of the rote-based, scores-focused education system and brain drain to foreign countries.[5] These weaknesses can be overcome through massive reforms and the influx of copious funds. But, these are unlikely in the short term, given the lack of strong technological leadership (unlike China) and India's economic burden of still significant poverty, under-nutrition, illiteracy, low access to medical care and lack of infrastructure. Hence, if India is to keep up with an increasingly belligerent China's rapidly increasing military capabilities, it must consider and utilise foreign technology to build up its DIB and meet the needs of its defence forces.

A very fundamental question that arises is whether countries can indeed import technology and then build capabilities in design, development and manufacture to ultimately reduce their dependence on foreign countries and thereby achieve self-reliance. A study carried out in 2007 concludes that although licensed production (a form of technology transfer) has led to a significant level of competence in the building of India's domestic defence industry, it has singularly failed to help India in the design and production of advanced weapons systems.[6] But is this true for all countries? Some countries which have recently built up such capabilities are Israel, South Korea and China. How have they achieved this? Has it been through the pursuit of purely indigenous defence R&D policies or have they been able to acquire the capability with the help of external assistance?

A recent study on the evolution of the defence industrial capabilities of these countries indicates that significant technological assistance has been received from allies and a substantial national effort has been put in to successfully capitalise on it. In the case of Israel and South Korea, the US provided latest defence systems and then the technology through licensed manufacture, joint ventures for co-development and co-production and other arrangements for technology sharing over many decades.[7] Israel also received, and continues to receive, substantial foreign aid from the US, mandating it to purchase US arms. Such foreign-aided technology transfers were possibly less restrictive than the standard ones that were purchased and which dictated that only so much technology would be given as was paid for. From another source, it is learnt that Israel also gained significantly from technology held with Russian Jewish scientists and engineers who immigrated after the collapse of the USSR in the 1990s. The study also mentions efforts at reverse engineering and espionage as routes taken by some countries to acquire foreign technology.

In the case of China, the study mentions that assistance from Russia and Israel enabled it to copy and imitate foreign systems. In addition, China evolved innovative ways to absorb and upgrade imported technology. China's technological development strategy is a four-part process known as "Introduce, Digest, Absorb, and Re-innovate" (IDAR) which aims at turning foreign technology into a re-made domestic variant.[8]

We can also draw from experiences in the civil technology domain. The United Nations Conference on Trade and Development (UNCTAD) published the collated findings of three case studies of successful transfer of technology (ToT) ventures in 2003.[9] In the Introduction, the paper emphasises the importance of ToT by mentioning how economically weaker countries can only catch up if they learn from the experience and practice of the more advanced countries. The paper goes on to describe how the firms in the case studies all acquired technology through numerous means and successfully adapted them to local conditions.

An argument of a co-researcher is that building a country's defence systems' development and manufacturing capabilities to advanced levels, is only possible after such capabilities have been acquired in the civil industry.[10] On the other hand, it is also known that advancements in the defence industry can generate spin-offs to spark and boost civil industry as was particularly apparent in the US in the 1970s. In more recent times, however, there is evidence of commercial technology leading some fields and many significant spin-ons being utilised gainfully in the defence sector. Which, then, should come first is difficult to say. Among the younger industrialised countries of Israel, South Korea and China, the rise of the civil industry to advanced levels has accompanied their success in the defence arena. In India's case, the advances made in the automobile and information technology industries and the influx of some commercial R&D ventures appears to indicate that a corresponding advancement in the respective defence sectors is therefore feasible. If this is so, the gainful absorption of foreign technology, as has been accomplished by Israel, South Korea and China, should certainly be possible by India.

Transfer of Technology (ToT), as a phrase by itself, can generate widely differing perceptions from a recipient country's perspective. For many, it can appear to be a transfer of information and hardware which allows the buyer to almost magically and independently build up on for future upgrades or even superior designs. The Indian Defence Production Policy (DPrP) of 2011 itself states that ToT would be monitored to ensure absorption of technology, after which, 'successive generations of equipment would be developed in the country'.[11] If it was as simple as that, India would have achieved self-reliance in world-class fighter aircraft, helicopters, armoured tanks, artillery guns and numerous other systems which have been license manufactured through ToT, a long time ago, considering the enormous effort put into these projects over the past four decades. Some aver that no technology *actually* gets transferred and such arrangements only create unwanted dependence on other nations.[12] Yet another view is that ToT is a half measure, not capable of creating design and development capabilities.[13] Further compounding the confusion is, as stated by Encyclopedia.com, the difficulty in defining the exact nature of this activity, partly because the term has many different connotations.[14] There exists, therefore, a strong case for the obtaining of a clear and authentic understanding of this subject.

Though many Indian papers and articles make a mention of ToT, there exists no definitive literary work, in the Indian defence environment, which provides a detailed coverage of ToT from foreign sellers to Indian agencies.[15] What exactly is the 'technology' in ToT? What are the capabilities that ToT confers on the recipient? Are there any characteristics of technology which make it more attractive for acquisition through ToT? What are the benefits and costs of ToT to the recipient? Are there any restrictions on ToT? Are there different modes of ToT, and if so, which are these? These are some of the main questions that are attempted to be answered in this book. Filling this information gap will help government policy-makers, as well as public and private companies, better understand the nuances, thereby enabling them to frame more effective policies and strategies. If this understanding is built up into intimate knowledge, it can significantly improve the quality and quantum of ToT and ultimately bring India's defence technological capabilities closer to the world leaders.

Notes

1. The inability of the Indian defence industry to absorb and capitalise on foreign technology received has been observed and commented on by numerous agencies and persons. The Comptroller Audit General has commented on the general lack of success achieved by the OFs and the DPSUs in achieving self-reliance and, in particular, the HAL in failing to absorb the technologies of the Russian Sukhoi Su 30 MKI fighter in their 2014 report at http://www.cag.gov.in/sites/default/files/audit_report_files/Union_Compliance_Defence_Army_Ordnance_Factories_35_2014, accessed on September 11, 2018. Also see Maj Gen Bhupinder Yadav (Retd), *Intellectual Property Rights and Defence Production*, http://www.defproac.com/?p=2435, accessed on September 11, 2018; Brig Gurmeet Kanwal, *Defence Procurement: Learning from Experience* at https://www.vifindia.org/article/2015/july/15/defence-procurement-learning-from-experience where the author states that no ToT has occurred, accessed on September 11, 2018; Mrinal Suman, Technology transfer under 'Buy and Make' is a misnomer, available at http://www.forceindia.net/StumblingBlocksMay2009.aspx, accessed on July 21, 2017.
2. See Laxman Kumar Behera, *Examining the Feasibility and Affordability of Raising the Share of Defence Expenditure to Three Percent of GDP,* IDSA Issue Brief, August 20, 2018 at https://idsa.in/issuebrief/feasibility-and-affordability-defence-expenditure-gdp-lbehera-200818, accessed on

January 7, 2019 where he describes the scarcity of funds for defence due to socio-economic development compulsions.

3. See Yogita Rao, 'Only 10 Indians on list of world's top scientists', *Times of India* Pune edition, January 4, 2019 where the miniscule contribution of Indian scientists to world class research is reported.
4. See http://blogs.timesofindia.indiatimes.com/cash-flow/india-is-trips-compliant-our-response-is-who-cares-this-government-has-not-been-as-ambitious-as-we-hoped/, last accessed on September 15, 2018 for an account of weaknesses in the Indian IPR framework which precludes sufficient innovation. The semi-developed DIB is evident from India's large defence import bill and miniscule defence exports.
5. As shared by a senior DRDO scientist at IDSA, New Delhi in 2017.
6. Manjeet S. Pardesi and Ron Matthews, *India's Tortuous Road to Defence-Industrial Self-Reliance*, Defense & Security Analysis, 2007, 23:4, 419–438, DOI: 10.1080/14751790701752451, p. 433 at http://dx.doi.org/10.1080/14751790701752451, accessed on September 11, 2018.
7. See Ranjit Ghosh, *Indigenisation: Key to Self-Sufficiency and Strategic Capability,* IDSA, New Delhi, 2016, pp. 46, 48, 51, 53, 61, 65.
8. Ibid., pp. 70, 72, 78.
9. UNCTAD, Transfer of Technology for Successful Integration into the Global Economy, 2003, available at http://unctad.org/en/docs/iteipc20036_en.pdf, accessed on September 11, 2018, pp. 3–24.
10. Gp Capt Vinay Kaushal (retd) in a fellows' seminar at IDSA on April 20, 2017.
11. Government of India, Ministry of Defence, Defence Production Policy, 2011 at https://mod.gov.in/dod/omsorders/defence-production-policy-2011 accessed on September 11, 2018.
12. Mrinal Suman, 'Technology Transfer under "Buy and Make" is a misnomer', *Force Magazine*, October 2014 at http://www.forceindia.net/StumblingBlocksMay2009.aspx, accessed on July 21, 2017.
13. K.G Narayanan, 'Doctrine of Self Reliance in Defence Technologies: Road to Nowhere or Way to Go?', *Journal of Defence Studies*, 4(3), July 2010, p. 33.
14. See http://www.encyclopedia.com/topic/Technology_Transfer.aspx, accessed on September 11, 2018.
15. A DRDO publication covers the procedure for ToT from DRDO agencies to Indian firms. See https://www.drdo.gov.in/drdo/English/IITM/DRDO-guidelines-for-ToT.pdf, accessed on September 12, 2018. However, knowledge contained within this document has extremely limited applicability to the subject of ToT from foreign sellers.

1

A Brief Historical Perspective[1]

India's journey towards production of modern defence equipment has been slow and arduous. The Ordnance Factories (OFs) were established with British technology in the 1800s and 1900s, and these were utilised to some extent for meeting the domestic needs of the subcontinent and those for the two World Wars. Since their capabilities were limited, the decade post-independence, saw the direct acquisition of weapons systems from the major military powers.[2] Simultaneously, a start was made in the 1950s to establish a Defence Industrial Base (DIB) by the setting up of the Indian Defence Research and Development Organisation (DRDO) which was tasked to indigenously design and develop defence systems for the Indian military services. This was accompanied by the establishment of a few Defence Public Sector Undertakings (DPSUs) which would take on the manufacturing of defence systems.[3] The next few decades saw the collaborative military production (a variant of today's ToT) programmes of foreign weapon systems such as the Alouette helicopters, 106 mm recoilless guns, Nissan jeeps, Shaktiman trucks and Gnat fighter aircraft from the French, the US, Japan (Nissan), West Germany (MAN) and Britain (Folland Aircraft), respectively.[4]

These contracts essentially enabled the assembly of parts of the equipment in India, in what has typically come to be known as licensed production (LP). The foreign firms would provide a 'license' to assemble and produce a defined number of equipment using parts which were supplied by them. After an initial supply of fully-formed (FF) equipment to acquaint the Indian workers with the operation, maintenance and testing aspects, the equipment were supplied in what was later termed as Semi-Knocked Down (SKD) kits and consisted of a collection of the major subsystems. The foreign firm provided the know-how to assemble these and then test and 'produce' the fully-formed equipment. Once this capability was reached, smaller parts would be supplied in Completely Knocked Down (CKD) kits for enabling more production activity and greater value addition in the Indian factory.

Early in the 1960s, India approached the British to allow Licensed Manufacture (LM) (another variant of ToT) of the Lightning fighter aircraft. This was refused and hence the Soviet Union was approached, leading to an agreement in 1962 to produce the MiG 21 fighter aircraft in India.[5] This was the start to a long defence technology relationship with the Soviet Union. By 1980, nearly 70 per cent of Indian military hardware was of Soviet origin.[6] India however, also maintained an open stance for receiving LM offers from the other major powers such as Britain, France, Germany and other European countries.

The LM mode improved on the LP by adding an indigenous manufacture (IM) stage after the FF, SKD and the CKD stages. In this stage, components of the equipment were manufactured in India using the know-how received from the foreign firm, and where possible, Indian raw material. However, many parts still needed to be supplied by the foreign firm which manufactured them using its proprietary technology and these were termed proprietary parts. A collection of the proprietary parts, required for a single equipment, came to be called an Indigenous Manufacture (IM) kit.

Licensed manufacture as the preferred means of acquiring high population major defence systems was not without hitches. In the MiG 21 programme with the Soviet Union, shortages of trained manpower and poor quality facilities hampered production, which was limited to the assembly of sub-systems and major parts. Complaints of poor quality of the produced aircraft also plagued the Hindustan Aeronautics Limited (HAL), the DPSU which produced the aircraft.[7] Delayed timelines due to various reasons, forced the outright purchase of more aircraft such as the 50 Hunters from the UK and 150 Su-70s from the USSR.

In the 1980s and 1990s, the Indian DIB showed signs of being able to deliver some indigenous systems. Some of the well-known programmes are the Main Battle Tank (MBT), the Light Combat Aircraft (LCA) and a string of missiles systems under the Integrated Guided Missile Development Programme (IGMDP).[8] Progress however, was slow and many voids in other fields of military capability existed. Hence, LM continued for the induction of large population systems such as the T 90 tanks, Flycatcher and Reporter radars. It was probably around this period in the 1980s and the 1990s that these LM contracts started being termed as Licensed Manufacture with Transfer of Technology (ToT) or simply ToT, technology being the wherewithal required to manufacture a substantial portion of the parts.[9]

In 2001, the Indian Government decided to take a quantum step ahead in its economic liberalisation policy by opening the defence sector to private companies.[10] In order to maintain a transparent and efficient process, the Ministry of Defence (MoD) drew up and promulgated the Defence Procurement Procedure (DPP) in 2003. This would guide all the connected agencies and enable faster processing of acquisitions in the desired competitive scenario. Licensed Manufacture under the head 'Transfer of Technology' (ToT) was included in the DPP and its subsequent revisions.

In the past decade, despite the introduction of a number of indigenous systems such as the MBT Arjun, Advanced Light Helicopter (ALH) Dhruv, Akash Air Defence weapon systems etc., imports continue unabated. In fact, India is one of the largest importers of military equipment in the world today.[11] Among the systems being imported, many are being manufactured or proposed to be manufactured under ToT. These include the Sukhoi 30 MKI fighter aircraft, the battle tank T-90, the Scorpene submarine, the Light-weight Long-range Transportable Radar (LLTR) and many others. Besides these, there are the successful Brahmos missile and the Long Range Surface to Air Missiles (LRSAM) systems which have been developed through partnerships with Russian and Israeli firms respectively, the technology that they brought being the winning factor.

In 2008, Defence offsets were introduced in the DPP. These provisions were subsequently revised and a Defence Offset Guidelines issued in 2012. These guidelines listed six different avenues for their execution. Out of these, four pertain to some form of ToT, indicating the significance being accorded by the Indian Government to the field.

On September 25, 2014, the Indian Government launched the Make-in-India campaign with the primary goal of making India a global manufacturing hub. This was to be achieved by encouraging multinational and domestic companies to manufacture their products within the country, for the domestic as well as the global market. Defence manufacturing was one of the 25 sectors selected by the Make-in-India initiative.[12] A defence deal was signed during the Indian Prime Minister's visit to Russia in December 2015 which will see the Kamov Ka-226 multi-role helicopter being built in India. This is widely seen as the first defence deal to be actually signed under the Make-in-India campaign.[13]

By 2016, India was deluged under a plethora of ToT proposals from a number of developed countries and their firms. Foremost was the USA which offered 17 technologies, with another 24 on the cards. These did not include four 'path finder' projects which were identified by India and the US for co-production of defence products based on comparatively simpler technologies.[14] Besides the US, firms from numerous other developed countries had also joined in to offer ToT for a number of defence systems, some as significant as fighter aircraft and submarines. One of these firms offered 'robust' and 'no holds barred' ToT[15] while another offered 'true'[16] or 'real' ToT with ' full control over system design and software'.[17]

In mid-2017, the Indian MoD released a chapter of the DPP 2016, which spelt out a new initiative of selecting Indian private firms as "strategic partners" for the manufacture of four major systems—fighter aircraft, helicopters, submarines and armoured fighting vehicles. Once nominated, these Indian firms are expected "to seek technology transfers and manufacturing know-how to set up domestic manufacturing infrastructure and supply chains".[18] This is a major step for the country which has traditionally depended on the DRDO and the state-run OFs and DPSUs for developing and producing such systems to meet the needs of the defence forces.

A broad look at the facts above, indicate the significant contribution that was made, that is possible and that is expected from ToT contracts with foreign firms. More than four years past the announcement of the Make-in-India initiative however, there are no significant successes reported in ToT projects. Instead, an increasing number of delayed and scrapped ToT projects are being reported.[19] This is despite an experts committee having submitted a detailed report (which included ToT) on the way forward in July 2015 and the government issuing detailed procedures in the DPP 2016. Why this is so, is a puzzle which calls for a fresh look and deep introspection. The first step clearly is to understand the nuances of ToT from the fundamental levels and work our way through to how the desired goals can be achieved.

Notes

1. A major portion of this chapter is taken from the author's article "Transfer of Defence Technology to India: Prevalence, Significance and Insights", *Journal of Defence Studies*, IDSA, October 2016 at http://www.idsa.in/jds/jds_10_4_2016_transfer-of-defence-technology-to-india, accessed on September 12, 2018.
2. Ron Matthews, *Defence Production in India*, ABC Publishing House, New Delhi, 1989, pp. 35–37.
3. Laxman Kumar Behera, *Indian Defence Industry: Issues of Self Reliance*, IDSA Monograph Series, New Delhi, No. 21, July 2013, pp. 14–21.

4. Ron Matthews, note 2, p. 39.
5. Ibid., p. 42.
6. Laxman Kumar Behera, note 3, p. 40.
7. Ron Matthews, note 2, pp. 60–61.
8. Ramadas Shenoy, *Defence Research and Development Organisation 1958-82,* DESIDOC, DRDO, Delhi, 2006, pp. 271-272.
9. See Sakti and Indrani Mukherjee, *International transfer of Technology*, Mittal Publications, New Delhi, 1989 where the authors use the term ToT to represent LM.
10. Laxman Kumar Behera, note 3, p. 44.
11. See *Times of India*, 'India Flounders in Attracting FDI in Defence Production, Gets only Rs 1.17 Crore in 4 Years' at https://timesofindia.indiatimes.com/india/india-flounders-in-attracting-fdi-in-defence-production--gets-only-rs-1-17-crore-in-4-years/articleshow/63207644.cms, accessed on September 12, 2018.
12. See http://www.makeinindia.com/sectors, accessed on July 29, 2016 where the defence manufacturing sector is listed.
13. See https://en.wikipedia.org/wiki/Make_in_India, accessed on September 12, 2018.
14. See Amit Cowshish, *Indo-US Defence Cooperation: Harvesting Defence Technologies* at http://www.idsa.in/idsacomments/IndoUSDefenceCooperation_acowshish_131015, accessed on September 12, 2018.
15. See http://economictimes.indiatimes.com/news/defence/germany-offers-india-deal-for-next-generation-submarines/articleshow/52138779.cms, accessed on September 12, 2018.
16. See P.R. Sanjai, http://www.livemint.com/Companies/RPY9NAB0BQNaSrKaCThOAI/Saab-offers-to-make-Gripen-in-India-with-transfer-of-techno.html, accessed on September 12, 2018.
17. See http://economictimes.indiatimes.com/news/defence/iaf-modernisation-plan-saab-offers-gripen-fighter-jets-under-make-in-india-with-full-control/articleshow/50253759.cms, accessed on September 12, 2018.
18. 'Def PSUs, Ordnance Cos can Compete for Sub Deal', *Times of India*, May 21, 2017.
19. Newspapers and defence magazines published in 2018 have reported delays in numerous ToT projects such as the Scorpene submarine one, the scrapping of the Israeli Spike anti-tank missile project and the South Korean advanced mine sweepers project due to ToT issues and many obstructing issues such as US firms communicating their inability to provide the full ToT being asked for by the Indian Government.

2

Understanding the Nuances[1]

Introducing the term 'Technology'

The last few centuries have witnessed an exponential growth in scientific discoveries and inventions. These were put to practical use for a variety of purposes—from mass production of articles, to transportation, to communication, to improving the quality of life of people and building military might. The Oxford Dictionary defines this application of scientific principles for practical purposes as 'technology'.[2] The word has a historical origin in the 17th century from the Greek tekhne (art, craft or a way in which things are gained) with logos (word, speech) which would literally translate to "words or a discourse about the way things are gained", but otherwise be understood more closely as *tekhnologia* or 'systematic treatment'.[3]

Today, the word 'technology' is frequently used and can have several connotations. An all-encompassing view sees it in five entities. It is a *process* by which scientific principles are applied, or the *devices* created by this process, the *knowledge* that makes the process possible, a *subset* of the devices and knowledge required in a certain field e.g. Automotive technology and finally the *system* containing all these with their developers and users.[4] A view which is more focused on the wherewithal required to deliver, however, would go by the definition that technology comprises "skills, methods and processes used in the production of goods or services or in the accomplishment of objectives, such as scientific investigation". Technology can be either the knowledge of such methods or it can be embedded in the working of machines.[5]

Transfer of Technology and its Broad Classification

The *transfer* of technology (ToT), has similarly been defined in numerous ways. One of the simplest and universally applicable definitions says that it is the process by which technology or knowledge developed in one place or for one purpose is applied and exploited in another place for some other purpose.[6] This movement could involve physical assets, know-how and technical knowledge.[7] The UNCTAD draft International Code on the Transfer of Technology (the draft ToT Code), describes technology transfer as the transfer of "systematic knowledge for the manufacture of a product, for the application of a process or for the rendering of a service".[8] Another definition, in the academic sector, defines it as the process of commercialisation—or of bringing technologies to the marketplace.[9]

The variance in definitions can be understood with a little more clarity, from the knowledge of the types of transfer—which can be vertical or horizontal. Vertical transfer is the transfer of technology from fundamental research to applied research to development of the product or process and then to production, while horizontal technology transfer is the movement of technology used in one place, organisation, or context to another place, organisation, or context.[10] For some unfathomable reason, existing literature largely uses the phrase 'Technology Transfer' (TT) for describing either of the two forms, while 'Transfer of Technology' (ToT) is used typically for the latter.[11]

ToT can also be broadly classified into four categories based on the nature of technology suppliers and recipients.[12] The first is international technology transfer, after being developed in one country, to the firms of another country as is commonly seen in the defence technology domain. The second is North-South technology transfer from the developed to the undeveloped countries for accelerating economic and industrial development as prompted and encouraged by the UN and the other world bodies. The third is the transfer of private technology from one company to another. And the fourth is the transfer from universities or research laboratories to companies for commercialisation. International technology transfer and North-South technology transfers tend to be driven directly by foreign policy and national economic concerns, while the other two types are driven by a balance of corporate, business and policy interests.[13]

Understanding the 'technology' in ToT

This book focuses primarily on horizontal transfer of defence technology from foreign sources to the Indian industry while drawing relevant lessons from the others. When seen with an emphasis on industry, this horizontal ToT covers the transfer of the "*skills, knowledge, methods of manufacturing, samples of manufacturing and facilities*". Or as the transfer of "*an organised knowledge of production*", with "*a set of instruments or tools, materials, know-how and abilities*" which may be "bought and sold as *capital goods, human labour* and *information*".[14]

In the International defence environment, there are references to 'technology' being specific information necessary for the 'development', 'production' or 'use' of a product. This information could be in the form of technical data or technical assistance. 'Technical data' may take forms such as blueprints, plans, diagrams, models, formulae, tables, engineering designs and specifications, manuals and instructions written or recorded on other media or devices such as disk, tape and read-only memories. 'Technical assistance' may take forms such as instruction, skills, training, working knowledge and consulting services.[15]

In the Indian Defence environment, there are references to technology being the complete expertise (engineering-manufacturing documentation to enable fabrication, assembly and test of item), or expertise to maintain the system in service (called Maintenance ToT).[16] While another relates to it as the process of licensed manufacture and yet another (this by the DRDO) quotes the National Academy of Engineering (India) as defining it as "*including all the infrastructure necessary for designing, manufacture and repair of technological artifacts-engineering know-how, manufacturing expertise and various technical skills—all are equally important parts of technology*".[17] In DRDO's Guidelines for Transfer of Technology, the word 'technology' has been used to denote any design, know-how, process, product, subsystem and system.[18] The Indian government's Defence Procurement Procedure (DPP)[19] states that ToT (when contracted) shall be "*comprehensive, covering all aspects of design, manufacturing know-how and detailed technical information which will enable the Production Agency to manufacture, assemble, integrate, test, install and commission, use, repair, overhaul, support and maintain the license product. Design data shall include the details that are needed to give design disposition during production on deviation/concession; modify/upgrade the license product and substitute parts and systems of the license product as required by the certifying agency and the production agency.*"

From a study of all these definitions, two distinct aspects of technology, in the context of ToT, come to the fore. One aspect covers its components such as knowledge, skill, expertise, know-how, methods, technical data, documents, machines, tools, end-products, infrastructure etc. and the other specifies the capability that it delivers i.e. development/creation of the product, manufacture, use, maintain, repair, overhaul, etc.

The Components of Technology in ToT

A closer examination of the first aspect i.e. the components, reveals three distinct categories—one, technical data or information, two, hardware comprising of sample products, machinery and infrastructure and three, technical skills and abilities; each with their own nuances of transfer. Technical data or information can be transported through paper documents or digital media and pose no problems for effective transfer or absorption, unless they require translation. The second, sample products, machinery and infrastructure, requires transportation by different modes and matching resources such as industrial power and water. The transfer of the third category, technical skills and abilities, which can only be carried, transferred and absorbed by humans, is a little more challenging. Widely differing technical capabilities between the seller's and the buyer's reps, coupled with differing work cultures and languages can sometimes make the transfer and effective absorption of this category an extremely daunting task. It is interesting to note that technical skills such as know-how are also considered Industrial (now Intellectual) Property (IP) along with technical data and information and these are treated at par with property such as machinery or infrastructure.

The Capabilities Conferred by ToT

The second aspect of ToT, that is, the capability that it delivers, also needs further deliberation. Going by this aspect, we have definitions of two types of ToT which are already in common use in the Indian defence environment. One is ToT for Manufacture, which is generally referred to as simply ToT, and the second is ToT for Maintenance/Repair/Overhaul (MRO), commonly referred to as MToT. Are there any other variants which exist? The definitions above mention that ToT is implemented to enable the 'use' of the product. Should ToT also not therefore cover an Operate ToT or OToT, especially since such contracts for 'Operate and Maintain' have been executed in the past?[20] There are also MToT variants with differing depths for maintenance, repairs and overhaul of the product. For the sake of comprehensiveness, it is worthwhile covering all variants.

The definitions of technology discussed earlier, also include a 'development' capability and a 'design' component. Does this mean that ToT could also empower the technology recipient to design and develop its own products? A glance at the general nature of ToT arrangements discussed in various literature and the media indicate that such arrangements are extremely rare.[21] In the Indian defence environment, though no specific references have been made, there is indirect input that such a transfer, if at all acceptable to the supplying country, would cost an enormous amount running into a hundred times that of manufacture.[22] Yes, the passage of the DPP which describes design data as conferring the 'disposition to deviate from specifications or modify or upgrade a part or substitute the part', does aspire for a minor form of such a transfer, but in a very limited sense, more as a measure to overcome potential stoppages in manufacturing than for the development of new products.

Despite its near non-existence, it may be worthwhile defining such a transfer as Design & Development ToT (D&D ToT), if only to refer to a transfer that is strongly sought after by technology seekers. In the case of the DPP, the additional capability that is requested for may be termed as a ToT with capability for limited design deviations/modification/upgrade, which we could abbreviate as DToT (Limited).

So a holistic view of ToT and its variants can be drawn up as in Table 2.1. The variants are listed in increasing order of capabilities conferred and depth of technology transferred. It has been the general observation that contracts for each level of ToT also invariably include the previous level. For example, an MToT would automatically involve an OToT, or a PToT would automatically involve an OToT and an MToT. Also, the 'deeper' the ToT, more is the capability (and hence self-reliance) conferred.

Table 2.1: Assigning of ToT variant definitions

Capability desired	ToT needed
Operate	OToT
Maintain	MToT (M)
Repair	MToT (MR)
Overhaul	MToT (MRO)
Produce/Manufacture/ assemble/integrate	PToT
Minor Design deviation/ modification	DToT(Limited)
Upgrade/develop variants/ develop alternate products	D&D ToT

↓ Deeper

Source: Prepared by the Author

Process and Product Technology

Another categorisation of the components of technology being transferred is the division into process technology and product technology. Process technologies include manufacturing ones such as wave soldering and laser cutting and testing ones such as ultrasound or X-ray analyses. Product technologies, on the other hand, consist of material composition, form dimensions, designs and other details which define the end-product. A product is manufactured and tested through numerous processes and each process can be used in the manufacture or testing of numerous end-products. ToT agreements typically cover product technologies and their generating process technologies, in case the latter are not already available in the recipient country. Though one should not compare the two, transfers of process technology are less frequent, and in most cases, more expensive, compared to that of product technology.[23]

The 'Know-Hows' of Manufacture and 'Know-Whys' of Design

Achieving or acquiring the capability to design and develop its own systems is undoubtedly the ultimate goal for any country.

What exactly are the components of knowledge which enable such a capability? And why is it not possible to acquire it through the apparently non-existent D&D ToT? The answer can be discerned from a close examination of the difference in D&D ToT and PToT. Manufacturing, enabled by PToT, primarily requires 'know-how' which Wikipedia defines as the practical knowledge on how to accomplish something.[24] The knowledge of 'how' to fabricate the concerned parts, 'how' to test them, 'how' to assemble the parts, 'how' to inspect and test them as an integrated whole, are all elements of know-how required for production. In some cases, additional knowledge is provided in order to know 'how' to rectify or offset deviations in quality of the parts and 'how' to modify the system keeping within the specified limits. What this 'know-how' does not include however, is the knowledge required to carry out major modifications or upgrades or manufacture future, more capable versions of the product. This additional knowledge, which has been referred to as the 'know-whys' of design, is not divulged by the technology seller simply because, by doing so, the technology recipient acquires the knowledge to design and build products which could compete with those of the technology seller. Development of military systems necessitates an immense amount of investment in terms of money, time and resources. Why then would a developing firm or country fritter this investment away to a likely competitor?

A little more insight on what is meant by 'know-whys' is in order here. Let us take the simple example of a helicopter blade. The know-how needed to manufacture it would include the method to deliver a blade with a specified metallurgical composition using a specified process of moulding or forging to provide a desired shape, dimension and strength. This combination of the right composition, process, shape and strength would ensure the blade provides a certain amount of thrust at a certain speed of rotation without it deforming or breaking within a certain amount of usage. Possible compositions could number up to many hundreds and so also would the types of processes, shapes and strengths. The developing firm would probably have taken many hundreds of iterative experiments and trials using extremely expensive laboratory instruments to meticulously document and arrive at a conclusion as to 'why' a particular combination of composition, process and shape are optimal. If this documented knowledge, sometimes referred to as a 'legacy document',[25] were to be obtained by the recipient firm, it would empower the firm to further improve the blade without depending on any inputs from the developer. In many cases, however, the knowledge acquired during development may not be fully documented resulting in a component of knowledge known only to the developing scientist(s). This component, referred to as 'tacit' or 'implicit' knowledge, is acquired from 'learning by doing' patiently over many years and is generally difficult to acquire through formal ToT.[26] Large scale, collaborative R&D work that is prevalent these days, also means that this knowledge is held by large numbers of scientists, each specialising in contributory fields, therefore making a meaningful transfer (even if genuinely intended), extremely difficult.

Does the near non-existence of D&D ToT mean that no transfers occur during and immediately after the Research and Development (R&D) stage? Literature published in the field indicates that this is not necessarily true. The proliferation of research activities among the small and even micro enterprises today, throw up situations where a company may not have the means to undertake commercialisation or the company prefers to receive a once-off lump sum payment for the innovative technology.[27] In collaborative research too, situations arise where a transfer of IP ownership from one of the collaborative research partners to another is effected to allow the partner to go ahead alone.[28] Since technology also matures in stages as is depicted in the Technology Readiness Levels (TRL) concept of the Department of Defense, USA, it is quite possible that small research firms may not be in a position to take spin-off technologies to maturity and decide therefore to sell it to another firm in return for suitable remuneration.[29] We shall dwell more on this aspect in the chapter on exploring all avenues ahead. For now, we shall assume that ToT essentially implies that which delivers production capability or what we have termed PToT.

Intellectual Property Assignments and Licenses

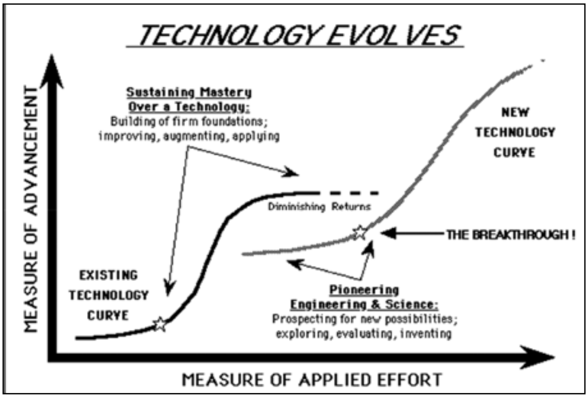
How are technology transfers actually implemented? Since 'technology' exists in the form of property—physical and intellectual, ToT essentially translates into either an assignment of the property or licensing of the use of these properties by the technology holder to the technology recipient. An intellectual property (IP) assignment is a permanent transfer of ownership of an IP, such as a patent, trade mark, copyright or know-how, from one party (the assignor) to another party (the assignee) on the payment of an agreed remuneration. Consequently, the assignee becomes the new owner of the intellectual property. A licence agreement, on the other hand, is a contract under which the holder of intellectual property (licensor) grants permission to another party (licensee) for the use of its intellectual property, within the limits set by the provisions of the contract.[30] These typically involve either a one-time fee for use of the license or a royalty fee to be paid for every product manufactured through the use of the license. Assignment and licensing are considered the primary forms of 'commercialisation' of technology.

In cases of collaborative effort, agreements normally specify that the technology which each partner brings is protected as *background* IP and may be used by the other on the delivering of a specified remuneration. Technology that is developed jointly then assumes the form of *foreground* IP that is owned jointly.[31]

Technology Evolution

Technologies go through a life cycle which initially starts as a phenomenon being discovered in a laboratory through fundamental or basic research. This could lead to inventions which use this phenomenon. The concept of utilising this phenomenon or the invention for a specific purpose is then proven through applied research. If successful, the concept is developed into a prototype and tried in real life conditions. If successful, it is then productionised. Even after production, technologies are continually improved upon, increasing their utility and reliability. As a newer technology appears on the horizon, the technology is exploited fully for maximum returns and eventually retired to give way for the new technology. This life cycle is depicted very aptly by the Technology S curve shown in Figure 2.1.

Figure 2.1: The Technology S Curve



Source: https://carteblancheleeway.wordpress.com/tag/s-curve/

The stage at which a technology is adopted is critical to its economic exploitation. Adopting a technology at a very nascent stage when the technology is not fully ready may throw up teething problems in manufacture[32] and poor reliability of the product, while the adoption at a very late stage will result in difficulties in maintaining it due to obsolescence issues.

In the context of defence technology where the competitive edge over an adversary is crucial, the importance of acquiring a *new* technology with a critical edge is immense. Countries which have developed cutting-edge technologies are, therefore, reluctant to participate in deeper forms of ToT immediately, no matter what the price offered.[33] However, they may be willing to do so at a later stage when they have developed a newer replacement. Commercially too, advanced or newer technologies would cost more and recipients may have to understand this during their acquisition cycles. Most developers will naturally attempt to squeeze the most out of their developed technologies and will be unwilling to assign their full and unfettered rights until the technology holds no promise for further development.

Life Span and Potential of Technologies

As brought out in the section above on evolution, technologies have a limited life span. As technologies advance at an exponential rate, so does their obsolescence rate, causing the average life spans of technologies to become increasing shorter. Computing hardware which had a life of around 10–15 years in the 1980s, today has a life of no more than five years. The lives of technologies also vary greatly among different disciplines. A typical defence system such as a battle tank, missile system, artillery gun, ship or aircraft would comprise of parts of four broad disciplines namely - metallurgical, mechanical, electronics and information systems. For economic considerations, systems are typically exploited to the full extent of the lives of the most durable parts, with upgrades replacing those parts which have become obsolete. It would therefore be useful to attempt an estimation of lives of each of the disciplines as detailed in Table 2.2.

How is this information relevant to ToT? One, it provides the perspective that ToT cannot sustain the defence needs of a country for an indefinite period of time and going ahead, the lives of technologies will become increasingly shorter, necessitating more frequent ToT.[34] It also provides the perspective that electronics and information systems will most likely require upgrades (through a ToT) at some point of time in the life of large systems such as war ships, tanks and aircraft.

Table 2.2: Life of Technologies

Technology discipline	Life in years
Metallurgical/material e.g. bodies, frames, structures of ships, aircraft, battle tanks, etc.	20-50
Mechanical moving parts e.g. Engines, gearboxes, breech mechanisms, mechanical linkages	15-30
Electronic subsystems e.g. Radars, communication systems, night vision devices, Thermal imagers, etc.	10-20
Information systems and software	5-10

Source: Prepared by the Author.

Note: Figures are intended to be indicative only.

Discoveries and inventions have varying levels of impact in the world of technology. They also have different potential for exploitation. What if there are two or more competing technologies which have different potentials for growth? Take the example of LCD versus OLED display technologies. While both are equally competitive through their respective strengths, OLED technology holds the promise of flexible (bendable and roll-able) displays which is likely to revolutionise how gadgets are designed, used and stored.[35] From the ToT perspective, obtaining the one with greater potential would give a head-start at a later stage when improvements/upgrades are needed.

The Global Factory and ToT

Globalisation of production has been getting increasingly evident over the last decade or so. Cheaper and widespread information networks coupled with cheaper transportation are the primary drivers behind this model which has led to the increasing division of production into separate stages carried out in different locations. As domestic firms move part of their production to other countries, we see that technology, knowledge and capital become more important than land, the traditional source of state power. Technological changes, including the rise of e-commerce, have made global operations cheaper and more manageable. Managers in companies with global operations have learned to 'fine slice' their activities and to locate each 'stage' of activity in its optimal location and to control the whole supply chain, even when not owning all of it. These technological and managerial drivers have been augmented by political changes towards far more openness in previously closed economies.[36]

In the above scenario, it is clear that outsourcing of product development activities including design of sub systems, accessories, etc. is not only here to stay, but is likely to increase in the future. Technology seekers must, therefore, critically assess the foreign supplier's actual possession of technology and his capability to transfer it.[37]

'Spin-ons' from the Civil Domain

Till the 1970s, military technology was always ahead of its civil counterpart. Spin-offs from these military technologies were proclaimed to be one of the significant benefits of running military R&D programmes. In the past decade or so, however, the reverse is being increasingly seen.[38] Newer technologies, such as Nanotechnology and Biotechnology are expected to progress much faster in the civil domain as compared to the military, since their civil applications hold much more promise and large conglomerates are willing to invest massively in their development. ToT in these leading civil areas may, therefore, provide a fillip to their respective military production capabilities.

Absorption of Technology

Absorption of technology can be defined as the process involving the physical acquisition of the constituents of technology followed by their development or modification to suit the transferees needs (such as language translation or conversion to local units of measurement), followed again by assimilation of the knowledge/technology to build competence in utilising it independently and finally, putting it into successful practice.[39] Where technology can be used in the same form that it is delivered, the process is called technology *adoption*, while if there is a need to modify it to match with existing infrastructure, processes, workforce skills, etc., it is termed technology *adaptation*. Since such differences invariably exist, absorption aims at arriving at a stage where the technology is successfully adapted to deliver products of the desired quality. Though the quality standards of the foreign seller firm are always targeted, a shortfall may have to be accepted due to the limitations of a workforce working at new skills and processes and the local supply of lower quality or non-matching raw materials, components and parts.

It is usually taken for granted that the technology provided by a transferor will be absorbed fully by the recipient firms who are eager to put it to use. Mere desire however, is not enough. In general, the larger the gap in the technology used by the transferor and transferee, the more difficult and expensive it becomes to absorb the transferred technology.[40] In some cases, the investment required may be too high to be economically viable and assessing this aspect beforehand is obviously imperative. More specifically and taking each of the three constituents of technology, we find that full absorption of technology will require a few pre-conditions. The first constituent of technical literature will require the recipient workforce to be adequately literate and technically competent enough to read and assimilate the know-how provided in them. The second constituent of machinery will need to be installed with matching industrial machines and infrastructure such as forging or wave soldering machines and temperature, humidity and dust free rooms. And the third constituent of technical know-how will require a motivated, receptive and versatile workforce to assimilate new skills and manufacturing techniques through training sessions conducted in foreign language translations and hands-on work with new machines. Numerous challenges exist and these will need to be addressed by the top management to motivate the workforce, monitor progress and take timely mid-course corrections.

Successful absorption requires the developing of good understanding and mutual trust between the transferor and transferee organisations, based on a well-defined agreement, executed in a target oriented schedule, using multi-functional teams of the transferee and strong leadership with effective communication skills for overcoming the resistance to change. Sufficient motivation of the recipient workforce is imperative especially to overcome the 'not invented here' syndrome.[41] Greater technical ability and innovative skills help the transferee workforce to adapt quickly and effectively. R&D personnel of the transferee firm can hence be immensely useful in bridging the technological gap between the transferor and the transferee firms.

How is the level of absorption achieved to be assessed? The quality of the final product, time and resources used, avoidable wastages due to manufacturing defects and confidence of the workforce as well as customers are strong indicators of the level of absorption. The quantum and speed of absorption is likely to be high in the initial stages, gradually slowing down as it reaches its optimal level after sufficient hands-on work. Changes in design necessitated by the use of local raw material or parts with differing specifications or changes in customer's requirements to suit local conditions can create delays. Also, process technology is invariably capital intensive and labour saving in the developed transferor countries while transferee countries such as India may opt for older, cheaper, labour intensive machines which invariably deliver lower product quality.[42] Addressing these changes requires good coordination with the transferor's designers and some amount of design knowledge of the transferees.

It has been established that more-developed countries are in a stronger position to absorb technology.[43] In some cases, the high level of technology of the transferees has enabled them to even bring about improvements to the product.[44] Hence, transferee countries and firms stand to benefit greatly by improving their technology levels through education and indigenous R&D efforts.

Benefits of PToT to the Seller

The primary benefit of PToT to technology sellers is the revenue through which they can recover their R&D costs and build profits. Besides this, some companies may use PToT to create an industry standard such as GSM and CDMA for mobile phones. Establishing such a standard would provide them a head-start and enable capturing a larger share of the market. Some companies may sell their technology to partner a firm that has the resources or complementary assets needed to commercialise it.[45] Governments use PToT of defence systems as an instrument in building strategic relations with another country. In doing so, they also provide a fillip to their own defence industries which supply proprietary parts and machinery for maintenance, repair and overhaul. Once the buyer countries become dependent, the seller country acquires the ability to apply pressure through linkage or leverage on the buyer country to accede to more agreeable policies.[46] At times, this dependency can hinder the operation of ToT-manufactured systems when critically needed and may therefore, impinge on a country's defence technological sovereignty.[47]

Benefits to the Recipient

There is no doubt that PToT has some distinct benefits for the recipient country. Besides the primary benefit of meeting the particular need in a cheaper, faster and easier method than developing the product from scratch, PToT has many side benefits.[48]

First, the acquisition of technology in physical form leads to an awareness of its capabilities in the recipient country. This 'technology diffusion', provides a fillip to the overall technology awareness in the country and motivates people in various sectors to strive for higher, more productive means.[49]

Second, new technology for manufacture brings new industrial machines and processes and thus helps to modernise the production system. New processes require enhanced skills which are acquired by the work force of the recipient country.[50]

Third, production lines invariably need subsidiary firms to manufacture ancillary parts and therefore it promotes local value chain development accompanied by industrial growth and economic development.[51]

Fourth, increased production through PToT would create jobs leading to increased employment and also tax revenues.[52]

Fifth, the replacing of outright purchase with local manufacture would lead to a savings in foreign exchange and a reduced dependence on the foreign source for system sustenance. In cases where there is a potential for export and the PToT provides access to the OEM's global supply chains, it could bring in foreign exchange and improve the country's trade deficit.[53]

Sixth, foreign technology invariably requires some level of adaptation to match local conditions. The need for this adaptation of the new technology can drive innovation and technological prowess within the recipient country.[54]

Seventh, the technology transferred can be used to complement existing or planned indigenous technology for its commercialisation.

Eighth, higher, world-class technology transferred to the country will foster the local development of internationally competitive enterprises.

The Costs to the Recipient

The flip side is that the price of PToT is often challenged as being exorbitant since technology seller firms have been known to take advantage of the oligopolistic nature of the imperfect high technology market. Besides the basic cost (which is itself difficult to value accurately and can be easily inflated), technology suppliers have been known to extract excessive returns through a multitude of measures listed below.[55]

- High royalties and fees for licensing subsequent batches of production cause a heavy burden.
- Costs for right to use the trade marks.

- Costs through artificially hiked up prices of parts from intra company sales.
- Costs for profits capitalised in the acquisition of shares in the receiving company.
- Costs for some parts of the profit of fully owned subsidiaries which have no special provision to pay for technology transfer.
- Costs due to overpricing of capital goods sold to the transferee i.e. industrial machines and equipment.

One would assume that PToT to a less developed country with significantly cheaper labour and infrastructure, such as India, would enable manufacture of products at a cheaper price than that supplied directly by the foreign seller firm. This assumption is unfortunately, not always true. Ron Matthews cites the examples of Gnat fighters which were produced in India, at a unit cost of US$ 2.5 million which was in excess of the import price, and of the Anglo-French Jaguar aircraft which, in 1980, was estimated to be produced at Rs 200 million which was double that of buying the plane from Britain.[56] This aspect of costlier PToT delivered products is true for developed countries too. In a more recent document, he states emphatically that "licensed production adds considerably to cost" and "is several orders of magnitude more expensive when compared to off-the-shelf acquisition" while discussing a successful licensed production of a British aircraft in the US and the licensed production of the US Boeing Apache helicopters in the UK which cost £ 40 million per helicopter compared to £ 12 million that Israel paid for helicopters directly purchased from the US around the same time in the late 1990s.[57]

Why is PToT Costlier than Outright Purchase of Systems?

Literature providing a statistical basis for reasons why PToT manufactured systems are costlier than those produced by the OEM is not readily available.[58] However, a collection of views from various sources suggest that besides the hiking of costs of licenses, shares and capital goods by the seller, ToT involves additional costs in the acquisition of new factories and process technologies or reconfiguring, re-equipping and retooling existing ones. These acquisitions can be doubly expensive if they are not utilised after the ToT enabled manufacture of the systems needed is completed. Then there is the training of workers and a costly learning period where defects will occur though in decreasing magnitude as skills improve to the optimal, transport of sub-assemblies and parts from overseas locations to the recipient country, transport of PToT products to testing and certifying agencies abroad and back, and most significantly, the inefficiencies of manufacturing at low volumes as compared to the OEM.[59] Another form of cost is that due to "managing the risks involved when an OEM relocates production away from its established domestic defence economy".[60] These risks could be the lack of raw material or managerial issues in re-engineering manufacture processes in a foreign work environment.

Additional reasons which afflict less-developed countries are sub-optimal management, low availability and standard of workforce basic skills and the fact that the foreign OEM may have used expensive automated machinery while the recipient firm may have used less expensive but also slower and less accurate machines leading to more wastage due to defects in manufacture. Though the cost of labour in less developed countries is much lower, this advantage is largely neutralised by their equally low productivity.[61] Perceptually, the escalation in parts prices and foreign exchange rates could be another factor, since actual manufacture continues many years after the signing of the contract. A significant portion of the parts of the system are also to be manufactured in the recipient country after indigenously designing and developing them. Such development using sub-optimal capabilities has its inherent risks of failure, entails long gestation periods and is costly, especially due to the limited volume of products. And finally, the cost of transportation, electricity, land and infrastructure could be higher in the recipient country.

A somewhat consoling aspect is that though the production of ToT enabled systems works out to be costlier than an outright purchase, the difference is reduced when costs over their complete lifecycle are compared. This is due to the availability of less expensive product support (as compared to foreign product support) and possibly some cheaper spare parts mass-manufactured in the country.[62] The cost of subsequent upgrades is also likely to be lower due to the ready availability of trained personnel, machinery and supporting eco-system of sub-contractor firms.[63] A broad survey has also indicated that private sector firms with better management practices are more likely to be able to keep costs down as compared to state-run enterprises such as the DPSUs and OFs. A sufficiently high volume of products to 'break-even' was quoted by most as the single most important factor in providing a competitive price.[64]

Restrictive Trade Practices and Restraints

Besides imposing apparently unreasonable costs, suppliers also attempt to guard the business angle to their technology by forcing the recipient to agree to numerous trade restrictions and restraints. While some are considered acceptable, many have been termed unreasonable or monopolistic/anti-competitive, and those in the civil domain, have been sought to be banned or restricted through appropriate legislations in the buyer countries as well as the UNCTAD Code of Conduct on ToT, with limited success. A glance at the list of restrictions that have been known to be imposed is enlightening.[65]

- Restrictions on field of use, volume and territory over inordinately extended durations of time.
- Restrictions on right of the recipient to sell the product of the ToT to persons other than those designated by the seller.
- Restrictions on Research and Development in the field. Since this could very well fall under anti-competition practices, it is now being applied as restrictions on the right to any improvement, modification or enhancement of the know-how and also

restrictions to participate in the development or manufacture of a similar product or create derivative work based on the licensed equipment.[66]

- Tying i.e. imposing on the technology recipient the obligation to purchase, apart from the technology wanted, additional inputs such as raw materials, machines, etc.
- Price fixing i.e. imposing on the technology recipient, prices fixed by the technology seller.
- Restrictions after expiration of Industrial/Intellectual Property Rights.
- Restrictions on the technology recipient to challenge the validity of the rights conferred by the PToT contract.
- Grant back provisions which impose on the technology recipient an obligation to transfer back to the seller any improvements, inventions, additional experience, etc. in the working of the technology transferred. These are now being replaced with clauses prohibiting modification, disassembly and reverse engineering.[67]
- Export restrictions or export permission for specified countries only, higher royalties for exported products, etc.

A close look at the restrictions against the opportunities that PToT may offer for improving capabilities in indigenous design and development reveals that the recipient's hands are well and truly tied. There is no freedom whatsoever for the recipient to channelise the know-how that has been obtained either for upgrading the product or for the development of other similar products. The best that can be expected are minor innovations through stretching the design deviation limits. This severe limitation in ToT contracts is possibly one of the major reasons for Indian agencies not being able to build up on foreign defence technology in the past many decades.

India, like many other countries in the 1960s and 1970s, enforced protective measures against unfair restrictive trade practices through appropriate legislation, though these were marred by numerous weaknesses. One such legislation is the Foreign Exchange Regulation Act of 1973 which was revised in 1976 to regulate imports of technology. Some of its important provisions, later strengthened by government guidelines, were the limiting of royalties, phased payment for technical know-how, freedom of Indian party to sub-license, no restrictions on exports and freedom to manufacture items patented in India. Unfortunately, the Act also provided a number of exemptions for sophisticated technology, thereby self-defeating its provisions. The Monopolies and Restrictive Trade Practices Act of 1969 similarly specified eight cases that were exempt from its provisions. The Indian Patents and Designs Act also provided numerous exemptions and thus could not check monopolistic trends in the production and sale of patented articles.[68] Today these legislations stand superseded to newer laws which have reduced the vulnerabilities that existed. The issue, however, has become increasingly complex by the growing emphasis on IP protection over the past two decades, which counters to some extent, the thrust on reducing anti-competitive practices.

One may ask—are these restrictive trade practices and legislations to counter them applicable to the defence technology domain? While all the restrictions listed above are imposed by defence technology sellers, legislations to counter such practices, do not apply, since defence technology transfers are invariably overseen by governments which have negotiated deals based on a variety of other considerations such as extending credits or accepting payments in kind or the local currency. Government-to-government agreements on defence cooperation take precedence here.

Dependence on Foreign Suppliers

An acknowledged drawback of PToT as against the indigenous development of systems is the dependence that it creates on the foreign sellers or OEMs for the supply of critical parts of the system. These parts which are manufactured only by the OEMs are termed 'proprietary' and OEMs attribute their inability to provide their production technology to a number of reasons. First is the apprehension that the technology, which forms their trade secret, could be compromised and leaked to competitors or that the technology would be secretly used by the recipient firm to emerge as a competitor. Second is that their transfer will dilute their brand and damage their competitiveness.[69] Third is that their manufacture is extremely expensive and uneconomical at the low scales which buyer firms cater to. Besides these, a possible reason is that the foreign OEM holds an obligation to its government to keep a control on the number of weapons that can be produced by the recipient country/firm. This control is accentuated by international regimes such as the Wassenaar Arrangement which aim to monitor weapons production and sale so as to prevent their proliferation to irresponsible state and non-state actors. These reasons are clearly *bona fide* and therefore, it becomes extremely difficult for buyers to place OEMs under contractual obligations to provide their proprietary technology.

How serious a drawback is this dependence? We shall see in the chapter on exploring all avenues that successful PToT is greatly benefitted by close and long term relationships between the transferor and transferee firms. If such relationships are maintained, the acquiring of the proprietary parts either for manufacture of additional systems at a later date or for replacing failed pieces in the operational systems should not pose any problem unless their production is being terminated. Well-established OEMs normally give a sufficient two to three years notice for such terminations so that buyers may place final (or life-time buy) orders to cater to their future needs. Cost effective life-time buy of spares necessitates accurate prediction of the material and spares that are required in the residual life of the equipment and there are proven techniques and software such as Opus 10 and VMetric which are in use around the world for such predictions.[70] Another means of avoiding such dependency, after the mandated product support/IP validity period, is early development of import substitutes and there are usually dedicated departments in defence industries which cater to this need.[71]

It may be noted that in the case of India, the collapse of the Soviet Union in the 1990s caused the sudden drying up of spares sources in its break-away states. The collapse also caused severe delays in acquisition of new Soviet defence systems and considerable time elapsed before alternate sources could be found. The sanctions imposed by advanced countries post the 1998 nuclear weapon test added another barrier to the supply of critical components. Then the 1999 Kargil conflict and the 2002 Operation Parakram which was prompted by the Indian Parliament attack, both involving massive deployment of equipment, accentuated the existing problem of the lack of spare parts as well as technological support from foreign countries. These five events happening in quick succession snow-balled these voids into crisis-like proportions and set off a series of steps all massively focused on building self-reliance and reducing dependence on foreign countries.

However, what are the possibilities that such a situation will repeat itself? Acquisition of new replacements for aging systems should get faster with the maturing of the DPP and the newly raised Acquisition Wing. Also, India's increasing import of defence systems from the US has now reduced the heavy dependence on Russia. These factors, along with India making good progress towards gaining entry into the Multi-lateral export control regimes such as the Missile Technology Control Regime, the Wassenaar Arrangement (WA), the Nuclear Supplies Group and the Australia group, make a repeat of such a situation quite unlikely.

Other Apprehensions

There is a full eco-system of around six thousand Medium, Small and Micro Enterprises (MSMEs) in the Indian defence industry. Many of these are engaged in R&D and production of sub-assemblies and parts of DRDO-designed systems. These firms are apprehensive of imported ToT, which they believe could take away their business built over many years of a long-standing relationship with the DRDO. This apprehension however, may be unfounded since, as we will see in the chapter on implementing PToT, there is a large proportion of subsystems of imported ToT produced systems which always need to be designed and manufactured by local firms. In fact, these firms stand to benefit in the long-term since their products will need to be of world class standards, and the foreign OEM's technology will enable them to do so.

Notes

1. A major portion of this chapter is taken from the author's article 'Transfer of Defence Technology to India—Prevalence, Significance and Insights', *Journal of Defence Studies*, October 2016 at http://www.idsa.in/jds/jds_10_4_2016_transfer-of-defence-technology-to-india, accessed on September 12, 2018.
2. See https://en.oxforddictionaries.com/definition/technology, accessed on September 12, 2018.
3. See http://web.engr.oregonstate.edu/~funkk/Technology/technology.html, accessed on September 12, 2018 and see note 2.
4. See note 3.
5. See https://en.wikipedia.org/wiki/Technology, accessed on September 12, 2018.
6. See http://www.utrs.com/technology_transfer.html, accessed on September 12, 2018.
7. See K. Ramanathan, *An Overview of Technology Transfer and Technology Transfer Models*, APCTT at http://tto.boun.edu.tr/files/1383812118_An%20overview%20of%20TT%20and%20TT%20Models.pdf, accessed on September 12, 2018, p. 4.
8. See the United Nations Conference on Trade and Development (UNCTAD) document titled 'Transfer of Technology', 2000, p. 5 at http://unctad.org/en/docs/psiteiitd28.en.pdf, accessed on September 12, 2018.
9. See http://www.rochester.edu/ventures/about/what-is-technology-transfer/, accessed on May 20, 2017.
10. E. Mansfield, 'East-West technological transfer issues and problems, international technology transfer: Forms, resource requirements, and policies', *American Economic Review*, 65(2), 1975, pp. 372–376 as referred in http://tto.boun.edu.tr/files/1383812118_An%20overview%20of%20TT%20and%20TT%20Models.pdf, accessed on September 12, 2018.

11. A Google search on 'Technology Transfer' threw up seven of the first ten sites indicating it as the process of transferring the findings of scientific research to the industry for commercialisation. The phrase 'Transfer of Technology' has been typically used to indicate transfer of production technologies to other countries or organisations for exploitation.
12. See http://www.encyclopedia.com/topic/Technology Transfer.aspx, accessed on September 12, 2018.
13. See http://www.encyclopedia.com/topic/Technology_Transfer.aspx, accessed on September 12, 2018.
14. See https://en.wikipedia.org/wiki/Technology_transfer, accessed on September 12, 2018 and Sakti and Indrani Mukherjee, *International Transfer of Technology*, Mittal Publications, New Delhi, 1989, p. 2.
15. See Wassenaar Arrangement, *Best Practices for implementing Intangible Transfer of Technology Controls* at https://www.wassenaar.org/app/uploads/2015/06/ITT_Best_Practices_for_public_statement_2006.pdf, accessed on September 12, 2018.
16. See Mrinal Suman, *Will Offsets bring Technology to India* at http://mrinalsuman.blogspot.in/2015/03/will-offsets-bring-technology-to-india.html, accessed on September 12, 2018.
17. See Prahlada S. Radhakrishnan and Parimal Kumar, 'Leveraging Defence Offset Policy for Technology Acquisition', *Journal of Defence Studies*, January 2009, p. 115.
18. See DRDO Guidelines for Transfer of Technology, p. 2 at https://www.drdo.gov.in/drdo/English/IITM/DRDO-guidelines-for-ToT.pdf, accessed on September 12, 2018.
19. See Ministry of Defence, Govt of India, *Defence Procurement Procedure*, 2008, p. 122.
20. The Star 1000 radar contracted by Bharat Electronics Ltd consisted of an 'Operate and Maintain' function.
21. A Lockheed Martin rep during an interaction at IDSA, New Delhi in May 2017 shared that such an arrangement existed between the US and Japan in the F2 fighter project. Safran Electronics and Defence stated in reply to a questionnaire in June 2016 that it is offering a 'design and upgrade' license, amongst others.
22. As shared by a senior DRDO official during an interaction in April 2017.
23. See Phyllis L. Speser, *The Art and Science of Technology Transfer*, The Google Books Digital Store, 2005 describes product technology, process technology and services. A differentiation in product and process technology has been drawn from the book.
24. See https://en.wikipedia.org/wiki/Know-how, accessed on September 12, 2018.

25. As mentioned by a senior retired GM of an Indian DPSU.
26. Ramadas P. Shenoy, *Defence Research and Development Organisation 1958-82,* DESIDOC, DRDO 2006 Delhi, p. 177. Also see S.A. Wahab, *Defining the Concepts of Technology and Technology Transfer: A Literature Analysis*, International Business Research, 5(1); January 2012 at https://www.researchgate.net/publication/228450493_Defining_the_Concepts_of_Technology_and_Technology_Transfer_A_Literature_Analysis, accessed on September 12, 2018 who quotes Tihanyi and Roath (2002) that technology can include information that is not easily reproducible and transferable. Based on this argument technology is seen as 'tacit knowledge (Polanyi, 1967) or firm-specific, secrets or knowledge known by one organisation' (Nonaka, 1994). Technology as the intangible assets of the firm is rooted in the firms routines and is not easy to transfer due to the gradual learning process and higher cost associated with transferring tacit knowledge (Rodasevic, 1999). Valuable technological knowledge which is the intangible assets of the firm is never easily transferred from one firm to another because the technological learning process is needed to assimilate and internalise the transferred technology (Lin, 2003).
27. See European IPR Helpdesk Fact Sheet *Commercialising Intellectual Property: Assignment agreements* at https://www.iprhelpdesk.eu/sites/default/files/newsdocuments/Assignment_Agreements_0.pdf, accessed on September 12, 2018.
28. See Licensing in the R&D phase in https://en.wikipedia.org/wiki/Technology_life_cycle#cite_note-2, accessed on September 12, 2018. Generally, contractual provisions among the members of the consortium allow a member to exercise the option of independent pursuit after joint consultation; in which case the optee owns all subsequent development.
29. See https://en.wikipedia.org/wiki/Technology_readiness_level, accessed on September 12, 2018, for a view of Technology Readiness Levels.
30. See European IPR Helpdesk Fact Sheet *Commercialising Intellectual Property: Assignment agreements* at https://www.iprhelpdesk.eu/sites/default/files/newsdocuments/Assignment_Agreements_0.pdf, accessed on September 12, 2018.
31. See https://en.wikipedia.org/wiki/Background,_foreground,_sideground_and_postground_intellectual_property, accessed on September 12, 2018.
32. Manufacturing Readiness Levels (MRL) is an implemented index in the Dept of Defence, USA. See https://en.wikipedia.org/wiki/Manufacturing_Readiness_Level, accessed on September 12, 2018.
33. Adapted from Wikipedia on 'Licensing in the ascent phase' at https://en.wikipedia.org/wiki/Technology_life_cycle#cite_note-2, accessed on September 12, 2018.

34. See Bharat Verma, *Indian Defence Review*, p. 114 at https://books.google.co.in, accessed on September 12, 2018 and substantiated by numerous other sources.
35. See http://www.diffen.com/difference/LCD_TV_vs_OLED_TV, accessed on September 12, 2018.
36. See P.J. Buckley, 'The Impact of the Global Factory on Economic Development', *Journal of World Business* (2008), pp. 1–13, doi:10.1016/j.jwb.2008.05.003.
37. See S.P. Ravindran, 'Technology Inflows: Issues, Challenges and Methodology', *Journal of Defence Studies*, IDSA, New Delhi, January 2009, p. 140.
38. See Amitav Mallik, *Role of Technology in International Affairs*, Pentagon Press and IDSA, New Delhi, p. 4.
39. See Vijay Kumar Khurana, 'Technology Absorption and Diffusion at https://www.slideshare.net/VijayKrKhurana/technology-absorption-diffusion-15896608, accessed on September 12, 2018.
40. As mentioned by a spokesperson of the European aircraft firm Airbus on August 26, 2016 at a seminar in New Delhi.
41. K. Ramanathan, note 7.
42. Sakti and Indrani Mukherjee, note 14, pp. 26–27.
43. See United Nations Conference on Trade and Development (UNCTAD), *Transfer of Technology,* New York and Geneva, 2001, p. 91.
44. See Ron Matthews, *The UK Offset Model—From Participation to Engagement*, RUSI, July 2014, p. 24, where he mentions that US licensed production of the UK's Hawk and Harrier jets—the Goshawk and AV-8B aircraft, respectively—led to substantially improved versions of the original British aircraft.
45. See Encyclopedia of Management, *Technology Transfer* at http://www.encyclopedia.com/topic/Technology_Transfer.aspx, accessed on September 12, 2018.
46. See Ron Matthews, *Defence Production in India*, ABC Publishing House, New Delhi, 1989, p. 4.
47. See Stephan Frühling, *Sovereign Defence Industry Capabilities, Independent Operations and the Future of Australian Defence Strategy*, ANU Strategic and Defence Studies Centre, accessed at sdsc.bellschool.anu.edu.au/our-publications/centre-of-gravity-series on September 12, 2018, where the author discusses the need for sovereign defence industry capability to reduce dependence on allies who may withhold sensitive technology when needed.
48. Sakti and Indrani Mukherjee, note 14, p. 9 and Encyclopedia of Management, *Technology Transfer* at http://www.encyclopedia.com/topic/Technology_Transfer.aspx, accessed on September 12, 2018.

49. Technology Diffusion is explained in UNCTAD, *Transfer of Technology,* New York and Geneva, 2001, p. 7.
50. Ron Matthews, 'The UK Offset Model—From Participation to Engagement', RUSI, Whitehall, London, 2014, p. 43.
51. Ibid.
52. Ibid., p. 35.
53. Ibid.
54. UNCTAD, *Transfer of Technology,* New York and Geneva, 2001, p. 7.
55. Sakti and Indrani Mukherjee, note 14, pp. 10–11.
56. Ron Matthews, *Defence Production in India*, ABC Publishing House, New Delhi, 1989, p. 17.
57. Ron Matthews, note 50, p. 24.
58. See Ron Matthews, note 50, p. 42 where he states that evidence is hard to come by on the additional costs of licensed production as compared to off-the-shelf acquisition. He, however, suggests further reading Michael W Chinworth, *Inside Japan's Defence: Technology, Economics and Strategy,* Brassey's, New York, NY, 1992 on the raised costs of Japanese license-produced US weapon systems in relation to procuring direct from a US defence contractor.
59. Ibid., p. 26.
60. Ibid., p. 41.
61. Productivity of Indian workers is roughly one-third and one-sixth that of Russian and US ones respectively, as per *Times of India*, 'India will soon have more workers than China', but they will be less productive, New Delhi, September 19, 2018. Also see Laxman K Behera, 'BEML Disinvestment: What about the other DPSUs and OFs?', *Indian Defence Review*, January 23, 2017 at http://www.indiandefencereview.com/spotlights/beml-disinvestment-what-about-the-other-dpsus-and-ofs/, accessed on September 12, 2018 where he mentions that the average labour productivity of Indian DPSUs is less than one-fifth of that of major global defence companies.
62. As mentioned by a senior manager of the finance dept of a DPSU in March 2016.
63. As mentioned by an experienced retired IAF officer in May 2016.
64. As surveyed during the Aero-India show in Bangalore in April 2016.
65. See Sakti and Indrani Mukherjee, note 14, pp. 38–72 and A.A Kutty and S. Chakravarty, 'Emerging Challenges in Technology Transfer Licenses', *Journal of Intellectual Property Rights*, Vol. 16, May 2011, pp. 258–266.
66. These restrictions have been noticed in the contract document of a recent ToT project.
67 Ibid.

68. Sakti and Indrani Mukherjee, note 14, pp. 76–78.
69. Ron Matthews, note 50, p. 22.
70. Features of Opus 10 developed by Systecon, Sweden and VMetric developed by TFD Group, USA can be viewed at the websites of the developing firms www.systecon.se/defense/our-tools and www.tfdg.com/products/so.html, accessed on September 12, 2018.
71. In the Indian military services, life time buys of spare parts from the foreign OEM are executed when their (spare parts) production is within two years of closing down.

3

Aligning ToT to National Goals[1]

At this juncture, we need to take a step back and deliberate the national goals that ToT activity should be aligned with. Should it be a single-minded thrust of developing *superior military strength* through the production of systems with *superior technology vis-à-vis India's adversaries* as has been enunciated as an overriding objective in the Defence Production Policy (DPrP) issued by the Indian Government in 2011?[2] This assumes importance due to China's increasingly belligerent attitude and significant technological advancements which are way ahead of India's. But, this can be achieved by outright purchase of superior weapon systems instead of ToT that is tedious and costlier.[3] So are there secondary objectives, such as that of achieving *strategic autonomy* through the unattainable self-sufficiency aka autarky, though this goal is unaffordable and ideally pursued through indigenous development? If not self-sufficiency then is *self-reliance* the objective as has been stated in the DPrP 2011? Or, instead of self-reliance, the more nuanced *sovereign capability* in select areas as introduced in the draft DPrP 2018? There are also other benefits such as *industrial growth*, *economic development*, *technology diffusion*, *savings in foreign exchange* and the *creation of new jobs*, the last being one of the primary objectives of the Make-in-India programme.[4] What about *profitability* which will enable monetary returns for the large investment invariably made for ToT? Though internal demand for ToT-manufactured products may be limited, products of global standards could well be supplied to meet global demand. And finally, with limited capital available with the Indian Government, the aspect of maintaining *economy* in expenditure is also important. Undoubtedly, these additional factors are also relevant and can contribute collectively to help India develop, in addition to military strength, its industrial and economic capability.

Self-reliance in defence production has been a goal ever since India gained independence. It was in the pursuit of this goal that the DRDO, DPSUs and a few more OFs were established. The catchword has been *indigenisation* and there has been no dearth of strategies and initiatives to promote it. While overall indigenous development and production in India has significantly increased in technology levels and volumes over the decades, it has unfortunately been offset by an equally fast evolution of defence technology in the world. Consequently, the Indian defence forces continue, as in the past, to depend on large imports of competitive defence technology systems.

So how is this self-reliance to be achieved? There is no doubt that a deep commitment, investment in indigenous defence technology development and initial technological support from friendly countries can achieve substantive self-reliance as has been demonstrated in the Indian space and, to some extent, nuclear technology domains. But, India's developing-country status has precluded any such major investment and hence, Indian defence technology still lags behind in most fields. Many frustrating attempts to push harder on the indigenous route do not seem to help. It is in this discouraged environment that we find a few references which allude to the 'unnecessary need to re-invent the wheel' and the use of ToT as a 'jumping board'[5] or a means of 'leap-frogging to close the technology gap'.[6] Can ToT enable or accelerate the journey to self-reliance? The matter is debatable and the first step to assessing this would be to delve a little deeper into what is meant by self-reliance.

Self-reliance in defence technology was described by the late K. Subrahmanyam, the Convener, National Security Advisory Board in the year 2000, when he compared it to self-sufficiency. He described self-sufficiency as the in-house production of everything that is needed by the Armed Forces, a state which he averred was impractical for a developing nation possessing limited resources.[7] In a more generic sense, his stand is supported by Ron Mathew's view that "though self-sufficiency may be a country's proclaimed goal, it is invariably economically infeasible", to which he adds the example of the technology sharing within NATO countries.[8] A further strengthening of this view comes from the examination of the import of defence systems by various countries today, which indicates that there is, in fact, no country, developing or developed, which does not import some amount of defence equipment. In the year 2016, for instance, among the top developed countries, USA imported arms worth US$ 512 million while Russia imported an equivalent of US$ 169 million.[9]

Self-reliance, on the other hand, was defined by K. Subrahmanyam as the equipping of the Armed Forces to match India's adversaries, with a range of weapons and equipment either foreign or indigenous, and if they were foreign, the country must be capable of maintaining them to their full operational effectiveness and should be confident of spares and ammunition support under all conditions.[10] In stating this, he indirectly indicated the possibility that foreign countries would refuse or be unable to supply essential material or technology for operating or maintaining the equipment. This capability to operate essential weapons without external support is remarkably congruent with the recent focus on developing sovereign capability in select areas of defence manufacturing.[11]

Another definition of self-reliance can be obtained indirectly from the objectives set by a self-reliance review committee headed by Dr. APJ Abdul Kalam in 1992. The committee, which defined the self-reliance index (SRI) as the percentage share of the indigenous content (IC) in the total procurement expenditure, suggested the objective of achieving a SRI of 70 per cent from the existing 30 per cent, over a ten-year period ending in 2005.[12] This target has not been achieved till today and the Indian Government, through the DPP 2016, now stipulates, inter alia, a minimum SRI of 40 per cent in the Buy Indian Designed, Developed and Manufactured (IDDM) category of defence systems or ambiguously, 60 per cent if the design is not indigenous.[13] How this figure of 70 per cent was arrived at by the committee and why it should be so, is not clear, especially since the costs involved would make increasing of IC economically unviable beyond differing levels for different systems. Reasons for these different economic ceilings can be the differing vintages of technologies used, differing requirements of local manufacturing capabilities, differing requirements and availability of raw materials and skilled workers and differing populations planned to be produced.

So does ToT enable self-reliance? There is no doubt that PToT provides the capability of manufacturing a significant portion within the country, thus meeting the SRI objective. It is also well-known that PToT contracts of the past have invariably included the requirements for operation and maintenance, thus meeting K. Subrahmanyam's perspective.

Unfortunately, the focus on self-reliance which, as mentioned earlier, translates to indigenisation and is measured through the SRI, has a few drawbacks. It stresses the need to indigenise a large majority of the parts of the imported defence system even if many are unsuited to manufacture in India, entail much higher costs due to low scales of production and ultimately may be produced at lower quality standards. This particular aspect of indigenisation ultimately boils down to *import substitution*, which aims at replicating imported parts, and which has been a long standing objective in the state-run OFs and DPSUs.[14] The Kelkar Committee recognised the shortcomings of such a focus and recommended in 2004, that "there is a need to go beyond import substitution to involve capability enhancement and development, increasing know-why, design and system integration".[15] Though these were generally accepted by the environment as valid and commendable objectives, no method has apparently evolved to quantify them and replace the SRI as yet.

Hence, the SRI continues to be used in quantifying the national objective of self-reliance and therefore, the focus on indigenisation or import substitution remains top on the agenda. In terms of exercising indigenous abilities, import substitution narrows the focus of the Indian defence industries to innovating, designing and developing alternates for specific imported modules or parts which have already been in use for a large portion of the life of their technology. In fact, many of these parts are close to obsolescence when it is realised that import substitution is imperative.[16] So the focus devolves on developing parts for functions, and at specifications, which are *outdated*. This clearly means that the developed part will have no utility for newer systems employing newer technology which delivers smaller, lighter, more reliable and maintainable but, less energy consuming parts, performing at higher speeds and delivering superior output. Is this beneficial to the country in terms of technological effort and output? Wouldn't it be more effective to simply purchase and stock the needed spares parts in appropriate, scientifically predicted quantities as discussed in the earlier chapter, thereby freeing up resources to concentrate on developing newer technology?

A factor which strongly goes against the goal of self-reliance is the Global Factory. The Swedish firm SAAB offers its world class Gripen fighter aircraft with a US engine, Italian radar and US or Israeli missiles.[17] The US F-35 Joint Strike Fighter aircraft was jointly developed with portions of the system contributed by nine countries.[18] Many of the Indian DRDO developed systems incorporate subsystems from a range of foreign countries. One reason why such arrangements for multiple-country-sourced subsystems are found to be successful is that advanced countries have focused on perfecting specific areas of technology to become world leaders in them.

So instead of just self-reliance, can technology transfer *also* build world class design, development and manufacture capability and thereby contribute to achieving the more productive and profitable goal of *technological leadership*? A leadership in a field such as Nano-technology or Micro Electro-Mechanical System based sensors where the products of Indian firms compete internationally in performance and price for a dominant share of the world market? Or, coming down a notch lower, can technology transfer build these capabilities for producing technologies which are superior and can compete with the rest of the world? Where international OEMs look to outsource some of the parts of their contemporary systems from Indian firms? Such an achievement would build foreign-country dependence thereby strengthening India's bargaining power for complementary technologies as well as attract collaborative projects with advanced countries.

Working towards this *technological superiority,* in just a few areas, would enable *profitability* and the other benefits of industrial growth, economic development, technology diffusion, accrual of foreign exchange and creation of new jobs. Unfortunately, technological superiority will require the know-whys of design and since it is established that PToT does not provide any, it appears that it cannot help in any effort in this direction. For the time being therefore, we shall focus on self-reliance as the primary objective of PToT and see how it can be implemented in its pursuit.

In the chapter on exploring new avenues, however, we will find that there are modes which involve the collaborative efforts of foreign firms with their Indian partners and for success in such ventures it becomes essential that common goals are set. It is needless to say that goals such as India's self-reliance, industrial growth and economic development as well as the creation of jobs in India are not likely to enthuse foreign partners. Technological superiority leading to profits and garnering a larger share of the global market, however, can be very strong drivers. The inclusion of technological superiority as a goal thus, appears almost inevitable, if such joint ventures are to be leveraged.

Notes

1. A large part of this chapter has been taken from the author's articles, 'Transfer of Defence Technology to India: Prevalence, Significance and Insights', *Journal of Defence Studies*, October 2016 at http://www.idsa.in/jds/jds_10_4_2016_transfer-of-defence-technology-to-india and 'Transfer of Defence Technology—Exploring the Avenues for India, *Journal of Defence Studies,* 11(3), July-September 2017, pp. 69–98 at https://idsa.in/jds/jds_11_3_2017_transfer-of-defence-technology, accessed on September 12, 2018.
2. Government of India, Ministry of Defence, 'Defence Production Policy', 2011, para. 2 at https://mod.gov.in/dod/omsorders/defence-production-policy-2011, accessed on September 12, 2018.
3. See Kevin A. Desouza, 'Examining the Case for Complete Transfer of Technology' at http://idsa.in/idsacomments/examining-the-case-for-complete-transfer-of-technology_kadesouza_210317, accessed on September 12, 2018, where the complexity of ToT is detailed and Ron Matthews, *The UK Offset Model—From Participation to Engagement*, RUSI, July 2014, p. 41 where the higher cost of ToT produced systems is discussed.
4. The Indian government hopes to create 100 million new jobs through the programme by the year 2022. See http://timesofindia.indiatimes.com/business/india-business/Make-in-India-Mission-2022-100-million-jobs/articleshow/51005411.cms, accessed on September 12, 2018.
5. See Mrinal Suman, 'Will Offsets bring Technology to India' at http://mrinalsuman.blogspot.in/2015/03/will-offsets-bring-technology-to-india.html and Brig Gurmeet Kanwal, 'Defence Procurement: Learning from Experience' at https://www.vifindia.org/article/2015/july/15/defence-procurement-learning-from-experience, accessed on September 12, 2018.
6. See S.P. Ravindran, 'Technology Inflows: Issues, Challenges and Methodology', *Journal of Defence Studies*, 3(1), 2009.
7. See K. Subrahmanyam, 'Self-Reliant Defence and Indian Industry' at http://www.idsaindia. org/an-oct-00-2.html, accessed on September 12, 2018.
8. See Ron Matthews, *Defence Production in India*, ABC Publishing House, New Delhi, 1989, p. 17.
9. See http://www.indexmundi.com/facts/indicators/MS.MIL.MPRT.KD/rankings, accessed on September 12, 2018. A large portion of these figures though, could be due to purchases of local products of foreign countries for meeting offset obligations.
10. See K. Subrahmanyam, note 7.
11. See the draft 'Defence Production Policy 2018' at https://ddpmod.gov.in/sites/default/files/Draft%20Defence%20Production%20Policy%20 2018%20-%20for%20website.pdf, accessed on September 12, 2018.

12. Standing Committee on Defence 2006-07, 14th Lok Sabha, *Defence Research and Development Organisation (DRDO)*, 14th Report, Lok Sabha Secretariat, New Delhi, 2007, p. 3.
13. Ministry of Defence, Govt of India, *Defence Procurement Procedure*, 2016, p. 2.
14. See Laxman Kumar Behera, *Indian Defence Industry—An Agenda for Making in India*, IDSA, New Delhi, 2016, p. 46, 59, 72.
15. See Ajai Shukla, 'Indigenisation: A False Debate', *Business Standard*, September 10, 2013 at http://www.business-standard.com/article/economy-policy/indigenisation-a-false-debate-113091001027_1.html, accessed on September 12, 2018.
16. Obsolescence is the latter stage of a component's life when no new replacements are likely to be received due to the phasing out of its production.
17. See http://www.airforce-technology.com/projects/gripen-e-multirole-fighter-aircraft/, accessed on September 12, 2018.
18. See https://www.f35.com/global, accessed on September 12, 2018.

4
Implementing PToT

In the second chapter we took a look at the nuances of PToT from an external view. Here we look into how PToT is actually implemented. As an evolution of the licensed manufacture mode, PToT is initiated when a license for manufacturing a system is purchased from a foreign government or firm. The license is embodied in a contract which typically specifies the number of systems, the timeline for delivery of the 'technology', validity of the license and of course the cost of the deliverables. Since manufacturing capability cannot be built overnight, the process is drawn out into stages, progressively increasing the proportion of manufacture work that the transferee firm executes. The extent to which this work content is increased will depend on the extent of local production or indigenisation that is being targeted. Where transferor-transferee technology level gaps are large, this content is typically low, while smaller gaps enable a higher level of indigenous content (IC).

Stages in PToT

The increasing work content in PToT necessitates that the recipient firm go through specific stages with each one building on the capability acquired in the preceding one. These stages are described below:

Supply of Fully Formed (FF) Systems: ToT and local manufacture activity is always preceded by the purchase of complete systems either in a separate or the same contract. These systems are used to meet the emergent needs of the recipient country and also serve to familiarise the users, maintainers and production agencies with them. Production agencies need to acquaint themselves with the performance testing, operations and maintenance aspects which are knowledge they will be required to use or impart after a system is completely integrated. One of these systems can also be used as a 'golden piece' to compare the performance of the ToT-manufactured pieces with. For foreign seller firms, this arrangement allows them to keep their production lines 'warm', simultaneously allowing the industrial, hands-on training of workers of the transferee firm. Such hands-on work also enables the fine tuning of the initial estimation of workforce, additional machinery and skills that will be needed.
Assembly of Semi-Knocked Down (SKD) Kits: SKD kits typically comprise of sub-systems, assemblies or large parts. In the case of a battle tank, these could be the engine, auxiliary engine, sprockets, wheels, transmission boxes, hull, turret, optical sights, gun barrel etc, while for a radar, these could be the antenna frame, operator console, transmitter system, receiver system, air conditioner etc. These could be initially pre-tested in the transferor's premises and later, tested at the transferee's, once such testing facilities have been established. After the assembly, the system is put through performance tests called Factory Acceptance Tests and then delivered to the customer.
Integration of Completely Knocked Down (CKD) Kits: CKD kits comprise of smaller sub-assemblies or modules or even discrete parts which are integrated to form the sub-systems or assemblies that were supplied in the SKD kit. So for an engine, these could be the fuel pump, oil pump, starter assembly, battery charging alternator etc. For electronic systems, these could be modules and cards for amplification, signal processing, power supplies, etc. These would typically be pre-tested at the OEMs or his subcontractor's premises. Once integration into sub-systems is done, tests would be carried

out in the transferee's premises, before they are integrated into the complete system.

Component Level Assembly (CLA) Stage: This stage is not so commonly known and documented. It involves, as the term implies, the assembly of components such as the piston, piston rings, cylinder liners, cylinder heads of engines or processor chips, capacitors, induction coils, resistors, diodes and other such components of electronic modules. Pre-testing of components at OEM's or supplier's premises and testing of assembled modules or cards at transferee's premises is carried out. This stage typically requires a significant amount of investment in special machinery coupled with high levels of expertise and therefore may not always be included in the ToT programme.

Indigenous Manufacture (IM) Stage: In this stage, the foreign OEM supplies only a few proprietary items while the remaining are produced by the transferee firm and his indigenous sub-contractors using raw materials. The foreign OEM enables indigenous production by providing the 'technology' or know-how in documents and assistance through consultants. This technology is however, not uniformly supplied across the entire range of parts. In some, it may be detailed down to the manufacturing process while in others it could be just a set of technical specifications and test parameters. We discuss why this is so, in the next section.

The Indian DPP prescribes these stages (less the CLA) as a 'Phased Manufacturing Programme' with Stage 0 being that when FF systems are received, followed by Stage 1 for the SKD, Stage 2 for the CKD and Stage 3 for the IM kit deliveries and connected production activity.[1]

Understanding the Production Eco-system

To understand why the 'technology' provided by the transferor firm is not uniform and 'complete', we need to understand the eco-system that foreign OEMs typically work in. Foreign OEMs which supply defence systems typically integrate parts, of which, only a limited portion, called proprietary parts, is manufactured by themselves. Other parts are sourced from sub-contractors, also called Tier 1 firms, through four distinct methods of production, elucidated below.

In a Build to Specifications (B2S) contract, the OEM provides the technical specifications of the desired product which may include the detailed dimensions, external clearances, performance characteristics (output desired for a certain input) and reliability of the product. The subcontracted firm uses these to design the product, develop its manufacturing process and manufactures it for supply to the OEM. For successfully achieving this, the phases of prototyping, trials and evaluation, etc., may be required and can take considerable time, effort and money.[2] Since development is involved, there is also a risk that there may be delays or even failures. OEMs sometimes reduce this risk by tendering to multiple firms simultaneously and awarding a contract to the firm which has been successful. Successful firms invariably patent their products to prevent imitation thus securing a market and ensuring sufficient returns to recover their development costs.

In a Build to Design (B2D) contract, the OEM provides the technical specifications as well as the design/engineering documents (which could be patented) of the part required. The design/engineering documents cover the drawings (design), acceptable tolerances, material compositions, surface finish required or in the case of electronic modules, the circuit diagrams, net list showing connections between all components of a PCB and Gerber diagram showing the layout of components on the PCB. The subcontracted firm is now required to develop or use its own (possibly patented) process to manufacture the part to match the design specified in the engineering documents. It must be noted that there could be multiple manufacturing technologies which deliver the same part and the subcontractor is free to use any of them.

In a Build to Print (B2P) contract, the OEM provides the technical specifications, the design/engineering documents and thirdly, the manufacturing process documents, the latter two, possibly patented. The manufacturing process documents would include manufacturing drawings, detailed work instructions/manufacturing processes, quality requirements, detailed specifications of the product at intermediate stages, test methods and acceptance/rejection criteria. In addition, the OEM may provide the test jigs and equipment as well as the know-how and tacit knowledge through training sessions conducted by technical consultants of the OEM.[3] The subcontracted firm executes its production strictly as per these documents/instructions and using material or parts from sources recommended by the OEM. Challenges however, are faced when the manufacturing infrastructure, machines or even raw materials available to the subcontracted firm do not match those recommended by the OEM. Some amount of adaptation using innovative engineering skills becomes necessary here, but when this is not fully successful, it could lead to products of sub-optimal quality. In cases of unacceptable quality, there may be no option but to purchase the costlier OEM recommended machines or raw material and amortize the cost across the volume of products.

In terms of technology transferred, B2P clearly is comprehensive and complete, while B2D and B2S transfer a decreasing quantum, respectively. Another aspect is that while Tier 1 firms produce and supply the sub-assemblies to the OEM, they could similarly outsource some of the constituent parts of their products from Tier 2 firms and they could in turn, to Tier 3 firms and so on. OEMs producing large defence systems such as fighter aircraft and battle tanks may operate with three tiers and more.

The fourth category consists of parts which are commercially available and meet the requirements of the system. These have been commonly termed COTS (Commercial Off-The-Shelf) items. In the recent decade, a military category called MOTS (Military OTS), used primarily in defence systems, have also become available. With rapid advances in commercial and dual-use technology through research fuelled by returns from global-scale sales, the proportion of COTS/MOTS components in defence systems have become significantly large. Manufacturers of these parts patent and closely guard their technology and will not transfer their technologies unless they are close to becoming obsolete. However, equivalents from other manufacturers may be available in the market.

A word on proprietary parts is due. These parts could be those for which no suppliers are available or whose manufacture requires close involvement of the OEM. These also include parts which form the trade secret or USP which gives the system its edge over competitors. It could range from special purpose electronic modules to mechanical parts requiring a specific metallurgical composition and very precise dimensions and even embedded software, as is being increasingly incorporated in recent times. No equivalents are generally available in the market.

PToT Execution through the Indian DPP

When foreign OEMs are contracted for PToT by technology seeker countries, they are invariably constrained by the eco-system that they work in. Subcontractors who have developed and patented a part of the system may not wish to license it out for manufacture in another country fearing competition in the future as well as the possibility of IPR infringements. So the OEMs are constrained to offer only as much as they themselves own as IP and that of a few willing subcontractors.

The drafters of the Indian DPP, presumably with an understanding of these constraints on OEMs, have laid down an optimal mix of the five categories of parts described above and the 'technology' deliverables for each category as detailed in Table 4.1.

Table 4.1: Categories of items and their technology deliverables in PToT

Category	OEM's source	Foreign OEM's Deliverables for ToT				
		Manufacture process documents, training	Engineering drawings / design	Performance/ Procurement specifications	Details of OEM's single subcontractor	Details of source of supply
1	Design and manufacture process developed in-house	Yes	Yes	Yes	Not required	Not required
2	Design developed in-house but manufacture out-sourced	No	Yes	Yes	Not required	Not required
3	Design and manufacture out-sourced	No	No	Yes	Yes	Not required
4	Purchased as per specifications (as COTS/MOTS)	No	No	Yes	No	Yes
5	Proprietary, designed and manufactured in-house	No	No	No	No	No (OEM will provide)

Source : Prepared by the Author.

As detailed in the table, the technology delivered is the most comprehensive for category 1 items and reduces progressively as we move down towards category 5. In correlation, the DPP states that category 1 are those where the technology delivered is deemed to be 'complete' or 'CToT'. It then follows up by stating that category 2 items are also to be considered 'CToT', even though the manufacturing technology is not provided for these items. For category 3 items, the DPP states that it is to be assumed that technology has not been provided. An extension of this logic would indicate that category 4 and 5 items are also to be considered as those where no technology is provided. The DPP also indicates a framework for the minimum accepted proportion on a cost basis. Categories 1 and 2 should comprise of a minimum of 60 per cent of the total cost of the system, categories 3 and 4 not more than 25 per cent and category 5 not more than 15 per cent.[4] This proportion can however, vary among different types of systems.

A parameter used in the DPP which is superimposed on this evaluation, is the Indigenous Content (IC) in the PToT manufactured system. PToT can be executed under the framework of the DPP through two routes. The 'Buy and Make (Indian)' route (M&B(I)) enables Indian firms to obtain technology through PToT from foreign OEMs in the phased manner described earlier in this chapter and then supply those systems to the GoI with the condition that there should be 50 per cent IC in the 'make' portion of the contracted number. The 'Make and Buy' route (M&B), on the other hand, allows the GoI to contract foreign firms for supply of FF systems followed by a PToT to a designated Indian production agency in the phased manner above.[5] The IC required here may be specified as per the judgment of the acquisition agency.

The IC has been amply defined in the DPP as the value of the supplied system after excluding—one, the value of the imported components, their transportation and insurance, two, the expenditure on services from non-Indian entities and citizens, three, expenditure on royalties, licenses, consultation fees paid out of India and four, expenditure on Indian taxes, cesses, octroi and other statutory levies. This leaves the work content, material and parts which are actually provided or manufactured in the country.

Yet another parameter superimposed on the two above is the 'value addition' by Indian firms in the category 1 and 2 items during the CKD and IM stages. This has been specified as a minimum of 30 per cent in the CKD stage (after excluding the cost of the CKD items), and 60 per cent in the IM stage. This value addition (VA) parameter appears to be synonymous with the IC, but has probably been used to include the labour cost of integration, assembly, checkout and testing.[6]

The Case for Full Transfer of Technology[7]

A common refrain in the Indian defence sector is that defence procurement contracts should contain the clause for *full* or *100 per cent* ToT.[8] India's DPP itself mentions 'comprehensive' ToT and 'complete' ToT as a requirement in numerous places.[9] The fact however, is that full ToT has remained elusive. As a case in point, while the Russian T-90 tank contract in 2001 was touted as a successful example of full ToT, a few years later reports surfaced that the ToT was incomplete.[10] In tune with this Indian experience, Brazil has been facing similar problems with its insistence on full ToT.[11]

This raises several questions. What exactly is *full* ToT and why is it that it cannot be ensured, even from friendly nations? Is it correct that foreign OEMs intentionally and maliciously deny the technology of the most critical parts of their equipment to Indian recipient agencies? Why is it that these requirements cannot be brought under contractual obligations enforceable by law?

With very little information available on the details of troubled ToT contracts, not much can be said on what has gone wrong. However, we can certainly attempt to understand what exactly amounts to 'full' ToT, and why it is so difficult to implement.

Firstly, there have been complaints that foreign OEMs do not provide sufficient know-whys which would transfer design and development capability to Indian firms. This, as we have discussed in the chapter on the nuances of ToT, is an unreasonable expectation. Developers will not provide this capability fearing the transferee might later compete with them. Also, as will be brought out in the chapter on exploring the avenues ahead, know-whys come (if at all) at a huge unaffordable cost. So, the argument that the ToT is not complete because design and development capabilities have not been delivered really does not hold good.

So what could constitute a full ToT? Clearly, it would be an arrangement where *all* parts of the system fall in category 1. As we discussed in the earlier section on the production eco-system, such a situation is extremely unlikely and the DPP has factored this in by providing a possible proportion to include other categories also.

What if India was to demand a high proportion of category 1 items, say 80 per cent? Foreign OEMs may be willing to provide all the technology, but at a higher price. The higher price enables them or their subcontractors to recover what they could stand to lose in their markets to the recipient firm. In the category 3 items, the single subcontractors, fearing a loss of business might charge a proportionately higher price. In the category 4 (COTS) items, the manufacturers normally would never part with their IP. But if they do, for some extraordinary reasons, they will charge a price to compensate for the global loss of business, which will be cost-prohibitive to India. The manufacture of category 3, and to a larger extent, category 4 items, also invariably requires expensive, highly advanced process technologies. Acquisition of such process technologies will turn out to be economical only if they are used for mass production at the scales which are needed in the global market. Limited to the domestic market, therefore, the relationship between the cost versus the coverage of technology transferred, which likely follows the law of diminishing returns, would make technology acquisition beyond, say 80 per cent, increasingly cost-prohibitive, with no matching and assured gains. Even if it is 100 per cent, we need to remember that it would be only manufacturing technology. India would still be dependent on the know-whys of design that reside in the foreign seller firms for enabling major improvements and upgrades.

Paradoxically, the lack of OEM deliverables of the manufacture process in category 2 items and the design in category 3 and 4 items actually has a positive side. It provides Indian firms an opportunity to indigenously develop internationally competitive processes/designs, build know-hows and know-whys, create intellectual property (IP) and then exploit it to join global supply chains. If all the processes and designs (foreign) were delivered on a platter, Indian firms would remain forever dependent on foreign sellers for use of the latter's IP. Being the easier option, Indian firms can easily get habituated to asking for and receiving complete ToT thereby precluding the exercise and growth of their own design, development and innovative engineering capabilities.

Coming to the technology of proprietary parts, as we discussed in the chapter on nuances, foreign OEMs are reluctant to part with it citing apprehensions that it would be used to compete against them or be compromised to other parties or dilute their brand and damage their competitiveness.[12] The low scales of production of Indian buyer firms would also make it uneconomical and finally, foreign governments would not permit it so as to keep a control on the number of weapons that can be produced by the recipient country/firm. The latter is in tune with the Wassenaar Arrangement which aims to monitor weapons production and sale globally so as to prevent their proliferation to irresponsible state and non-state actors. All these reasons are clearly *bona fide*, and India, with a world standing as a responsible nation upholding ethical standards and promoting peace and trust, is committed to maintaining such values.

Challenges in the Indian Acquisition System[13]

The Indian acquisition system is guided by two major directives of the Government of India (GoI)—The Defence Procurement

Procedure (DPP), last revised in 2016, and the Defence Production Policy (DPrP) 2011. Many of the national goals communicated in these two documents overlap while some are unique to each. In Table 4.2 below, excerpts conveying the goals directly or indirectly have been listed and short descriptions in brackets have been added to summarise or represent their contents:

Table 4.2: National Goals Conveyed by the DPP and DPrP

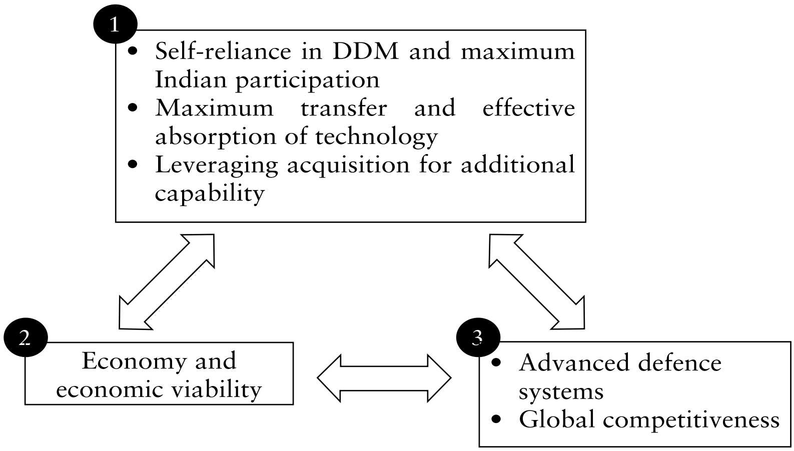
Goals conveyed by both documents	Substantive self-reliance in design, development and 'manufacturing in defence sector, in as early a time frame as possible'.[14] [15] [16] [17] (**Self-reliance in DDM**) 'ensure increased participation and development of the Indian industry'.[18] [19] (**Indian participation**) 'needs of the armed forces being a non-negotiable and an uncompromising aspect,[20] the overall aim of ensuring that our forces have an edge over our potential adversaries at all times – in immediate terms as well as in sustainability – will be ensured'.[21] (**Acquisition of Advanced defence systems**)
Goals conveyed through the DPP	'To improve efficiency of the procurement process'.[22] (**Efficiency**) 'maintaining highest standards of transparency, probity and public accountability, fair competition and level-playing field'.[23] (**Probity**) 'a balance between competing requirements such as expeditious procurement, high quality standards and appropriate costs'.[24] (**Quality and Economy**)

	'comprehensive Transfer of Technology (ToT), pertaining to critical technologies as per the specified range, depth and scope'.[25] (**Maximum ToT of critical technologies**) 'to give a complete exposure to them on design practices of OEM'.[26] (**Leveraging for additional capability**) 'the technology absorption levels agreed to while concluding ToT contract have been achieved'.[27] (**Full Technology absorption**)
Goals conveyed through the DPrP	'Sub-systems/ equipment/ components that are not economically viable or practical to be made within the country may be imported, ensuring their availability at all times'.[28] (**Economic viability in India**) 'addressing any issue which impacts the competitiveness of the Indian defence industry in comparison to foreign companies'.[29] (**Global competitiveness**) 'producing state of the art defence equipment/ weapon systems/ platforms within the price lines and timelines are globally competitive'.[30] (**Advanced defence systems and Global competitiveness**)

Source: Prepared by the Author.

Leaving out the neutral objectives of efficiency and probity, we find that the objectives which support each other can be grouped into three different clusters. And in the pursuing of the objectives (through ToT), each cluster adversely affects those of the others. A schematic of this inter-relationship is shown at Figure 4.1.

Figure 4.1: Inter-relationship between Clusters of Objectives



Source: Prepared by the Author.

To elaborate, the objectives of cluster 1 essentially ask for more technology and capability, which in turn, will cost more thereby, impacting the economy objective of cluster 2. Also, achieving self-reliance translates to indigenisation which does not always mean cheaper parts. In fact, there are parts which could be much more expensive to manufacture in India due to the lack of raw material/ components/machinery and the low scales in which they are required. So attempting to achieve self-reliance beyond a certain point can be cost-prohibitive. The objective of cluster 3 asks for newer, advanced technology, which again, will cost more and impact economy. The acquisition of newer technology in cluster 3 also means a wider gap between the imported technology and the technological capabilities of the Indian industry. This in turn, means that less technology will be absorbed leading to more dependence and less self-reliance.

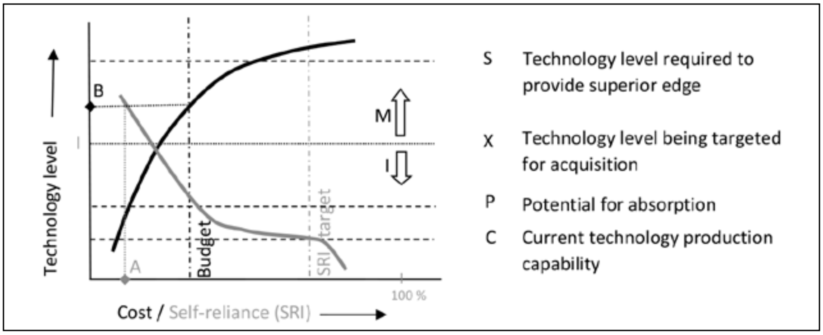
Now, the DPP prescribes a competitive two-stage proposal selection system where the deliverables offered by interested vendors are first objectively assessed through document inspection and then field trials for clearing a stated threshold in performance and technical specifications. The price bids of the cleared offers are then opened in the second stage, to select the offer quoting the least price. The second stage thereby, is instrumental in achieving of economy in acquisition.

A defence system supplier who wishes to compete in the process is confronted with two conflicts. One, where he can supply newer technology, but at a higher price, and two, where he can supply more technology, but again, at a higher price. To remain competitive therefore, he will opt for the oldest technology which meets the performance criteria and the least quantum of technology acceptable. This tendency of offering of older technology has been countered somewhat by the DPP 2016's assessment of enhanced performance parameters (EPP) which credits the bidder offering newer technology with a notional reduction in his price quoted (thereby improving his chances of winning).

The buyer, which is the Indian military, is also confronted with conflicts. He wishes to acquire the newest technology to increase his winning edge over his nation's adversaries. But he is constrained by a budget and the absorption capabilities of the local defence industry. He also wishes to acquire maximum self-reliance through acquiring more technology, but is constrained again, by a budget and by the technology-production capability of the local defence industry. This complexity can be further understood by the conceptual line graph at Figure 4.2 below.

The vertical axis indicates the technology level of a defence system in general, with the bottom representing, say, the technology of a third generation fighter aircraft and the top representing a sixth generation. Four levels—S, X, P and C within this range—are marked with horizontal dashed lines and signify levels as annotated. The horizontal axis indicates two variables—the cost of the system in black and the achievable Self-Reliance Index (SRI) in grey. The black line graph indicates

Figure 4.2: Fixing of desired technology level for ToT



Source: Prepared by the Author.

that, as we look for more advanced technology to attain a greater military edge, the procurement cost increases exponentially. The grey line graph indicates that, as we look for more advanced technology, the SRI achievable by industry progressively decreases since the gap between the technology being acquired and the potential for absorption increases. Conversely, if we opt for lower technology levels, the SRI achievable increases gradually at a steady rate till it reaches the potential for absorption and then increases quickly till it reaches a point where the remainder becomes difficult to indigenise as the foreign OEM will not part with the small portion of proprietary technology or the components concerned are grossly uneconomical to manufacture indigenously.

So, while the military (arrow marked 'M') strives for more advanced technology to gain a battle-winning edge over adversaries, the local industry (arrow marked 'I') asks for lower technology to achieve greater SRI. This phenomenon is proven by the statement of the Narendra Sisodia Committee of 2007, which pointed out that the Qualitative Requirements (QR) set by the defence services were aggregated from several systems in the global market and beyond the minimum capability needs, and involving the domestic industry would promote self-reliance by projecting realistic requirements in keeping with its potential.[31]

Which level of technology should then be acquired? One way of simplifying this conundrum, is to assess and fix as many variables as possible. The technology that delivers a superior edge over the adversary's is one, and this is represented as line S in Figure 4.2. Another is the current technology production capability as well as the potential for absorption by the local defence industry, represented by lines C and P, respectively. Assessing these can lead to an understanding of the highest level and quantum of technology that can be realistically absorbed.

Now, if the budget (for effecting economy) and the self-reliance target are flexible enough, then it is a simple matter of selecting the technology level S. If however, the budget is limited, then it becomes a matter of accurately assessing which level of technology fits in the budget as denoted by the point B on the vertical axis. And this in turn dictates the level of self-reliance or SRI that can be achieved as denoted by point A.

So, much of the solving of the decision-making problem lies in obtaining an accurate market value (or price) of different technologies (and their systems) as well as an accurate assessment of the Indian defence industry's technological production and absorption capabilities. Unfortunately, both these tasks are not easy at all.

Valuation of the Technology in Defence ToT

In the chapter on understanding the nuances of ToT, we had seen that technology as Intellectual Property (IP), can either be assigned to another entity, who then becomes the new owner, or licensed out for use by another agency. In the context of PToT to India, where production is limited to domestic needs and economy is to be achieved, technology is always acquired through the cheaper route of acquiring licenses to use it. These licenses, or contracts for PToT, are invariably limited to a specific number of systems. Hence, the technology acquired is essentially the manufacturing know-how for producing this specific number of systems.

Valuation of this technology is made extremely complex by the numerous approaches available and variables involved. The seller will value it on the basis of the R&D investment which he is yet to recover, profits he desires to plough back into development of the next generation technology and the future sales he can expect. If the profit margins in the segment are generally known, a market thumb rule is that 25 per cent of it is ploughed back to the developer.[32]

The buyer, on the other hand, would be willing to pay the lowest price in a competitive bid, which essentially translates to the market value. Hence, sellers will invariably be limited to this market value which will depend on market forces such as supply and demand, inflation, foreign exchange rates and factors such as how advanced the technology (and its system) is, the technology's residual life, its potential market size, availability of alternate systems/technologies, market competition, quality of IP, etc.[33] Also, the sale of weapon systems or their technology is invariably a strategic decision by the foreign government and therefore, prices may vary depending on bilateral relations between the seller's and buyer's countries, how critical the systems are to the buyer country, military cooperation between the countries for mutual benefits in the region etc.[34]

With so much complexity involved, no definite method appears to be available for valuing the ToT component of Buy and Make contracts in the DPP.[35] Besides the numerous factors listed in the paragraph above which influence the market value, the quantum of technology being acquired will also dictate the price demanded. As we have discussed in the section on acquiring full ToT, the cost of technology is likely to increase disproportionately as the quantum to be acquired goes beyond an inflection point. This inflection point will vary depending on differences in the level of technology being acquired and the technological level of the recipient firm or industry. Differences in a couple of generations may place it as low as 30 per cent while a single generation may raise it to 70 per cent.

Fitting the technology within a budget therefore requires judicious fixing of the proportion of the five categories of items depending on the cost it would incur as well as the capability of the local industry. There is no point asking for a larger quantum of say, category 2 and

3 items if the capability of the industry to manufacture or design/develop them does not exist. Clearly, for higher technology systems being procured, a lower quantum of technology transfer would be more practical and cost effective.

Coming back to the DPP, the ToT component of the deliverables being purchased is broken down into know-how and documentation, industrial training for each of the phases, training on design liaison, and technical assistance. The cost of the FF systems, SKD, CKD and IM kits are separately listed.[36] Since the DPP recommends the selection of the lowest bid among a consolidated price comprising that of the systems, their maintenance package and ToT, it is very likely that the ToT costs get limited attention, though some comparison with other vendors bids is probably done out of academic interest. However, how advanced the technology is, essentially gets characterised in the systems and their performance levels and therefore, it is probably sufficient to base the value of ToT on a proportion of the consolidated figure.

Assessing the Defence Industry's Technology Absorption Capabilities and Production Capacity

For the effective absorption of a technology, it is not necessary that the defence industry should already possess the capabilities (in that technology) to assemble the subsystems, test systems, manufacture parts or develop them. But, it is necessary that the industry have the *potential* to learn the processes, upgrade their infrastructure and re-organise themselves, if required, to deliver within a reasonable amount of time. This clearly requires a mentally agile, academically and technically sound and motivated workforce, capital for investing on new infrastructure and flexibility of the transferee firm to adapt. A R&D element can also help in understanding the technological aspects well and adapting the technology to suit local conditions. Strong leadership will, of course, be essential to bring everything together cohesively.

An objective assessment of the ingredients mentioned above, as they apply to the different stages of FF, SKD, CKD and IM stages can help in obtaining an overall view. In the IM stage, the capability to produce quality products through the B2P, B2D and B2S routes, in the time available, is critical. Assessing this capability before-hand may be complicated since these are invariably outsourced from the OEM's Tier 1, 2 or 3 firms. In the Indian competitive private eco-system, tier firms are invariably over-optimistic of their capabilities and make promises which are not always kept.[37] The transferee firms who have developed their tier firms in close partnership will be better positioned to conduct such assessment and effect improvements, if necessary.

It is worthwhile spending substantial time and efforts to assess in detail the existing capabilities or potential accurately. In the Russian T-90 battle tank contract of 2001, it was assumed that the technology for common rubber items would not be required since the earlier T-72 battle tank contract of the 1980s had transferred such manufacturing capability. Much later it was realised that all the earlier Indian manufacturers and suppliers had closed shop and rubber items had to be imported again. Hopes are now being pinned on a JV between a Russian firm and an Indian one which plans to manufacture these parts in India.[38]

Assessment of production capacity, as against capability, is a relatively much easier task. The capacity of the Indian transferee firm and its subsidiaries would already be established from the existing production orders that they are servicing. However, specialised infrastructure which may be needed for new technology may take time and capital and their prospective availability will need to be accurately estimated.

PToT Complexities in the Indian DPP

The ToT portions of the DPP cover in great detail the objectives and process to be followed, with all possible angles and potential loopholes plugged, so as to ensure the acquisition of maximum technology at minimum cost. Unfortunately, the over-emphasis in this direction, with tighter clauses being added through successive editions, appears to have increased the complexities to such an extent as to make it almost impracticable.

As mentioned earlier, the Indian DPP provides two routes for PToT, not considering those possible through the offset policy. The B&M(I) route (which allows Indian firms to compete for supply of systems after absorption of foreign technology) has been accorded higher priority over the B&M route (where an Indian OF/DPSU/ Private firm is nominated for receiving ToT) possibly because it allows for competition within the industry and is hence expected to deliver cost competitive products. However, for larger systems such as fighter aircraft, submarines, etc., which require massive investment and proven capability, the production agencies available, are invariably not more than one and hence competition is not possible. The ToT section of the DPP prescribes the latter route for such systems.

Both the routes are essentially expected to follow the same process of phased manufacturing and the ensuring of technology transfer through the categorisation of the items explained earlier in this chapter. This process has been deliberately overlaid with clauses to ensure the three objectives of achieving self-reliance, acquiring advanced defence systems and being economical as discussed earlier. In addition, the DPP lays great stress on the acquisition of critical technologies needed by the Indian industry and also a number of other desirables.[39] A deep look at these clauses, however, throws up a number of undefined variables and implementation issues which are not easily solved. Unfortunately, no information on the authors of the numerous editions of the DPP is available, except the latest DPP 2016, which is known to have been finalised by a Group of Experts committee in 2015. This committee has built on the earlier version with added focus on the Make-in-India programme. Hence, they too are unable to shed any light on the background to the inclusion of the original clauses.[40] Therefore, the complexities are addressed with some amount of speculation on what the drafters must have intended. The analyses of these complexities are covered in generally decreasing order of significance below.

The DPPs, right from the 2008 edition, mention that key or *critical technologies* need to be identified and specified in the Request For Proposal (RFP) as mandatory for transfer in the ToT process.[41] The DPP 2016 states that these should be specified in the range, scope and depth necessary.[42] What constitutes critical technology and what is meant by range, scope and depth, however does not seem to be clear in the environment. To ensure such transfer, DPP 2016 states in another place that no item which is critical from the technology point of view can be acceptable as proprietary.[43] Proprietary items, as mentioned earlier, are those which give the system its edge over the competition and whose technology is hence, closely guarded and never shared. This clause hence, might very well lead to the rejection of deserving systems, whose OEMs do not wish to compromise their proprietary technology. We will analyse in detail what could possibly constitute critical technology and the complexities involved in acquiring them through ToT in the section ahead.

Another vexing aspect concerns the indigenous content (IC) to be achieved at various stages of ToT and which is required to be specified in the RFP.[44] In a connected way, the DPP states that the foreign OEMs should transfer technology to such a depth as to ensure a value addition by the Indian PA of at least 30 per cent in the CKD stage and 60 per cent in the IM stage.[45] While this puts across the sentiment that larger IC or Indian value addition is desirable, it is also known that the absorption capability of the Indian industry is not unlimited. Further, more technology transfer means more costs. If more ToT is desired, and there are references in the environment for the asking of *full* ToT as discussed earlier, it means that maximum items of the system should fall in category 1. However, the value addition in category 1 items is restricted to the manufacturing process only, whereas, that in categories 2 and 3 are much more, involving in addition, indigenous process development and product design, respectively. Hence, maximum IC/value addition and maximum quantum/depth of ToT become conflicting requirements beyond a point and since the DPP appears to strive for both, it becomes difficult to decide where to draw the balance. Also, whether increased costs due to more depth in ToT are worthwhile investments, is difficult to gauge without knowing the details of the processes involved and their utility to the Indian industry. The DPP, in its flow charts for deciding the optimal route of acquisition, states that the cost (of ToT) should not be prohibitive.[46] But, here again, what level of expenditure is considered cost-prohibitive is not clear. Also what if part of the technology offered already exists in the country? Does it qualify for ToT? And does the OEM still get credit for its transfer?

Another vexing clause states that the technology (to be transferred) should be current, state-of-the-art as used in contemporary systems. The terms 'current' or 'state-of-the-art' are not easily definable and this hence, introduces an element of arbitrariness which is clearly not desirable. Also, contemporary systems could consist of a basket of subsystems with new and older technologies. Where is the line, differentiating these, to be drawn?

ToT is required to be 'comprehensive' and 'complete' as stated by the DPP, which, going ahead, contradicts this stipulation by accepting that the OEM may not be able to transfer his proprietary or even category 3 and category 4 items' technology.[47] In a similar manner, it states that the vendor should provide 'total' support and facilitate ToT of the sub-systems from his sub-vendors/OEMs.[48] These contradictory clauses and ambiguous expectations from the vendor can be extremely confusing for both, executing agencies and vendors.

Then there are clauses which require foreign OEMs to provide in-depth technology details at the early request-for-information (RFI) stage to enable the setting of parameters in the RFP. The OEMs, which are operating in a highly competitive environment, will be unwilling to share these beyond a certain depth, even if confidentiality and non-disclosure agreements are signed. To arrive at the parameters in the RFP, the critical technologies will need to be identified and all technologies verified as state-of-the-art. Then we have the task of specifying the ratio of distribution of technologies in categories 1 to 5 and the proportion of Manufacturer's Recommended List of Spares (MRLS) to be made or assembled in India.[49] The latter two need the matching of the smaller parts/modules and even some of the components of the systems with the manufacturing capability potential of the Indian industries. Since these potentials are not recorded and difficult to assess, they are, in effect, unavailable to the foreign OEM or the SHQ officers. Hence, how is the ratio of distribution of the categories to be realistically assessed?

Then there are clauses which are highly ambitious and whose realization is questionable. One asks for technical information/data updates of all upgrades undertaken in the entire life cycle of the product to be provided at no additional cost.[50] Another asks for 'complete exposure' to design practices of the OEM so as to enable upgrades during the complete life cycle of the product.[51] Though OEMs will be willing to provide information and design knowledge for minor upgrades so as to improve reliability or overcome weaknesses in the system, it is too far-fetched to expect the same for major upgrades involving significant performance enhancements at no additional cost. The source code of embedded software has been asked for along with the Firmware Support Manual, presumably with the intention that it can be further developed by Indian firms.[52] Here too, it is known that source code is never given (in a form allowing its further development independently) because it can then be exploited by the receiver, thereby reducing the developer's returns. The OEMs, however, will be willing to provide capabilities for executing minor changes in software for its maintenance.

Then there are clauses which are difficult to execute due to the complexity of their nature. At the RFI stage, after the services qualitative requirements (SQRs) have been finalised, the prospective foreign OEMs for the ToT are required to be short-listed based on various parameters, one of them being their ability to transfer requisite technology.[53] How is this ability to be assessed? One way would be to check if the foreign OEMs have successfully transferred their technology in the past. But since OEMs are invariably reluctant to provide details of their earlier contracts with other countries, such an evaluation is not easy. In another place, the DPP stipulates that before awarding repeat orders on Indian technology recipient firms, the technology absorption levels agreed to in earlier contracts should have been achieved.[54] Technology absorption levels are a function of the knowledge and demonstrated capabilities of a firm and can become complicated to assess when quality levels are not fully achieved and exact causes are distributed over internal and external factors.

In the case of the Buy (Global) category, the DPP states that ToT may be considered 'essentially to provide the buyer with leverage during negotiations or even post contract stages'. Also 'it may cover only certain critical product items such as fuel/ warhead contents of a missile or ammunition of gun etc'.[55] Such a clause gives the impression that even after the selection of a system the foreign OEM can be pressurised into supplying ToT of critical items which, as a deliverable, may not have been even mentioned in the RFP! In the background of the emphasis on probity and fairness, this clause seems completely incongruous.

There are a few more complexities of a minor nature for which solutions seem readily available. These, along with possible solutions to the above vexing issues, we will discuss in the penultimate chapter.

Analysis of the Utility of PToT in the Acquisition of Critical Technology[56]

The DPP does not explain *why* critical technologies of the imported system are required to be identified and obtained through ToT. A scan through published documents reveals that the importance of developing critical technologies in the defence sector was first highlighted by the committee headed by the then Scientific Advisor (SA) to the Defence Minister, Dr. Abdul Kalam, in their report submitted on October 27, 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 quotient from 30 per cent in 1992 to 70 per cent by 2005 and also identified critical technologies such as Gallium Arsenide devices, fibre optics, smart weapon subsystems, heavy particle beams, focal plane array and hypersonic propulsion for future research and development.[57]

Since then, a very strong emphasis has been placed by the Government of India (GoI) and the Defence Research and Defence Organisation (DRDO) on the acquisition of these critical technologies. As quoted by a DRDO scientist, the DRDO has maintained a "focus on its primary aim of establishing self-reliance in critical defence technologies, guided principally by compulsions of national security".[58] The reasons for developing such technologies were enumerated as 1), "immunity against technology denials", 2), "enabling the pursuit of an independent foreign policy without having to kowtow to global powers" and 3), that "an indigenous technology base provides an impetus for a country's economic development".[59] This was also brought out in the comments of the then Prime Minister in 2008 that "at the heart of self-reliance is our ability to define the strategic and critical areas in which to build national capability".[60]

In the absence of any evidence to the contrary, it appears that the GoI, while communicating the overall objective of achieving self-reliance, has accordingly stressed on the acquisition of critical or key technologies through ToT in its successive editions of the DPP. The DPPs stated that these technologies need to be identified in consultation with the DRDO and would necessarily have to be identified at the Request for Information (RFI) stage so that they could be included in the Request for Proposal (RFP) issued to the vendors.[61]

The Defence Production Policy (DPrP) 2011 of the GoI, while emphasising the objectives of achieving substantive self-reliance and providing equipment with a superior edge over the adversaries, states that "in all cases of Transfer of Technology, DDP along with DRDO, HQ IDS and SHQs will be involved in identification and evaluation of *requisite* technology, and subsequently would be responsible to ensure that appropriate absorption of technology takes place in the Indian industry. Thereafter, successive generations of the weapon systems/ platforms will be developed in the country".[62]

While both the Dr Abdul Kalam Committee report and the DPPs stress the importance of holding critical technologies, there is a significant difference between the two. While the committee stresses on *developing* them, the DPPs stress on *acquiring* them through ToT. *Developing* them would result in the building up of the all important know-whys for design and development in addition to the know-hows for manufacturing. *Acquiring* them *through ToT* (especially the licensed manufacture mode mentioned in the DPPs) only provides the know-hows of manufacturing. Hence, while the former leads to capabilities to build an unlimited number of successive upgrades and variants, the latter enables only the limited manufacture of the current version with the added burden of the inevitable dependence on the OEM for proprietary parts. To this extent, the DPrP's assumption that after acquisition and absorption of the technology through ToT, "successive generations of the weapon systems/platforms will be developed in the country" appears to be weakly premised and overly optimistic.

This notwithstanding, one can assert that acquiring the manufacturing technologies of critical subsystems will still benefit the DRDO and enable it to develop systems with greater indigenous content. Therefore, leveraging acquisition contracts for acquiring critical technologies through ToT appears to be a clever approach to 'kill two birds with one stone'. Unfortunately, since the DPP and the DPrP do not explain what is considered 'critical' technology, there is a void in the understanding of this aspect which even the well-informed in the environment have been unable to explain. One can arrive at five explanations, on what 'critical' technologies could mean, with each of these raising its own set of questions.

One is that it is technology without which the system will not perform its key function.[63] Going by that explanation, if we take a missile boat, would this mean that the missile system is critical and the floatation, propulsion and surveillance and communication systems are not? Similarly, in a battle tank, the armour plated hull, the power transmission, gun, missiles system and even optronic sights are all important to enable its functioning. So which of these are critical and which are not?

The second is that it is technology that is desired by India and included in the 20 critical technologies list of the DPP which can be offered to DRDO for offset credits.[64] These correspond to the critical technologies identified by the Dr Abdul Kalam committee and are all highly advanced technologies, many still in the development stage in foreign countries. Over the past few years, some offset offers of these technologies have been received and evaluated by the DRDO. During interactions with the OEMs, the DRDO made it known that the know-hows as well as the know-whys of these are required, to which the OEMs responded with unaffordable prices up to a hundred times the cost of manufacture. The foreign OEMs also indicated their apprehension that their technology would be used by the transferee to compete with them in the future. Another angle on this definition is that contemporary systems being procured with ToT (which are typically a couple of generations behind the cutting edge) are not likely to have any of these advanced technologies. So does that mean that there are no technologies in these contemporary systems which need to be classified as critical?

The third explanation for what constitutes critical technology is that it is technology which is available in contemporary systems, but not available in India, and can be used in DRDO designed systems in the future.[65] Does this mean that the Service HQs/ DRDO should identify which subsystems of the system being procured are not being manufactured in India? What if the critical technology has very limited demand in the industry and hence setting up a manufacturing capability becomes uneconomical? Or the technology of the subsystem is already halfway through its life and is likely to be replaced soon? There are 6000 Medium, Small and Micro Enterprises (MSMEs), 60 private firms, 9 DPSUs and 41 Ordnance factories manufacturing defence equipment in India. How are the voids to be identified since a comprehensive competency map of the Indian industry is yet to be fully collated. Current databases in the DRDO laboratories cover manufacturing technology available for systems which are being developed by them and not country-wide capabilities. Another question is whether the foreign OEM will share all the intricate details of his technology at the RFI stage since, as per the DPP, the critical technologies need to be specified in the RFP?

The fourth is that these are technologies that are not available in India and the absence of which can negatively impact operational availability, combat capability, and long-term life cycle support of a system.[66] This would mean that subsystems and parts which are likely to fail during the life of the system should be manufactured in India using the requisite critical technology. What if the numbers needed are too few to allow for efficient economic utilisation of such a technology? Such a requirement of holding spare assemblies and parts or the capability of their repairs are normally assessed scientifically by the maintaining agencies of each of the three military services during their maintainability and maintenance evaluation trials and requisite solutions worked out. These solutions are typically, the stocking of spare assemblies/parts and contracting of Maintenance ToTs (MToT) for their repairs. There is no need, therefore, to supplement such a requirement with additional 'critical' manufacturing technology unless it makes economic sense.

The fifth is that these are technologies "the withholding of which would bring the production or operation of a particular system to a halt".[67] This definition presupposes that foreign countries may decide to suddenly and without good reason, stop the supply of certain parts including the critical proprietary parts, thereby halting production or preventing replacement of failed parts of systems in operation. Does this mean that technologies of all the proprietary parts are to be considered critical? OEMs are unlikely to provide such proprietary technology, and even if they did, they would be priced exorbitantly and possibly a drain on the economy with no matching returns. OEMs will however, be open to providing spares of the proprietary assemblies or parts as part of the MToT package mentioned above. As regards halting of production, why would a foreign seller suddenly withhold a proprietary part which he has agreed to supply in a contract? Such a situation may only occur if sanctions are suddenly imposed on India for a violation of international regulations or treaties, or a violation of the seller's Intellectual Property Rights (IPR), by the Indian buyer firm, both of which, it can be assumed, are highly unlikely.

From a study of the above five, the third definition of what constitutes critical technologies seems to be the most relevant, supported somewhat by some aspects of the others. So 'critical' technology to be acquired through ToT would be those manufacturing technologies which are desirable in India for the production of subsystems, which can be used in DRDO developed systems. These desired technologies would comprise both the product technology (which covers the specifications and engineering drawings) as well as manufacturing process technology in the form of process description documents, special machines and know-how, in case the latter is not already available in India.

Unfortunately, product technology/design cannot be used to produce more than the licensed/contracted number due to contractual restrictions as well as the foreign seller's control on the proprietary items. Hence, its utility during and after the contract period is limited to technology diffusion among the workforce or some amount of the contractually prohibited reverse or derivative engineering. Reverse/derivative engineering is not always successful and does not provide tacit knowledge or the know-whys necessary for independent design and development. There is no doubt that some successful defence systems have been modelled after others, but such efforts are akin to 'chasing the tail' of older technologies which are matured and on their way out and hence will squander precious R&D resources.

Manufacturing process technologies, such as laser drilling, wave soldering, X-ray testing, etc. and the know-how to use them can be of great use but are expensive and typically purchased separately by Indian firms since they have wide applicability over a range of products, both military and civil. Hence, acquisition of these through ToT contracts may only skew ToT prices due to their high cost. Also, what if a process technology was acquired but cannot be put to economic use due to inadequate demand, both domestic and export? What if such processes are required only intermittently, with the danger of the loss of workforce skill? What if the raw materials required for these processes are not available in India and have to be imported at great expense? These are uncertainties in the 'business case' that are extremely difficult to analyse and gauge in the current acquisition system which processes a wide range of relatively smaller orders of equipment, by SHQ officers, DRDO scientists and Department of Defence Production (DDP) officials who are under-informed on the business angles of manufacturing technology.[68]

We now come to the biggest challenge in acquisition of critical technologies through ToT; competing defence systems of different countries employ technology developed in their country's R&D eco-system and therefore, may greatly differ from each other. Let us take the hypothetical example of competing Russian, Swedish and Israeli search radars, which use, say, the technology of older and cheaper, cascaded radio frequency amplifiers, more current and expensive travelling wave tubes and advanced, very expensive solid state devices, respectively. If the SHQ and the DRDO select solid state technology (which is the most advanced), and that is specified in the RFP, it would rule out the first two competing systems. Since foreign OEMs are well aware of the broad technology used in their competitor's systems, they could easily take advantage of the single vendor situation to overprice their system.

One suggestion offered to overcome this situation is that the technology of all the three competing radar systems should be listed in the RFP as acceptable. This could be done and will probably be successful if any of the three technologies could be utilised by the DRDO. Unfortunately, none of these would be compatible with the Indian DRDO developed radars which now use active electronically scanned arrays. This leads us to infer that the technology identified as critical must be in consonance with or at least compatible with DRDO/indigenous technology. Ensuring such compatibility, however, greatly limits the competition and increases the probability of the occurrence of single vendor situations.

With different technologies come different strengths. What if the DRDO wanted to obtain the best technology from each country—the rugged hulls/bodies/airframes of Russia, the superior electronics of Europe and the advanced digital systems of Israel? How would all these be acquired when only one system (and therefore OEM) can be ultimately selected?

We can thus see from our discussion, that the focus on acquisition of critical technology in the DPP leads to issues which severely hamper the DPP's primary purpose of enabling the smooth acquisition of a military system. Besides this, the very unclear understanding of what is considered critical can lead to great confusion within the acquisition agencies. And finally, the benefits of acquiring these critical technologies are not very clear. No content appears to have been published on any useful acquisitions of critical technology through ToT in the past decade and hence it appears unlikely there will be any in the future. In case such technologies are needed by the DRDO, it appears that the best way forward is to directly purchase them. Nonetheless, since no confirmation of the uselessness of acquisition of critical technologies through ToT over the past decade is available, we will not completely rule out this clause and discuss some solutions in the penultimate chapter of this book.

Complexities in the Strategic Partnership Chapter of the DPP 2016

Chapter VII of DPP 2016, covering strategic partnerships of the Indian Government with the Indian private industry, was issued separately by the Indian MoD in mid 2017 after finalising its many features. Essentially, the chapter enables Indian private sector firms to engage with foreign OEMs in long-term tie-ups for the production of four major defence systems-fighter aircraft, helicopters, submarines and armoured fighting vehicles/main battle tanks.[69] These partnerships would supplement the already existing capacity of the OFs and the DPSUs and enhance competition besides drawing benefits from the advantages that private firms have over public sector agencies. The overall objective has been clearly articulated as the reducing of dependence on foreign imports and building of self-reliance and even self-sufficiency through R&D for future long-term upgrades.

The chapter repeatedly stresses the importance of transfer of technologies from foreign OEMs and their absorption by Indian firms. It mentions manufacturing ToT, which would correspond to the PToT or DToT (limited) variant discussed in the chapter on nuances, while the modes of transfer have been left open to a wide range and listed as joint ventures (JV), equity partnerships, technology-sharing, royalty or any other mutually acceptable arrangement. While this flexibility is a welcome step after the rigid model of PToT prescribed by the main DPP document, there are a few complexities which could possibly hamper ToT.

At one point, the chapter states that the MoD will work out government-to-government (G2G) support for licensing, ToT and provisions for IPR issues.[70] But further ahead, it states that foreign OEMs will, in the EOI stage, provide a formal acceptance of their government that necessary licenses to transfer technology will be granted and that such a commitment may also be supported by inter-governmental agreements to be signed between India and the country concerned, at the stage of award of contract.[71] Leaving the outcome of the long-drawn process to a G2G negotiation (which may not necessarily go our way) at the final step, is leaving too much to chance. Also, it can become tedious and inefficient, if such a negotiation is to be held for every contract, big or small, that is to be concluded.

The process of short-listing the systems and the OEMs involves the initial issue of a request for information (RFI) to prospective OEMs. On the receipt of this information from the OEMs, the SQRs and the range and depth of technology to be transferred will be finalised by the Indian acquisition agencies. These will then be communicated through expressions of interest (EOI) to the responding OEMs who will be given two months to submit details of range, depth and scope of technology offered, extent of indigenous content proposed, extent of eco-system of Indian vendors/manufacturers proposed, measures to support the SP in establishing systems for integration of platforms, plans to train skilled manpower and extent of future R & D planned in India. OEMs will be short-listed based on these criteria, over and above the compliance of their defence system to the SQRs.[72]

Prima facie, the process appears workable. But, expecting the OEM to respond within two months with such detailed information, covering hundreds of hardware modules is extremely far-fetched. Assessing which technology can be transferred to achieve what IC requires a very deep understanding of the capabilities of the Indian industry, the availability of raw materials and machinery and a host of other factors. In many cases, such an understanding will only come while practically executing a project. As in the main DPP, what is meant by the range, depth and scope of technology is unclear and this may lead to unnecessary delays till these are clarified.

Short-listing of OEMs based on the SQRs of the systems and extent of ToT, IC, eco system, support measures, skilling and R&D means that a threshold has to be defined for each of these and only those OEMs whose offer in SQRs and these six ToT linked areas clears the threshold will be accepted. Setting the right threshold will therefore need a deep insight into what is feasible in the Indian industry. Setting a very high SQR and ToT threshold will commit the SP and OEM to targets which may not be technologically or economically viable. Setting of a lower SQR but higher ToT threshold, on the other hand, will lead to the acquiring of older technology which is cheaper and can be absorbed to greater range, depth and scope. Such technology, however, may not hold potential for improvement and therefore efforts and expense in R&D and building upon them may well go waste.

As in the DPP 2016, the SP model projects the requirements of maximum quantum of ToT and maximum IC which, as we discussed earlier, conflict with each other beyond a certain point. In addition, the SP model asks for the delivery of R&D capability for enabling the development of future upgrades of the systems. This is equivalent of asking the OEM to help the Indian partner to step into areas which might threaten the OEM's own core business. Also, what if this R&D capability is held by another agency and is beyond the OEM's control? Foreign governments also impose severe restrictions on such transfers as we shall see in the chapter ahead. The stress on self-reliance and even self-sufficiency as the end objective in the chapter further accentuates this use-and-throw concept. Why would a foreign government or company agree to such a self-defeating arrangement?

Also, how are these offers of ToT, IC, skilling, etc. to be evaluated for feasibility and more importantly, utility? For instance, some manufacturing plants may be created as a part of the eco-system, but their products may have limited demand in the country, leading to prices which are higher than that of the OEM or his subcontractors. A section of the chapter states that the technical offer shall include details of the equipment, company's willingness to meet mandatory requirements related to indigenisation roadmap, transfer of technology, etc.[73] Is willingness alone sufficient to ensure their final execution?

A section states that the SP should formulate a research and development roadmap to achieve self-reliance within the country in respect of the segment.[74] As we will see in the next chapter, R&D is expensive, risky and needs inputs from fundamental research. The notion that self-reliance in the segment could be achieved by simply committing to a road map, therefore, appears overly optimistic.

Another states that "to achieve self-reliance within the country, subsequent acquisitions in the identified segments/platforms should ideally be carried out from Indian companies under Buy (IDDM), Buy (Indian), Buy and Make (Indian) and Make categories of acquisition under DPP. This can be accomplished only when Indian companies make considerable, long-term investments in capacity creation and capability development including infrastructure, tiered ecosystem of vendors, skilled human resources, futuristic R&D etc."[75] The question is—will such long-term and large investments in narrow fields of technology generate sufficient return on investment, in an age where disrupting technologies are mushrooming every few years across the world? These disrupting technologies develop from discoveries and inventions made through fundamental and applied research, an area in which India is significantly behind the developed countries.

Complexities in the Indian Defence Production Policy 2011

The Indian Defence Production Policy (DPrP) of 2011, broadly highlights substantive self-reliance as the national objective to be worked towards, preferably through indigenous design, development and manufacture, and where not practical or economically viable, through the import of subsystems or equipment. It appears to accept that ToT may have to be resorted to but places a condition that "the DDP along with the DRDO, HQ IDS and the SHQs would be involved in identification and evaluation of requisite technology, and subsequently would be responsible to ensure that appropriate absorption of technology takes place in the Indian industry. Thereafter, successive generations of the weapon systems/platforms would be developed in the country". It further goes on to state that "Upgrades will be carried out by the Indian Industry as far as possible. The DRDO, HQIDS, SHQs, OFB, DPSUs and the private sector will work in close coordination for continuous upgradation in systems".[76]

As discussed in the earlier section on critical technologies, the DPrP's assumption that if ToT is 'appropriately absorbed' by Indian firms, they will obtain the capability of design and development of futuristic variants and systems, is unfortunately fundamentally flawed. Even reverse engineering of transferred technology, which is contractually unacceptable, will not provide the necessary know-whys and will result at the most, in duplication with some minor improvements.[77] This would also of course lead to a hostile technology partner and drying up of a potential source.

Another vexing direction is that the DDP along with DRDO, HQ IDS and SHQs will be jointly responsible for ensuring appropriate absorption of technology.[78] First, distributing this responsibility over such a wide number of agencies effectually dilutes it and leaves none of them firmly accountable. Second, the HQ IDS and SHQs have no capability in this field, while the DRDO being essentially a R&D agency may have just a theoretical understanding.

The DPrP seems focused on achieving self-reliance while also stating that the weapons produced should enable our (armed) forces to have a (military) edge over the country's adversaries. These, as we have seen in the earlier chapter, conflict with the fact that India, as a developing country, has limited economic resources. One could also ask why it has ignored the possibility that the Indian DIB could be developed for mass production of systems for the global market? Such mass production is probably the only way systems which have an edge over India's adversaries, especially China, can be manufactured economically.

ToT in the Draft Defence Production Policy 2018

This draft of 2018 which, when approved, will succeed the policy of 2011, is a potpourri of many relevant and futuristic nuances interspersed with somewhat exaggerated claims of indigenous capability as well as over-ambitious goals. The goal of self-reliance has been stressed, as in the past, and further nuanced very appropriately into strategic independence and sovereign capability in select areas.[79] This has been supplemented with a worthy objective of export to friendly countries. Then the mention of the significance of indigenous R&D in the light of the decreasing predictability of future needs appears to be of sound reasoning. However, the stated vision to make India among the top five countries of the world in Aerospace and Defence industries, the achieving of technological leadership in defence products, the leveraging of R&D strengths to catapult India as a developer of next level of frontier defence technologies in the world and making India a leader in cyberspace and AI technologies are clearly over-ambitious goals, which will involve unaffordable levels of investments and risks.[80]

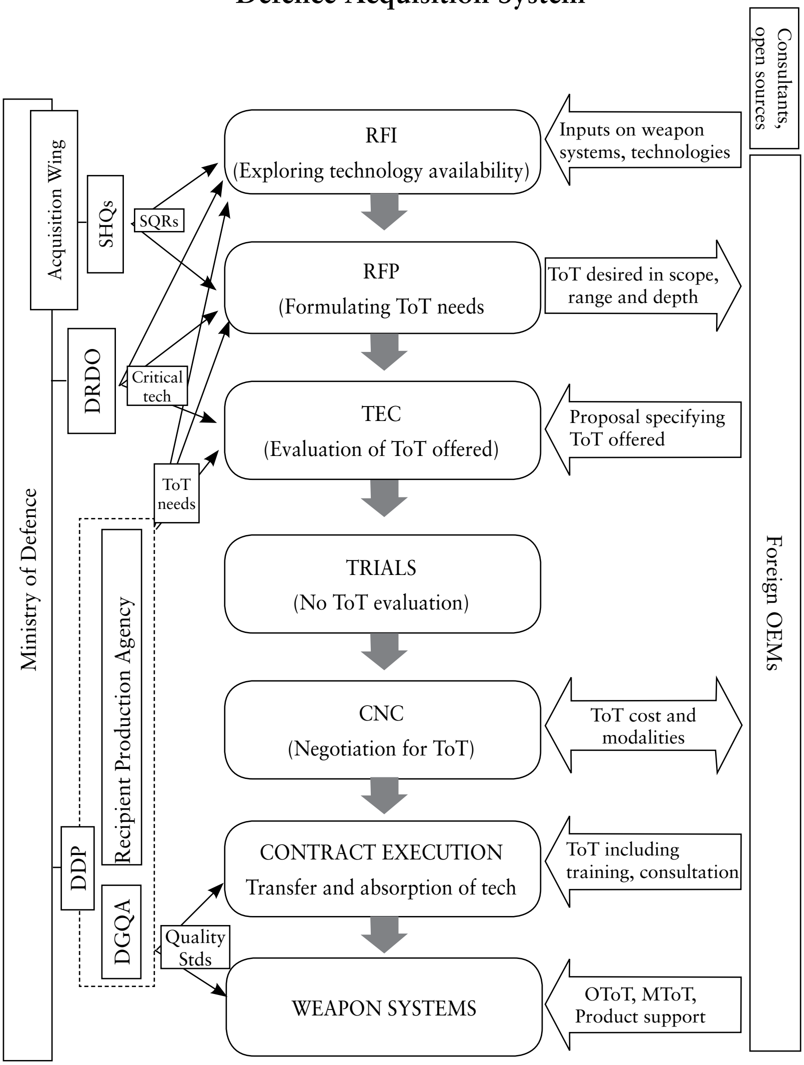
On the ToT front, while deploring the fact that licensed production of several technological platforms are still on, the draft states the need to facilitate faster absorption of technology, encouraging collaborations to acquire latest technology, manufacturing processes, skill-sets and R&D, to undertake 'Competency Mapping' of private defence industry including MSMEs, to establish their core competence/ability to absorb various technologies and to set up technology transfer facilitation centres.[81] Indirectly, it also indicates an openness to more ToT by stating that the FDI regime in defence would be further liberalised, FDI up to 74 per cent under automatic route would be allowed in niche technology areas, that the Government would support infusion of new technology/machineries in the OFB/DPSUs, the DPSUs/OFB would explore acquisition of technology through mergers/acquisitions globally and global majors would be encouraged to set up manufacturing capabilities of their platforms in India, both to cater to domestic needs and export from India.[82] In doing so, the draft communicates the realisation that ToT is a vital instrument in development of the DIB and needs to be utilised to the largest extent possible.

As for complexities in ToT, it has steered clear of those in the DPP 2016 and DPrP 2011 which we have discussed earlier. From a larger perspective of the DIB and defence economy, however, it would have been beneficial to state the approach to be followed to match up to India's adversaries, especially China, as well as the means by which the very ambitious goals stated can be economically achieved.

Understanding the Indian ToT Acquisition and Implementation Process

Along with the DPrP and the DPP which serve as policies and broad procedures, it is necessary to understand how ToT cases are processed and which agencies are involved in the Indian defence acquisition system. In Figure 4.3, we see that the three Service Headquarters (SHQs) obtain relevant information from open sources and through Requests for Information (RFI) issued to prospective suppliers of the weapon systems. The relevant DRDO laboratory then studies the information received, identifies the critical technologies and communicates them to the SHQ. The range, depth and scope of these technologies are not, however, identified and nor is the likely cost or commercial viability of purchasing and utilising such technology.[83] These aspects are left to the SHQs who consult the production agencies nominated for ToT in the Buy and Make route. But, in the Buy and Make (Indian) route, there are no nominated agencies, just prospective private firms, many of which have no prior experience. This leaves the military officers in the SHQs with little technical understanding of the product and process technologies used in the system, the Indian industry's capability to absorb it and factors such as domestic and global demand, raw materials required, etc., for assessing the business case. The RFPs formulated are hence, prone to being sketchy and incongruent to the needs of the defence industry, besides being completely impractical as regards critical technology acquisition.

Figure 4.3: Processing and Execution of ToT Cases in the Indian Defence Acquisition System



Source: Prepared by the Author.

In the current procedure where multiple foreign weapon systems are evaluated, selection of the system decides the technology which is to be acquired. Hence, working out of the numerous implementation issues can only be effectively addressed during the final Contract Negotiation Committee (CNC) stage. This too, is limited to the ToT clauses spelt out in the RFP and will not provide the flexibility which is needed to resolve complex issues. Once the contract is signed, responsibility of implementation shifts to the production agency and the DGQA, together overseen by the Department of Defence Production (DDP). Since the RFPs were sketchy and the negotiations limited, the production agencies will invariably be saddled with implementation issues which could not be fully gauged earlier. The pressure on achieving challenging timelines will then force an implementation approach where ToT and indigenous content take a backseat. When push comes to shove, the DDP will stress on production output and not the effective absorption of technology. Once production is complete, it is doubtful if any of the numerous agencies involved in the complete cycle, will bother to check and ensure that the technology absorbed is utilised gainfully.

The lack of a cohesive effort among the numerous agencies involved has prompted observers to suggest the need for a monitoring agency such as a ToT oversight committee. This is clearly, a major aspect which needs to be addressed and we shall do so ahead. Before we attempt to tackle all the complexities and issues brought up in this chapter, however, we need to explore all the modes and avenues available for ToT, besides the PToT that we have discussed so far.

Notes

1. Ministry of Defence, Government of India, 'Defence Procurement Procedure', 2016, p. 133.
2. See S.P. Ravindran, 'Technology Inflows: Issues, Challenges and Methodology', *Journal of Defence Studies*, IDSA, New Delhi, January 2009, p. 137.
3. Ibid. Also refer http://www.elitetecheng.com/blog/build-to-print-vs-build-to-specification/, accessed on September 12, 2018.
4. Ministry of Defence, Government of India, *Defence Procurement Procedure*, 2016, pp. 129–132.
5. Ibid., p. 2.
6. Ibid., p. 131.
7. A major portion of this section has been taken from the author's IDSA Comment 'Examining the Case for Complete Transfer of Technology'

at http://www.idsa.in/idsacomments/examining-the-case-for-complete-transfer-of-technology_kadesouza_210317, accessed on September 12, 2018.

8. See Amit Cowshish, 'Galvanising "Make in India" in Defence: The Experts' Committee Chips In', *Journal of Defence Studies*, 10(1), January-March 2016, p. 8 at http://www.idsa.in/system/files/jds/jds_10_1_2015_galvanising-make-in-india-in-defence.pdf and http://timesofindia.indiatimes.com/india/after-sukhoi-mistake-india-to-go-for-russian-5th-gen-fighter-only-with-full-tech-transfer/articleshow/57546519.cms, accessed on September 12, 2018.
9. See the Defence Procurement Procedure (DPP) 2016 at https://mod.gov.in/sites/default/files/dppm.pdf_0.pdf, p. 1 and p. 128.
10. See http://indiandefence.com/threads/t-90-tank-technology-transfer-supply-of-assemblies-hit-russian-stonewall.13057/, accessed on April 22, 2017.
11. See Anil Chopra, 'Defence Offsets and Transfer of Technology', *Indian Defence Review*, 30(1), January-March 2015 at http://www.indiandefencereview.com/news/defence-offsets-and-transfer-of-technology/0/., accessed on September 13, 2018.
12. See https://www.newsclick.in/us-defence-firms-dont-want-transfer-technology-india, accessed on September 13, 2018 which reports that the US-India Business Council which represents 400 US firms has stated that they need stronger assurances that they will not require to part with their proprietary technology.
13. This section has been largely taken from the author's article 'Transfer of Defence Technology—Moving beyond Self Reliance towards Technological Superiority', IDSA Issue Brief, July 31, 2017 at https://idsa.in/issuebrief/transfer-of-defence-technology_kadesouza_310717, accessed on September 13, 2018.
14. Government of India, Ministry of Defence, Defence Production Policy, 2011 at https://ddpmod.gov.in, accessed on September 13, 2018, para 4.
15. Ibid., para 2.
16. Government of India, Ministry of Defence, Defence Procurement Procedure, 2016 at https://ddpmod.gov.in, accessed on September 13, 2018, p. xi.
17. Ibid., p. III.
18. Ibid., p. ix.
19. Ibid., p. xi.
20. Ibid., p. 1.
21. Government of India, Ministry of Defence, Defence Production Policy, 2011 at https://ddpmod.gov.in, accessed on September 13, 2018, para 2.
22. Government of India, Ministry of Defence, Defence Procurement Procedure, 2016 at https://ddpmod.gov.in, accessed on September 13, 2018, p. III.

23. Ibid., p. 1.
24. Ibid., p. xi.
25. Ibid., p. 1.
26. Ibid., p. 136.
27. Ibid., p. 29.
28. Government of India, Ministry of Defence, Defence Production Policy, 2011 at https://ddpmod.gov.in, accessed on September 13, 2018, para 4.
29. Ibid., para 5.
30. Ibid., para 6.
31. Laxman Kumar Behera, *Indian Defence Industry: Issues of Self Reliance, Institute for Defence Studies and Analysis*, New Delhi, 2013, p. 66.
32. See S.P. Ravindran, note 2, p. 147.
33. Ibid., pp. 145 to 147.
34. The Soviet systems (and technology) acquired in the 1970s and 1980s were priced on government-to-government agreements favouring India. Also, the purchase of Rafale fighter aircraft from the French Company Dassault, was negotiated by the Indian government in the final stages for a significant reduction in price. See http://www.huffingtonpost.in/2016/09/23/rafale-deal-for-36-fighter-jets-finally-inked-between-india-and/, accessed on September 13, 2018.
35. From interactions with various functionaries in MoD, DRDO, DPSUs and representatives of OEMs.
36. Government of India, Ministry of Defence, Defence Procurement Procedure, 2016, p. 145 at https://ddpmod.gov.in, accessed on September 13, 2018.
37. As remarked upon by some functionaries of the Acquisition Wing in the MoD.
38. As mentioned during an interaction with the management of the concerned DPSU in March 2017.
39. Government of India, Ministry of Defence, Defence Procurement Procedure, 2016, pp. 1 , 2, 33, 128 at https://ddpmod.gov.in, accessed on September 13, 2018.
40. The lack of information on the authors of the DPP is extremely vexing since many aspects could have been clarified by the environment and improvements made through an informed approach.
41. Ministry of Defence, Government of India, Defence Procurement Procedure, 2008, p. 122.
42. Government of India, Ministry of Defence, Defence Procurement Procedure, 2016, pp. 1, 2 at https://ddpmod.gov.in, accessed on September 13, 2018.
43. Ibid., p. 130.
44. Ibid., pp. 2, 17.

45. Government of India, Ministry of Defence, Defence Procurement Procedure, 2016, pp. 131, 132 at https://ddpmod.gov.in, accessed on September 13, 2018.
46. Ibid., pp. 39, 40.
47. Ibid., p. 128.
48. Ibid., pp. 1, 128, 129.
49. Government of India, Ministry of Defence, Defence Procurement Procedure, 2016, pp. 2, 16 at https://ddpmod.gov.in, accessed on September 13, 2018.
50. Ibid., p. 135.
51. Ibid., p. 136.
52. Ibid.
53. Ibid., p. 29.
54. Government of India, Ministry of Defence, Defence Procurement Procedure, 2016, p. 29 at https://ddpmod.gov.in, accessed on September 13, 2018.
55. Ibid., p. 34.
56. Content in this section has been taken from the author's article Does Acquisition of Critical Technologies through ToT truly benefit India?, Issue Brief, IDSA, June 20, 2017 at https://idsa.in/issuebrief/does-acquisition-of-critical-technologies-through-tot-truly-benefit-india_kadesouza_200617, accessed on September 13, 2018.
57. See S.N. Mishra, 'Self-Reliance Index and the Enduring Legacy of Kalam', *Indian Defence Review*, October 2015 at http://www.indiandefencereview.com/news/self-reliance-index-andthe-enduring-legacy-of-kalam/, accessed on September 13, 2018.
58. Nabanita R. Krishnan, 'Critical Defence Technologies and National Security: The DRDO Perspective', *JDS*, 3(3), July 2009 p. 91.
59. Ibid.
60. Ibid.
61. See DPP 2008, p.2, 122, DPP 2011, p. 2,9,10,127, DPP 2013, p. 2,4,9,12, 135 and DPP 2016, p. 1, 2, 33, 103, 128 at www.mod.nic.in, accessed on September 4, 2018.
62. See the 'Defence Production Policy 2011' at www.mod.nic.in, para 12, accessed on September 4, 2018.
63. This is one of the interpretations by a senior DRDO scientist.
64. See the Defence Offset policy in DPP 2016 p. 63, 64, 83. This view was expressed by a DRDO scientist as a possible interpretation.
65. S.K. Palhan, H.C. Gandhi and Brig S. Bhalla (Retd), *Defence Industrial Base 2025*, Centre for Joint Warfare Studies, New Delhi, 2010, p. 49. This view has also been expressed by a senior DRDO scientist.
66. This has been received as one possible interpretation, from a member of the Committee of Experts which approved the DPP 2016.

67. Ajai Shukla, 'Indigenisation: A false debate' at http://www.businessstandard.com/article/economy-policy/indigenisation-a-false-debate-113091001027_1.html, accessed on October 5, 2018.
68. Service HQs (SHQ) officers are not given much exposure to manufacturing, DRDO scientists do not have experience in building 'business models' and Department of Defence Production (DDP) officials deal with manufacturing technology used in the Ordnance Factories and Defence Public Sector Undertakings (DPSUs) which are generally speaking, considered not as up to date as their private counterparts.
69. Government of India, Ministry of Defence, 'Defence Procurement Procedure 2016' (Updated), p. 434 at https://ddpmod.gov.in, accessed on September 13, 2018.
70. Ibid., p. 434.
71. Ibid., p. 435.
72. Ibid., pp. 439, 440.
73. Ibid., p. 441.
74. Ibid., p. 442.
75. Ibid., p. 443.
76. Government of India, Ministry of Defence, Defence Production Policy, 2011, para 12, 13 at https://ddpmod.gov.in, accessed on September 13, 2018.
77. See Mrinal Suman, 'Technology Transfer under "Buy and Make" is a Misnomer', *Force Magazine*, October 2014 at http://www.forceindia.net/StumblingBlocksMay2009.aspx, accessed on July 21, 2017, where he mentions that through reverse engineering, DRDO is invariably limited to duplication only.
78. Government of India, Ministry of Defence, 'Defence Production Policy, 2011', para 12 at https://ddpmod.gov.in, accessed on September 13, 2018.
79. Government of India, Ministry of Defence, 'Draft Defence Production Policy', 2018, p. 1 at https://ddpmod.gov.in/sites/default/files/Draft%20Defence%20Production%20Policy%202018%20-%20for%20website.pdf, accessed on September 15, 2018.
80. Ibid., pp. 2–4.
81. Ibid., pp. 2–5.
82. Ibid., pp. 6–9, 12.
83. As learnt through interaction with officials of DRDO in May 2017.

5

Exploring All Avenues[1]

PToT that we have discussed in the earlier chapters has been the predominant mode of technology transfer in the Indian defence sector over the past many decades. Its variants include, in increasing order of technology transferred, licensed production and licensed manufacture. These have been mainly facilitated through government to government (G2G) agreements in the state-run OFs and DPSUs. In the last decade however, many private firm to private firm (P2P) or private firm to state-run agencies (P2S) PToT contracts have been initiated and executed. Foreign private firms are understandably, cost conscious and are particular that they deliver only as much as has been paid for. They also come under their foreign government regulations which control how much technology and which technology they are permitted to transfer. Hence, in projects where the Indian transferee has pressed for greater technology deliverables (as is expected), private transferors have suggested shifting to G2G contracts which probably allow more flexibility.[2] Besides these variants of PToT, however, there are numerous other forms of ToT and mechanisms which facilitate them. In this chapter, we will explore all these avenues, conventional and unconventional, and attempt to gauge their effectiveness in meeting the national goals that we have discussed earlier.

Other Conventional Modes of ToT

After PToT, the most common of the conventional modes being linked by the Indian media to ToT, are joint ventures (JVs) for co-development and co-production (JV-CD-CP). Joint ventures, as the name suggests, are independent entities formed from the contribution of two or more agencies or companies, to achieve common goals. For such an arrangement to be successful, it is necessary that both partners contribute by bringing in complementary technologies, in addition to funding.[3] India has used this arrangement through collaborations with Russia for developing and producing the successful Brahmos missile system[4] and Israel for the Medium Range Surface to Air Missile System (MRSAM), which has been recently announced as being successful.[5] The DRDO's Fifth Generation Fighter Aircraft (FGFA) development with Russia is also a JV-CD-CP project with both parties agreeing to invest equally in 2007, though till 2018, the Indian share had reached a mere 15 per cent.[6] The programme has been greatly delayed since 2007 due to differences between the parties, a common weakness in JV arrangements.[7] The current status is that India has stressed on cost effectiveness and insisted on full technology transfer so as to build the capability to develop the next upgrade indigenously as well as the indigenous Advanced Medium Combat Aircraft (AMCA).[8] In the earlier mentioned projects, India's DRDO is reported to have developed a significant part of the systems—in the Brahmos, it was the inertial guidance unit, while in the MRSAM system, it is the target homing system.[9] On the positive side, it has been reported that 70 per cent of the MRSAM system will be indigenous when productionised. However, there are also unverified and possibly biased reports that the DRDO contribution was minimal, limited to making a few changes in the versions for the Navy and Army.[10]

Irrespective of whether there was any contribution by Indian agencies, it is unclear in both the Brahmos and MRSAM projects, whether any technology has actually been transferred. From working together, India should have gained the know-whys in system design as well as product development and production process development that Russia and Israel employ. Through working together, a fair amount of knowledge on the Russian and Israeli portions of the systems may have been gleaned. But, have the know-whys or the know-hows of developing and manufacturing those portions been obtained through mutual agreement and consent? Contrary to the impression that many may hold, JVs actually allow the owner to maintain a tighter control on its technology. That is why owners are willing to use relatively newer technology in JVs as compared to that in Licensed Manufacture.[11] This aspect seems to tie in with reports on the dissatisfaction of the Indian team on technology transfer issues in the JV CD-CP of the 200 light helicopter project with Russia.[12] A pertinent factor to be noted is, that this arrangement leads to joint Intellectual Property Rights (IPR) as well as shared international market space and therefore the technology cannot be exploited and exported with the freedom that pure indigenous technology can be, though it is comparable with PToT that is limited by similar restrictions.[13]

From the self-reliance perspective therefore, the JVs CD-CP do not appear to be overly beneficial. The fact is that India or Indian firms will remain dependent on the foreign partner for his portion of the system until an indigenous version is developed. The development of the indigenous version too, is very likely to be restricted by contractual clauses inserted by the foreign firm so as to protect its business interests. So while the average PToT would lead to a dependence on the transferor for say 30 per cent of the parts of the produced system, which can be subsequently reduced through import substitution, a JV could involve a dependence of 50 per cent which may be more difficult to reduce due to the relatively newer technology employed. For technological superiority, however, it offers some benefits in terms of exposure to world standards of design and development of processes as well as world standard products. But from the cost effectiveness angles, since development projects in general are prone to risks of delays and sometimes even failures, this arrangement will invariably turn out significantly more expensive than a PToT one.

JVs are also used for co-production only (**JV-CP**). Lockheed Martin's JV with the Turkish Air Industries (TAI), a state-owned company, for the production of F-16 aircraft in the 1980s successfully produced a total of 308 aircraft over a period of around 12 years.[14] The JV was initially, held by the TAI with a major share of 49 per cent, Lockheed Martin with 42 per cent and General Electric with 7 per cent. Investment of a total of US$ 137 million was made with US$ 70 million from Turkish partners and US$ 67 million from the US partners, and this was later supplemented by the latter with another US$ 100 million, which would have made the JV a foreign majority owned one. Lockheed Martin provided three experienced Directors for five years and the General Manager for fourteen years. From the experience gained from building 80 per cent of the F-16 aircraft, the TAI began branching out into other areas to include parts of the transport aircraft CN-235 and A400-M, modifications of Boeing 737s into an Airborne Early warning aircraft and helicopters Angusta Mangusta T-29 and Sikorsky T-70 Blackhawk. The TAI also developed a modification centre where they upgraded aircraft such as the C-130s, F-4s, T-38s and F-16s. The company is now developing indigenously designed Unmanned Aerial vehicles, basic trainer aircraft and even a T-FX fifth generation fighter aircraft.

Interestingly, after 20 years, the Turkish Government bought the shares of the US partners and the TAI is now wholly held by government entities. Lockheed Martin claims that it remains closely associated with the TAI and values its partnership as a major supplier for the next generation platform.

Lockheed Martin has had similar success in other parts of the world such as Belgium, the Netherlands and South Korea. With the latter, it has co-developed the new T-50 and F/A-50 aircraft for the global market place and is also helping develop Korea's KF-X next generation fighter. The contract with the Korean companies is purported to have been a strategic alliance or partnership/teaming model with clearly defined work-share, rather than a JV. The partnership entailed a much higher investment by the Korean companies but, included greater freedom such as a clause allowing the Korean companies to buy out the IPR at a later stage.

Lockheed Martin, it appears, has also helped the Japanese with the development of the F-2 fighter programme. This was a case where the Japanese paid upfront for the US firm to impart capabilities of designing, developing and manufacturing their aircraft, a rare example of the much sought after D&DToT discussed in the chapter on nuances. Though the exact amount paid is not known, it is purported to have been exorbitant, clearly unaffordable for a developing country.

Forming of JVs, whether for co-development and/or co-production, is considered a more complex, risky and time-consuming task than executing PToT and is hence recommended in cases where the complementary capacities, infrastructure, technology or capability available with the partners requires engagement for a longer term.[15] However, when such arrangements fit well, the results can be extremely rewarding as can be seen in the case of Lockheed Martin's JV with the TAI.

The modes we have discussed so far all relate to systems level ToT. At a smaller scale, we have sub-contracting across country borders that enable foreign technology to be acquired by local firms. These take the form of B2P, B2D and B2S contracts which we have discussed in the chapter on implementing ToT. We shall take a re-look at these from the ToT angle.

B2P contracts entail the foreign firm providing the technical specifications, engineering documents and manufacturing process documents. The local firm executes the task strictly as per the above documents/instructions and using material or parts from sources recommended by the foreign firm. Unfortunately, a few proprietary components of the seller firm are invariably required, thus leading to a dependence on them. Another disadvantage is that the arrangement provides the know-hows of the manufacture process, but not the know-whys of design. B2P contracts are usually considered a ToT, so foreign firms need the approval of their government or even international export control agencies, if applicable.

In a B2D contract, where the foreign firm provides the technical specifications and engineering documents, the local firm is required to develop or use its own process to manufacture the part. The advantage here is that an indigenously available manufacturing process technology is being utilised thereby avoiding the cost of purchasing a license for a new one or the royalties for using it repeatedly. The product design however, is considered IP and royalties will need to be paid for its use.

The B2S contract, it is sometimes argued, is not a transfer of technology.[16] Whatever the opinion, it is necessary to cover it here because these contracts are invariably combined with B2P and B2D ones to produce the different parts of a system under PToT. The foreign firm provides the specifications and it is now left to the local firm to design, develop, manufacture and supply the product. For successfully achieving this, the phases of prototyping, user trials and evaluation may be required and will therefore take considerably more time, effort and money as compared to B2P or B2D.[17] However, since the B2S mode is not considered a ToT by many, it doesn't require export permissions of the foreign government or international export control regimes. Also, since the local firm has developed the product on its own, it holds the IP rights and the know-whys, and is therefore free, as well as capable, of exploiting them for producing product upgrades or variants or for that matter, applying the technology for other purposes.

Facilitators

Encouraging Foreign Direct Investment (FDI) in local firms is a common policy used by governments to facilitate technology transfer into JVs with local firms. These JVs could be of the non-equity or equity form. The non-equity form is essentially a strategic alliance where the foreign investor offers the technology whose value makes up part or the whole of his investment, while the local partner offers the infrastructure, workforce, management etc. The foreign investor becomes the technology partner/supplier, while the local firm absorbs it. The technology could be transferred in a number of ways such as the PToT mode or through contract manufacturing/subcontracting using the B2P, B2D or B2S arrangements. FDI and technology can also be channelled in a similar manner into JVs where the equity is shared.

The level of investment and control of the partners in the running of the JV is a critical issue for foreign technology seller firms. Firms holding proprietary rights over cutting-edge and niche technologies, which have little or no competition in the world, may insist on a near wholly owned subsidiary while those offering a little older technology may be satisfied with a 51 per cent majority share of investment. The majority share enables the foreign firm to keep a tighter control on its technology and thereby prevent it from leaking out to competitors. India's current policy allows an FDI in defence firms up to 49 per cent through the automatic route and 76 per cent for 'state-of-the-art' (now 'modern' technology), in the non-automatic route. The FDI limit in the automatic route is now proposed to be increased to an FDI of up to 76 per cent for 'niche' technologies.[18] While what is considered 'niche' has not been shared, it can be presumed that these would include factors such as its criticality and lack of availability in the country.

Another facilitator for the acquisition of technology that is pursued world-wide is Defence Offset. Myriad forms of this counter-trade exist across the 80 countries that use it today.[19] In India's case, a foreign OEM, to whom a large contract for the manufacture and supply of systems has been awarded, is obligated, in return, to use any of six avenues for benefitting India's defence and allied industry. Out of these six, four pertain to technology transfer in their different modes. The transfer could be by sub-contracting or PToT, through direct contracts or JVs with private firms (non-equity or equity), or

PToT with government agencies and finally acquisition of critical technologies by the Indian DRDO.

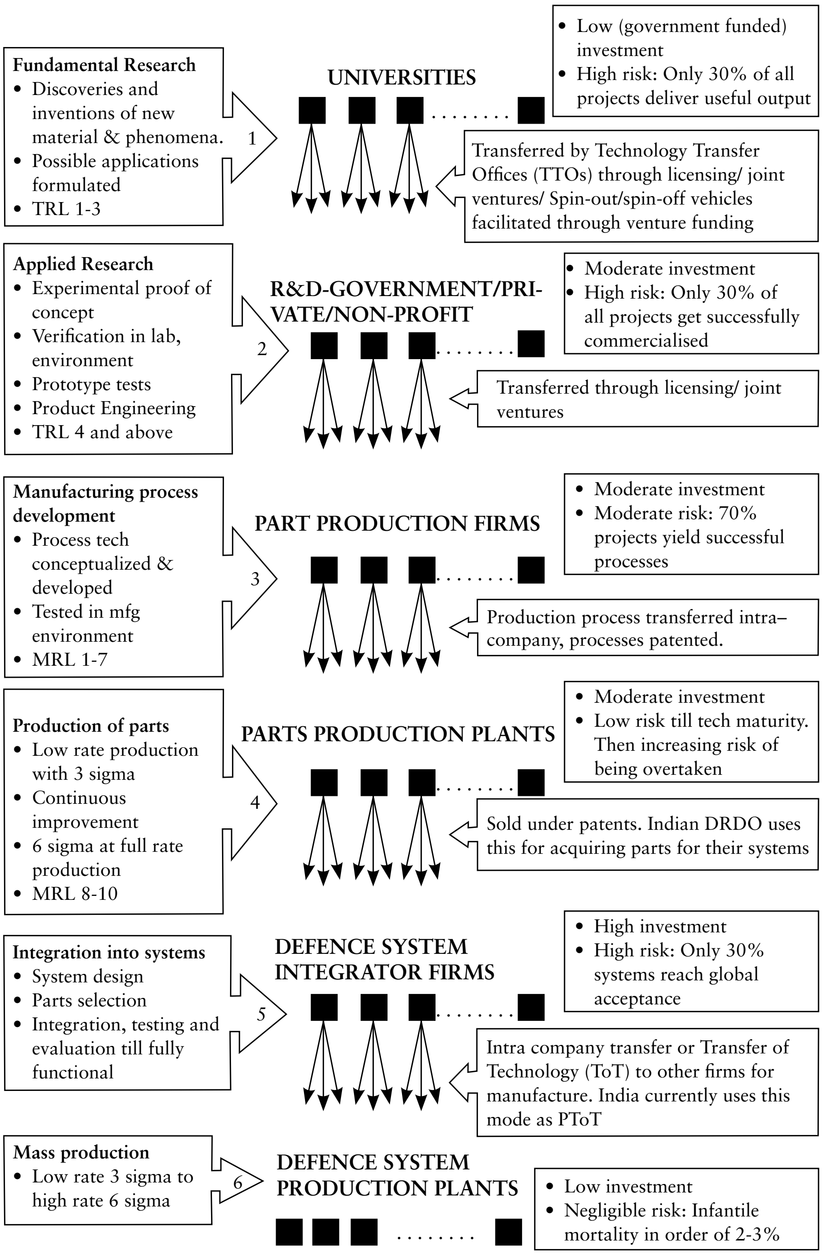
That defence offsets can be an effective method for leveraging the current 'buyer's market' for extracting technology transfer is not fully established though pockets of success have been reported. Among the less technologically developed countries, which India leads, there are the cases of Malaysia and Indonesia being able to use ToT through offsets to develop capabilities in composite material manufacture to global standards.[20] Among the developed countries, the UK has benefited significantly from offset arrangements with the US, not only garnering manufacturing technologies but also R&D ones.[21] However, crafting the ideal arrangement in areas where the recipient country's lower technological levels are within reach of the foreign transferor's can be extremely challenging. India's offset policy provides ample space within which such matches can be identified, but so far no notable successes of significant ToT through offsets have been reported. The policy which was formally introduced in 2008 is relatively new, though, and with time, the outlook is still optimistic.

For enabling the last option of ToT through the Indian offset programme, that is, the acquisition of critical technology by DRDO, the DPP provides a list of 20 technologies such as MEMs based sensors, actuators, RF devices, Focal Plane arrays and Nano Technology based sensors & displays. Though these have been specified, the DPP makes no mention of whether the technology desired is for manufacturing or designing/developing a product or process. Going by inputs from reliable sources, it appears that the intention was and is to acquire the know-whys of design, in addition to the know-hows of manufacturing products with that technology. It is broadly known that though eight proposals under this avenue have been received, none of them have been accepted due to the exorbitant prices quoted, which are to the tune of a hundred times that of the manufacturing technology. This fact ties in with the exorbitant price of D&DToT discussed earlier in the chapter on nuances. Also, paying upfront for technology has the advantage that the deliverables are well-defined and sellers will respond with concrete tenders. The Indian Defence Offsets, on the other hand, incorporate complex credit systems, undefined variables (such as the know-whys mentioned above) and a limited credit margin.[22] Hence, it may reasonably be concluded, that this avenue, in its present form, is unlikely to enable useful transfers in the future.[23]

Widening the Scope

So far we have identified and analysed the conventional forms of technology transfer. But, are there possibilities for more avenues? Avenues which can provide newer technology thereby enabling the closing of the gap with the advanced countries? Let us widen the ToT umbrella, where 'Technology' does not merely cover the knowledge of use/operation, maintenance, repair, overhaul, production or design and development of a defence system, but all the knowledge that is generated and transferred in the path to realisation of the defence system.[24] Such a path, which we can call the technology maturity and productionisation path (TMPP) can be broadly divided into six steps–1) discovery or invention of a new material or phenomena through fundamental or basic research, 2) development of its application and prototyping through applied research, 3) development of the process for manufacturing the part, 4) mass-manufacturing the part, 5) designing systems and integrating the developed parts (and others) into them and finally, 6) productionising the system. A pictorial view is provided in Figure 5.1. The initial step broadly reflects the environment in the United States and most developed western countries where fundamental research at universities is funded by government, corporates and non-profit organisations. Even though some research in universities and non-profits are government funded, the creators in the universities can control the use of the invention by a one-time payment for a license after

Figure 5.1: The Technology Maturity and Productionisation Path



Source: Prepared by the Author.

Note: Figures quoted are speculative. TRL–Technology Readiness Levels, MRL–Manufacturing Readiness level.

committing itself to certain conditions.[25] These licenses can be used by R&D agencies to develop new, useful and non-obvious products, which can be patented to prevent imitation and secure monetary returns.

The figure depicts how 'technology' subsequently evolves and is vertically transferred downstream from one developer to one or many recipients along the TMPP.[26] Each transfer of new technology invariably comes with patents/licenses to prevent imitation as well as to channel back income from royalties to the creators.[27] Some steps may use unpatented, established technology along with new ones to deliver its product. Each step depicted, less 4 and 6, entails the use of know-hows to develop the product of that step, and in the process, learns to 'know why' the product needs to have, say, certain dimensions or compositions of material. To amplify this point, one can see that in step 1, one would need to know *how* to conduct the research. During the research, an understanding of *why* the application will work only in certain conditions will develop. In step 2, one would need to know *how* to develop the technology and design the product. In the process of doing so, it will be learnt *why* specific dimensions or composition of material are necessary to achieve the performance desired. In step 3, one would need to know *how* to develop the manufacturing technology thereby generating know-whys on the processes, settings and specifications of each manufacturing activity. In step 5, one would need to know how to design a system.[28] Thereby an insight into *why* a particular dimension or composition or configuration is necessary to achieve a performance characteristic will be developed. However, in steps 4 and 6, only a limited amount of know-whys are generated, though these too have their significance such as those generated while fine tuning the production process to reduce the incidences of defects to a minimum level such as six sigma. The awareness of the need for know-hows required at each step as well as the know-whys generated enables us to visualise which components of knowledge are needed to acquire capabilities at each stage. The numerous references in the Indian environment, to the know-whys not being transferred in PToT contracts essentially pertain to those generated in step 5 i.e. the system design stage.[29]

From the figure, it can also be seen that each step involves an investment and an uncertainty of success (or a risk of failure). Some steps, such as step 1, could require low funding (generally government funded) but entail high risk while step 3 entails moderate funding with moderate risk.[30] In the R&D stage at step 2, due to the need for high investment and the presence of high risk, Small and Medium Enterprises (SMEs) may turn to sharing the incipient technology in a quasi-licensing framework enabled through Venture Capitalists (VCs), while large corporates may opt for joint R&D through strategic alliances or partnerships.[31] After the R&D stage, when business gains of successful projects start to neutralise development costs, the ownership of the technology could change either to stock holders of an Initial Public Offering (IPO) or one of the partners of a strategic alliance. These owners typically use strong patents to extend the life of the technology and do not share it till competing technologies start eating into its share of the market. Sharing then, could be either through licensing or participatory exploitation in a joint venture, especially with firms of developing countries where the technology is still unmatched. The latter option is considered superior due to the greater control of the technology owner and dual income through investments as well as royalties.[32]

At step 3, the development of the mass manufacturing process of a developed and patented part could be executed by intermediary firms or manufacturing firms with process development capabilities. These processes can also be patented to prevent illegal imitation and for obtaining monetary returns. Sometimes development of cost-effective manufacturing processes can, however, take extremely long and necessitate large investments.

At step 4, production firms obtain a license for use of the process to manufacture, paying a royalty on each product produced. These parts are then sold under legal agreements protecting the patents from violation by copying, reverse engineering, imitation, etc.

A similar framework for system development exists at step 5 where the process of integrating the system as well as the developed system itself can be patented. At this stage, the integrator firm or OEM can either sell the finished system from its production plant or sell the production technology to other production plants. The latter is the activity we have defined as PToT.

The technology in PToT is clearly a finely finished product, with meticulous documentation for all aspects of integration, testing and quality assurance. When delivered to new firms, it is also invariably supplemented with the technology for operation, maintenance, repair and overhaul (if applicable). The manufacture processes are also matured with many contributory factors for failures being removed over a period of time. Little is left to be worked out by the recipient firm, which can employ technically less knowledgeable, less skilled and therefore, cheaper labour. Hence its suitability for less developed countries. In this arrangement, production can be executed with very little involvement of the transferor and with greater freedom to the recipient. However, in being so, it also holds a higher risk (to the seller) for the technology to be compromised and therefore, is used predominantly for older technology.

Opportunities for India?

Now that we have a broad understanding of the evolution and movement of technology, let us see if we can make use of it in our search for more avenues of ToT. A close look at Figure 5.1 will show that each step of the TMPP and the transfers after that are actually opportunities available for obtaining technology.

At step 1, could India partner with the advanced countries for fundamental research in select fields? It's true, fundamental research may throw up discoveries or inventions with a wide umbrella of applications from medicine to manufacturing, and may not lead to military ones. On such an eventuality, the applications can be used by the respective industry in India. The India-US Science and Technology Forum which evolved in the year 2000 after many decades of increasing cooperation in the S&T fields, now has multiple programmes for interaction by students, researchers and entrepreneurs. Such forums exist with other countries too.[33] Could the activities in this area be ramped up to draw more benefits?

After step 1, could the DRDO laboratories use transfers of the findings of fundamental research (through licenses) to develop products which are patentable? It is possible that of the competing technologies developed only some are selected by the foreign government/agencies while there are others which hold promise, but will not be utilised. Could the DRDO use such unutilised technologies? Of course, this may require significant investments and entail uncertainties in success. But, couldn't this risk be mitigated by distributing the investment in a range of projects? If such transfers cannot be out rightly purchased, could India not fund some of the research projects at step 1 and maybe supplement them with Indian scientists deputed for specific durations for licensing rights? It is known that global OEMs such as Saab, Nexter and Lockheed Martin have sponsored research projects in very niche areas with numerous universities around the world. Then, why can't our DRDO and Indian private giants explore such opportunities in addition to the Indian research that they currently sponsor?

The Indian Department of Science and Technology's Global Innovation and Technology Alliance (GITA) is a potent arrangement where Indian researchers and developers avail opportunities for partnering in research with their counterparts in advanced countries such as the UK, Canada and Israel.[34] The technologies covered are wide ranging, from affordable healthcare to smart cities to the Internet of things, Micro Electro Mechanical Systems (MEMS) and strategic electronics in areas such as Power, Telecommunication etc. Can similar arrangements be made for defence or dual-use applications? A step in this direction was taken when the US named India a major Defence Partner (MDP) and communicated through a joint statement in June 2016 that "India would receive license-free access to a wide range of dual-use technologies in conjunction with steps that India has committed to take to advance its export control objectives".[35] This has been taken further by the announcement of an agreement with the US's Defence Innovation Unit Experimental (DIUx) in Silicon Valley which deals with civil technologies which may have applications in defence.[36] Can these be utilised for co-researching and developing new technologies and can the same arrangement be replicated and utilised for obtaining dual-use technology from other advanced countries?

Is it possible for scientists of Indian origin who have created inventions in foreign universities to assert that the benefits of their research be channelled to their parent country? There is a huge population of Indian scientists in the US and the European universities who are probably willing to provide such technology to India. Can their work be legally harnessed through inter-governmental agreements providing appropriate clauses in research agreements with them?

Step 2 is actually a consolidation of numerous sub steps where the technology is developed through Technology Readiness Levels (TRLs) four and above. Is it possible for Indian R&D agencies to step in to take on such projects or at least a portion of the development such as product engineering for which a large Indian talent pool is available? The joint R&D and technology sharing agreement with the US initiated as far back as 2006 and the later Defence Trade and Technology Initiative (DTTI) provides such an opportunity for the DRDO.[37] But, these are on an extremely small scale. Can such arrangements be explored in a larger way, and also with other countries? Can Indian private giants explore such research arrangements? Again, as in step 1, funding these projects will yield licenses for product manufacturing, while co-opting our scientists will provide the know-hows of design methodology and the know-whys of the design of the product.

At step 3, could Indian agencies take on the design of the manufacturing process or develop the technology deployed in manufacturing? This step has been reported to provide the highest value addition in the path.[38] If they are not competent enough as yet, could a team of scientists be associated with these projects to gain the know-hows of the development activity and the know-whys of the output? Advanced Manufacturing Research Centres around the world today collaborate with universities, equipment suppliers, manufacturing technology providers, production companies and their supply chains to develop world leading manufacturing systems and processes. Could some of the DRDO specialists in manufacturing technology join these for improving Indian manufacturing technology and processes?[39]

At step 4, could Indian production plants obtain a license and mass manufacture the products to six sigma quality? Again, if they cannot, then could select engineers be associated to build capabilities in the field?

At step 5, parts can be purchased under patent protection agreements and integrated into systems. This is an activity which the DRDO and now the private sector, has been doing for quite some time through JVs for co-development and co-production as covered earlier. However, have the benefits of this arrangement in terms of obtaining world class know-hows of system design and the know-whys of the developed systems been consolidated? A large scope for further capability building in this area would always exist. Instead of co-development, could co-opting of brilliant Indian scientists into foreign projects provide a win-win situation for India and the foreign partner?

The idea of co-opting local scientists with foreign projects is not new to the Indian environment. The positive results of international collaborations of R&D institutions and production agencies with foreign willing partners have been extolled in numerous fora.[40] A DRDO scientist has quoted how, in the 1990s, 30,000 Chinese scientists were sent out to join research projects in foreign universities and these are now coming back in droves with precious technology. And how, India needs to do something similar by sending out teams of DRDO scientists and military personnel for a few years at a time to acquire technology. But, what would they do and how, are aspects which do not seem to have been dwelt on so far. In case these have been dwelt on and found infeasible then what were the hurdles—insufficiently deep strategic ties or inadequate funds or inadequately exposed/incompetent researchers? Knowing the pitfalls will enable us to overcome them.

For the pursuit of national goals, which of the options offers greater benefits? As we can see, all the options would clearly increase self-reliance since a portion of the development or the manufacturing activity is shifted to Indian soil. The latter steps of 5 and 6 are the easiest and cheapest, requiring relatively lower technical knowledge and abilities, and this is probably the reason why it has been the dominant mode in India. For technological superiority, however, it is clear that one would have to move upstream. That is, instead of limiting ourselves to steps 6 and 5, we would need to target the earlier steps so that newer, superior products can be integrated to form newer, superior systems. And the higher upstream we go, the higher the possibility of achieving technological superiority, ultimately achieving leadership through breakthroughs at step 1 or 2.

It is very likely that many of these options have been attempted by the Ministry of Science and Technology or the DRDO. But if so, what were their outcomes and what were the reasons for their failures? For, there are apparently no success stories being reported in the area. These need to be made public, because India's defence industry today includes numerous private giants and over 6000 MSMEs. All these stand to gain by past experience which would help them build ways to tap the development chain of the advanced world.

Unconventional Technology Transfers

With the wider perspective, we realise that all forms of knowledge related to prospective technological products or their evolution can contribute in some way to a country's technological capabilities. The propagation of this knowledge (or technology), which falls outside the conventional forms discussed earlier, can take place through various media and methods. Among these, a significant group of activities come under the category of technology diffusion.

Technology diffusion has been defined as activity which creates an awareness of that technology in the country/region.[41] This could be with or without deliberate intent by the government or the foreign supplier firm. Activity without deliberate intent would include the coverage in media such as the internet, television, newspapers, periodicals, movies and even chat groups. Deliberately intended activities by the foreign supplier firm could be the purchase of inputs, components and services from local firms, requiring the latter to become familiar with the technology. Deliberately intended activities by the host government would include training requirements for local personnel or the compulsory licensing of technology to local firms.

Then, there are modes which go beyond technology diffusion and are more focussed, deliberate and expensive. These, which we could term 'technology acquaintance', cover foreign visits by selected persons, technical seminars, journals, published papers, study groups, technology monitors/intelligence, trials and most significantly in respect of defence systems, joint exercises with foreign military forces.

Technology diffusion and acquaintance are significant methods to build awareness of the capabilities of different competing technologies. As such, they contribute effectively to selection in the acquisition process and provide a relatively inexpensive and easily accessible means to initiate activity to acquire and incorporate the technology into own systems. However, whether these activities alone can generate enough knowledge to develop new systems is highly questionable. Many young DRDO scientists have stated that the inputs to their work were the papers published in the public domain as well as seminars in India and abroad.[42] However, if this were the case, there would be no need for technology transfers and the effort and cost for executing them.

Another avenue for transfers, are those enabled through flight of human capital. Scientists and engineers defecting or migrating to new countries, the attracting of scientists back to their home country and the export and re-importing of students are the major ones. This form of technology transfer is not new. In the late 19th century, a large number of American students were 'exported to' and 're-imported from' Germany to gain experience in fast growing technical fields.[43] China too, sent large numbers of students abroad after 1978 to gain skills necessary for the country's economic and social development.[44] And finally, there is always the possibility of hiring foreign engineers. Around 2002, the Chinese automotive firm Chery hired the services of an Austrian engineering specialist to transfer the technology of engine design and the know-how to build one. Chery opened its new plant in 2005 with a plan to manufacture 1,50,000 engines to start with. The cost, however, was a huge US$ 370 million which Chery planned to recover through the economies of scale in the Chinese market.[45]

So if China can use a foreign engineering specialist and the US and European countries can use Indian scientists for their R&D, what is to stop India using foreign scientists? It appears absurdly simple. The high cost of the background IP (know-hows) that the scientist will bring and that of the IP that he will generate (know-whys and design) is one obstacle.[46] By delivering both these, he however, terminates his own market value, at least as far as that product is concerned. Hence, though he will deliver the final product, it is unlikely that he will share his complete spectrum of know-hows and know-whys. The second is that it will most probably require the foreign government's approval under its export control regulations. These regulations are invariably in line with the Wassenaar Arrangement (WA) where even briefing of a foreign visitor is judged as an intangible ToT, requiring an explicit authorisation.[47] And lastly, in today's collaborative R&D environment, it may take not one, but many scientists, possibly networked in alliances to deliver the goods. Notwithstanding these obstacles, intergovernmental agreements can facilitate such use of foreign scientists and engineers as has been achieved in the successful Arihant nuclear powered, nuclear armed submarine project.[48]

Acquiring of foreign factories and design houses by Indian firms have been reported in the recent past, giving the impression that it will automatically transfer technology to India.[49] However, factories or their machines, by themselves, do not provide complete, usable technology. As we discussed in the chapter on nuances, they need to be accompanied by technical literature as well as the critical know-how which resides as tacit knowledge in the developers and engineers. Both these are considered IP and need to be purchased through legal agreements. Unfortunately, IP can be exorbitantly expensive especially if it pertains to design and development. Since, governments in countries such as the US, fund many of the fundamental research programmes which lead to design and development of products, transfers to foreign persons or agencies are not permitted without authorisation. Employees of these factories who hold the know-how will also need to be sufficiently motivated to transfer it to workers in a foreign country who will eat up their own jobs!

Special machinery or software which enable cutting edge R&D or production, do have significant technology transfer gains, especially if they are accompanied with training and technical consultants. China has been known to procure special machines in excess to their requirement for subcontracts, so as to learn to use them for their development work. How well this strategy worked is not certain, especially since the machines would have required maintenance and product support from the OEM. Nevertheless, a trained worker from the subcontract factory would probably be able to make good use of them for duplicating products.

Lastly, there is a category which uses unethical means such as illegal imitation or reverse engineering and technology espionage.

PToT contracts invariably prohibit reverse engineering and use of the transferred technology for other purposes, for a specified duration of say 15 years. Beyond the period, reverse engineering is used for bona fide reasons of modifications for local conditions or indigenisation/ import substitution of parts nearing obsolescence. Illicit reverse engineering, however, has been used by many countries in the past, and China is said to have used this route for its current success. China's route is said to have followed a progressive path along the stages of duplicative imitation, creative imitation, creative adaptation and architectural innovation.[50] Duplicative imitation involves copying products closely with little or no technological improvements. Creative imitation aims at generating imitative products but with new performance features such as the Chinese J-7 Chengdu fighter-aircraft which is a copy of the Soviet MiG 21. Creative adaptation generates products which are inspired by existing foreign-derived technologies but differ from them significantly. An example is the case of the Russian Su-27 fighter aircraft whose Russian transferred technology was absorbed and mastered by the Chinese and subsequently reverse engineered, illicitly, to produce the J-11B. The J-11B is reportedly a generational improvement over the Su-27 with the addition of new capabilities such as a reduced radar cross-section, improved fire-control radar, wide use of composite materials, a new flight control system, a digital glass cockpit, and a Chinese-developed engine. Not surprisingly, this led to a sharp chill in Chinese–Russian defence technological cooperation when it was discovered by Moscow. Architectural innovations are those that change the way in which components of a product are linked together, while leaving the core design concepts (and thus the basic knowledge underlying the components) untouched.[51] A variation of this is 'indigenous innovation', which provides a quasi-legal arrangement of re-assembling existing (foreign) technologies in different ways to produce new breakthroughs.[52] The Dong Feng-21B anti-ship ballistic missile, which US strategists have dubbed the 'aircraft carrier killer', is one such example where China reportedly rearranged existing technologies to build the system.[53]

While it has been openly advocated that India should take this path, and attempts have probably been made, some senior scientists are sceptical of it, stating that it isn't as easy as it may seem. The graduation from imitation to creative innovation would clearly need the know-whys of design and how China has been able to acquire them is still not clear. One possibility is the accumulation of knowledge through serial production of Russian fighter-aircraft upgrades over an extended period of time by China. China made variants of Russian aircraft MiG 15, MiG 17, MiG 19 and MiG 21 which were equivalent to their J4, J5, J6 and J7, respectively and then made their indigenous J8. Such serial production enables the transferee to understand some of the reasons for changes being made from the earlier version and gain incremental quantities of the know-whys with every subsequent version. This can possibly explain China's success with reverse engineering Russian fighter aircraft, but not other systems such as the Dong Feng 21B.

In the meantime, reverse engineering is getting more difficult, as an increasing proportion of the composition of defence systems is in the form of software, making it well-nigh impossible to reverse engineer through studying and replicating the hardware, as has been the approach in the past. Overall, though there have been a few incidences of successful reverse engineering, a general and substantive opinion is, other than the fact that it is illegal and not to be encouraged, efforts through these modes cannot be relied on and this strategy is fraught with the risk of alienation from dependable sources and friendly countries.

Technology espionage is undoubtedly illegal, but is not unheard of. In the technology acquisition/introduction/pre-concept stage, the Chinese defence Science and Technology system employs open source information collection and espionage activities to overcome the restrictions imposed on transfer of defence-related technology due to the various arms control regimes.[54] Technology espionage has also been reported in other parts of the world and was probably even state-driven during the Cold War period. In the current age of networking and cyber warfare, continuous attempts are made to hack into the systems of adversaries, with the acquisition of their technology being a significant objective. However, the aim here would possibly be to acquire knowledge on their weaknesses and not the entire design and manufacturing process.

Challenges

In this chapter we have covered the numerous avenues of ToT and dwelt a bit on their strengths and weaknesses as well as obstacles that they may face. There are, however, a few challenges of a general nature and relevant to India, which have not been covered so far and need a look.

The US International Traffic in Arms Regulations (ITAR) stipulates that US persons, organisations or companies may transfer articles and technology listed in the US Munitions List (USML) to foreign persons or agencies only through an export authorisation or license by the US government. The authorisation may take the forms of Foreign Military Sales (FMS) of USML items to foreign governments, an export license for temporary or permanent export of defence articles or technical data, a Warehouse and Distribution Agreement for exporting through a warehouse located in foreign territory, a Technical Assistance Agreement for training and technical discussions and a Manufacturing License Agreement for export of manufacturing know-how.

From this it appears that there exists no scope for obtaining any technology deeper than manufacturing i.e. PToT. The ITAR considers any divulgence of the USML technology to foreign persons visiting the US including students as deemed exports.[55] The ITAR also prohibits re-transfer of the USML articles or technology from an authorised foreign person to another without authorisation.

However, when it comes to universities attended by foreign students, the ITAR states that fundamental research resulting in findings which are made public are not restricted even when they may involve the design and construction of defence articles. Interpretations of the term 'fundamental' vary considerably between the US universities and while the University of Michigan was successful in obtaining an opinion of the government that research on satellites was fundamental, Stanford University maintains that in terms of Technology Readiness Levels (TRLs), any work beyond TRL 4 does not classify as such.

The ITAR has had considerable restrictive effects on US defence trade and technology transfer. In the F-35 Joint Strike Fighter (JSF) collaborative project, the UK and Australian Governments demanded a guarantee that the US would fully disclose the technology needed before them committing any further to it. In the F-X2 programme, the Brazilian Government chose the French Dassault Rafale over the Brazilian Air Force's choice of Boeing Super Hornet due to concerns over technology transfer barriers and ITAR regulations.[56]

The ITAR of the US appears to be the most stringent export control regulations adopted by a major exporter anywhere in the world. European countries, Russia and Israel, all have national regulations which are apparently less stringent and therefore appear to be more attractive as sources of technology.

Among the internal challenges, we have quite a few. One is the work culture of 'jugaad', or at least its negative version, which encourages quick innovations for short-term and cheap solutions, thereby assigning a lower priority to delivering quality and long-term capability building.[57] An aspect that many of the foreign OEMs have stressed on is that long-term relationships deliver better products and help build solid capabilities. Also, foreign OEMs have perfected their work systems and practices over decades to deliver complex weapons such as fighter aircraft and missiles which have a high degree of reliability. Indian defence industry, on the other hand, is much less developed and will need to assimilate the work cultures of the foreign OEMs to successfully deliver products of world class standards.

Yet, another challenge is the risk averse attitude in the Indian Government and public sector environment, especially in defence acquisition. A spate of scandals in defence purchases over the past three decades has taken its toll, leading to a state of almost decision paralysis in the earlier government. Investments in steps 1, 2, 3 and 5 all entail significant risks. How these risks will be absorbed in the Indian defence system of accounting which is founded on 'making every rupee pay' is a question which will need to be answered by the top leadership in the finance ministry. And finally, we have the challenge of the quantum of **investment** needed. Being the largest importer of defence equipment in the world, in a buyer's market, may enable the leveraging of orders for benefits up to ten or twenty per cent of their value. But, the investment needed for pursuing many of the avenues listed in this paper will exceed this value many times over. Building up a strong and sound business case will hence be required and it may be worthwhile employing the most competent, experienced and dependable agencies for this. These too, may not be available in India and there may be no recourse but to turn to those abroad for this vital task.

Trust as a Critical Factor

Since successful technology transfer requires willing and wholehearted delivery (especially for the tacit knowledge component residing in the developers) from one party to another in return for commensurate returns, it is imperative that the relationship between the two is initiated and then sustained as a win-win one.[58] Actions by technology seekers to draw more than what has been formally agreed to, may very well embitter the relationship. If the transaction was one of buying goods, such as raw materials which do not require product support, it may work. But, technology transfers require extensive support well after it has been formally executed. An indicator to this fact is that Indian factories which received technology have held on to Russian technicians for more than a decade after commencement of production.[59]

So, the one extremely important factor for the success of any technology transfer venture is trust. Indian scientists, agencies and manufacturing firms will need to earn the trust of the advanced countries that their IPR will be protected and their due returns will be remitted. The western world collaborates among themselves because they have built a huge level of trust amongst themselves. The US F35 JSF was jointly produced by no less than nine countries, though the US and the UK had a 90 per cent share.[60] This could not have been done without this vital ingredient.

In a broad survey in June 2016, foreign firms interested in ToT in India were asked what they were looking for in their Indian partners. The wish list drawn up from their responses included financial strength and stability, availability of infrastructure, technically knowledgeable and skilled manpower, cost competitiveness, quality systems in place and a record of dependability and compliance. All of these are common factors required for success in any business. Compliance to legal agreements, however, is especially important for ToT arrangements, and many foreign firms have voiced their apprehensions here. Unfortunately, the apprehension is much justified, with India ranking 178th among 189 countries on the enforcing-contracts parameter in the Ease-of-doing-business index.[61]

Trust in Indian agencies and firms can be built on strong work ethics and a sound IP protection regime comprising of robust laws and well run, specialised courts. Many initiatives have been taken by the Indian Government over the past two decades to fulfil India's obligations under the Trade Related Aspects of Intellectual Property Rights (TRIPS), an international agreement promulgated in 1994 and administered by the World Trade Organisation (WTO), of which India is a founding member.[62] These initiatives involved multiple revisions of the Indian Patents Act of 1970, the 2013 amendments to the Copyright Act of 1976, the enacting of the Commercial Courts Act 2015 which classifies IP disputes as commercial and therefore entitled to swift, expert adjudication[63] and the promulgation of the National IPR Policy in May 2016.[64]

Despite these actions by the government, India continues to have a dismal rating on IPR protection. In February 2017, India was ranked 43rd out of 45 countries, according to a report by the US Chamber of Commerce's Global Intellectual Property Center (GIPC). The report stated India's key areas of weakness as the National IPR Policy which does not address fundamental weaknesses in India's IP framework, the limited framework for protection of life sciences IP and patentability requirements being outside international standards among others. The GIPC also re-emphasised how India would have to build twice the standards required by TRIPS to enable large scale innovation and investment in India.[65]

Unfortunately for India, the negative experiences of the US and the European countries who exported technology to China have only accentuated their apprehensions in this aspect.[66] The concerns of the foreign OEMs are varied and range from illegal sharing of software codes and blueprints, patent and design infringement, piracy and copyright violations, counterfeiting of products and indiscriminate production of licensed technologies, indiscriminate copying of licensed processes and non-payment of royalties.[67]

The effects of a weak IPR regime have been showing up from time to time. In the MRSAM project with Israel, a report mentioned that one of the reasons for delays was the effort to apply political pressure for transfer of Israeli technology while there were concerns that the technology would not be adequately protected by Indian patent laws.[68] Similar concerns have been expressed in the Scorpene submarine project with France and the P-75 submarine project with Russia. On one occasion, Russian representatives have remarked that they would be more comfortable transferring technology to government agencies like the OFs than private firms which could not be relied on. Clearly, a lot needs to be done for India to build the trust and confidence of foreign OEMs that is necessary for successful R&D collaborations and ToT.

Summarising the Complete Spectrum

If we attempt to look beyond the conventional, and study the broad evolution of 'technology' as a body of knowledge passed on till the materialising of a defence system, we come across numerous steps of activity and points of technology transfer. Each of these steps and points therefore, become potential opportunities for India. Of course, whether these can be successfully tapped will depend on one, the national regulations of the foreign country such as ITAR, two, India's relationship with it, three, India's capacity for investment and risk and four, the absorptive capabilities of the Indian agencies and nationals intending to acquire the technology. This means that very concerted efforts will need to be put in to identify and shortlist suitable countries and projects, assess the risks, secure the investment and finally groom and select capable agencies and individuals to execute it.

A pertinent aspect of technology that needs to be understood is that it is not an article which can be received and stocked. Among its three broad constituents of technical literature, machinery and know-how, the last is the element that binds it all together and needs to be assimilated through training and absorbed by the workforce through practical application in the development/production process.[69] In PToT of step 6, this is facilitated by the workforce progressively taking on an increasing share of the work through the SKD, CKD and IM stages. Similarly framed learning curves will need to be created for building up know-hows required in all the earlier steps. Even after such learning activity, the know-hows will need to be constantly improved through practical application in real life projects.[70] Leaving them unused for even a brief duration might severely deplete them irretrievably.[71]

Along with the conventional modes and the potential technology transfer opportunities, there exist numerous other unconventional avenues to gain useful knowledge related to and required for the evolution of a technological product. Every avenue varies in focus, depth of application, effectiveness, investment and risk involved and

Table 5.1: Modes/Avenues of ToT along the TMPP

Step	Technology Transfer Modes and Avenues	
	Modes and avenues available in the step	Opportunities for acquisition after step
1. Fundamental Research: Wide focus, low investment, high risk	Sponsored research, co-research, collaboration in international research networks, sponsored Indian students and researchers, hiring of foreign scientists	Import of fundamental research output
2. Applied Research: More focused, moderate investment, high risk	Co-development, sponsored Indian scientists, hiring of foreign scientists, import of special machinery for R&D, Subcontracting (B2S)	Import of product designs
3. Development of Manufacturing Process: Focused, moderate investment, moderate risk	Co-development of process, hiring of foreign engineers, turn-key projects by foreign firms for building of an industrial plant and transfer of process technology, Subcontracting (B2D)	Import of process technology
4. Mass production of parts : Focused, moderate investment, low risk	Subcontracting (B2P), Training on production and maintenance, Co-production, Technical collaboration in production, Acquisition of factories, Import of special machinery for production and testing,	Import of parts
5. Integration into systems: Moderate focus, high investment, high risk	Joint venture for co-development of systems, hiring of foreign scientists/ engineers through consultancy, Outright purchase of design and development capability	Import of system designs
6. Mass production of systems: Focused, low investment, negligible risk	PToT (Licensed production/ manufacture) foreign aided / G2G/ P2S/P2P , JVs for co-production, strategic alliance/teaming for co-production/workshare, use of foreign technicians for guiding production, acquisition of factories/ special machinery	Import of systems

7. Exploitation of systems	Use of foreign engineering consultancy for sourcing, Outright purchase of defence systems, their use and maintenance, Technology diffusion, Technology acquaintance

Source: Prepared by the Author.

each also pertains to different steps in the TMPP. An aligning of the different modes with each step is attempted in Table 5.1. An additional step has been added to those in Figure 5.1 indicating the exploitation of the system and its technology. This step is home to many lighter, unconventional forms which precede serious ToT activity.

Current efforts in the Indian defence technology environment essentially focus on the later steps, with the production agencies using PToT at step 6 and the DRDO engaging in systems design and integration at step 5. The DRDO's valid emphasis on acquiring the know-whys[72] of design instead of just know-hows of production, from foreign technology sellers, is an effort to move upstream into step 5. Such an acquisition of know-whys will indeed serve to build more self-reliance through design and development of indigenous systems. However, pursuing the design know-whys of step 6 PToT delivered systems is akin to 'tail chasing' with India forever trying to catch up but, inevitably staying a generation or two behind the leaders.[73]

If India desires to achieve technological superiority, it needs to move upstream and build world class capabilities in the earlier steps of technology evolution. If indigenous efforts to build such capabilities are not fruitful, then avenues to import it could be explored. This import is not a simple purchase from a seller. Neither is it free of risks. It can only be achieved through painstaking effort and significant investment over a considerable period of 10 to 20 years, maybe more. To reduce the risks, specific fields of technology may be targeted where India possesses some indigenous resources and is placed at an advantageous or at least even footing with others. And finally, investments in these areas will need to exceed the critical mass necessary to bring results.[74]

Notes

1. This chapter is taken from the author's article 'Transfer of Defence Technology: Exploring the Avenues for India', *Journal of Defence Studies*, 11(3), July–September 2017, pp. 69–98 at https://idsa.in/jds/jds_11_3_2017_transfer-of-defence-technology, accessed on September 13, 2018.
2. Russia has advised India to conclude the P 75I project under a government deal as it has too many complexities of technology transfer. See Manu Pubby, 'Germany Offers India Deal for Next Generation Submarines', *The Economic Times*, May 6, 2016 at http://economictimes.indiatimes.com/news/defence/germany-offers-india-deal-for-next-generation-submarines/articleshow/52138779.cms, accessed on September 13, 2018.
3. Nalin Jain, CEO GE, in an interview by *Defence and Technology magazine*, published in their January-February 2014 edition.
4. See https://en.wikipedia.org/wiki/BrahMos, accessed on September 13, 2018.
5. See https://en.wikipedia.org/wiki/Barak_8, accessed on September 13, 2018.
6. See http://economictimes.indiatimes.com/news/defence/indo-russia-fifth-generation-fighter-aircraft-will-be-completely-new-not-linked-to-sukhoi-t-50-russia/articleshow/57185821.cms, accessed on September 13, 2018.
7. See 'Leading Strategic Alliances: A Case Study, Journal of Business Case Studies' – March 2008 at https://clutejournals.com/index.php/JBCS/article/download/4764/4854, accessed on September 13, 2018 where Segil (1998) reports that 55 per cent of alliances fail within three years. Other researchers (C. Ellis, 1996; S. Parise and A. Casher, 2003) also estimate the failure rate at 50 to 60 per cent. This overall lack of success is probably due in large measure to the frequent tensions between competition and co-operation inherent in alliances (Bharat and Tarun, 2004).
8. See http://timesofindia.indiatimes.com/india/after-sukhoi-mistake-india-to-go-for-russian-5th-gen-fighter-only-with-full-tech-transfer/articleshow/57546519.cms, accessed on September 13, 2018.
9. See http://currentaffairs.gktoday.in/india-israel-develop-mr-sam-missile-system-army-02201741678.html, accessed on September 13, 2018.
10. See http://www.indiandefensenews.in/2016/06/barak-8-lrsam-israel-and-india-fight.html, accessed on September 13, 2018.
11. See https://en.wikipedia.org/wiki/Technology_life_cycle, accessed on September 13, 2018.
12. See http://timesofindia.indiatimes.com/india/delayed-indo-russian-venture-to-produce-200-light-helicopters-for-1-billion-finally-set-to-take-off/articles, accessed on 15 October 2017.

13. See S.P. Ravindran, ‘Technology Inflows: Issues, Challenges and Methodology’, *Journal of Defence Studies*, January 2009, p. 136.
14. Information received during presentation by Lockheed Martin reps in IDSA on May 19, 2017.
15. Government of India, Ministry of Defence, ‘Guidelines for establishing Joint Ventures’ by DPSUs, 2012.
16. However, DRDO’s Guidelines for Transfer of Technology, state that substantial intellectual input is provided to derive detailed specifications. Hence these could be considered ‘technology’ and their communication to another party, a ToT.
17. See S.P. Ravindran, note 13, p. 137.
18. Government of India, Ministry of Defence, ‘Draft Defence Production Policy’, 2018, p. 6 at https://ddpmod.gov.in/sites/default/files/Draft%20Defence%20Production%20Policy%202018%20-%20for%20website.pdf, accessed on September 13, 2018.
19. See Ron Matthews, ‘The UK Offset Model: From Participation to Engagement’, RUSI, Whitehall, London, 2014, p. 25.
20. Ibid., p. 35.
21. Ibid., pp. 47, 51, 52 and 54.
22. A representative of a foreign OEM has stated that the multipliers of 2, 2.5 and 3 offered in the Defence Offsets guidelines need to be in the range of 20 to 30 at least to have any significant value for the D&DToT being expected.
23. As of early July 2018, no worthwhile agreements with any foreign agency had materialised in this mode.
24. ‘Technology’ is closely related to ‘knowledge transfer’ as mentioned in https://en.wikipedia.org/wiki/Technology_transfer, last accessed on September 13, 2018 and numerous other sources.
25. See https://en.wikipedia.org/wiki/Bayh%E2%80%93Dole_Act, accessed on September 13, 2018.
26. See descriptions of vertical and horizontal transfer at https://en.wikipedia.org/wiki/Technology_transfer, accessed on September 13, 2018.
27. See http://www.rochester.edu/ventures/about/what-is-technology-transfer/, accessed on May 20, 2017.
28. Former DRDO chief Dr. V.K. Saraswat in an interview by *Defence and Technology*, published in their November–December 2013 issue, speaks of the need for know-hows for designing.
29. See ibid where DRDO chief Dr. V.K. Saraswat speaks of the know-whys not being delivered in ToT contracts.
30. See https://en.wikipedia.org/wiki/Technology_transfer, accessed on September 13, 2018.

31. See licensing options in https://en.wikipedia.org/wiki/Technology_life_cycle, accessed on September 13, 2018.
32. Ibid.
33. See http://www.dst.gov.in/international-st-cooperation, accessed on September 13, 2018 where cooperation with ten developed countries currently exists.
34. See GITA's at https://www.gita.org.in/, accessed on September 13, 2018.
35. See https://thewire.in/41534/us-names-india-as-a-major-defence-partner/, accessed on September 13, 2018.
36. See https://mea.gov.in/bilateral-documents.htm?dtl/30358/Joint_Statement_on_the_Inaugural_IndiaUS_2432_Ministerial_Dialogue, accessed on September 13, 2018.
37. See http://economictimes.indiatimes.com/news/defence/defence-trade-and-technology-initiative-india-us-agree-on-2-new-pathfinder-projects/articleshow/51800651.cms, accessed on September 13, 2018.
38. 'Design as Integral Part of Make in India', *The Economic Times*, January 17, 2017 at http://blogs.economictimes.indiatimes.com/et-editorials/hi-tech-design-must-be-an-integral-part-of-make-in-india/, accessed on September 13, 2018.
39. *Defence and Technology,* 'Jet Engines', January–February 2014.
40. Former DRDO chief Dr. V.K. Saraswat in an interview by *Defence and Technology*, published in their November–December 2013 issue.
41. United Nations Conference on Trade and Development (UNCTAD), *Transfer of Technology,* New York and Geneva 2001, p. 7.
42. As obtained by the author during seminars and interactions.
43. Donald E. Stokes, *Pasteur's Quadrant: Basic Science and Technological Innovation*, Brookings Institution, Washington, DC, pp. 38–41, 1997. Taken from *Policy Implications of International Graduate Students and Postdoctoral Scholars in the United States,* available for download on https://www.nap.edu, accessed on September 15, 2018.
44. Cui Ning, 'Record Number of Scholars Headed Abroad', *China Daily,* December 22, 2004 at http://www.csc.edu.cn, accessed on January 21, 2017.
45. James Kynge, *China Shakes The World, the Rise of a Hungry Nation*, p. 81, at https://play.google.com/books.
46. Background IP is defined at https://en.wikipedia.org/wiki/Background,_foreground,_sideground_and_postground_intellectual_property, accessed on September 13, 2018.
47. See https://www.wassenaar.org/app/uploads/2015/06/ITT_Best_Practices_for_public_statement_2006.pdf, accessed on September 15, 2018.
48. Though the Arihant project has been reported to be largely indigenous, it is reportedly based on the Russian Akula class submarine and involved

training of an Indian crew (read OToT) on the Russian leased INS Chakra as well as guidance by Russian engineers in its development. See https://en.wikipedia.org/wiki/INS_Arihant, accessed on November 7, 2018.

49. The Kalyani Group acquired the Ruag factory in Switzerland, Mahindra Aerospace the general aircraft manufacturer Gippsland Aeronautics in Australia. See http://www.financialexpress.com/archive/bharat-forge-offers-local-solution-to-armys-needs/1205541/ and http://www.thehindu.com/business/companies/Mahindra-buys-major-stake-in-Australian-firms/article16853553.ece respectively, accessed on September 15, 2018.
50. Tai Ming Cheung, 'The Chinese Defense Economy's Long March from Imitation to Innovation', *Journal of Strategic Studies*, 2011, 34(3), pp. 328-330 at https://www.tandfonline.com/doi/abs/10.1080/01402390.2011.574976, accessed on September 15, 2018.
51. Ibid., p. 330.
52. Ranjit Ghosh, *Indigenisation: Key to Self-Sufficiency and Strategic Capability,* IDSA, New Delhi, 2016, p. 78.
53. See https://www.business-standard.com/article/economy-policy/indigenisation-a-false-debate-113091001027_1.html, accessed on September 15, 2018.
54. Ranjit Ghosh, *Indigenisation: Key to Self-Sufficiency and Strategic Capability,* IDSA, New Delhi, 2016, p. 78.
55. See https://en.wikipedia.org/wiki/International_Traffic_in_Arms_Regulations, accessed on September 15, 2018.
56. See https://en.wikipedia.org/wiki/International_Traffic_in_Arms_Regulations#Academic_work_and_the_.22Fundamental_Research_Exemption.22, accessed on September 15, 2018.
57. L.K. Gupta, 'Is Jugaad Killing Innovation and Quality?' at http://www.impactonnet.com/node/1275, accessed on September 15, 2018.
58. See European Parliament, 'Dual use Export Control, 2015', p. 31, 2015 at http://www.europarl.europa.eu/RegData/etudes/STUD/2015/535000/EXPO_STU(2015)535000_EN.pdf, accessed on September 15, 2018 where it mentions that the key barrier to indigenous production of controlled goods is often tacit knowledge.
59. As learnt during a visit to an ordnance factory in April 2017.
60. Ron Matthews, *The UK Offset Model: From Participation to Engagement*, RUSI, Whitehall, London, 2014, p. 24.
61. See http://www.allresearchjournal.com/archives/2016/vol2issue1/PartK/2-1-70.pdf, accessed on September 15, 2018.
62. TRIPS aims at protecting Intellectual Property Rights (IPR) to promote technological innovation in a manner conducive to social and economic welfare. See https://en.wikipedia.org/wiki/TRIPS_Agreement, last accessed on September 15, 2018.

63. See http://www.managingip.com/Article/3580941/Reshaping-perceptions-about-Indian-IP-law.html, accessed on September 15, 2018.
64. See www.thehindu.com/business/all-you-need-to-know-about-the-intellectual-property-rights-policy/article8600530.ece, accessed on September 15, 2018.
65. See http://blogs.timesofindia.indiatimes.com/cash-flow/india-is-trips-compliant-our-response-is-who-cares-this-government-has-not-been-as-ambitious-as-we-hoped/, accessed on September 15, 2018.
66. Bhupinder Yadav, *Defence Proac Business News* at http://www.defproac.com/?p=2435, accessed on September 15, 2018.
67. Ibid.
68. See http://www.indiandefensenews.in/2016/06/barak-8-lrsam-israel-and-india-fight.html, accessed on September 15, 2018.
69. See the chapter on understanding the nuances for a description of the three constituents of ToT.
70. Ramadas P. Shenoy, *Defence Research & Development Organisation, 1958–1982,* DRDO, New Delhi, 2006, p. 177 where he explains the importance of 'learning by doing'.
71. 'P 75: First "Make in India" Submarine', *Economic Times*, March 28, 2016 at https://www.pressreader.com/india/the-economic-times/20160328/282089160902644, accessed on September 15, 2018.
72. As stressed by former DRDO Chief Dr. V.K. Saraswat, in an interview by *Defence and Technology*, published in their November–December 2013 issue.
73. The very appropriate phrase "tail chasing" is courtesy Cmde Sujeet Samaddar (retd) who was one of the external discussants in the seminar in which the contents of this chapter were presented.
74. This ties in with the words of former DRDO Chief Dr. V.K. Saraswat, 'diffused investment in a subcritical manner will lead to sporadic knowledge generation but does not create technology', in an interview by *Defence and Technology*, published in their November–December 2013 issue.

6

Making it Work for India

A short recap on the goals we need to work towards would help us get started. We have the all-important technological edge that the weapons systems of the Indian armed forces should have over India's potential adversaries. The adversaries include increasingly belligerent China whose recent technological advances indicate that it would match the technology leaders—USA and European countries, in a decade or two. Hence, India would need to work towards technological leadership or at least *technological superiority* in the global arena. We then have the goals and national benefits of *self-reliance*, *economic* and *industrial growth*, *technology diffusion*, *savings in foreign exchange* and the *creation of jobs*. For the vital foreign partnership required, we have the imperatives of *profitability* and the garnering of *larger global market share*. And through all these, due to limited financial resources in the country, we cannot lose sight of *economy*.

The next step would be to decide the modes of ToT that India should adopt for working towards achieving these goals and benefits. Here, we could divide the task into two sub-steps. The first is the evaluation of the various conventional modes which are useful and pragmatic and how they can be implemented through the DPP. And the second is to analyse the larger picture which includes a host of issues such as the optimal use of unconventional modes, offsets, the Make-in-India initiative, etc.

Evaluating the Conventional Modes Available and their possible Implementation through the DPP

From the earlier chapter on avenues, we find that there are ten conventional modes of ToT, including the variants. These are, in generally decreasing order of cost and technology delivered—outright-purchase of design, development and manufacture capabilities (D&DToT), JV for co-development and co-production (JV CD-CP), JV for co-production (JV CP), foreign aided and G2G PToT, Commercial PToT, Licensed production (PToT without IM), strategic alliance/teaming for work-share, and for smaller assemblies or parts - the sub-modes of B2P, B2D and B2S. These can be facilitated through direct contracts, FDI or Defence Offsets. Each of these have their distinct benefits, costs and challenges and distinguishing them will enable the selection of the optimal mode for each defence system desired by India.

An additional avenue for acquisition of critical technologies by the DRDO through Defence Offsets has also been attempted over the past few years, but proposals received have been cost-prohibitive precluding any material gain and placing a question mark on the viability of such an arrangement. In all the modes, know-whys of the foreign design are keenly sought, but the exorbitant and unaffordable D&DToT, then the JV CD-CP arrangement, the JV CP and the foreign aided G2G PToT are the only ones which appear to provide a useful quantum.

Now, the DPP provides for ToT through its two routes of B&M(I) and B&M and goes ahead to describe the ToT clauses and process at numerous places.[1] At one, while defining the attributes for categorisation, it mentions that the industry can provide the systems as per indigenous content stipulated for phased production i.e. the SKD, CKD and IM stages.[2] At another, in the standardised format recommended by the DPP for RFPs, it states that 'the Govt of India, Ministry of Defence is desirous of *licensed production* of (generic name of equipment) under ToT'. At a third, in an appendix devoted to guidelines for ToT, the Licensed production/manufacture mode is described in detail specifying not only the phased manufacture through the SKD, CKD and IM stages, but also the proportion of the five categories of items and the deliverables in terms of documents, training and other resources of the mode.[3] The impression gained by any reader of the DPP is therefore, that ToT is to be done in the PToT/Licensed Manufacture mode.

Does such an emphasis by the DPP on the PToT/Licensed Manufacture mode help achieve the national goals and benefits mentioned in the beginning of this chapter? PToT is undoubtedly the cheapest, quickest and most easily implementable mode, but it also has the serious disadvantages of delivering relatively older technology without the know-whys and introducing dependence for proprietary parts, and is therefore unhelpful in achieving *technological superiority* and complete *self-reliance*. As we have discussed, there are other modes which provide more current technology with a greater quantum of know-whys, though these entail collaborative efforts which could be more expensive, riskier and take longer for fructifying. Why should these modes not be an option in the DPP? The JV CD-CP mode has been used successfully by the DRDO for the Brahmos and MRSAM systems. Why not allow the private sector the freedom to engage in such projects, especially the JV CP mode which has been used so successfully in Turkey?

To develop a broad understanding on which other options are beneficial and to what extent, it may be useful to compare the major conventional modes on their pros and cons. The information available on each of these is insufficient to provide a definitive measurement of them but a very broad assessment based on anecdotal evidence, informal views and some reasoning provides us the comparison in Table 6.1.

The first three modes listed are essentially PToT with varying degrees of technology transfer and can all be accommodated in the current DPP. Next on the list are the work-share arrangement, JV CP and JV CD-CP which have comparably greater benefits, but do not explicitly appear as options available in the DPP. The last mode of D&DToT provides the greatest benefits, but is clearly cost-prohibitive, an option that only wealthy countries can afford.

Though there is a heavy emphasis on PToT in the DPP, there appears to be a window for accepting arrangements where only the Indigenous Content (IC) criteria needs to be fulfilled. In paragraph 8 of Chapter I which describes the B&M(I) route, there is no mention of the PToT related SKD, CKD or IM kits, while it mentions a minimum 50 per cent IC. In paragraph 9 which describes the B&M route, it mentions, 'the AoN according authority would approve either an appropriate ratio of FF, CKD, SKD and IM kits; or a minimum percentage of IC on cost basis for the "Make" portion'.[4] Thus, both routes hold an independent option based on minimum percentage of IC, which can accommodate the modes of strategic alliance for work-share, JV CP and JV CD-CP. It may be noted that though the DPP does not specify ToT through JVs, the Defence Production Policy 2011 allows for them via its statement that 'all viable approaches such as formation of consortia, joint ventures and public private partnerships etc. within the Government approved framework will be undertaken'.[5]

However, there is one significant clause in the DPP which stipulates for both the ToT routes, that there shall be the 'transfer of critical technologies in the specified range, depth and scope'. Since the work-share, JV CP and JV CD-CP modes may not facilitate such a transfer in significant quantum and not in the PToT manner described in the DPP, this becomes a major limiting factor.

The transfer of "critical" technologies is an issue which is highly complex and debatable. The subject has been discussed to a great extent in the chapter on implementing ToT and the findings so far are that acquisition of the manufacturing technologies of "critical" technology, bring numerous complexities into the acquisition process and ultimately deliver limited benefits. If the DPP was to permit overlooking of this clause, there could be four modes for the defence industry to choose from i.e. PToT and its variants, work-share, JV CP and JV CD-CP.

Table 6.1: Comparison of conventional modes of technology transfer for defence systems

Mode	Broad concept of work	Relationship between transferor and transferee firms and duration	Vintage of technology typically transferred (in generations behind current)	Investment required from transferee (multiple of random figure z)	Relative quantum of Technology transferred and capabilities delivered to transferee	% Value addition by transferee over programme duration	Know-whys transferred to enable independent development of future upgrades	Other advantages	Other drawbacks
1. Licensed Production (PToT without IM)	Assembly of SKD and CKD kits	Seller – Buyer, short term (3 – 5 years)	2 generations old	10z	Low - Production, Testing, O level maintenance	10 to 20%	Negligible	Quick, streamlined, low risk production	Transferor does not ensure quality or provide market for products, requires extensive control
2. Licensed Manufacture (PToT)	Assembly of SKD and CKD kits followed by integration of Indigenous Manufacture kits comprising of proprietary parts with balance indigenously manufactured parts	Seller – Buyer, short term (3 – 8 years)	2 generations old	20z	Medium - Production, Testing, manufacture of 20-30% parts, O level, I level and D level maintenance	20 to 40% (phased increase)	Negligible	Slower, less streamlined and higher risk than above due to indigenous manufacture component	In addition to above, Transferor does not ensure development or manufacture of parts by subcontractors as also a market for them

3. Foreign aided/ G2G PToT	As above	Seller – Buyer but with stronger cooperation (3 – 8 years)	1 generation old	20z	As above but with additional inputs	20 to 50%	More than that above	As above. Also faster resolution of conflicts on what technology is to be transferred	Transferor provides closer cooperation and may be influenced through diplomatic means to provide developmental assistance and market for products
4. Joint venture for co-production (JV CP)	Gradual increase of work localisation based on organisational, technological readiness as well as commercial viability	Close partnership with committed investment and shared profits and liabilities. Long term (8 – 15 years)	1 generation old	40z	Medium - Production, Testing, manufacture of 30-60% parts, O level, I level and D level maintenance	20 to 50% (phased increase)	Low/medium	Transferor can use his established management model to run the JV and develop subcontractors. Risks shared with foreign partner. Less government intervention needed	Transferee workforce needs to adjust to new management rules and systems.
5. Strategic alliance / Partnership/ teaming for work-share	Established capabilities pooled to create system with minimal joint work	Partnership with shared profits and liabilities, medium term (6 – 10 years)	1 generation old	20z	Low - System integration and testing, O level maintenance of foreign work share	30 - 60% (system integration plus portion of transferee subsystems)	Low (integration of system only)	Minimal adjustment by transferee to transferor's systems	Requires both partners to hold complementary technologies

6. Joint Venture for Co-development and Co-Production (JV CD-CP)	Established development capabilities pooled to develop system design and production	Partnership with shared profits and liabilities. Long term (8 – 20 years)	Current generation	100z	High - System design and testing, O level maintenance of partner's subsystems	30 - 70% (system design and integration plus portion of transferee subsystems)	Medium (Design and integration of system)	Technology diffusion from partner's subsystems	Joint development requires good teamwork and rapport between partners. Risks of delays due to disagreement on various issues will exist.
7. Outright-purchase of design, development and manufacture know-how (D&DToT)	Transferor teaches transferee workforce through complete design, development and manufacture stages	Seller (Teacher) – Buyer (Student). Short term (5 -8 years)	1 generation old	1000z	Very high - System design, development and manufacture	40 to 60 %	High	Fresh workforce open to assimilating new technology means quick and relatively hassle free implementation	

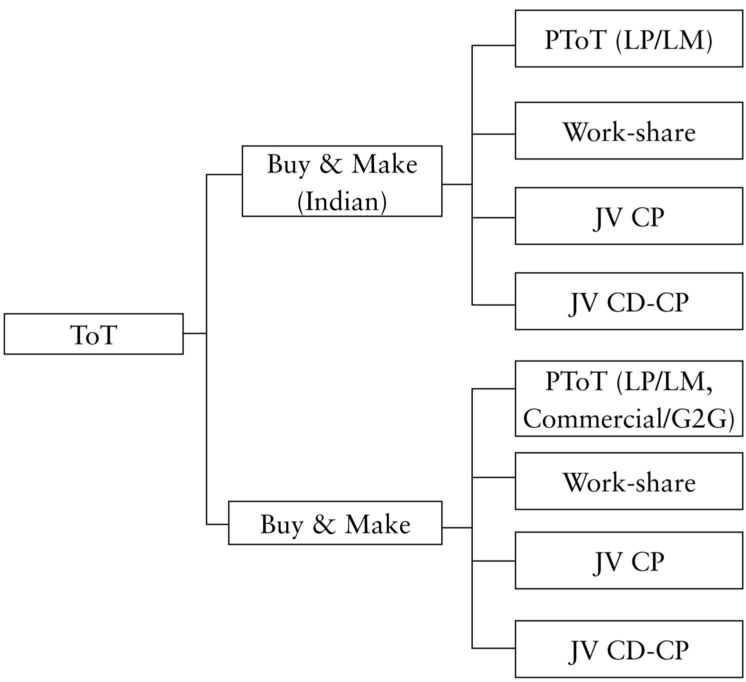
Source: Prepared by the Author

Notes: 1. O, I and D levels of maintenance correspond to that required at Operator level, Intermediate level and Depot level

2. Figures are speculative

How should the DPP now accommodate these modes? The major problem is that the DPP goes into tremendous detail on how PToT has to be sufficiently evaluated and then optimally executed for the end benefits of maximum technology transfer (especially of critical technologies), value addition and indigenous content by specifying numerous conditions and clauses on a host of aspects. These details may not be pertinent to the work-share, JV CD-CP or JV CP modes. Hence, the DPP could ideally enclose these details in a separate annexure dedicated for PToT, while similar details could be drawn up for the work-share, JV CD-CP and JV CP modes and enclosed in an annexure dedicated to each. We thus arrive at the options in the chart at Figure 6.1.

Figure 6.1: Opening up more Modes for ToT through the DPP



Source: Prepared by the Author.

Taking the two broad routes of B&M(I) and B&M to be suitable for smaller systems such as communication sets, radars, small arms, artillery guns etc and large platforms such as warships, submarines, fighter aircraft and armoured vehicles, respectively, we can attempt to map the most suited mode to each type of system depending on the *urgency* of the need, manufacturing *technology available* in the country, the state of *indigenous development capability*, the *life* of the system and *population needed*, all of them measured in two levels—high or low.

So small, current communication sets with a high level of urgency, a high level of manufacturing technology available in the country, a high level of indigenous development capability, a low life and required in high population might be very suited to manufacture through the work-share arrangement under the B&M(I) route. We could similarly map other systems based on these criteria, a few examples of which are detailed in Table 6.2.

Table 6.2: A Template for Selecting Optimal Modes of ToT

System	Size	Urgency	Manufacturing technology available	Indigenous development capability available	Life	Population needed	Optimal mode
Current Radio sets	Small	High	High	High	Low	High	Work-share, B&M(I)
Futuristic Radio sets	Small	High	Low	Low	Low	High	PToT, B&M
High power radars	Small	Low	High	Low	High	Low	JV CP, B&M(I)
Diesel submarine	Large	High	Low	High	High	Low	JV CD-CP, B&M
Next generation Fighter aircraft	Large	High	High	Low	High	High	JV CP, B&M
Futuristic Fighter aircraft	Large	Low	Low	Low	High	Low	JV CD-CP, B&M

Source: Prepared by the Author.

A word of caution is due here. The optimal modes listed in the table are suggestions and not sacrosanct. There could be numerous projects which, due to their specific features, should be optimally addressed through other modes.

Finding Solutions to the Complexities in the Indian DPP

We will now attempt to find solutions to the complexities brought up in the chapter on implementing ToT.

The first vexing issue is that of critical technologies being transferred in the specified range, depth and scope. Though we have been able to open up more modes by removing the critical technology clause of the DPP in the earlier section, it does not mean we cannot exercise this clause in each of the individual modes. As discussed in the chapter on implementing ToT, however, it is extremely difficult to define which technologies are critical and even more so, to include them without disturbing the acquisition process. There are two options here. The first is to shift this clause to the offset package desired from the seller, thereby leaving it to the discretion of the seller. For orders expected to be below Rs 2,000 crore, (for which Offsets are not applicable), the critical technologies clause could be waived off. The second is to allow the acquisition wing, the freedom to waive this clause in cases where the complexities impede expeditious execution or place undesirable single vendor situations in the procurement process. As for the clause that 'no item which is critical from the technology point of view can be acceptable as proprietary', there is no option but to drop it. Proprietary items would, perforce, contain some amount of critical technology and expecting to obtain such technology would either result in a no-response or exorbitant and irrational commercial bids or in near-obsolete technology bids.

What do we mean by scope, range and depth of ToT? Defining these terms in the DPP would guide the various agencies involved in drawing up a RFP in a more objective manner. A possible set of definitions is that 'scope' could denote the variants of ToT desired as covered in the chapter on nuances. That is, whether it is OToT, MToT, PToT or DToT (limited). The 'range' could specify the sub-systems for which ToT is required such as the radar transmitter, antenna control system and power generator equipment. And 'depth' could denote, within production ToT, the technology required as per the increasing levels provided for category 3, 2 or 1 items respectively. One could argue that leaving these terms undefined may provide project managers the lee-way to ask for deliverables such as the know-whys of design or other such path-breaking assets to the ultimate benefit of the country. But, the know-whys of design are most likely to be simply unavailable, being diffused over a huge melange of scientists. If, by some chance they are available, they will most likely be blankly refused or charged exorbitantly for. Attempts to acquire them through RFP stipulations may thus end up with no bids or exorbitant ones or obsolete technology. If they are exorbitant and still needed, they could be acquired directly through a separate agreement, thus preventing the confusion of the defence system acquisition process. The scales of prudence thus, tilt favourably towards defining these terms.

Which ToT should be considered cost-prohibitive does not have an easy answer. As we discussed in the chapter on nuances, the cost of ToT products are invariably more than that of products directly purchased from the OEM. But, how much more is considered cost-prohibitive would depend on how much of the transferred technology is expected to be utilised (in terms of population of the product) as well as its criticality to the Indian DIB. A possible yardstick is postulated in Table 6.3.

Table 6.3: Possible Ceilings beyond which, the ToT Proposed can be Considered Cost-Prohibitive

Expected population of product to be acquired	Criticality to the Indian DIB	Cost of ToT considered prohibitive in terms of the ratio of increased price of ToT product to that when product is directly purchased from OEM
High (over 100)	High (No equivalent available in DIB)	Over 1.5
High (over 100)	Low (Equivalent being developed / available in DIB)	Over 1.2
Low (below 15)	High (No equivalent available in DIB)	Over 2.0
Low (below 15)	Low (Equivalent being developed / available in DIB)	Over 1.5

Source: Prepared by the Author.

The next issue is that of the conflicting requirements of maximum Indigenous Content (IC) or value addition with maximum quantum/ depth of ToT. The ideal situation would be where the Indian industry is provided the opportunity of adding maximum value (and therefore IC) in areas where they possess the capability and alongside, facilitate maximum ToT in range and depth for the remaining, provided that such ToT can be technologically and economically utilised. To achieve such an understanding prior to drawing up the RFP will require a deep understanding of the system being acquired and a huge understanding of the capabilities of the industry. Acquiring both of these will be extremely difficult in the short RFI–RFP time-window of three to six months available, and especially with the current structure of the SHQs, acquisition wing and MoD which do not hold engineering personnel with domain knowledge covering both areas. This lack of knowledge is especially acute in the private industry domain, since none of their representatives are formally integrated into the MoD organisation.

There are three possible solutions. The first is that the order be split into two portions. The 'Buy' is executed first with a commitment and a competitive bid for ToT from the seller, thus allowing sufficient time and access for the examination of the technology of the bought systems and the capabilities of the corresponding elements of the Indian industry. Visits to the foreign OEM and its subcontractor's factories may also be conducted during this time so as to obtain a close look at their processes. When such examination is complete, the ToT or 'Make' portion can be executed through a separate contract, based on the competitive bid earlier submitted by the seller, and specifying in detail the scope, range and depth of ToT required. This we can call the *Split-Order* option.

The second solution is to waive off the scope, range and depth of the ToT criteria and simply state a desirable and attainable IC or value addition. This would provide the foreign seller and Indian buyer the freedom of identifying the technology which can be successfully and economically transferred and who, together, will arrive at a package which is optimal. Here, one needs to exercise some caution in setting the minimum level of IC. In the exuberance to get the maximum (and buoyed by the over-optimistic views of the local industry), it is very possible that the levels are placed at higher than those that are technologically feasible as well as economically optimal. Instances of Indian firms being unable to manufacture some parts of the foreign product and many to the desired quality standards, are pointers to this malady.[6] Being conservative in estimating and fixing the levels of IC desired is probably a better approach. It must also be noted that the quantum of IC achievable would rise gradually as the technology is absorbed until it reaches the optimal level. Hence, agreements must provide for such graded increase over the numerous phases instead of expecting the optimal IC from the word go. This arrangement could be termed the *Defined IC* option.

The *Defined IC* option also caters well for situations where part of the technology is available in the country. Such availability reduces the cost of ToT required and hence makes the ToT manufactured product cheaper. We can see that this option fits in well with the work-share mode while it could have varying levels of utility in the others. The IC defined in such cases would comprise of two portions. One is the portion that is available in the country and the other is the portion that is desired to be manufactured through ToT.

The third solution is to waive off the IC clause leaving just the scope, range and depth of technology as the selection criteria. This arrangement would work well for new areas, where no technology, or very little of it, is available in the country. However, whether the offered technologies can be effectively absorbed and can be utilised economically would need to be assessed before proceeding ahead. This arrangement could be termed the *Defined ToT* option.

Imported defence systems consist of sub-systems, some of high, locally unavailable technology such as the seekers in missiles and others of low, commonly available technology such as power generation sets. For the former, a JV CD-CP with *Defined ToT*, may be desirable, whereas for the latter, a work-share with *Defined IC* is more suitable. Though apparently complicated, such a differentiation would lead to the maximising of valuable ToT and IC for optimal benefits to the Indian industry.

The clause that ToT should be provided without license fee and there should be no restriction on domestic production, sale or export is expecting far too much (especially if modern technology is expected) and may instead increase prices unnecessarily.[7] License fees are very nominal amounts (2–5 per cent of the product value) and are linked to the Intellectual Property Rights (IPR) being conferred by the foreign OEM. The acceptance of these licenses accompanied by a legal framework for protection of IPR would enable the building of trust that is needed for foreign OEMs to execute ToT. In case India wishes to extend production for any reason, the terms could be negotiated at a later stage to the mutual satisfaction of both parties.

The use of the term 'state-of-the-art' for describing the technology desired for transfer is really of no value. It has, in fact, the detrimental effect of generating unrealistically high expectations in the acquisition agencies, which are then psychologically biased against accepting anything perceived to be of a lower standard.

This term, therefore, needs to be dropped, as it has been for the GoI policy on FDI for defence equipment.[8] The terms 'current' and 'contemporary' could however, be continued. This would instil a perspective that aging or obsolete technology would not be accepted. For systems which could consist of a basket of subsystems with new and older technologies, a clause could be mentioned in the DPP that no technology should be so old that it may reach obsolescence over a major portion of the expected product life of the system.

The terms 'comprehensive', 'complete' and 'total support' too do not help much since there are clearly limits to how much technology can be practically or economically transferred. These could be replaced with the term 'defined quantum of technology' and supplemented with the definition of the end-goal in terms of depth of ToT or quantum (in percentage) of IC, as the case may be.

Asking for in-depth technology details at the early request-for-information (RFI) stage to enable the setting of parameters in the RFP as well as the specifying of the ratio of distribution of technologies in categories 1 to 5 and the proportion of MRLS to be made/assembled in India, appears to be a creditable quest. However, an accurate and useful outcome can only be achieved after extensive analysis involving multiple agencies and is, therefore, difficult to achieve within the time-line of two or even six months, especially in large systems. Projects employing the *Split-order* arrangement would have sufficient time and could greatly benefit from such detailed analysis. In the others, however, this may simply create unnecessary assessment and matching activity leading to delays and frustration among both parties. ToT contracts have been executed in the past without going into these details and have turned out quite successful.

With regard to the MRLS, typically, a maximum of 10 to 15 per cent of its range consists of fast moving (FM) items which are required frequently. Manufacture of these FM items in India should be economically suitable though exceptions may occur. If dependency on the OEM is to be reduced (in an economical way), the initial quantity of spares could be predicted scientifically and procured, followed by a lifetime-buy at the midlife of the system.[9] It is expected that by this time, the spares consumption rate would have stabilised, facilitating accurate prediction of the future need.

The ambitious clause asking for technical information/data updates of all upgrades undertaken in the entire life cycle of the product to be provided at no additional cost may be amended to state ‘that required for minor upgrades essentially to improve reliability’. For major upgrades, it could be at a cost mutually agreed to by both parties. Such an arrangement is not new and has been used in numerous contracts, particularly in product support. The clause asking for ‘complete exposure’ to design practices of the OEM so as to enable upgrades during the complete life cycle of the product, needs to be dropped and replaced with a more reasonable one asking that adequate exposure to design practices of the OEM be provided to enable the disposition to deviate from specifications or modify or upgrade a part or substitute the part (which may be necessary due to differing grades of local raw material or locally manufactured parts) to overcome potential stoppages in manufacturing or maintenance. The OEMs would also be willing to provide exposure to design practices which enable improvement in reliability through substituting some parts with improved ones.

The clause asking for the source code of embedded software, would reject deserving systems, whose OEMs do not wish to part with their USP or core technologies, which have become increasingly software based. It is also infructuous, detrimental and financially injudicious. The first, because the source code without other supporting documents such as the software design, database structure and algorithms cannot enable reliable modification or upgrades. The second, because it relieves the technology seller from the responsibility of removing bugs and errors that may exist or creep into the software (through modifications). And the third, because it would unnecessarily increase the cost of the ToT. Hence, this generic clause too needs to be dropped. However, the supply of source code (and supporting documents) of specific embedded software, which are needed for full utilisation of the systems and where the need for regular updating or modification to meet local requirements is expected, could be worth the cost and more agreeable to the OEM.

The clause that the ability to transfer requisite technology is to be assessed while short-listing of prospective foreign OEMs, is a difficult one to address. Some foreign OEMs may provide data of previous ToT contracts with other countries, but what if an OEM possessing valuable technology is attempting this for the first time? Does this fact make it ineligible, when it is very possible that it may transfer technology quite effectively? The ability could be assessed through the OEM's technical documentation on SKD/CKD/IM kits and procedures, its holding of training staff, training facilities, interpreters, conversion charts for specifications, etc. But these too, it may invest in, only if the contract is awarded. This clause may, therefore, best be dealt with as a desirable and not essential condition. It is extremely unlikely that an OEM would not invest adequately on the resources needed for transferring technology when it stands to gain considerably through its increased sales orders.

The DPP also stipulates that before awarding repeat orders, the technology absorption levels agreed to should have been achieved. As mentioned earlier, technology absorption levels are a function of the knowledge and demonstrated capabilities of the recipient firm and can become complicated to assess when quality levels are not fully achieved and exact causes are distributed over internal and external factors. However, such assessments are definitely necessary, especially through a third party, since the transferor and transferee parties would be inclined to blame the other for failures. This clause could, therefore, be modified to state that no uncompensated shortcomings on the part of the OEM in earlier contracts should be pending.

The clause in the Buy (Global) category, stating that ToT may be considered 'essentially to provide the buyer with leverage during negotiations or even post contract stages' is quite incomprehensible and could be incorrectly interpreted as mentioned in the chapter on implementing ToT.[10] Since this route would invariably involve a G2G agreement, such a clause could be used within the internal procedures of the GoI. For the DPP, however, we're better off by dropping it.

The clause which states that 'the OEM shall provide an itemised parts list in the Technical Bid and itemised price list (IPL) totalling to end product unit cost in Commercial Bid' appears to have been inserted to ensure prices of all parts are made known beforehand so as to prevent exorbitant pricing by the OEM during subsequent purchases of spares.[11] However, the end product unit cost would also include many more components of cost. One is the cost of labour required for assembling the various items and testing the system. The second is, as brought out in the section on valuation in the chapter on implementing PToT, approximately 25 per cent of the price of the system which is retrieved by the developing agency as design costs. The third are overheads such as those for marketing and sales. And finally, there is the inevitable profit component, which is kept extremely confidential by the OEMs for ensuring their business interests. Hence, forcing a seller OEM to adhere to this clause would leave him no choice but to inflate the prices of the items listed in their various categories. This can have an extremely detrimental effect when spare parts are bought either with the system or subsequently at such inflated levels. One solution would be to ask the OEM to disclose the consolidated figure of the design, marketing, sales and profit components in the price of his product, and provide a breakdown of the remaining which should cover the cost of parts and labour for assembling and testing the product. The OEMs, however, are unlikely to disclose these too, given the confidentiality with which they treat their pricing methods. Since the prices of spare parts, likely to be required, are listed in the MRLS in its competitive bid, the need for obtaining the itemised price list is considerably reduced. The best way forward therefore, is to delete the portion of the clause asking for the IPL to total up to the end product unit cost.

The clause that the vendor should provide total support and 'facilitate ToT of the sub-systems from his sub-vendors/OEMs, if desired by the buyer' also needs to be addressed.[12] What if the buyer indicates that a particular technology is desired but the OEM is not able to influence the sub-vendor to transfer it? Or is able to transfer it, but at an exorbitant price? It may be better to ask the vendor to provide the price of the technologies of the sub-vendors and whether they are willing to transfer them. A post-contract decision could then be taken, on whether the technologies need to be bought.

The setting of the ideal proportion of systems to be delivered from FF, SKD, CKD and IM configurations appears a simple exercise. However, the tendency to lower the proportions of the earlier stages to increase overall IC (the DPP mentions that the FF stage could even be omitted[13]) needs to be curtailed, since recipient agencies would need sufficient time to absorb the technology at each stage and develop indigenous parts required for the IM stage.

Possible Solutions for Complexities in the Strategic Partnership Chapter

From what we have learnt in the chapter on nuances, the concept of a long-term relationship with foreign technology sellers, as is propounded by this chapter of the DPP, definitely holds merit. Long-term relationships are preferred by foreign sellers who wish to gain and consolidate market space. The Swedish aerospace firm, Saab, has in fact proposed a hundred-year relationship, though this seems excessive and clashes with the Indian focus on building self-reliance. Hence, this has probably been received in Indian circles with the trepidation that stems from India's long history of subjugation by foreign imperialistic powers. From the technology recipient's perspective, however, a long-term relationship allows for the initial gradual absorption to build up steadily, based on sound concepts and practices and ultimately reach a creditable level as can be seen in the case of Turkey's joint venture with Lockheed Martin. Moving upstream in the TMPP from manufacturing to system design to development and research can also be achieved through such relationships provided a deep level of trust is created and maintained. Hence, a relationship in the range of ten to twenty years would seem ideal, proportionate to the size and complexity of the system. The possibility of extending it continually must also be tied in and emphasized so as to build a deeper, more productive relationship.

The objective of building competition is also worthy, though some may question whether India can afford to create and maintain two or more separate manufacturing facilities for the large systems covered in this chapter. The economics of such an arrangement definitely need to be studied and concrete steps taken only after it is concluded that this approach is truly beneficial.

The risk and tedium of negotiating with a foreign government for allowing the ToT at the final step of every contract conclusion could be overcome simply by doing it for the complete spectrum at the preparatory stage. This clearly needs a detailed study of what technology would be sought in the future and strong negotiations to get the foreign government to accede to transferring them. Who would execute this study and execute the negotiations, needs to be worked out and will be addressed ahead.

The problem of identifying and assessing the technologies and their quantum which could be successfully transferred, within a short span of two months, can be obviated through the *Split-order* model as has been suggested for the DPP. In the case of submarines however, a *Split-order* could turn out to be expensive if initially purchased submarines do not turn out to be suitable for ToT. Here, a *Lease-and-order* model instead, would work out favourably. This model would provide sufficient time during the lease period, for the acquisition agencies to gauge the optimal threshold in SQRs and ToT aspects for the subsequent ToT phase.

The maximum ToT versus maximum IC conflict could be addressed in a similar fashion to that of the DPP by the use of the *Defined IC* and *Defined ToT* approaches. The definitions of scope, range and depth of technology recommended for the DPP in the earlier section could similarly be adopted. The asking of R&D capability for future upgrades alongside manufacturing, if at all acceptable to the OEM would result in it feeling threatened and insecure and therefore, a reluctant technology transferor. This clause could, therefore, be modified to specify 'that R&D which is required for enabling disposition to deviate from specifications or modify or upgrade a part or substitute the part so as to prevent stoppages in production'. This aspect must also be practiced during execution since foreign OEMs would retreat on the first sign that the R&D is being used for developing future upgrades independent of them.

The freedom of the OEM and SP to choose amongst a variety of ToT arrangements such as JVs, equity partnerships, technology-sharing, royalty or any other mutually acceptable arrangements is a very welcome feature since the optimal arrangement would depend on a host of factors best known to the two partners. The clause allowing the SP to have cooperative arrangements including transfer of technology and teaming arrangements with the DRDO/OFs/DPSUs would also be extremely beneficial since these arrangements could utilise existing indigenous knowledge and capability to raise the potential capability of the SP to absorb higher levels of technology and achieve higher IC, respectively. However, the limiting of FDI in the OEM-SP partnership to 49 per cent, apparently for the goal of self-reliance, would hinder the OEM in steering the JV towards globally competitive technological standards.[14] Such standards would be required if India is considering export to friendly countries as stated in the draft DPrP 2018. A greater openness to accepting higher FDI levels appears to be slowly setting in with the draft DPrP 2018 stating that FDI up to 74 per cent would be accepted under the automatic route for niche technologies. If this level of FDI is indeed permitted, and there is concrete global demand for the product, the foreign OEMs would be more willing to accept joint responsibility for quality as entailed by this chapter and the need for obtaining a written commitment from the OEM and SP on skilling, indigenisation roadmap, R&D facilities, etc. becomes unnecessary.[15] The partnership would, over a period of time, settle for the most economical arrangement while still maintaining global standards, thereby benefitting the Indian government as its primary customer and achieving profitability through global sales. While such an arrangement will not enable subsequent purchases through Buy (IDDM) or even Buy (Indian), it would provide a significantly high level of IC.

The need for a Three-Stage Process for Acquisition involving ToT

We have discussed earlier, the two stages of defence-system acquisition through technical evaluation and then selection of the lowest commercial bid. Many systems might make it to the second stage and may contend for selection, but what if the ToT offered with some of them is inadequate or unsuitable? What if the technology offered is adequate but the Indian industry does not hold sufficient capability in those particular areas?[16] To take our earlier example of radars using different technologies from Russia, Sweden and Israel, the solid state technology of Israel is the most advanced but Indian firms may have an absorption capability only in the Swedish TWT technology. What if some technologies can be used in several other systems, thus saving additional expenditure and effort in them?[17] What if some technologies have greater potential for further development than others which have reached their limit? And finally what if the technology of a system is exorbitantly expensive, though the system by itself is the cheapest?

Attempting to club the myriad ToT nuances with the technical specifications of the system for technical evaluation in the first stage may well lead to conflicting requirements and bring the acquisition process to a grinding halt. The solution appears to be the conduct of a separate stage for evaluating the ToT offered. The QRs for this ToT evaluation stage will need to be set by personnel who have a deep understanding of the technologies being evaluated and the capabilities of the Indian industry. The stage could be held sequentially after the technical/field evaluation, since those systems which are technically superior are generally produced using superior, more desirable technology. Those meeting the ToT requirements could then contend for the commercial bid stage where the OEM offering the lowest combined price of the systems and the ToT can be selected.

Tackling Complexities in the Defence Production Policy

Major changes in the DPrP appear to be in the offing, seeing the numerous new angles which have been included in the draft DPrP 2018. Hence, we shall not dwell too much on DPrP 2011.

The fundamental flaw of expecting Indian agencies to develop all future upgrades after ToT from foreign OEMs, has been removed in the draft of 2018. There is also no mention of the difficult proposition that the DDP along with DRDO, HQ IDS and SHQs would be jointly responsible for identification, evaluation and absorption of technology. However, the absence of a mention of India's potential adversaries and the need to match up technologically is conspicuous after its repeated stress in the DPrP 2011. This, may be prudent in a manner, since aiming to match up to China's superior technological and military strength may push India to unaffordable levels of expenditure. However, should this aspect be ignored altogether?

From the ToT angle, many new initiatives have been listed in the draft DPrP 2018 which would spur the utilisation and capitalisation of ToT. These are scattered across the various sections of the document. Among the goals and objectives, it states the facilitation of faster absorption of technology. In the strategies section is mentioned the encouraging of collaborations to acquire latest technology, manufacturing processes, skill-sets and R&D. Then, over the rest of the document, we have the mapping of the core competence/ability of private defence industries to absorb various technologies, the further liberalisation of FDI norms and allowing of FDI up to 74 per cent under automatic route in niche technology areas, technology transfer facilitation in the proposed defence industry corridors, supporting the infusion of new technology/machinery into the OFs and DPSUs, the acquisition of technologies by the OFs and DPSUs through global acquisitions/mergers, support for speedily indigenising components/ sub-assemblies from foreign OEMs, which are used for manufacture of final products under licensed production and the encouraging of global majors to set up manufacturing capabilities of their platforms in India, both to cater to domestic needs and export from India.[18]

Extremely beneficial is the added focus on exporting of defence equipment and systems which was completely absent in DPrP 2011. This, as we shall discuss ahead, is a critical shift of focus which can have path-breaking effects on the development of the Indian DIB through ToT. This initiative has however, been dampened a bit by the statement that as far as possible, all requirements of the defence forces will be manufactured domestically, thus indirectly indicating that the MoD would give preference to older, less reliable domestic technology as compared to modern foreign technology.

Some statements in the draft, however, appear over-ambitious and even delusional, at least in the near term. One of the over-ambitious ones are the achieving of self-reliance in the development and manufacturing of thirteen defence system categories from fighter aircraft, medium lift helicopters, warships, land combat vehicles to autonomous weapon systems, missile systems and others by year 2025. Achieving self-reliance in *manufacturing* these systems is somewhat feasible, but *development* of such systems, expectedly to world class standards, is another thing altogether. Among the delusional ones, we have the goal of making India a global leader in R&D and defence technology, that India should aim to become a developer of next level of frontier defence technologies in the world and that India become a global leader in Cyberspace and AI technologies. These goals would need strong fundamental research in Indian universities, which is practically absent, as well as an immense amount of investments, which India cannot afford. Therefore, the DPrP could do well to also state the constraints that

India has to face in the development of the DIB and then set realistic goals.

The need for an Acquisition Agency with a strong Technological Arm

Currently, defence ToT is acquired as an asset which comes along with the main product, that is, the defence system. The need for acquisition of the defence system itself is initially projected by the user directorates in the Service HQs of the Army, Navy and Air Force and then processed through the Weapons and Equipment (WE) Directorate of the Army HQ or equivalent in the Navy and Air Force, then HQ Integrated Defence Staff (IDS) (for systems common across the three Services), the Acquisition Wing, the DRDO, and the DDP. A large part of the collation and screening of technological inputs from prospective foreign OEMs in the RFI stage is done by the SHQs, WE directorate and HQ IDS whose officers, excepting the Navy, are by and large of a non-engineering background. These, therefore, bank upon the DRDO for vetting and providing advice on ToT aspects, especially the identification of critical technologies. Apparently, the DRDO neither provides inputs on the scope, range and depths required, nor ascertain the economic viability of utilising the technology and whether the nominated Indian production agencies possess adequate absorption capability. It is assumed that these aspects will be taken care of by the nominated technology recipient firms in due course.[19] Vetting and analysis of ToT proposals during the RFI, RFP, TEC and even trials stage are hence possibly given secondary importance (to the system's SQRs) and largely left to the concluding contract negotiation (CNC) stage with the selected vendor. The DDP and the concerned recipient firm are fully involved here, but there is not much that can be negotiated since the broad parameters have already been fixed at the early RFP stage.

Proposals for foreign ToT to Indian agencies also invariably lead to the manufacture of systems which compete with the indigenously developed ones by the DRDO. There is, hence, a strong conflict of interest involved in the tasking of the DRDO for vetting ToT proposals. Other agencies such as the DGQA and the maintenance departments of each service do have qualified and experienced engineers who could take on this task somewhat, but these are not involved in the process. Ideally, every Service HQ should have an integral element with engineers who are technologically updated and aware of the capabilities of the Indian industry. The Navy has some elements in the form of their Naval Design Bureau, Weapons and Electronics Systems Engineering Establishment (WESEE) and the National Institute for Research & Development in Defence Shipbuilding (NIRDESH), which is possibly the reason why the naval industries have made significantly more progress in absorption of technologies and indigenous production.[20] The Army has taken a step ahead by creating the Army Design Bureau, but it needs to be upgraded hugely with knowledgeable and experienced engineers to be able to understand and deal with technological issues.

A brief look at the acquisition agencies across the developed countries such as the US, UK, France and Germany indicate a significant proportion of top quality engineers dedicated for project appraisal and management. The French DGA—Armament Procurement Agency is known to have an enhanced technical capacity which reduced the information asymmetry with the local industry thus leading to effective project execution. A major contributory factor is the elaborate system of recruitment and training and devolution of senior management positions in the DGA which attract some of the best and brightest French students of engineering and administration. Many of these become specialists in developing sophisticated armaments.[21] The UK and Germany have merged organisations with technical capabilities for both acquisition and life-time support making them a one-stop shop.[22] The advantages are obvious - the responsibility of all technical matters right from laying down of technical specifications for acquisition to system development and manufacturing to in-service support and final withdrawal comes under one head thus always ensuring availability of the desired technical solutions to the armed forces.

The MoD's proposed new Defence Procurement Organisation could be structured on similar lines, though it would be better to name it the Defence Acquisition Agency (DAA). This because acquisition would include, along with procurement of systems, defence R&D and ToT. Merging the maintenance departments of the three Services with this agency, as is the case in the UK and Germany could possibly be put to effect later.

A need which has been repeatedly voiced over the last five years is the mapping of the competency of Indian firms and agencies in R&D, manufacturing and absorption of technologies. Suggestions on which organisation should take this on have ranged from the DRDO, DDP and DGQA to industry federations such as the CII, FICCI and ASSOCHAM to even defence think-tank IDSA. All are unfortunately, not quite suitable for various reasons. The DRDO, because of its conflict of interest with foreign ToT to Indian firms, the DDP, because its focus covers the OFs and DPSUs but not the private sector, the DGQA because of current internal management issues reducing its credibility, the industry federations and IDSA because they do not hold strong technological wings. The setting up of a new agency appears, therefore, the only way forward.

Such an agency could be drawn on the lines of the US Defence Technology Information Centre (DTIC). The DTIC and its Information Analysis Centres (IACs) are research and analysis organisations which support researchers, scientists, engineers and programme managers across all government, public sector and private sector agencies. It contributes significantly by reducing duplication and building on previous research, development and operational experience.[23] The DGQA, with its existing databases on defence firms and their products are the best suited to create such an agency, though it could do well to co-opt elements from the DRDO, OFs, DPSUs, private defence firms and the three military Services. Once created, it could be placed under the new Indian DAA.

If the MoD decides to create the DAA, where would the initial engineering staff come from? While the DRDO and DGQA could provide a few, it is the maintenance departments of the three Services that can be of great use. There are hundreds of competent and experienced Army, Navy and Air Force engineers who lie untapped in non-technical appointments, with no career growth prospects due to the steep pyramid structure of the organisation and whose higher ranks are dominated by officers of the fighting arms, executive cadre and pilots, respectively. Though these officers and technicians may be under exposed to R&D and manufacturing, they have a deep understanding of the working of a range of defence technologies. This, with their intimate understanding of the needs of the systems' users and their organisational skills can combine into potent starting material for this organisation. Such lateral absorption could also possibly be provided with avenues for promotions, thus ensuring high motivation levels.

In addition to the above, it may also be necessary to include representatives of the industry associations, that is, CII, FICCI and ASSOCHAM who would provide the private sector perspective. They could be employed as full-time consultants and could be given a say in all decisions which affect the DIB. Such participation in decision-making has been requested by the private industry for over a decade. And finally, we have representatives of the DRDO, DGQA, DDP (with OFs and DPSUs), private defence firms, IDAS and other smaller organisations. Getting the right mix and structure may take some initial shuffling around, but would get done in due time.

Who would lead the DAA? It will need a person with a defence engineering background, sensitive to the technology needs of the three Services, aware of the capabilities and limitations of the DRDO, DPSUs and private sector and a sound financial awareness. Circular or cross posting of senior officials of the three Services, the DRDO, DPSUs and even industry federations may throw up such a person, suitably endowed with strong leadership and management skills, in a few years' time.

The need for a Central Transfer of Technology Centre and Monitoring Agency

Acquisition of technology transfers, as described in the preceding section, is but one stage of the life-cycle of the ToT process. To ensure maximisation of the benefits of ToT, it is necessary that subsequent stages of implementation and consolidation be carefully executed. Such activity, unfortunately, is left almost entirely to the concerned recipient agency with little or no monitoring and guidance action.[24] Guidance would become increasingly important as new players such as the MSMEs are brought into the process. There is, however, no agency, government or private, which currently specialises in technology transfers in the defence domain and which can be in a position to provide such guidance. The civil domain, on the other hand, has agencies such as the Asian and Pacific Centre for Transfer of Technology (APCTT) run under the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP). A brief description of the organisation and functions of the APCTT is provided in Annexure I.

The existence of the APCTT and the depth of work being put in there is an indication that ToT is a complex and challenging subject, needing specialised centres. China has taken numerous initiatives to set up Technology Transfer centres as part of its thrust to building its technology base.[25] One of these is the Suzhou Branch of their Eastern Centre which aims to build a regional technological transfer platform gathering technological trading service, technological financing innovation, technological transfer, intellectual property service and big data of technological transfer.[26] The Indian Government has notified a scheme for Technology Acquisition and Development as per the National Manufacturing Policy 2011, but nothing in particular for the DIB. Such a centre would catalyse horizontal technology transfers from foreign sources and enable mentoring, monitoring and guidance of Indian firms.

The civil process, admittedly, has a few differences from the defence ToT acquisition and implementation process. The major one is the relative freedom that transferee firms have in searching, identifying, comparing, selecting and contracting the civil technology most suitable to its (or the market's) needs. This is not the case with Indian defence firms which are invariably thrust with technology which has been selected by the government. For category 2 and 3 items, however, Indian firms would need to execute such selection and implementation if the process and product technologies required are not available in the country. Here, significant lessons can be drawn from the civil process. The most significant of these is the life-cycle approach which involves planning, implementing, monitoring and guiding the complete process, right from conception to consolidation. A brief description of the problems which afflict transferee firms and how this approach helps overcome them is provided in Annexure II. Though it is focussed on ToT to SMEs, most of its elements are equally applicable to larger companies and agencies.

The need for an organisation which would oversee all ToT activities, from acquisition to implementation, has been projected by senior officials for quite some time. One such projection states that the "complete gamut of technology and its transfer should be administered by a duly constituted Defence Technology Oversight Committee (DTOC). DTOC should identify level and scope of technology needed to be imported, identify suitable recipients and oversee smooth transfer and absorption on ground."[27] The name however, depicts an organisation to check errors whereas the need, as described above, is for an organisation which takes ownership of the ToT process. A Defence Technology Transfer and Absorption Centre (DTTAC) hence is more suited for this task.

If the creation of such a centre were to be delegated to one of the existing agencies in the DIB, it would be the DGQA that is most suited. Besides having qualified and experienced technical personnel, it has many decades of accumulated knowledge in the overseeing of ToT manufacture projects. All that needs to be done is to involve DGQA personnel through the complete life-cycle of every ToT project, right from the RFI and RFP stages through the TEC and CNC and the subsequent implementation stages that they already oversee. Increasing their span of responsibility to cover the whole life-cycle would automatically allow it to take ownership of the ToT and ensure its success. However, it would be necessary for the DGQA to upgrade their knowledge and even creativity to transcend from an inspection and quality assurance role to pro-actively solving problems of indigenous equivalents in machines, components and raw materials which do not match those of the foreign OEM. Such pro-active innovative activity may come up against some failures initially, but would pay rich dividends in the long run.

A significant contribution that the DTTAC could make is the assistance in the consolidation and commercialisation of transferred and absorbed technology. In the production of category 2 and 3 items, which need time to mature, it is very possible that the technology absorbed along with the technology developed can be further utilised for other defence systems being produced in the country. Facilitating of these additional avenues for sales by the transferee firm can provide it additional revenue and therefore the opportunity for greater investment. This additional investment can help in consolidation, which would mean perfecting their manufacture to high standards of quality at competitive prices. This additional investment can further lead to commercialisation, which would mean the use and improvement of the process and product-design for sales to domestic and global markets. That such improvement is possible is borne out by the case of US licensed production of the UK's Hawk and Harrier jets—the Goshawk and AV-8B aircraft, respectively which led to substantially improved versions of the original British aircraft.[28] This result is however, in contradiction to the findings discussed in the chapter on nuances where it was assessed that improvements were neither permitted nor technically possible. The reasons for this particular one-off success, therefore, could be exceptional conditions—one, that the recipient agency, in this case, was technologically at par or even superior, to the transferor and two, that such improvement was permitted in the ToT agreement. Though Indian firms may not be in a similar position for the entire range of ToT products, it is possible that they would be for some of the less technologically advanced ones and therefore, negotiating for a suitable win-win agreement with the permission to attempt such improvement could be strived for.

The need for ToT and Absorption Guidelines

The DPP and DPrP 2011 stress the need for comprehensive ToT and ensuring of the absorption of the technology by Indian agencies. However, since we now know that full ToT is neither feasible nor economical, there is a need to guide Indian agencies on how the optimal quantum is to be worked out. Also, recipient Indian agencies would need to know what is expected from them in the absorption of technology and how its level will be assessed.

One significant contribution that the DTTAC could make is the drawing up of guidelines on ToT for the acquisition agencies and on absorption of technology for the implementing ones. Currently, there is a shocking lack of such literature dedicated to ToT in all the agencies involved right from the SHQs, the Acquisition Wing, DDP and the DGQA. This is, despite DPP and DPrP 2011 placing a considerable emphasis in this area. The DRDO has issued guidelines for ToT, but these guidelines concern the ToT from DRDO agencies to Indian production agencies.[29] Not much insight pertaining to ToT from foreign agencies can be gleaned from this document, except perhaps the existence of a few modes and the need for confidentiality and non-disclosure agreements to enable the transferee to study the technology desired for transfer.

Acquiring Cross-cutting Technologies Separately for Mass-manufacture

Cross-cutting technologies can be defined as the product and process technologies which are used across a range of defence systems.[30] For example, among product technologies, we have thermal imaging technologies which are used in manpack, observation post, armoured vehicles, helicopters and aircraft systems. Such technologies can also exist at the varying levels of system architecture that is, sub-systems, modules, components or materials. Most process technologies are used across a wide variety of systems and therefore also fall in this category. Some examples are provided in Table 6.4.

Table 6.4: Some Cross-cutting Technologies

Product technologies	Subsystems	Thermal imagers; multi-purpose radars which can be used for surveillance, target designation, target identification and missile guidance in air as well as on surface; Information and Communication Technology which connect different sensors and weapons systems in real time; signal processors which can be used in communication and radar domains, compact military grade power generators
	Modules	Military grade DC-DC power converters, batteries, handsets, night vision scopes, memory banks and processor boards
	Components	Military grade processor chips, memory chips, RF cables, electric cables, connectors, lithium cells
	Materials	Military grade alloys, composites, glass, rubber, camouflage paints etc
Process technologies		Laser drilling, wave soldering, ultrasound and X ray testing, advanced welding and forging techniques, electronic chip manufacturing etc

Source: Prepared by the Author.

ToT projects facilitated by the DPP are expected to cover the maximum scope, range and depth and, therefore, would include the technology of numerous cross-cutting technologies. But, orders through the DPP are always limited to the needs of the Indian military and their numbers, and therefore, would not permit the benefits of manufacturing at high scales of economy. If a central agency were to carefully analyse the cross-cutting technologies needed across all proposed ToT projects in a window of say, five years ahead, it would come up with aggregate quantities of subsystems, modules, components and materials which could be ToT manufactured centrally at lower prices and better quality. The standardisation of parts which would result from this approach would also bring in the benefits of cheaper and more effective maintenance, with lower spares inventory. A similar benefit could be accrued through selecting and acquiring process technologies for shared use by multiple agencies in the country.[31]

Some of the parts whose cross-cutting technologies are successfully absorbed and whose prices and quality are comparable with global standards could then be considered for global sales, thus bringing in revenue and helping neutralise the additional cost that ToT involves. It is important to note that the cheapest foreign technologies available may not necessarily be the best choice for such mass-manufacture. Technologies which have a high potential for growth, could be manufactured at a comparative advantage in India due to the ready availability of certain raw materials, machines and skills, and finally, have a significant global demand, may be better choices, though more expensive. Identifying such ToT projects and making them work successfully from a business angle would need competent persons and agencies at a national level. The current organisations in MoD, DRDO or DGQA are not suited since none of these have applied themselves to executing projects with the aim of global sales and profitability. The new DAA and DTTAC would have to involve business managers from competent and experienced private firms, in addition to production and quality engineers for achieving such success.

Helping Indian Subcontractors match Foreign Standards

The DPP and its chapter on SPs stresses on increasing value addition in ToT manufactured systems leading to higher levels of IC. However, when technological levels of the foreign OEMs and Indian recipient firms differ considerably, Indian firms would find it extremely difficult to absorb the technology sufficiently, so as to ultimately produce the product to quality standards and prices comparable with that of the foreign OEM. While contractual commitments may drive

Indian managers and workers to deliver, many are likely to give up especially with category 2 and 3 items where their lower indigenous capabilities are unable to develop a process or a product in the time frame and budget available. Greater levels of investment by the Indian firm for employing a more competent workforce and modern machinery may therefore be necessary, but this may raise the prices of the product far above that of the foreign OEM's subcontractor who is mass producing the same for the global market. How high an investment is acceptable, then becomes a critical decision.

One method is to look for the return on investment (RoI) expected from the absorbed or developed technology. If the product is required in large numbers or has applications in numerous other systems, or most importantly, holds the potential to be developed further into futuristic products of significant demand, the returns could justify the investment. Such an assessment would however, require a deep understanding of—one, the potential of the technology for future development and two, the complete spectrum of systems in which it can be used. This clearly cannot be executed by the Indian firm alone and a national agency would need to step in. The former could be taken on by the DRDO and the latter by the DGQA, but both would need to build additional competence in these fields to effectively execute them. Here again, the DTTAC is ideally suited for both tasks. A third input that is relevant is the in-service life of the product. ToT-manufacture of 'fast moving' parts which have short lives and will be required frequently during the service life of the system will clearly generate higher RoI though this may be spread over an extended period. These three inputs could be considered sufficient for arriving at the level of additional investment that is acceptable.

Treating Transferred Technology as a Financial Asset

Technology once transferred in the form of technical literature, machinery and skills needs to be maintained and kept alive so that its benefits are utilised right till the end of its life. There are instances in the past where such technology was transferred gradually to sub-vendors, but dried up when orders for the defence systems were halted. A few years later when a new version of the system was contracted for, it was wrongly assumed that the technology was available thus greatly hindering production.[32] One solution to this is that all received technology, including skills, be held as assets in account books and be periodically monitored for availability till such time it is declared obsolete. The DTTAC could handle this function easily.

Private Firms versus Government-run OFs and DPSUs

The objective of the SP chapter of the DPP 2016 to bring in private firms into areas which were the preserve of government-run OFs and DPSUs, appears worthy from the ToT angle because there are a few clear instances of private firms being more successful in technology absorption. The successful *Arihant* submarine project which involved transfer of Russian technology (through consultancy) to the Indian private firms L&T, Tata Power and Walchandnagar is one such example. There are more such instances of success that some Indian private firms have had in the ToT manufacture of ammunition and soldier protection gear. But, private firms also bring along complications, such as the ownership of IPR and the greater danger of proliferation in an insufficiently effective legal and enforcement environment. Foreign firms may be hesitant to step into such an environment unless strong safeguards are put in place.

The tendency to blindly enrol some new private firms just because they have financial clout and political connections may backfire as well. As mentioned in the earlier chapter, technically knowledgeable and skilled manpower, quality systems in place and a record of dependability and compliance are also vital ingredients. These attributes are developed over years of experience, self-analysis and refinement and it is foolhardy to assume otherwise. Many competent and established foreign firms have initiated JVs with such Indian firms, possibly assuming that they would garner contracts through their political connections and circumvent the system through ghost manufacturing (we shall discuss this ahead). But, whether these JVs will quickly develop into solid islands of modern, vibrant and progressive technology, capable of delivering systems of global standards and at a competitive price is very doubtful. It would be more fruitful to consider privatising an OF or DPSU or even a branch of them, thereby utilising the inherent knowledge, experience and security consciousness that they would bring.

Leveraging Dual-use Technology

The use of cutting-edge commercial technologies in defence systems is increasing every year. From drones to artificial intelligence to machine learning and even block-chain technology, there is no denying that there are massive spin-ons from these areas into defence solutions. The quantum of spin-ons will continue to rise seeing the massive global investment being made in these technologies as against the worldwide dwindling of defence expenditure. Hence, a pragmatic ToT policy must include an approach to tap into these. Global in-housing of commercial R&D in India has been increasing significantly and it may be worthwhile exploring ways to allow some of the technology developed to be transferred to Indian defence agencies. India's new major defence partner (MDP) status with the US and a new tie up with the Defence Innovation Unit in Silicon Valley, California must also be utilised to induct useful dual-use technologies.

Which Family of Technology?

In the chapter on nuances, we discussed the lives and potential of different technologies. These two factors can have a profound influence on the health of the Indian DIB. Developing or importing technologies which have short lives and little potential for further development would clearly be a wasteful investment of money and effort. In addition to this, we find that similar systems developed in different parts of the world use different technologies which, in turn have differing strengths and ease of absorption. India has broadly three traditionally strong defence technology families to choose from—Russian, European and US. In a very simplistic way, while Russian technologies are strong in metallurgy for hulls, frames and chassis, European ones have superior electronics and power plants and the US are leaders in digital computing, dual-use technologies and information systems. Of late, we have Israeli and South Korean technology which are strongly US influenced, but cheaper. And very recently, there are Japanese technologies, which are specialised in a few areas.

While importing systems and technology from a spread of countries appears to be a good method to achieve strategic independence and acquire at competitive rates, from the ToT benefits angle, it may not be such a good idea. Absorbing multi-origin competing technologies which deliver similar systems would dissipate our focus and effort resulting in overall shallow absorption. Instead, picking a technology which has a high potential for advancement and focusing on it for future needs will enable deeper absorption and higher exploitation. This would ultimately lead to manufacturing of ToT products at scales of economy and possibly at globally competitive quality and prices.

One might also claim that different origin technologies could be combined ingeniously for building systems with enhanced and more versatile capabilities, as indeed has been reported for the Chinese Dong Feng missile system.[33] But, the chances of such a success are somewhat bleak. Yes, old Russian tanks, aircraft and ships have been upgraded with technologies of other origins, but that has been made possible due to the shrinking size of electronics and some mechanical subsystems. In general, efforts at combining current technologies of different origins would be hampered by compatibility issues due to differences in standards used such as those for digital communication protocols, power supplies, torque ranges and ruggedness. This has been acutely felt in DRDO designed systems which incorporate multi-origin subsystems and invariably leads to compromises in weight, size, weather resistance and of course, cost.[34]

The advanced countries have also built different reputations for successful ToT. In the conventional submarine category, for example, India has had a good record with Germany and reduced levels with France and Russia. Similarly, the advanced countries have established different industrial footprints in India such as Germany having a comparatively larger one in some areas.[35] From the ease of absorption angle, Indian agencies have reported that Russian technology holds the disadvantages of requiring tedious translations of instructions, unfamiliar technological concepts which differ from international standards and therefore hold a proneness to misinterpretation. In comparison, European technology which follows NATO/international standards and are well-documented in English, are much easier to assimilate. Israeli technological literature is reported to have been sketchy and requiring extended scrutiny and revision.[36] Experience with US technology has been limited, but is expected to hold the advantages that European technology has.

In terms of research and development of futuristic technologies including dual-use ones, the US is clearly way ahead and is likely to stay there for a considerable period of time. Material, components, modules and subassemblies used by the US systems are also more widely available across the world as compared to the Russian ones. For long-term projects such as the SP ones therefore, barring a few exceptions, it makes eminent sense to veer towards US technology either directly or through US allies such as Israel, South Korea or those in Europe.

Setting up G2G ToT Foundation Agreements

In the section on possible solutions for the complexities in the SP chapter, we came up with the need for strongly negotiating with foreign governments for a spectrum of technologies which would be required in the future. Here, it is relevant to draw from an observation made by the UNCTAD document on ToT, on the weaker bargaining position of technology recipients 'which is exacerbated by the relative lack of information about technology, caused by the absence of adequate numbers of skilled specialists who could evaluate the technology on offer.'[37] As was discussed earlier, the current system involves personnel of the final recipient agencies for negotiations. Since contracts with an Indian agency come up infrequently over five or ten years and each system has its own team, it is highly unlikely that any of the personnel of these agencies will develop deep insight, skills or knowledge to help steer a negotiation beneficially. The DTTAC could step in here, with personnel who are repeatedly involved and exposed to such negotiations in their respective fields of technology and thus gain the precious knowledge and experience required.

Successfully concluding such agreements which permit ToT is not a single or simple step. Governments gradually build a relationship of security and trust through sequentially agreeing on ensuring security of information, mutual sharing of resources, protection of IPR, confidentiality and non-disclosure, transfers of minor technologies and finally major ones, all the while, encouraged by the positive response of the other party. These too, would be subject to their legislated regulations such as the US's ITAR.

Occasionally, foreign governments legislate special relationships, such as India's MDP status with the US, which allow concessions and benefits to countries with which they have developed a deeper strategic relationship. India's close relationship with the erstwhile USSR, which led to substantial ToT, is a case in point. Similarly, Israel and South Korea benefitted greatly from their allied status with the US in acquiring cutting-edge technology. Building such strategic relationships with developed countries steadily is, therefore, of great importance if their technology is to be acquired.

Leveraging Defence Offsets

Whether India's defence offset policy has enabled effective transfer of valuable technology is not yet established. Some views have stated that no worthwhile technology has been received while others mention that very low levels of it have. While persons of Indian agencies attribute this to foreign OEM's holding back on valuable transfers, persons representing the foreign OEMs have pointed out low levels of local technological expertise, uncertainty in local capabilities, a complex offset and ToT policy and low offset multiplier credits as the reasons. There is clearly a need to analyse the Indian system critically to generate remedial steps.

In other parts of the world, though, defence offsets have enabled countries to acquire manufacturing and even R&D technologies. However, these come with a cost premium which vary from country to country but can generally be pegged at around 7 to 10 per cent.[38] The premium is attributed to the additional costs incurred by the foreign vendor on searching for local suppliers (or manufacturers), risk reduction measures (such as multiple sourcing) and logistics besides the numerous costs related to ToT as described in the chapter on nuances. Direct contracts for ToT may avoid the offset induced premium components but these would still have to be borne to some measure by the recipient government or firm which would need to take on these searching and risk-reduction tasks.

The success of ToT contracts, whether through offsets or direct means, depends on the trust between the two parties and convergence of their goals for mutual benefit.[39] Here, using the offset route can either be beneficial through the allowing, as in India's case, the space for foreign OEMs to identify and choose the optimal arrangement with trustworthy and goal-matching local agencies, or detrimental, if the offset policy and its execution are not well constructed and effective, respectively. Let's have a look at some of these issues.

A notable problem with offset programmes is their tendency to attract short-term ToT-enabled manufacturing programmes which leave inadequately utilised investments in infrastructure, training and tooling on their completion.[40] This waste of investment can be overcome through long-term planning to include post-offset operations, largely by the local ToT-recipient agencies, assisted by a national agency such as DTTAC and guided by the foreign OEM.

Another problem with offsets is its purported susceptibility to corruption. Though no clear proof that corruption is endemic to the offsets system has come forth, it is accepted that the risks do exist especially in the more prescriptive offset model that India pursues.[41] Such risk is particularly high in developing countries with low levels of industrial capacity, which makes it 'near-impossible to fulfil direct offset commitments, creating the temptation for obligors to bribe recipient company management and forge evidence of compliance'.[42] Such temptation to forge evidence of compliance equally applies to the recipient firm. Consider this. Foreign OEM A is required to transfer technology to Indian agency B to enable the manufacture of category 1, 2 and 3 items. However, the quality-manufacture of category 2 and 3 items at comparable prices with that of A's original sub-contractor depends a lot on the technological absorptive capability of B and his local sub-contractors. When ambitious timelines and prices are set by under-informed government authorities and higher management, many of B's sub-contractors might initially try but give up falling back on the foreign OEM's supplied parts, which are then carefully disguised as being locally manufactured. Software components are extremely easy to disguise while hardware parts can be pushed past corruptible government or third party inspection agencies. This phenomena which we can term 'ghost manufacturing', however, can and does exist irrespective of whether ToT is executed through offsets or direct means. We will look at how it can be tackled in the next section.

Despite its cost premium and challenges in implementation, offsets as a facilitator of ToT, could still be beneficial (as compared to direct ToT contracts) since they provide Indian firms an opportunity for export through access to the foreign OEM's global value chains. However, this benefit can only be obtained if Indian firms are successful in absorbing the technology, closing the technology gap and delivering globally competitive products in performance, quality and price. Not all Indian firms can achieve this and definitely not with all products. These firms and products would need to be singled out and provided government and industry support to reach there.

Improving the Indian offsets policy and implementation for more effective ToT would require continuous monitoring and remedial action by a dedicated team of knowledgeable economists, defence technology engineers and administrators. The current arrangements of using inexperienced military officers in the DDP and under-informed DDP personnel in the Defence Offsets Management Wing, guided by a lone research scholar will need to be hugely upgraded.[43] Yet another task for the DTTAC.

One immediate improvement needed is in the DPP's offset credit of only 10 per cent on the Indian value addition in goods which are manufactured through ToT and bought back by the OEM.[44] This has been reported by a representative of a foreign OEM as being too low for any worthwhile investment. This clearly needs to be increased significantly after consultation with Indian firms and foreign OEMs. Perhaps, greater credits could also be provided for higher levels of technology, though these may require to be quantified.

The lack of noteworthy ToT has prompted some to advocate the 'directed' offsets arrangement which forces the foreign OEM to deliver specific technologies which are notified in the RFP. Another suggestion being put forward is that the technology being offered should be disclosed by the foreign OEM and evaluated for worthiness before taking the final selection step of evaluating the commercial bids. Both of these appear to have merit, but they would increase the complexities in an already complex acquisition process. In both cases, it is important to ensure that these technologies are economically viable, technologically promising and within reach of Indian agencies. Ensuring this would require immense understanding of the capabilities of the Indian defence industry and the technology being targeted, and is best taken on by a specialised, technologically aware agency such as the DTTAC.

Another improvement needed is in the route which enables technology acquisition by DRDO. The multipliers of 2, 2.5 and 3 are grossly low, considering that the know-whys are expected to be transferred. Foreign OEMs have stated that the multipliers should be in the range of 30 instead of 3. Calibrating this figure for the optimal value needs to be done after a deep understanding of the deliverables expected and what foreign OEMs will expect in return.

An interesting arrangement for ToT through offsets has been implemented by Turkey. The value of technology being delivered by a foreign OEM is not verified by the Turkish Government. However, offset credits for this amount are given only when the value of exported products exceeds that of the technology.[45] This appears to be an excellent idea, and will invite positive responses by foreign OEMs if they are confident that Indian firms can absorb and deliver globally competitive products in quality and price. Such confidence will come through demonstration of these capabilities in a few areas as is being done by some Indian firms which are manufacturing products for OEMs such as Boeing and Lockheed Martin.[46]

Overcoming Ghost Manufacturing

Stringent checks on hardware imports and inspections during local assembly can ensure that cheaper, more reliable foreign OEM parts do not surreptitiously take the place of the desired ToT-enabled locally manufactured ones. However, this means excessive monitoring and controls by a third agency which, too, is not entirely infallible. Another method, which has been tried recently, is the using of a three-party model instead of the usual two-party one. In the latter, the foreign OEM and ToT-recipient firm execute an agreement for the delivery of all hardware and technology to enable the recipient firm to locally manufacture the desired indigenous content and assemble the system. This model allowed OEM parts and even partly integrated assemblies to reach the recipient's firm unchecked, giving way to suspicions that the recipient firm was doing less (and therefore absorbing less technology) than they were supposed to. In the three-party model, the customer, which is the acquisition agency of one of the defence Services, receives the hardware initially, while the technical literature, training and consultancy is provided directly to the ToT-recipient firm. This has been tried out recently, with the FF systems being issued by the customer agency directly to military units while the remaining hardware, which comprised of the SKD or CKD or the IM kits, was then handed over by the customer agency to the recipient firm after a physical check.[47] The recipient firm was thus, left with no option but to absorb the technology needed to manufacture the category 1, 2 and 3 items and deliver the integrated and assembled systems. Inability to do so in a few parts, would inevitably have to be reported to the customer agency for enabling alternate arrangements to be made with the foreign OEM.

Expectedly, many representations were made by the ToT-recipient firm, and some of them were justified. One was that the FF systems should have been handed over to the firm initially for familiarising the workforce before being issued to the military units. Another was that these systems were provided maintenance support by the OEM without involving the product support team of the firm, thus denying them live data and maintenance experience. Some representations stated 'serious' deficiencies in the technology received, which were partly genuine, needing additional software suites and special tools which were not available in the country. Timelines for indigenous development of some category 2 and 3 items were expectedly overrun, while for some, the firm openly stated they were not in a position to achieve. The reasons cited, again were genuine, such as the lack of access to certain high technology machines and lack of expertise in the country. Overall, as a project, it may have run into very rough weather, but for the acquisition system, it has brought to the fore, the challenges that Indian firms face. No doubt, this experience will help in drawing up better ToT arrangements in future which factor in the limitations of the absorptive capabilities of the defence industry.

Though the three-party model is a significant improvement over the two-party one, it still requires a considerable amount of control and supervision. These can slow down processes and are again prone to dilution by self-serving elements. A faster, more effective model, which self-aligns itself to achieve technological excellence, is free collaboration between the foreign OEM and the Indian firm for common goals of profitability and global market presence. Such a model would spontaneously identify and build on the strengths of both partners with an optimal arrangement evolving over time. This is more in tune with the liberal industrial participation model of offsets which the UK followed with considerable success in obtaining manufacturing and R&D technologies.[48] However, such a model requires the recipient country to possess much higher levels of technological absorptive capabilities which match the technological levels of foreign transferors. India is currently not in this league, but is there a way to reach there quickly?

Raising Technological Absorptive Capabilities

The conundrum on how high a level of technology should be targeted in ToT projects, which we discussed in the section on complexities in the Implementing ToT chapter, actually has a simple, though not easily achievable, solution. The existing technological levels of the Indian defence industry as well as its potential for absorbing higher technologies could be raised for absorbing higher technologies so as to narrow the gap with the level required for acquiring the edge over India's potential adversaries. While the former requires large investments and considerable technological upgrade effort, is it possible to quickly and thriftily raise the latter, that is, the potential for absorbing higher technologies, to appreciably higher levels?

Technological absorptive capabilities depend on the prevalent technological awareness, knowledge, expertise and skills in the country. High levels of these cannot be built without adequate access to matching infrastructure, machinery and processes. In addition to these is the requirement of innovation, because foreign technology invariably requires modification to cater to local environment, raw materials and existing infrastructure. Innovation requires strong fundamental technological concepts combined with analytical and creative ability.

Part of the technological knowledge and innovation required by the industrial base of the country can be obtained through the tapping of existing R&D agencies. A good example is the case of

Brazil's private firm Embraer effectively using scientists of Brazil's state-run Institute for Research and Development in the 1990s to build up its capability of absorbing foreign technology.[49] India can attempt to do the same by using the scientists of the Department of Science and Technology (DST) and more significantly the DRDO. These scientists could also help in the indigenous development and production of category 2 and 3 items which can be, in many instances, too challenging for the local Indian industry.

But here again, we have the conflict of interest. Foreign ToT manufactured systems, besides being officially outside their mandate, are potential competitors to DRDO's indigenous ones. The single engine fighter ToT project, for example, which was proposed in 2016 with Saab's Gripen and Lockheed Martin's F-16 competing, was a potential threat to the Indian HAL's Light Combat Aircraft developed by the DRDO. Expecting DRDO to deliver high technology knowledge to help these succeed may be asking for too much. The way ahead could therefore be to select those areas for prospective ToT where DRDO has acquired considerable R&D knowledge but cannot deliver a system due to the lack of Indian industrial capability or capacity. These areas could be twin-engine fighter aircraft, UAVs, medium lift helicopters, attack helicopters, self-propelled artillery, fifth generation anti-tank missiles, submarines and missile boats. Other areas which are hindered by poor manufacturing quality such as ammunition and explosives, small-arms, protective gear and clothing etc can also benefit from DRDO's knowledge.

R&D knowledge which focuses primarily on product technologies may not, however, be enough to deliver absorptive capabilities in manufacturing. As we discussed in the chapter on exploring all avenues, acquiring of advanced manufacturing technologies is necessary for achieving technological superiority. Unfortunately, the Indian DIB does not appear to have a specialised agency with any significant knowledge in this field. Though the Society of Defence Technologists (SODET), comprising of serving and retired personnel of the OFs and DPSUs have played a role in optimising manufacturing techniques, they are nowhere in the league of, for example, UK's Advanced Manufacturing Research Centre (AMRC). The AMRC is a financially independent agency which accepts foreign investment and focuses on identifying, researching and resolving advanced manufacturing problems.[50] It also has a strong link to the University of Sheffield's department of engineering, thus benefitting from the department's accumulated academic expertise which, it is presumed, is in the basic or applied research domains. That India can greatly benefit from a similar resource is obvious, but how is it to be created and developed to such advanced levels?

Mass-manufacturing technologies has been India's weak area from the beginning. While countries such as Taiwan, South Korea and China have been able to acquire and successfully establish global-standard electronic chip fabrication plants, India has not been able to cross this threshold despite a serious attempt a decade ago. The investment required is massive—to the tune of US$ 15 billion, something that the government is now considering.[51] The lack of such component manufacturing plants also means that technology which can be absorbed in that area as well as the IC achievable is greatly limited.

Though the DRDO has been able to develop systems with performance apparently comparable to some global standards, the systems produced have been plagued with poor reliability. While weak product design could be one contributory factor, weak manufacturing technologies and processes is probably a larger one. The reasons for the latter are numerous, ranging from low investment capabilities to lack of domestic competition. There appears only one way to develop world class standards here. And that is through foreign ToT.

Making ToT Cost-effective

Though India is one of the largest importers of defence systems in the world, its defence budget has not been rising in terms of percentage of GDP over the past few years. This could be due to the pressures of tackling the still significant levels of poverty, illiteracy and poor nutritional and health coverage. Additional expenses on ToT (as compared to outright purchase of systems) therefore need to be critically analysed for commensurate national benefits.

In the chapter on nuances we had discussed the numerous reasons for ToT manufactured products being costlier than those purchased outright from the foreign OEM. A majority of the causes are lessened in intensity by simply raising the volumes of ToT enabled production and extending it over a longer period of time. Hence, high-population, longer-life systems such as fighter aircraft, large UAVs, light helicopters, battle tanks, artillery guns, portable battle-field surveillance radars, small arms and anti-tank missiles systems appear attractive areas for the utilisation of ToT.

Increasing production output through global sales of products, which otherwise face low domestic demand is another route. For this however, Indian firms will need to achieve global standards in performance and prices. Breaking into a highly competitive global market is fraught with risks though, and is best attempted with the assistance of globally established firms.

Another method to bring down costs is to acquire process technologies that have civil applications, especially those that are likely to be significantly used within the country. This would need a decent understanding of the civil industry and its future. The industry associations of CII, FICCI and ASOCHAM along with other technical organisations such as the Institute of Engineers can be of immense help here. These would be needed to feed their input into a central defence agency such as the DTIC. Such networking would also be required to bring in an understanding of the dual-use technologies which could be acquired and utilised.

The use of common cross-cutting technologies among ToT manufactured systems, also, would lead to efficient utilisation of acquired process technologies by sharing them across several manufacturing agencies. As we discussed in the families of technologies, this means that opting for one, or at the most two, families would enable the Indian DIB to capitalise on them. Opting for US and west European technology which have large areas in common, therefore, makes eminent sense. Israeli and South Korean technologies which are influenced largely by the US, could prove to be beneficial as well, especially if they are less expensive and not controlled through such stringent regulations as the US's ITAR.

The competitive bidding model for acquiring suitable technology at the cheapest price is commonly followed across the world and would be beneficial for India, but for the fact that it could lead to the induction of a variety of technologies which do not have much in common. Imagine simultaneously holding the technologies of Russian light helicopters, French fighters, Japanese sea-planes, US multi-role combat aircraft and US combat helicopters. It would be an insurmountable task to economically absorb all their technologies. However, if, in addition to the price of the end-product and its life-cycle costs of operation and maintenance, we factor in the life-cycle costs of operating and maintaining the necessary process technologies, as well as their residual lives and their potential for growth, we may be able to shorten the list. But residual lives of process technologies and their potential for growth are extremely challenging to define and quantify. Could we, for instance, study and predict how long the Russian surface to air S-400 Triumf missile system will lead in its genre or how long its producing process technologies will stay relevant?

Even though such prediction is difficult, it should not be shrugged away. Effort and application in these areas may not provide clear timelines, but they will reduce the risk of acquiring short-life, no-growth technologies considerably. For this, we again need a competent and focused, technical organisation. Yet another task for the DTIC.

Matching Work-cultures for Maximum Transfer and Benefits

In the thrust to obtain maximum technology and absorb it, very little attention is paid to the challenges faced by differing languages and even less, differing work-cultures, among the transferor and transferee firms. In the JVs, which are a major vehicle of ToT, however, the high rate of 60 per cent breaking up within the first five years is largely attributed to these differences, also called the 'human' factor.[52] For the JVs with firms of developing countries, such as India, the JV failure rate is even higher, owing to a larger human factor, which includes in addition to the above, the lack of local legal knowledge, divergence on agreed-upon objectives, differing deadline perceptions, etc.[53]

Taking the levels of difficulty experienced in overcoming differences of language first, we find that Russian and French ToT are likely to be the most challenging, requiring interpreters, while German, Swedish and Israeli are somewhat less, due to their greater use of English. Though English translations of technical literature are available or contracted, these use sentence constructs that are somewhat alien and unfamiliar to the Indian workforce. US, UK, Australian or Canadian ToT are much easier on this front, though both parties may have difficulty in adjusting to the other's accent. All of them, therefore, can benefit to varying degrees through use of intermediaries who are familiar with the languages of both parties.

Work-culture in the OFs and DPSUs are openly acknowledged to be far from satisfactory and this was one of the reasons for bringing in the private industry. Some of these private industries which are well-established, such as Larsen & Toubro, are much better off, but these are few and far between. How then are ToT projects, which require deep understanding, trust and partnership between the foreign transferor and Indian transferee firms to be successful? Bringing a change in work-culture to meet those of the foreign transferors, even halfway, requires very strong leaders who are convinced of the need and are capable of strongly influencing their workforce. Do Indian firms possess such leadership, and adequate quantities of it?

Russian work-culture can be said to be highly authoritarian, with rigid rules and an emphasis on accountability, standardisation and meticulousness. West-European and American work-cultures are less authoritarian with a greater emphasis on consulting, teamwork, learning, creativity and also meticulousness. This comparison indicates the greater likelihood of knowledge (and therefore technology) transfer from the latter. Indian work-culture differs from both by promoting individual excellence as against teamwork, being boss-centric, discouraging questioning (and therefore learning), avoiding challenges (due to inadequate knowledge), and finally the culture of *Jugaad* which is the use of quicker, cheaper, easier methods at the cost of quality and long-term benefits.

How are these different work-cultures to be coupled for maximum technology transfer? Expecting leaders to bring in work-culture changes within a few months of signing a contract may be too demanding. Is there a case for intermediaries? Intermediaries who have specialised in reducing these differences through presentations, group discussions, mock activities and counselling? Such workshops for strengthening work-culture have been held in the private sector for commercial products. But, for defence firms where, security and accountability for information and assets is imperative, there is a need for specialised intermediary firms. These firms will need to employ personnel who are familiar with western work-culture, defence systems, technology and high security standards. Recently retired Indian military officers of the weapons maintenance departments, with a grooming in their organisations which are still imbibed with western work-cultures can fulfil these requirements exceedingly well.

Building Trust

Intermediaries can help bring work-cultures together, but they cannot set up foundations on which trust between partner firms can be nurtured and built. These foundations comprise of well-designed national regulations on the protection of foreign IPR, ToT directives and offset policy.[54] These would then need to be implemented in a smooth and effective manner, which professional organisations such as the DAA and DTTAC could facilitate.

A measure that will assist the building of trust in Indian defence agencies, along with other commercial benefits, is India's membership of the Wassenaar Arrangement (WA), approved in December 2017.[55] From the ToT angle, acquiring membership, by itself, does not lift any restrictions for receiving technology.[56] Also, being a member does not guarantee the supply of WA controlled items or technology. In both cases, the decision lies with the government of the supplier country. However, being a member increases trust in India as a responsible partner in ensuring international peace and therefore, increases the possibility of receiving controlled items from supplier countries, which are in most cases, WA members.[57] Further, in cases of ToT, WA member suppliers are obligated to ensure re-exports to a third country are permitted only on their express authorisation and re-export or transfer is made in accordance with WA guidelines.[58] In such a situation, supplier countries are likely to be more amenable to providing authorisation to a trustworthy country which is a WA member. India's chances of re-exporting thus improve and in the case of defence systems, where the scales of economy are difficult to achieve through domestic demand, such freedom can be a crucial deciding factor for achieving economically successful production. Membership of the Missile Technology Control Regime (MTCR) and the Australia Group, which India has recently acquired, bring similar benefits in their respective fields.

Trusting that the buyer country will not "steal" their technology is one aspect. The other is the trust that the buyer country will protect their IP from leaking out to the environment and there on to competitors.[59] For this trust to be achieved, Indian firms will need to have strong, world class level protection in their information systems to prevent cyber espionage or hacking from external agencies. Internally too, Indian firms will need to install strict IP control with their employees. The Indian Defence Security Manual of 2013 is a good start in this direction, though it focuses mainly on the security of Indian defence assets, information and IP within the private sector.[60] The manual can be updated to include measures to protect foreign IP as well. Foreign OEMs will need to be consulted on this issue and steps accordingly taken to bring the manual up to their acceptable levels. Implementation will then need to be enforced and internalised to generate adequate levels of foreign OEM confidence and trust.

There has recently been a significant improvement in India's ranking from 44 out of 50 countries, to 36 in the global IP index.[61] But clearly, a lot more needs to be done. Instead of waiting for the national environment to improve further, it may be worthwhile for the MoD to issue a code of conduct for Indian defence firms to follow, for the protection of foreign IP. Though this may not hold legal sanctity, it will help instil a higher level of conscientiousness which will eventually lead to higher trust levels. To ensure the compliance of Indian ToT recipient firms to legal agreements, it may be prudent to appoint dedicated ombudsmen and even special courts to deal with these cases in the defence ToT arena, fairly and expeditiously.

Increasing FDI in ToT

A persistent issue troubling the Indian defence sector is the extremely low quantum of FDI in comparison to other sectors. The FDI attracted from April 2014 to December 2017 was a paltry Rs 1.17 crore as against India's capital procurement contracts of Rs 1.25 lakh crore in the same timeframe.[62] While 41 FDI proposals/joint ventures have been approved for manufacturing defence equipment both in public and private sectors, the total FDI in the defence sector from 2000 to 2018 is a meagre Rs 35 crore.[63] The Indian Government has been conscious of this and has relaxed the limits successively over the past decade from allowing 26 per cent initially, to 49 per cent through the automatic route. In the non-automatic route, the government has relaxed the limits from 49 per cent to 74 per cent, provided the technology offered is state-of-the-art. This too has been relaxed by replacement of the term 'state-of-the-art' with 'modern' and 'niche', though what these new terms stand for has not been defined. Despite these, however, no major JVs or partnerships have been announced with FDI over 50 per cent. The government is now contemplating allowing of up to 74 per cent FDI under the automatic route in niche technology areas as reflected in the draft DPrP 2018.[64]

What could be the reasons for this, almost negligible, FDI? One is that, though a plethora of ToT tie-ups with foreign OEMs have been proposed and planned over the past many years, very few have actually fructified through purchase orders by the MoD. No information on what has caused the large majority of ToT proposals to flounder is available, but possible reasons could be the complex procedures and ambitious goals which we discussed in the chapter on implementing ToT. An agreement for ToT of the Israeli Spike anti-tank missiles for which elaborate trials and evaluation have been conducted over many years, has recently been shelved, with the Israeli firm expressing reservations on the clause asking for full transfer of technology.[65] This clearly points to a malaise in the acquisition system and until it is rectified, the confidence of foreign technology sellers will continue to be abysmal.

Other reasons for low FDI could be the low technological levels in the country, lack of skilled workers, high infrastructure costs, difficult labour and land acquisition laws, difficulties in initiating and running businesses and a lack of trust between the partners. Getting to the bottom of this troubling issue is imperative, but nothing substantial seems to have been done so far. A group of experts, preferably from an autonomous agency such as the IDSA, may be able to do the needful.

One major question which crops up is whether the Indian Government should promote FDI over 50 per cent in the defence sector. The GoI had circulated a proposal to increase the limit to 74 per cent as was done in the telecom sector, or even 100 per cent as is the norm in the US and European Union.[66] But apprehensions were voiced that foreign OEMs would stop supply of parts abruptly and without good reason and that ToT produced equipment would be sold to unfriendly nations. These situations can be avoided through G2G agreements and export controls respectively. There is the argument that even with greater FDI, foreign country export controls such as ITAR would still prevent cutting-edge technology from coming in. This is true, but there is a whole range of technologies below the cutting-edge which can greatly benefit India. There is the apprehension that foreign JVs would edge out Indian firms in the market through their superior technology and massive funding. And there is apprehension among the vast number of MSMEs which are dependent on DRDO-designed systems that their orders would die out. Here, indiscriminate crowding-out will be prevented by the GoI's current incentives for indigenous projects. However, Indian firms which are inefficient and incompetent would get edged out, while those which strive to meet global standards will garner adequate business. The MSMEs would switch to more advanced process and product technologies provided by the foreign firms, thereby becoming more competitive in the market.

How high then should the FDI limit be? Executing special resolutions will require a three-fourth majority vote and therefore, any figure over 75 per cent may be sufficient to provide the foreign partner adequate control.[67] With what is left, some control may be retained through differential voting rights shares, necessary strictures to safeguard control of the firm during national crises such as war and provisions for the government or Indian partner to buy back a majority share at a later date. Such an arrangement will draw the benefits of massive investments in India's cash-deficient defence economy, superior management practices and quicker adoption of effective work-cultures, which would all lead to greater, more effective ToT thus raising the possibility of being exploited for the global market. The strong, DRDO led 'Made-in-India' lobby may however look at such a major step with apprehension, fearing that it will be pushed to the margins. Such an apprehension is understandable and there is clearly a need to understand where indigenous R&D would be headed if the FDI gates are opened.

Then Whither Indigenous R&D?

Bringing foreign-run firms into the Indian DIB does not mean that the importance of indigenous R&D is diminished. Indeed, China is currently in the middle of an ambitious indigenous-R&D 'Made-in-China' wave after the success of its ToT-enabled manufacturing-for-the-world, 'Make-in-China' movement of the early 2000s. There is however, a significant difference. China, with its massive trade surplus and wealth, can and has, invested hugely in R&D. In addition, it has been able to attract 2000 scientists back through its 'Thousand Talents Programme' of 2008 for high salaries and positions in society. Of the three million Chinese who went abroad to study in the 1980s, one million have returned.[68] Another report has it that the students returning from advanced countries totalled 2.2 million in 2015.[69] This is akin to the late 19th century, when a large number of American students were "exported to" and "re-imported from" Germany to gain experience in fast growing technical fields.[70] Such an influx of latest technology helped the US build its leadership in industry and the same will, no doubt, happen with China.

India, on the other hand, is grossly short of investment, especially in the defence sector, and in terms of scientific mettle, way behind. Practically no break-through in cutting-edge fundamental and applied research has been reported in the last few decades and Indian universities remain painfully low in research standards. With the loss of a whole generation of young minds in research over the 1980s and 1990s, there is currently a void in scientific leadership.[71] Research being a long-term activity, it will probably take at least a decade or two for the handful of Indian Institutes of Technology (IITs) and Indian Institutes of Science, Education and Research (IISER) to deliver output which can be considered close to global standards. The state-run research centres under the Council of Scientific and Industrial Research (CSIR) and DRDO are hamstrung by the poor quality of recruits from a rote-based education system which stresses on achieving high scores instead of original research, innovation and creativity. The few R&D centres which foreign firms have set up in India are predominantly for product development, a latter part of step 5 of the TMPP and are limited to areas such as IT and automobiles. A few islands of futuristic design and development have been reported, but these are ironically, fully owned subsidiaries of foreign firms who will own the Intellectual Property (IP) of inventions of their Indian employees.[72]

Over the past few decades, the DRDO has focussed on developing defence systems with indigenous, modular system designs. One advantage of owning a modular system design is that changes can be made at will, so as to allow replacement of imported sub-systems with others of different countries thereby reducing dependence on any one country or company. Another advantage is that it promotes the use of indigenous sub-systems and parts which meet the performance criteria. But can this approach achieve globally competitive levels to match future Chinese systems? For that, the DRDO needs access to products developed from latest discoveries and inventions in the technologically advanced countries. These will be provided to India only when they become a generation or two old. Making globally competitive systems also requires advanced manufacturing processes which deliver systems of high reliability. Such industrial capabilities are expensive and in many cases, cannot be obtained from the advanced countries until they become old. For these two reasons therefore, it appears that indigenous DRDO systems will never reach globally competitive levels, at least, in the short term and at an affordable cost.

This does not mean that indigenous R&D has to be wholly sacrificed for induction of foreign technology. It will continue to hold great significance for achieving technological sovereignty in critical strategic areas such as ballistic and cruise missiles, nuclear weapons, cryptography and electronic warfare. Besides these, some areas can be reserved for indigenous designs where the DRDO is within striking distance of global levels of performance, quality and pricing. These areas will benefit greatly by the funnelling in of investments which would otherwise be dissipated over the wide spectrum that it is, of today.

This muted role for the DRDO can be adopted for the short term, during which the foundations of Indian research can be strengthened through import of foreign research technology and building up a strong research base of globally competitive universities and research oriented students. The option of bringing back Indian researchers and technologists from abroad must be pursued for accelerating this needed revival and resurgence. And then, maybe a decade or two down the line, the DRDO can re-invent and re-assert itself for playing the major role that it aspires for today.

Utilising Upstream Opportunities in the TMPP

In the chapter on exploring all avenues we discussed the opportunities available at each step of the technology maturity and productionisation path (TMPP). We have also discussed how cutting-edge dual-use technology, whose expensive research is funded by powerful corporates, is likely to occupy an increasing proportion of defence systems. This research is increasingly relying on global innovation networks which integrate dispersed engineering, product development, and research activities across geographic borders. Hence, if India is to utilise the upstream opportunities in the TMPP, Indian researchers will need to join and collaborate in the development work of these global innovation networks. Some of these maybe government-run and can possibly be joined through building stronger strategic ties with the developed nations, but many will be corporate-run and are therefore more approachable through corporatized research and technology organisations (RTOs) such as UK's QinetiQ. Corporatisation of research has spread globally, even in China which otherwise employs a policy tilted towards the state development regulatory model. India, therefore, needs to seriously consider taking similar steps—first in the dual-use areas and then the pure military ones at the earliest.

Productive R&D in India will, however, need a large enough base of capable prospective employees. Unfortunately, India's current rote-based, scores-oriented education system does not encourage and nurture research oriented human capital. Some latest government initiatives such as the conducting of hackathons and opening of *Atal* tinkering laboratories in schools are in the right direction, but these will not be enough to bring about the radical change that is needed. A vibrant national innovation system based on a strong IPR regime, which encourages, rewards and protects original innovators in a sufficiently competitive domestic environment, can make this change happen. But this again, can happen only through strong technological leadership at the top rungs of the government. This leadership appears to be greatly lacking in the current establishment, with a number of senior officials opposing western research techniques and established scientific findings with chest-thumping obscurantist claims of indigenous superiority. The only way forward, therefore, appears to be to import capable personalities from the Indian diaspora in the developed nations. The twentieth head of the US's eminent DARPA was a person of Indian origin! There are scores of such capable persons of Indian origin abroad. Why not bring such persons in and give them enough room for implementing changes and the resources to make them happen. This truly would be India's most powerful ToT project!

Making unconventional modes work

Sufficient amounts of technology diffusion and technology acquaintance of relevant defence systems and their technologies are essential for building adequate amounts of awareness among all the stakeholders which include the military, government policy-makers, the R&D agencies and the defence industry. Over the past decade, numerous defence expositions, seminars and interactions have been organised in India, showcasing foreign defence technologies from all the developed nations. Information on these technologies is also easily available on the internet. Some developed countries such as the UK, have openly published their defence technology strategies, defence industrial strategy and defence science and technology strategies in a bid to invite investment and guide collaboration with the private sector and other friendly countries. These documents give a great deal of insight into futuristic areas of technology as well as the technological strengths of the country. Joint military exercises with foreign nations are being held regularly, providing upfront experience to the Indian defence forces. Hence, there is no dearth of opportunities or sources for these two vital early modes.

Making this work, however, needs a coordinated, combined effort between all stakeholders. The Indian DTIC could be a focal point for the collation of relevant information and experiences across all these stakeholders. Once collated, these can be analysed for their relevance to the Indian scenario, their technical feasibility, affordability, producibility and supportability and then selection of the most suitable ToT modes and production agencies.

As we discussed in the earlier section, importing of world class scientists and technologists from the Indian diaspora can be of great value. The challenge, however, is in attracting them. While China has been considerably successful in bringing back their scientists and workforce from abroad, India attracted only 60,000 persons of Indian origin (PIO) in 2010. Most of these were given jobs which were not particularly rewarding and their contribution still goes largely unrecognised.[73] Unless more is done for them, very few of the 16 million Indians residing abroad are likely to be attracted back. The recent protectionist overtures by the US and some other advanced countries, however, do seem to be turning the gaze of Indians abroad toward India and the opportunity must be seized to make their return worthwhile.[74]

Acquiring of foreign factories in countries which are more open to their technology being transferred to India is no doubt, an option. The import of special machinery and production plants to manufacture, for example, electronic chips and components, can also greatly contribute to India's competitiveness. However, the technical feasibility of utilising them in Indian conditions and affordability need to be carefully analysed, and if workable, then carefully implemented using world class management to ensure success.

And finally, reverse engineering, the most controversial of non-conventional modes of ToT, especially the Chinese way, needs some deliberation.

Can India do what China did?

China's absorption and mastering of the technology and knowledge that was transferred to them by the Russians for the Su-27 fighter-aircraft and thereafter reverse-engineering it for developing and producing a next-generation fighter-aircraft defies the fundamental reasoning discussed in the earlier part of this book. The reasoning that possessing the know-hows of manufacture will not enable next-generation development unless the know-whys of design are available appears to have been belied by the Chinese. The case of the US improving on the UK's Hawk and Harrier aircrafts after license producing them, can be attributed to the transferee firm's superior technological levels and a freer technology transfer arrangement between the two allies. But that was not the case with China. How then did China do it, remains a puzzle. Also, China's graduating from imitation to creative innovation, as we discussed in the section on reverse-engineering, appears technically impossible without acquiring the know-whys of design. Were additional technical inputs received from other sources such as through espionage or dual-use technology imported for the civil sector? China has made great advances in obtaining the latter, making use of a situation where cheap mass production of electronic products for the world provided it the necessary leverage to coerce foreign firms to deliver more technology.

Pertinently, India has been and continues to be much better off as compared to China where the options for importing defence technology from developed countries is concerned. While China's options are limited to Russia, Israel and a few European countries, India has access to all the developed countries of the world. Hence, the sources for receiving defence technology are many times more than that of China and in the current global buyer's market, these can be greatly leveraged, through competition, to India's advantage. There are other advantages that India holds too, such as the large Indian S&T diaspora across the developed countries, the widespread use of the English language which is the carrier of knowledge in most parts of the developed world and the capabilities developed in the Information and Communication Technology (ICT) industry which can facilitate foreign inflows of technology through the global innovation networks operating today.

The larger question therefore, is not whether India *can*, but whether India *should* engage in illicit reverse-engineering as the central approach to the development of its DIB. Such an approach may provide quick gains in some areas as the Chinese experienced with the Su-27 fighter-aircraft case. But in the long run, technology providers will wise up to it and choke off future supplies. This may also endanger India's membership of the Wassenaar Arrangement and other international treaties which hold considerable significance in the globalised world of defence technology. A much stronger and productive approach would be to gain legitimate use of foreign technology and build up on it for mutual gains with the seller.

ToT for the Make-in-India Movement

The Make-in-India (MII) initiative introduced by the Indian Government in 2014 was aimed at making India a global manufacturing hub for increasing GDP share of the manufacturing sector to 25 per cent and creating 100 million jobs by 2022. Defence manufacturing was one of the twenty five sectors identified to contribute to this initiative. The initiative is similar to the one China adopted around fifteen years ago, where foreign firms were attracted through considerably cheaper labour costs and numerous other incentives. The strategy was to mass-manufacture by government-monitored massive factories for the global market at hugely cheaper prices, even if quality was not quite up to the level that customers desired. With steady inflows of revenue, China was then able to invest in improving quality so as to consolidate and widen its global customer base. Foreign firms which initially provided limited amounts of manufacturing technology, such as the assembling and packaging of products, were gradually lured to provide deeper amounts once a high dependence on their Chinese factories became evident. Today, with huge amounts of capital and technology available from its Make-in-China movement, and increasing availability of Chinese scientists nurtured abroad, China has moved on to the next level —that of Made-in-China where it seeks to research for, design and develop new products in addition to manufacturing them.[75]

If India is to succeed with its MII initiative the way China has, it will need to achieve product prices which are competitive with those of China. This is a difficult proposition considering India has a free market economy which tends to splinter manufacturing capacities amongst competing firms, thus precluding the advantages of manufacturing at large scales of economy. Besides this, there are numerous other hindrances such as high cost of capital, difficult land acquisition and labour laws, low availability of skilled labour, sub-optimal infrastructure and difficulties in starting and doing business. In the defence technology sector, however, the prospects are much brighter, since China stands isolated from foreign technologies and also does not have access to much of the global market. India, on the other hand, has access to contemporary defence technologies from all the developed countries and faces no restrictions on sale to the global market. Using this advantage to its fullest can clearly propel India significantly forward both economically and technologically.

One might posit that India should aim higher, at the Made-in-India strategy, where defence products are researched for, designed and developed in India. This has been the stand of the DRDO ever since the MII was announced and has even been introduced through the Indigenous Design, Develop and Manufacture (IDDM) focus of the DPP 2016. However, there are three cogent reasons why this will not succeed, at least in the near future. One is that India lacks the massive capital needed for high risk R&D projects. Two, it lacks an adequate base of scientists in numbers, and more importantly, quality. And three, it lacks the eco-system for it. An eco-system, which it is increasingly being acknowledged, needs copious amounts of innovations in commercial and dual-use technology in addition to that in hard-core defence technology, all brought together through a strong IPR regime and networks which integrate civil and government agencies for R&D.

So, the MII initiative for defence technology is clearly the way to go forward, as of now. But, a lot depends on what it is aimed at. Should it be for the much publicised self-reliance that India has aimed for ever since gaining Independence? Or is there a need to take a new direction? We look at this in the next and last section.

A New Defence Technology Acquisition Strategy—Going beyond Self-reliance towards Technological Superiority[76]

Let us take another look at the graphical Figure 4.2 that we analysed in the chapter on implementing ToT. As in the chapter, we see that, while the military (arrow marked 'M') strives for more advanced technology to gain a battle-winning edge over potential adversaries, the local industry (arrow marked 'I') asks for lower technology to achieve greater SRI. Going higher involves greater expense, less self-reliance but greater military strength, while going lower leads to higher self-reliance and the possibility of less expense.

What then, should be done? One solution to this conundrum is to raise the levels of C and P. That is, raise the technology levels that the industry is capable of producing and the potential to absorb, so that they come closer to level S. Production ToT or licensed manufacture contracts by themselves cannot enable this since they provide only the know-hows of manufacturing specific parts and systems. The know-whys of the design could possibly help, but these are either not provided or are simply unaffordable. Also, the know-whys acquired for say, a missile with a range of 4 kilometres may not provide enough knowledge to build a next generation missile of longer range of say 15 kilometres, which would need lighter, stronger material and maybe a different propellant. Raising such levels, hence, requires a wide and deep knowledge as well as skills base, which does not get built up by a narrow focus on frugal engineering based indigenisation of foreign parts as propagated by the goal of self-reliance. Raising these levels will clearly come at a cost which would go against the principle of economy. But if this cost could be initially borne, and levels C and P are raised to sufficiently high levels, we benefit not only by being able to absorb a larger quantum of higher-level technology but also by improving the chances for exports. These exports can bring in profits thereby neutralising the initial cost and improving the economic situation. For exports, however, the industry will need to work towards building globally competitive production capability. Such action to develop global competitiveness cannot be inspired by the goal of achieving self-reliance but by that of achieving technological superiority.

So, instead of self-reliance, striving for technological superiority and some profitability appears significantly more beneficial. But there emerge two imponderables. One is whether there are serious drawbacks of relegating self-reliance to a lower priority and the other, how is such a strategy to be made workable for a developing country?

Relegating self-reliance in numerical terms from an SRI of say, 70 per cent to 50 or even 30 per cent, doesn't appear particularly damaging as long as defence systems can be operated and maintained through future military operations without depending on foreign supplies. Such a situation can be achieved through the local manufacture of frequently used materiel such as ammunition and fast moving spares and the stocking up of scientifically predicted quantities of the sporadically needed remaining parts. Technological sovereignty however, may be critical in select areas such as long range ballistic and cruise missiles, nuclear weapons, cryptography and electronic warfare. Hence a dedicated focus on these areas, as is already prevalent in India, is necessary.

For the second imponderable, we find that there are a few but nevertheless, solid cases of developing nations achieving technological superiority assisted by technology transfers. One such case is that of Brazil's Embraer described in an UNCTAD paper on three case studies of successful ToT ventures.[77] The means used in these cases included licensing arrangements, collaboration with foreign firms, and foreign direct investment. Though each case described faced different paths and hurdles, all achieved success through a gradual leaning away from traditional import substitution (or indigenisation), which was focused on meeting domestic demand, to achieving international competitiveness. Brazil placed a greater emphasis on mastering technology in a few areas, over obtaining a larger share of value addition or indigenous content. This was done by a combination of indigenous efforts at learning and building capabilities as well as taking external assistance of consulting services, technology agreements and even research by leading multinationals.

Of course, the success of the firms in the study could not have been possible without some initial government support and interventions, such as those related to protective tariffs, subsidised inputs and low exchange rates. But, breaking into the global market ultimately needed internationally competitive products based on technological superiority. Since the risks of venturing into an unprotected global market were high, each firm forged alliances with foreign investors and suppliers for risk-sharing. In its conclusion, the UNCTAD paper stresses the importance of human resources development and domestic knowledge generation to become technology leaders and pioneers, thus acquiring a stronger bargaining position when entering into knowledge-sharing arrangements with foreign collaborators.

So, for bringing up the levels of C and P, the Indian defence industry needs to move up the capability curve through learning which is the key source of change and the most important mechanism for knowledge accumulation, innovation and growth. A large part of technical learning can be facilitated by using indigenous R&D

agencies. Embraer effectively used scientists of Brazil's state-run Institute for Research and Development towards this end. Hence, the DST and more significantly the DRDO, with its wealth of R&D knowledge, can play a vital role here. Further learning can then be facilitated through collaborations with R&D and manufacturing teams of the advanced countries for mutual benefits. And finally there can be the learning through JVs which are adequately controlled by globally established OEMs through an over 75 per cent share, for co-production and subsequently co-development.

Aiming for technological superiority and profitability through ToT will also have another benefit. The Indian armed forces will find their needs being increasingly met by the domestic industry, thereby reducing the need for the import of systems. And because an increasing portion of the ToT manufactured systems would be indigenously produced, it would result in greater self-reliance.

Notes

1. See Government of India, Ministry of Defence, Defence Procurement Procedure, 2016 available at https://ddpmod.gov.in, last accessed on September 15, 2018 p. 2.
2. Ibid, p. 14, para 20, p. 33, para 4(d) and p.34, para 5(d).
3. Ibid, p. 128-138.
4. Ibid, p. 2.
5. See Government of India, Ministry of Defence, 'Defence Production Policy', 2011 at https://ddpmod.gov.in, accessed on September 15, 2018.
6. The inability to locally develop and manufacture category 3 and even category 2 items due to various factors has been noticed and gleaned during interactions with connected personnel.
7. See, Government of India, note 1, p. 64, para 3.1(c).
8. The term 'state-of-the-art' has been replaced by 'modern' in the policy for FDI above 49 per cent as per the Annual Report 2016-17 of the Ministry of Defence, GoI at http://ddpmod.gov.in/sites/default/files/Annual%20Report%202016-17.pdf, p. 54, accessed on September 15, 2018.
9. See the section on dependency on the Foreign OEM in the chapter on nuances.
10. See, note 7, p. 34.
11. Ibid., p. 133.

12. Ibid., p. 128.
13. Ibid., p. 2.
14. A Vice President of Swedish firm Saab in a seminar on August 31, 2016 at New Delhi averred that for assured business from the Indian government for 20 years, an FDI less than or equal to 49 per cent is sufficient whereas for being globally competitive, an FDI over 49 per cent is essential.
15. See https://www.newsclick.in/us-defence-firms-dont-want-transfer-technology-india, accessed on September 15, 2018, where foreign firms have expressed their reluctance to be held liable for defects beyond their control.
16. See Commodore C.P. Srivastava, 'Project 75 (India) and the Australian submarine programme', *Indian Defence Review,* 33(1), Jan/Mar 2018, pp. 32–37, where he describes how the optimal technology to be acquired may depend on different aspects such as design, OEM's industrial footprint, OEM's experience and attitude to ToT, and local experience/ capabilities in some technologies.
17. One of the advantages of the Spike anti-tank guided missile, as intimated by a rep of its OEM, the Israeli firm Rafael Advanced Defence Systems, was that a large part of its technology could be utilised in its numerous and wide variants.
18. Government of India, Ministry of Defence, 'Draft Defence Production Policy', 2018 at https://ddpmod.gov.in/sites/default/files/Draft%20Defence%20Production%20Policy%202018%20-%20for%20website.pdf, accessed on September 15, 2018, pp. 3–6, 8, 9 and 12.
19. Mrinal Suman, 'Technology Transfer under "Buy and Make" is a Misnomer', *Force Magazine*, October 2014 issue at http://www.forceindia.net/StumblingBlocksMay2009.aspx, accessed on July 21, 2017.
20. The Indian Navy's considerable progress in comparison to the other two Services has been visible and commented on at numerous fora.
21. See 'The Dhirendra Singh, Experts Committee Report' at https://mod.gov.in/sites/default/files/Reportddp.pdf, accessed on September 15, 2018, pp. 199, 200.
22. Ibid., pp. 200, 212.
23. See Ranjit Ghosh, *Indigenisation: Key to Self-Sufficiency and Strategic Capability,* IDSA, New Delhi, 2016, p. 114.
24. Mrinal Suman, note 19.
25. Ranjit Ghosh, note 23, p. 78.
26. See http://www.techmonitor.net/tm/images/4/4d/15oct_dec_market_scan.pdf, accessed on September 15, 2018.
27. Mrinal Suman, note 19.
28. Ron Matthews, *The UK Offset Model: From Participation to Engagement*, RUSI, Whitehall, London, 2014, p. 24.

29. 'DRDO Guidelines for Transfer of Technology' at https://www.drdo.gov.in/drdo/English/IITM/DRDO-guidelines-for-ToT.pdf, accessed on September 15, 2018, p. 2.
30. The UK's defence technology strategy of 2006 defines cross-cutting technologies as those which can deliver military advantage across multiple domains. The essence here is the same, though its coverage has been enlarged to cover elements down to component level as well as process technologies.
31. The setting up of a common electronic chip level fabrication plant in India, as suggested in the draft DPrP 2018 is a good example of a cross-cutting process technology which can be utilised across the DIB.
32. The technology for rubber parts of the tank T-72 dried up in the 1990s when sub-vendors closed shop with the termination of orders. The subsequent tank T-90 project contracted in the early 2000s suffered major delays due to this void.
33. Bharat Dynamics Ltd, a DPSU, claim they had successfully combined Russian and French origin technology for delivering a competitive anti-tank missile system.
34. As communicated by a DRDO scientist in April 2017.
35. Commodore C.P. Srivastava, note 16, p. 37.
36. From feedback received from some Ordnance factories.
37. United Nations Conference on Trade and Development (UNCTAD), *Transfer of Technology,* New York and Geneva 2001, p. 92.
38. Ron Matthews, note 28, p. 25.
39. Ibid., p. 8.
40. Ibid., p. 26.
41. Ibid., pp. 32, 33.
42. Ibid., p. 33.
43. Dr Laxman Kumar Behera of The Institute for Defence Studies and Analyses, New Delhi is the only Indian researcher in this complex field.
44. Government of India, note 1, p. 65.
45. Smitha Purushottam, 'Report on Hi-Tech Defence Innovation: India's Need for a National Vision and Roadmap', *CLAWS Journal*, New Delhi, Winter 2011.
46. Boeing and Lockheed Martin have confirmed the capabilities of some Indian firms in manufacturing parts to global quality standards.
47. The Low-level Light-weight Transportable Radar (LLTR) for the Indian Air Force is being manufactured by BEL, Ghaziabad under license from Thales, France through such an arrangement.
48. Ron Matthews, note 28, p. 71.

49. UNCTAD, Transfer of Technology for Successful Integration into the Global Economy, 2003 at http://unctad.org/en/docs/iteipc20036_en.pdf, accessed on September 11, 2018, pp. 3–24.
50. Ron Matthews, note 28, p. 50.
51. Government of India, note 18, p. 13.
52. See https://www.thebalance.com/joint-venturing-101-1200766, last accessed on September 15, 2018. The advantage of holding an understanding of the transferor firm's work-culture is indirectly drawn from Ron Matthews, note 28, p. 49.
53. See https://www.thebalance.com/joint-venturing-101-1200766, last accessed on September 15, 2018.
54. Ron Matthews, note 28, p. 8.
55. See https://www.thehindu.com/news/national/wassenaar-arrangement-decides-to-make-india-its-member/article21293077.ece, accessed on September 15, 2018.
56. R.P. Rajagopalan, A. Biswas, 'Wassenaar Arrangement: The Case of India's Membership', ORF Occasional Paper # 92, May 2016, p. 9.
57. Ibid., p. 13. Also see European Parliament, *Dual Use Export Controls*, 2015 at http://www.europarl.europa.eu/RegData/etudes/STUD/2015/535000/EXPO_STU(2015)535000_EN.pdf, accessed on September 15, 2018.
58. Centre for Non-proliferation Studies, *Wassenaar Arrangement: Best Practice Guidelines on Subsequent Transfer (Re-export) Controls for Conventional Weapons Systems* at https://www.wassenaar.org/app/uploads/2015/06/3-Re-export.pdf, accessed on September 15, 2018.
59. See https://www.mid-day.com/articles/us-military-firms-want-security-of-classified-defence-information-in-india/18813197, accessed on September 15, 2018 which reports the concerns voiced by US firms.
60. Available at http://dipp.nic.in/sites/default/files/1403158012.pdf, accessed on September 15, 2018.
61. 'A new innovation era: India jumps eight places among 50 countries in global IP index', *Times of India*, February 9, 2019.
62. 'India Flounders in Attracting FDI in Defence Production, Gets only Rs 1.17 crore in 4 years', *Times of India* at https://timesofindia.indiatimes.com/india/india-flounders-in-attracting-fdi-in-defence-production-gets-only-rs-1-17-crore-in-4-years/articleshow/63207644.cms, accessed on September 15, 2018.
63. See https://economictimes.indiatimes.com/news/defence/totl-fdi-in-defence-sector-from-2000-18-is-rs-35-crore/articleshow/65038196.cms, accessed on September 15, 2018.
64. Government of India, note 18, p. 6.

65. See https://www.firstpost.com/india/defence-ministry-scraps-spike-anti-tank-guided-missile-deal-with-israel-all-you-need-to-know-4218575.html, accessed on September 15, 2018.
66. See ASSOCHAM-PWC, *Self-reliance in defence production: The unfinished agenda*, p. 15 at www.pwc.in, accessed on February 8, 2019.
67. Ibid.
68. See http://economictimes.indiatimes.com/news/science/india-and-chinas-chalk-and-cheese-approach-to-science/articleshow/53201796.cms, accessed on September 16, 2018.
69. Kala S. Sridhar, 'Comeback Kids on the Block', *The Economic Times*, January 14, 2017 at http://blogs.economictimes.indiatimes.com/et-commentary/now-that-qualified-and-successful-indians-are-returning-home-lets-not-disappoint-them-again/, accessed on September 16, 2018.
70. Donald E. Stokes, *Pasteur's Quadrant: Basic Science and Technological Innovation*, Brookings Institution, Washington, DC, 1997, pp. 38-41. Taken from *Policy Implications of International Graduate Students and Postdoctoral Scholars in the United States* at https://www.nap.edu
71. India's lack of R&D in the universities is mentioned at http://blogs.economictimes.indiatimes.com/et-commentary/innovation-in-india-lead-not-just-catch-up/, accessed on September 16, 2018.
72. 'Design as Integral Part of Make in India', The Editorial, *The Economic Times*, January 17, 2017.
73. See http://blogs.economictimes.indiatimes.com/et-commentary/now-that-qualified-and-successful-indians-are-returning-home-lets-not-disappoint-them-again/, accessed on September 16, 2018.
74. 'Contrarian Play', The Editorial, *Times of India*, April 20, 2017, states that between December 2016 and March 2017, the number of Indians in the US searching for jobs in India have increased ten-fold.
75. *The Economist*, 'The great experiment', January 12–18, 2019.
76. A large part of this section has been taken from the author's article 'Transfer of Defence Technology – Moving beyond Self Reliance towards Technological Superiority', IDSA Issue Brief, July 31 2017 at https://idsa.in/issuebrief/transfer-of-defence-technology_kadesouza_310717, accessed on September 13, 2018.
77. UNCTAD, note 49.

7

Putting it All Together

Do the insights documented in this book enable us to define how India should meet all its technological needs to counter its military threats? Not quite. It is a complex issue involving geo-strategic compulsions and the working out of the right proportion of trade-offs between self-reliance, inter-dependence with powerful supportive nations, operational effectiveness required against present and future military threats and finally but most importantly, the cost. Then there is the strategic domain and the conventional one. The strategic domain demands technological sovereignty since external support in these areas is unlikely. In the conventional domain, external support is much more likely to be available because of India's good relations with all the developed countries and as was experienced in the Kargil conflict of 1999. So, excessive self-reliance may not be necessary here. In both the domains, the cost involved becomes a critical deciding factor, especially since India's economic capacity is limited.

India's limited economic capacity for building defence capability is dictated by its greater need for economic, social and industrial development. This development is needed to overcome the still significant levels of poverty, malnutrition, illiteracy, lack of infrastructure and rising unemployment. In addition, India needs to match up to China's technologically advanced military capability, at least to a level of credible deterrence. Hence, building of defence capability needs to be dealt with by an approach which meets both economic development and technological advancement. The answer appears to lie in mass-manufacture and exports of defence systems or their parts which have sufficient global demand. One route is to develop and mass-manufacture indigenous systems that are globally competitive in performance and price. But indigenous development to globally competitive standards is hampered by low economic capacity to invest in expensive, long gestation period and risky projects, the acute shortage of basic and applied research capabilities, an under-developed ecosystem and a shortage of competent, innovative recruits for R&D. The other option—foreign ToT to Indian agencies, also involves an additional expense (compared to outright purchase of systems), but this expense is considerably less than that for indigenous R&D. And this expense can be recouped if India chooses to mass-manufacture some of the systems or parts in which India has a comparative advantage. Where exactly lies this comparative advantage and which are the enabling factors to be strengthened are clearly important inputs to guide the way forward. But these require an in-depth understanding of India's industrial and technological strengths and will need to be tackled separately for each technological segment. Assuming that such a comparative advantage in some areas is available, we can work out a broad strategy to maximise the benefits of ToT through the learning in this book.

It is clear that the strategic and conventional domains need to be tackled differently. In the strategic domain, the DRDO could continue to focus on self-reliance and even aim at technological sovereignty in select areas. It has done commendable work here and needs to be fully supported to the extent possible. An increase in the multipliers for offsets-enabled transfer of critical technologies of these strategic areas to the DRDO from a maximum of three to thirty will provide a significant boost and should enable the acquisition of some worthwhile know-whys. In addition, closer strategic ties could be forged with the US and its allies for allowing DRDO scientists to work and collaborate with their defence R&D. India's recent listing in US's Strategic Trade Authorisation (STA) category 1 is an indication that the US is willing to transfer sensitive and high-end technologies.[1] The US's allies could be expected to follow suit with their own legislations and thus, a wide range of available technologies could arrive quickly on the horizon. Maximising their transfer would need a comprehensive plan focused on acquiring the know-hows and know-whys in the six steps of the TMPP and these can be aimed at sequentially or even simultaneously through the numerous avenues listed in Table 5.1. Long-term and sufficient investments would need to be made to sponsor bright DRDO scientists for these missions abroad and the risk involved would need to be accepted.

The conventional domain then needs to be addressed by working out the minimum level of SRI necessary to enable these weapons systems to be effectively operated and maintained through future military operations. Materiel which are critical to system operation and frequently required such as ammunition and some fast moving spare parts can be locally ToT-manufactured and the remaining can be procured, stocked and replenished at scientifically predicted quantities to take care of future needs. Outside of these, the ToT enabled manufacture of parts at higher prices and lower quality in comparison to those of the OEM can be shelved, thus saving on expenditure. The DRDO needs to step in to support the local industry in absorption of technology, especially in the production/ development of category 2 and 3 items. The ToT enabled mass-manufacture of parts in global demand and where India has a comparative advantage can be ramped up for exports. For this, provisions for permitting such exports will need to be negotiated in the ToT agreements with foreign technology sellers. Also, since venturing into the global market will entail considerable risks, suitable alliances will need to be forged with foreign investors and suppliers for risk-sharing.

The advantage that India has over China in sources of advanced defence technology facilitated through its good relations with all the developed nations, could be leveraged. For new, high population acquisitions, such as the fighter aircrafts for the Air Force, the doors for foreign ToT need to be opened wide. The aim should not be to acquire the cheapest foreign technology, but ones which have significant balance life, greater potential for growth, which could be mass-manufactured in India at a comparative advantage, have sufficient demand in the global market and of course, is within reach of Indian firms so that they can be gainfully absorbed. Those technologies which could fill up an important gap in manufacturing processes and which would be sufficiently utilised could also be targeted. For ensuring successful transfer and absorption of modern technology and subsequent commercialisation for global sales and profitability, there is no choice but to allow and encourage JVs with FDI over 75 per cent, possibly with differential voting rights shares, necessary strictures to safeguard control of the firm during national crises such as war and provisions for the government to buy back a majority share at a later date. To achieve this success the Indian partner would need to upgrade its technological levels and for this, the DRDO's contribution is essential. For improving trust levels, the MoD could issue a code of conduct in foreign IP protection, to be adhered to by Indian firms, while for compliance to legal agreements, dedicated ombudsmen and even special courts may be set up.

But, here we come to an impediment. India can neither afford, nor is in a position to run two manufacturing facilities for fighter aircraft or other such technology and investment intensive systems.[2] This is due to the lack of economic capacity and due to limited technological resources such as skilled workers and competent production engineers, programme managers and quality assurance personnel in the sector. This means that eventually, it will become a question of which design is superior and cheaper to manufacture—the indigenous LCA or the foreign one. The foreign one is likely to have an edge because of its proven performance and reliability, decades of production optimisation and the foreign firm's closer access to products of new research in the developed world. It will be heart-breaking for the DRDO as well as

HAL to let go of a project which they have worked on for decades and come so close. But, for the LCA to break into the global market and be sustained there at an affordable cost is an extremely tall order. And hence, such an eclipse may become inevitable.

Despite the expected eclipse of many DRDO designed and OF/DPSU manufactured systems, indigenous R&D in select areas, especially those which are critical for technological sovereignty, could be continued. Areas where the DRDO has come close to achieving global standards could also be pursued so as to apply indirect pressure on foreign sellers to supply their technology at competitive prices. Sustaining such R&D would be challenging since funding would be limited and R&D resources may get diverted to foreign ToT projects.

The eclipsing of indigenous projects may lead to monopolistic situations with just one foreign-partnered SP in the sector. This lack of competition, will in turn, lead to inefficiencies and stagnation in technological growth. This situation could be circumvented by placing an obligation on the foreign majority owned firm to ensure a steadily increasing quantum of exports at least till its cumulative value equals twice the cost of technology charged. The profits thus received would also enable the offsetting of the additional cost of ToT that has to be borne by Indian agencies.

Focusing on the US and its allies for future technology would mean that technology from Russia would need to be reduced to areas where its benefits clearly outweigh the disadvantages of excessive technology variety. The successful Arihant submarine, which was produced in India with the help of some Russian technology, is one such example. The utility of acquiring fifth generation fighter aircraft (FGFA) technology from Russia, however, may need to be analysed in detail from the perspectives of compatibility with western technology, potential for further growth, ease of absorption and cost. Purchase of full-fledged systems from Russia such as the S-400 Triumf air defence missile system along with its maintenance technology, however, could be continued, so as to sustain the close strategic relationship that India holds with it. Such purchases would also be needed to counter China militarily until such time as India's technological absorptive and development capabilities reach levels comparable to that of China's military technology.

The PToT portions of the DPP clearly need to be revised with an eye on the perspectives and findings that have become apparent in this book. The overall intention of ensuring that every bit of technology available with the seller is squeezed out at the cheapest price needs to be replaced by a focus on making it more workable and a win-win arrangement for foreign sellers and Indian firms. Pilot PToT projects could be contracted to test the arrangements which are not entirely convincing and the learnings assimilated for improvements.

More avenues and modes of ToT need to be opened up in the DPP allowing for the choosing of optimal modes in all possible situations. The work-share could be used for systems where a significant portion can be independently manufactured in India, while the JV-CP and JV-CD-CP could be used where competent manufacturing and development capabilities are available respectively. The split-order or lease-order arrangement for large systems such as submarines, fighter aircraft, medium lift helicopters and armoured fighting vehicles is certain to ensure in-depth analysis and identification of foreign technology which can be successfully absorbed, consolidated and even improved upon. And using the *Defined IC* arrangement where the feasibility of absorption and cost of the various constituent elements of foreign technology is not known and the *Defined ToT* where it is, would cut expenditure while ensuring we get what we need. The DPP should allow for a gradual increase in IC over the numerous phases of the ToT project culminating at the optimal level.

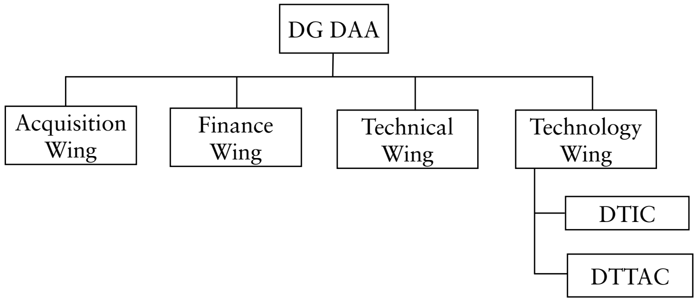
The encouraging of private firms to participate in strategic ToT projects as enunciated in the SP chapter of DPP 2016 is welcome, but there is a need to ensure the Indian partners are fully capable in terms of not just financial strength but also in availability of infrastructure, technically knowledgeable, experienced and skilled workforce, cost competitiveness, quality systems in place and a record of dependability and compliance. The current process of selection of defence systems through technical and commercial stages will need to be enhanced with a middle stage for clearing ToT requirements. An additional chapter in the DPP for the separate acquisition of cross-cutting technologies is needed to build aggregate demand and maximise the benefits of the technology acquired. In all cases, the urge to acquire full ToT must be critically reigned in to achieve the optimal trade-off between cost and useful, absorbable, high-potential technology.

The draft DPrP 2018 is a great improvement on the DPrP 2011. But it needs to provide realistic goals and pragmatic strategies to achieve them. These strategies would need to factor in the economic and technological constraints that the country currently faces and provide sound, workable steps that are to be taken to overcome them. Expectations from all stake-holders including the MoD itself need to be specified in the document, after confirming that they are realistic. Lastly, the government's plan for future ToT projects, giving out approximate budgets over the next five years, needs to be clearly stated to allow technology sellers to work out their broad proposals.

In the Indian defence offset system, offset credits need to be increased for worthy technology, directed offsets and pre-selection evaluation of offset offers tried out and the arrangement that Turkey has for paying of offset credits after the value of exports exceeds the value of technology imported, scrutinised for implementation. Planning by the OEM and Indian partners on continued utilisation of the assets created for an offset programme would enable the reduction of wasted investments. The three-party arrangement for ToT, to arrest ghost manufacturing and to gauge the actual levels of indigenous capability available in the country, is a tedious but important step for progress. The voids which become apparent would then need to be addressed at a national level for arriving at an optimal indigenous arrangement. Once the ball has been set rolling here, the three-party arrangement could be phased out for a more liberal ToT and offsets framework allowing for market forces to take over.

The implementation of all these improvements will need in-depth analyses, drawing up new templates and policies and test-proofing them before they are promulgated. Implementation will require the mentoring and guiding of Indian agencies and then closely monitoring their progress for timely course corrections towards the desired goals. For these tasks, the current Acquisition Wing of the MoD will need to be enlarged and transformed into a DAA as shown in Figure 7.1 with an additional Technological wing over their current acquisition, finance and technical wings so as to enable conceptualisation, guidance and monitoring of technology projects. The DAA would also need a DTTAC and a DTIC. The former is required for drawing up ToT and AoT guidelines, identifying new absorbable, high potential technologies, including cross-cutting and process ones for acquisition, assisting in ToT negotiations, taking ownership of all ToT projects and ensuring their consolidation and commercialisation. The latter, is required for collating all information on the defence industry and enabling research and analysis to support researchers, scientists, engineers and programme managers across all government, public sector and private sector agencies. The DGQA is by far the most suited

Figure 7.1: Proposed Internal Structure of the DAA



Source: Prepared by the Author.

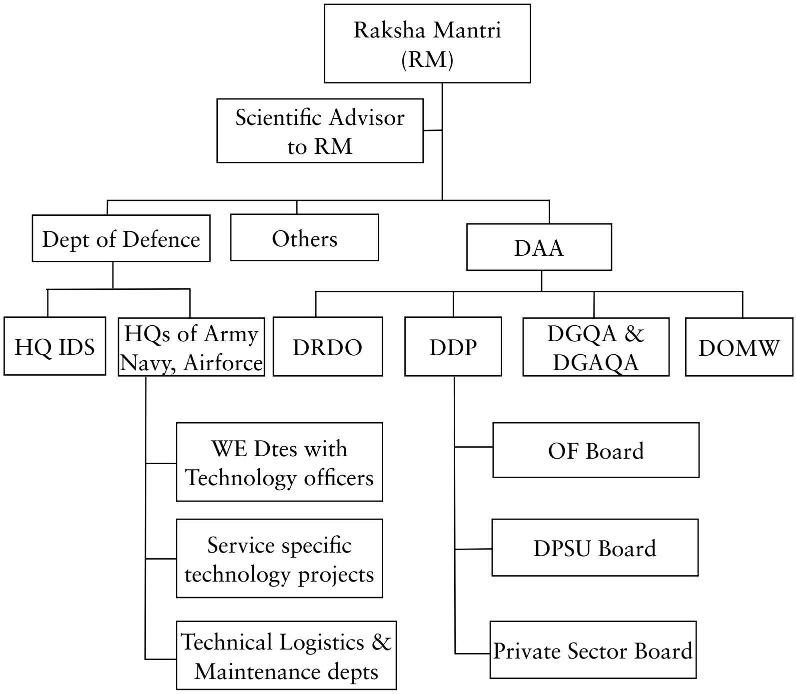
agency to create the DTTAC and the DTIC, but it must co-opt elements of the DRDO, DDP, DoI, OFs, DPSUs, private defence firms and maintaining agencies of the three military services. Once created, they can be brought directly under the Technology wing of the DAA.

The positioning of the DAA within the MoD is also important. It needs to be in a position to influence, direct and monitor all defence technology projects - indigenous and foreign assisted, thereby taking complete ownership of each, right from the metaphorical *womb* to the *tomb*. The positioning also needs to remove the conflicts of interest within the DRDO and facilitate smoother processing of ToT projects. The position in Figure 7.2 hence appears to be the best suited from most angles.

Figure 7.2 also covers all the other agencies in the MoD which would need to interact with the DAA. The WE directorate of the Army (and equivalent in the Navy and Air Force) would need to be supplemented with technology officers for each acquisition project. These will interact with the new Technology Wing of the DAA for ToT aspects, thus relieving the DRDO from its conflict of interest. The placing of the DRDO and the DDP under the DAA would enable the reviewing and rationalisation of their projects and their priorities. The constitution of a separate private sector board in the DDP would enable a level playing field vis-à-vis the OFs and DPSUs. The placing of the DGQA under the DAA instead of the DDP, as it currently is, would ensure that quality in ToT projects are enabled without conflicts with production targets. And the DOMW, under the DAA, would ensure offset-enabled technology transfers across all sectors, from R&D in DRDO to manufacturing.

National academic, fundamental research and applied research agencies will need to be encouraged to increase learning so as to raise the levels of knowledge in dual-use and defence technologies. For this, collaborations with the DRDO as well as foreign universities would be needed using the brightest students. The focus should be on grooming technological leaders and pioneers who can compete in

Figure 7.2: Positioning the Proposed DAA in the MoD



Source: Prepared by the Author.

the global arena. Importing Indian students researching abroad and competent foreign faculty would give an immediate impetus though achieving this will be extremely challenging.

Select academic institutes need to be encouraged to take up research in advanced manufacturing processes and aim for global standards through exchange programmes and collaboration with established ones in the developed countries. Scientists and researchers need to be encouraged and rewarded for joining and contributing to global research networks for collaborative product development. Some of the DRDO laboratories could be corporatised and then privatised into for-profit RTOs. These could take up development work through collaboration with foreign RTOs up to TRL 6 levels for sale to the defence industries for productionisation and commercialisation. Private intermediary firms would be needed to enable assimilation of beneficial aspects of foreign work-cultures.

The greater focus on exports instead of self-reliance fits in beautifully with the Make-in-India-for-the-world initiative of the current government. How much comparative advantage can be achieved for manufacturing in India, would however, be the deciding factor for success. Reforms and incentives to overcome the high cost of capital, difficult land acquisition and labour laws, low availability of skilled labour, sub-optimal infrastructure and difficulties in starting and doing business would be needed. In addition, and more directly relevant to successful ToT, are the reforms to ensure the protection of foreign IP and those for the enforcing of contracts. These would build the all-important trust that foreign countries and firms need to have in Indian agencies.

Implementing these wide-ranging reforms is the first of the three most challenging areas facing India for successful ToT. The second is the overcoming of pressure from Indian conglomerates who will fiercely resist the move to allow foreign majority-owned JVs, who they fear, would edge them out of the domestic market with their superior funding, technology and management. These conglomerates would, therefore, do their best to influence the government in their favour, through political funding if necessary. And the third is the motivating of DRDO to transfer its wealth of R&D knowledge to the Indian industry, to adopt a status subordinate to the DAA and thirdly, to temporarily scale down their research span for a decade until Indian research revives. Addressing these three areas would require an immense effort from political leaders who are technologically knowledgeable and convincing. Leaders that India does not have at the moment and are nowhere on the horizon. The engaging of eminent Persons of Indian Origin (PIO) such as the twentieth head of DARPA, as advisors or into top level government posts appears to be the only possibility. But this too, is not certain to bring success unless a sizeable majority of the Indian defence ministry and DIB are convinced of the way ahead. This conviction could come through focusing on the two goals that we have concluded are necessary for success—achieving technological superiority and profitability. Self-reliance will follow.

Notes

1. See *The Times of India*, 'US move to promote India as defence trading partner boosts Delhi's NSG hope', August 1, 2018 at https://timesofindia.indiatimes.com/india/us-ease-of-export-controls-boost-for-indias-nsg-membership-bid/articleshow/65216665.cms, accessed on September 16, 2018.
2. As voiced by a senior research fellow at IDSA, New Delhi.

Epilogue

Dear Reader,
Though we have covered quite a bit, we still have a significant journey ahead—a journey where the ideas in this book are mulled over and critiqued for ways of implementing them. Some ideas may require trials in a small way to validate the concept and draw additional lessons. And there will be some whose effectiveness and benefits will reach desired levels only through several iterations. In all this activity, an openness of mind, flexibility of thought, an innovative yet meticulous mind-set, and sacrifice of our personal organisation's wants for the national interest will be needed. It will need being self-critical to identify our weaknesses, accepting them as challenges and a strong resolve to overcome them. It will also need the identifying of the positives in foreign technology, work cultures and values and assimilating them to complement our own strengths. This will result in a potent mix of the best of India and the best of the world. A mix that will beyond doubt, lead us to success, in achieving the goals of technological superiority, minimum necessary self-reliance, economic and industrial development and increased employment.

There is much research left to be done. The complex task of working out the right proportion of trade-offs between self-reliance, inter-dependence with powerful supportive nations, operational effectiveness required against present and future military threats and cost will need an interdisciplinary approach. Working out a procedure to arrive at the optimal trade-off levels between technology transfer and cost in respect of individual projects will need defence R&D scientists, production technologists and finance experts to co-research. Ascertaining the defence products which have sufficient global demand and their production sectors where India holds a comparative advantage for mass-manufacture at global standards will need knowledgeable and experienced programme managers, economists and technologists to critically research them. Deriving of a dependable technique for valuation of technology transferred will need finance and technology specialists. The reason for negligible FDI in the defence sector is a fifth area. These five research projects will need to be initiated and conducted in the open, self-critical and knowledge focused environment that exists in autonomous and well established think-tanks such as the Institute for Defence Studies and Analyses, New Delhi. These will take time, as all research does, and therefore need to be initiated at the earliest. Besides these, case studies on successes and failures in Indian defence ToT projects will add further insights. These case studies could not be included within this research work due to the lack of access to detailed information.

Every bit of policy research and its findings needs to be critically examined from all possible angles to validate (or invalidate) and enrich them with added nuances so as to reach a fineness which ensures success in implementation. This book is no exception. I request knowledgeable and experienced persons in the MoD, DRDO, OFs, DPSUs, DGQA, foreign and Indian defence firms, industry associations, the three military services and established defence economists to critically examine this book, its ideas and recommendations, for their strengths and weaknesses, and communicate them to the Indian defence technology community and even the open public through counter articles and research pieces. The resultant dialogue will deepen our understanding and provide solid insights on which we can move forward. If a consensus can be reached or at least a large majority is convinced of these, it can propel the government of the day to take the big decisions necessary to set the ball rolling in the right direction. Ultimately, it will be the success of the Indian people, achieved with the support of our friendly foreign nations.

Annexure I

The Asian and Pacific Centre for Transfer of Technology (APCTT)

This centre, run by the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), was established in 1977 in Delhi and aims at assisting developing and least developed countries to develop, absorb and adopt new technologies in an efficient manner. The centre focuses its activities in three fields—Science Technology and Innovation, Technology Transfer and Technology Intelligence.[1]

The Science, Technology and Innovation (STI) programme assists countries in overcoming the challenges faced in inclusive and sustainable development which are typically, subcritical resource allocation, lack of skills, ineffective policies, delivery and support mechanisms and weak inter-ministerial coordination. This is achieved by strengthening their capacity to evolve and adopt their own holistic approach to the development and governance of STI strategy.[2]

The Technology Transfer programme provides its ICT based On-line technology support mechanisms and a Technology Transfer facilitation service. The online support mechanisms provide connectivity to over 15 global technology databases, a site for offering technology, placing requests for technology as well as offering opportunities for business cooperation (Joint venture and Partnerships). The Technology Transfer facilitation service provides an information service on technology transfer, joint-venture, business/research partnerships and opportunities; organising of business-to-business meets, technology exhibitions and technology transfer related conferences and technology dissemination workshops and finally, support services to help techno-entrepreneurs interact with technology transfer intermediaries, source technology globally, and also explore venture capital financing.[3] The programme also builds capacity of SMEs in particular, to successfully handle the technology transfer process in a holistic manner and develop skills ranging from business case preparation, technology sourcing, technology assessment, technology selection, technology pricing, negotiation, contract finalisation, implementation and impact assessment.

The Technology Intelligence programme, through its periodicals *Asia-Pacific Tech Monitor* and *Value Added Technology Information Service (VATIS) Update* enables policymakers, SMEs and R&D agencies to keep abreast of emerging STI policy approaches and delivery mechanisms for technology-based national inclusive and sustainable development. They also assist SMEs to emphasize on technology innovation to succeed in the market and participate in the globalisation of technology, and in making informed and rational decisions during the technology transfer process. For R&D agencies, it helps build a focus on new and emerging technologies for sustainable development.[4]

Notes

1. See http://www.apctt.org/, accessed on September 16, 2018.
2. See http://www.apctt.org/science-technology-and-innovation, accessed on September 16, 2018.
3. See http://www.apctt.org/technology-transfer, accessed on September 16, 2018.
4. See http://www.apctt.org/technology-intelligence, accessed on September 16, 2018.

The Life Cycle Approach for Planning and Implementing A Technology Transfer Project[1]

This annexure commences with a brief presentation of common technology transfer problems faced by SMEs and is then followed by the "Life Cycle Approach for Planning and Implementing a Technology Transfer Project".

Technology Transfer Problems Commonly Faced by SMEs

Based on the work of Jagoda (2007) and Ramanathan (2007), problems faced by SMEs in planning and managing technology transfer may be classified into three categories namely, technology transfer process issues, corporate capability issues, and operating environment and National innovation System (NIS) issues. The problems are summarised below.

(a) Technology Transfer Process Issues

Problems during the technology justification and selection stage

- Wrong selection of technology based on misjudgements when preparing a business case for a TT project
- The cost of buying, installing, operating, and maintaining the technology is too high
- The technology selected is too complex for easy understanding and assimilation of the transferee
- The technology needs considerable adaptation to suit local conditions
- Obsolescence of technology while the transfer is in progress
- Problems during the planning stage
- Transferor (seller) underestimates the problems in transferring the technology to a developing country setting
- Transferor does not fully understand transferee needs

- Transferee managers are not involved in the planning which is carried out only by the transferor
- Too much attention is paid to the hardware to be purchased and not enough attention is paid to skills and information acquisition
- Overestimation of the technological capabilities of the transferee by the transferor thereby leading to unrealistic expectations on how well the transferee can meet target dates
- Poor market demand forecasting by the transferee of the outputs to be produced by using the transferred technology
- The objectives of the transferor and transferee are not compatible
- Mechanisms chosen for implementing the transfer are not appropriate

Problems during negotiations

- Differences in negotiation approaches and strategies
- Lack of trust between the transferor and transferee
- Goal incompatibility during negotiations
- Inability to reach agreements on pricing, product, and marketing strategies
- Both parties try to achieve results in an unrealistically short period of time

Problems during technology transfer implementation

- Shortage of experienced technology transfer managers
- Lack of trust in transferor developed systems by the transferee
- Inability to achieve quality targets
- Delay in obtaining supplementary materials, needed for quick implementation, from the local environment
- High cost and poor quality of locally available materials needed to implement the technology transferred
- Inadequate tracking of the technology during implementation
- Cost overrun due to poor implementation

(b) Corporate Capability Issues

Problems due to inadequate skills

- Inability of the transferee to attract the required skills due to financial and industrial restrictions
- Lack of experience of the transferee's workforce and absence of required skills at the industry level

- Lack of training of transferee personnel
- Absence of incentive systems at the transferee firm for learning and assimilating new technologies
- Language barriers that inhibit effective communication between transferor and transferee personnel and restrict effective transmission and assimilation of relevant information

Problems due to ineffective management

- Lack of visible and committed top management support for the project
- Lack of top management guidance to decide the type of the technology to be acquired, remuneration, incentives associated with the transfer, and the control of the flow of information.
- Differences in working methods and practices between the transferor and transferee managers
- Individual or organisational competition for the ownership of the technologies and the presence of the "not-invented-here" syndrome
- Failure of top management to identify transferee and transferor personnel who would work closely from project initiation through to full implementation

(c) Operating Environment and National Innovation System (NIS) Issues

- Shrinking of local markets due to adverse changes in the economic levels of the country
- Poor physical infrastructure
- Inadequate supportive institutional infrastructure to provide support in terms of finance, information, skill development, and technology brokering
- Inadequate mechanisms for intellectual property protection
- Lack of local suppliers who can deliver quality supplies and lack of policies to develop such suppliers
- High dependency on foreign suppliers and imports
- Lack of good education and training institutions to upgrade skills
- Ineffective legislation and incentives such as tax holidays, tariff adjustments, and industry parks to promote technology transfer
- Bureaucratic delays at various levels of government in obtaining approvals and clearances for finalising technology transfer agreements

- Ineffective and sometimes excessive government intervention and regulation
- Foreign exchange restrictions
- Inability of new ventures to compete with former monopolies, often owned by government
- Uncertain tax environments

These problems continue to affect SMEs and even large firms in many developing nations. While a SME may not be able to handle problems related to the operating environment and the NIS, it should nevertheless guard against these while working with the relevant Business Associations and Chambers of Commerce to lobby governments to rectify these.

Life Cycle Approach for Planning and Implementing a Technology Transfer Project

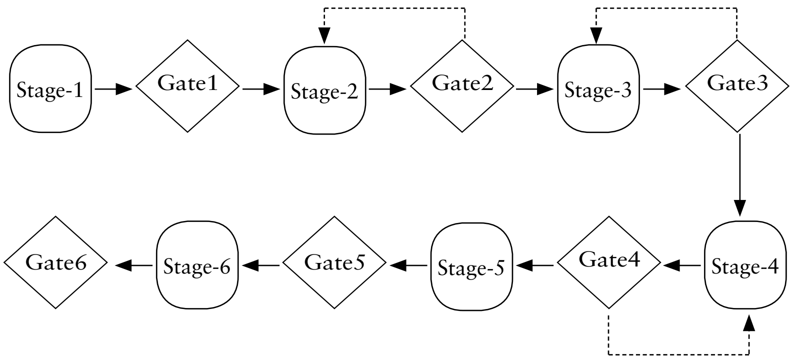
The "Life Cycle Approach for Planning and Implementing a Technology Transfer Project" is based on the stage-gate structure developed by Jagoda and Ramanathan (2005) for developing a systematic approach for planning and managing International Technology Transfer (ITT). For the sake of convenience and expository ease, henceforth, this model will be referred to as the TTLC (Technology Transfer Life Cycle) approach.

The TTLC approach takes a holistic view of a TT project from its "conception" right up to its "conclusion" and is based on the recognition of the fact that a life cycle of a TT project can be looked at from a process perspective as consisting of six major stages as follows.

- Identifying the technology needed and making a business case to obtain corporate approval
- Searching for possible technology sources and assessing offers
- Negotiating with short-listed suppliers and finalizing the deal
- Preparing a TT implementation plan
- Implementing and assimilating
- Assessing the impact of the TT project

This life cycle has been developed based on the lessons learnt from the study of popular models of technology transfer that have been reviewed in the previous section of this paper. The major stages in the life cycle are shown schematically in Figure 1. It can be seen that, in this generic framework, each stage is associated with a gate. The stages are made up of prescribed tasks with cross-functional and simultaneous activities. The gate or controlling point is at the entrance to each stage. Using the information generated at each stage, in-depth and critical evaluation is carried out at the gate that follows the stage. Based on the evaluation, a decision may be taken to go forward, kill the project, put it on hold, or recycle it. It is envisaged that, through this approach, proactive measures could be taken to avoid or minimize problems thereby enhancing the chances of successful TT. The main advantage of such an approach is that it could ensure that major activities are not carried out carelessly or even missed.

Figure 1: The Life Cycle Approach for Planning and Implementing Technology Transfer



Stage 1: Identifying CVD enhancing technologies	Gate 1: Confirming identified technologies
Stage 2: Focused technology search	Gate 2: Technology and supplier selection
Stage 3: Negotiation	Gate 3: Finalising and approving the TT agreement
Stage 4: Preparing a TT project implementation plan	Gate 4: Approving the implementation plan
Stage 5: Implementing technology transfer	Gate 5: Implementation audit
Stage 6: Technology transfer impact assessment	Gate 6: Developing guidelines for a new project

Stage 1: Identifying Core value Determinants (CVD) Enhancing Technologies

All enterprises whether they are large firms or SMEs can compete effectively only on the basis of "customer value creation." Customer value may be defined as a function of quality, delivery, flexibility, convenience, and cost (Ramanathan, 2001). Quality represents how well a specific good or service meets customer expectations. Speed describes the time needed to design, produce, and deliver the good or service as characterised by determinants such as cycle time and speed to market. Flexibility reflects how easily and quickly the firm can modify goods or services to meet customer needs in terms of aspects such as options and extent of customisation possible. Creating convenience for the customer implies not only speed of service, but also self-service, process visibility, and easy to use, streamlined, consistent, and reliable customer service. Lastly, cost refers to all objective and subjective costs that the customer incurs to acquire, use, and dispose of the good or service and includes dimensions such as discounts, rebates, and incentives.

Customer value is enhanced as quality, speed, flexibility, and convenience increases while cost decreases. These five determinants of customer value creation may be referred to as core value determinants (CVDs) (Ramanathan, 2001). To ensure sustainable competitive advantage a firm must offer its customers a CVD profile that sets it apart from its competitors. Thus, in Stage 1 it is important for the transferee firm to decide what technology or technologies it needs to create a unique CVD profile that will enhance its competitive edge vis-à-vis its competitors. The key activities that must be carried out at this preliminary stage of the technology transfer project are the following:

- An informal technology transfer steering committee (TTSC) is set up to study how competitors are using technology to enhance customer value and what technologies are available that could deliver even greater value.
- A list of technologies needed is developed and technology roadmaps are constructed to understand future trends of these identified technologies.
- Information for this is obtained through Internet searches, study of technical publications, exchange of communication with potential suppliers of technology, contacts with universities, etc.
- A quick market assessment that examines market size, market potential, and likely market acceptance of the proposed initiatives is carried out, mainly through the use of marketing expertise and contacts with key users.
- A technical assessment is also carried out to estimate, approximately, the resources and capabilities needed to adopt the new technologies, time needed, costs involved, likely risks, and possible barriers (including policy, legal and regulatory aspects).

Gate 1: Confirming Identified Technologies

Gate 1 is a "critical but supportive" screen. The decision-makers, usually a top management team, develop a set of "**must meet**" criteria to review the proposal. The criteria could include:

- Strategic alignment
- Project feasibility in terms of technical and resource considerations
- Magnitude of opportunity
- Market attractiveness
- Sales force and customer reaction to the proposed technology
- Regulatory, legal, and policy factors

Financial returns are usually assessed at this gate using simple financial calculations such as payback period. The decision-makers will, at this gate, modify, confirm the composition of the TTSC which will then be in charge of the project.

Stage 2: Focused Technology Search

This is probably the most important stage where detailed investigation is carried out by the TTSC. It is here that a strong business case for the technology transfer is built. This includes specifying in detail the following:

- How the technology sought is expected to enhance customer value by influencing the CVDs
- What components of technology are needed (hardware, skills, information, and organisational arrangements)
- The extent to which the abilities to use the technology are available in-house and what gaps have to be bridged
- The resource commitments needed and the expected benefits
- Prioritised short-listing of suppliers for the technology based on their business strategy, technological capabilities, experience in handling TT projects, past performance, and cross cultural expertise.
- Competitive analysis to assess the impact of the technology sought on competitiveness.

Based on a consideration of these aspects, a business case is developed that includes clear technology specifications, discounted cash flow (DCF) analysis, project justification, and business plan. Development of this business case requires multidisciplinary interaction and cross-functional cooperation. If this stage is carried out poorly it could have adverse impacts at the remaining stages and cause serious difficulties.

Gate 2: Technology and Supplier Selection

This is the final gate prior to the formal negotiation and launch stage where the project can be killed before it enters a heavy spending phase. This gate gives the go-ahead for a "heavy spend." Gate 2 critically examines the analysis of Stage 2 and rechecks against the major criteria used in Gate 1. The following steps need to be followed very carefully at this gate.

- All suggestions with regard to technology choice, components of technology needed, capability gaps to be bridged, resource commitments needed, expected benefits, and supplier profile ratings are critically examined.
- The technology will be assessed very rigorously using techno-economic, socio, and politico-legal factors.
- The preferred supplier ranking will be reassessed rigorously based on strategic fit and process support capability and may be modified from the ranking proposed in Stage 2.
- The financial analysis (DCF) is rechecked very rigorously here.
- The TTSC may have to revise the analysis in the light of the critical evaluations (as indicated in the figure) and submit the new analysis for further evaluation.

If the decision is a Go-decision then the TTSC is converted to a full technology transfer project team that is empowered, multifunctional, and headed by a leader with authority.

Stage 3: Negotiation

This is a critical stage where the TTSC now negotiates with the shortlisted suppliers. A critical issue in TT negotiation is the valuation of the technology to be transferred. The extent to which both parties can influence price depends on their respective bargaining power. The transferor's power arises out of the resources possessed such as ownership of a desired technology, brand name, reputation, management expertise, capital, and international market access. Transferee power often tends to have its roots in local knowledge and networks, access to local markets, raw materials and low cost labour, and political connections. To ensure effective negotiation, frequent contact and communication between both parties is imperative. The following activities need to be carried out at this stage:

- Agreeing upon a basis for the valuation of the technology and reaching agreement on issues related to payments and intellectual property protection – both short-term and strategic benefits have to be examined.
- Delineation of each party's contribution and responsibilities towards the TT project.
- Discussion of issues and methods related to the transfer of codified and uncodified aspects of technology including training.
- Creation of effective channels of communication between both parties including visits to each other's facilities.
- Consultation with government authorities to ensure concurrence with government policies and identification of possible barriers, likely policy changes and government support available.
- Finalising the most appropriate mechanism(s) for transferring the technology components sought.
- Preparation of a detailed transfer agreement with emphasis on ensuring intellectual property protection.
- Reaching agreement upon payment amounts, procedures, and time frames.

Gate 3: Finalising and Approving Agreement

This gate is operationalised once the negotiations have reached a satisfactory level and the parties express the desire to finalize the agreement through the drawing up of a legal agreement. This gate will critically evaluate the following:

- The comprehensiveness of the detailed transfer agreement
- The adequacy of intellectual property protection arrangements
- The appropriateness of the proposed mechanism(s) for transferring the technology
- The suitability and affordability of the payment amounts, procedures, and time frames

Stage 4: Preparing a Technology Transfer Project Implementation Plan

At the beginning of this stage a transferor of technology would have been chosen and since the creation of a sound organisational infrastructure is critical to the implementation of TT, this stage focuses on making organisational arrangements to receive the technology. The main activities during this stage are the following:

- Identification of changes to be made to the organisational structure and work design based on an understanding of the transfer components
- Identification of changes to be made in the knowledge management system and policy regimes to accommodate the new technology
- Development of pragmatic training and education schedules for the workforce that matches with the components to be transferred
- Formulation of measures to build good relationships between the transfer personnel
- Formulation of a realistic TT project implementation plan that can form the basis of a working relationship between the transferor and transferee
- Milestones are specified to help strengthen project management and control.

Gate 4: Approving the Implementation Plan

At this gate, the following aspects will be carefully scrutinised:

- Whether agreement has been reached with the transferor with respect to the schedule
- Adequacy of the training arrangements
- Adequacy of the modification of the infrastructure
- Intellectual property protection measures
- Durations of critical activities
- Quality assurance procedures
- Payment schedules

If these are satisfactory then a go-ahead signal will be given. Otherwise revisions will be needed. At this gate an initial payment to the transferor, if specified in the agreement, will also be approved.

Stage 5: Implementing Technology Transfer

Technology transfer implementation requires good project management. Changes to product or process technology may sometimes be essential to the successful implementation of a TT project. Very often, firms in developing nations are confronted with finding suitable people at this stage and close cooperation with the transferor may be needed to locate required skills. Scheduling the timely arrival of allied materials, parts, and services is essential to ensure successful implementation of the project. Training programs will also have to be scheduled and conducted either in-house or at transferor approved locations. The major activities at this stage include the following:

- Identification of changes to be made to the product or process to suit local conditions and making the necessary adaptations.
- Recruitment and selection of personnel not already available within the organisation and conducting training programs for existing staff.
- Development of improved remuneration plan to facilitate change management.
- Formulation of arrangements with ancillary suppliers of materials, parts and services based on a make vs. buy analysis.
- Maintaining links with government authorities to keep track of policy changes.
- Commissioning the transferred technology on or before schedule.

Gate 5: Implementation Audit

At this gate the scheduled activities and the goals set for the TT project are evaluated. The focus should be on gaining an understanding of barriers to the successful implementation of TT. The audit may focus on the evaluation of project implementation with respect to critical factors such as:

- Commitment displayed
- Conflicts experienced
- Time frames
- Cost incurred
- Quality achieved
- Extent of learning and skill upgrading
- New knowledge generated
- Communication effectiveness

The compilation of a comprehensive audit report outlining the lessons learned and identifying critical success and failure factors is important at this gate so that future TT projects could benefit from these insights.

Stage 6: Technology Transfer Impact Assessment

Assessing the impact of a TT project is difficult because it is a complex process with multiple outcomes that could emerge throughout the life of a project. Also, the intangible benefits of a TT project are difficult to evaluate. However, a well-structured impact assessment could be extremely beneficial and the impacts need to be assessed from customer, market, financial, technological, and organisational perspectives. The following activities are proposed for this last stage.

- Development of a "Balanced Scorecard (BSC)" approach to assess impacts.
- Identification of the variances (if applicable) between actual and expected outcomes and the formulation of organisational corrective measures.
- Examining the feasibility of improving the transferred technology.
- Identification of new or complementary technologies that could be transferred to consolidate the gains made.

Gate 6: Developing Guidelines for Post-Technology-Transfer Activities

At this gate important decisions have to be taken as to whether to continue to use the technology by improving it incrementally or go for another TT project. Successful TT projects can lead to strong and long partnerships between the transferor and the transferee and new projects could be initiated in a variety of ways. At this gate guidelines may be formulated, based on the experience gained at all the previous stages and gates for post-technology-transfer activities such as:

- A new technology transfer project
- Internal development
- A mix of both in partnership with the transferor.
- These decisions can then be fed into the corporate planning process of the organization.

Summary Remarks on the TTLC Approach

The TTLC approach is not purely conceptual. Its practical relevance, usefulness, and validity have been established through several case studies carried out by Jagoda (2007) in Australia and Sri Lanka. The main advantages of the TTLC approach are the following:

- The TTLC approach ensures that a TT project is considered holistically and incorporates much of the wisdom shared by various researchers and practitioners through their technology transfer models.
- The TTLC approach is structured to enable SMEs avoid many of the problems that they normally face when planning and implementing a TT project.

- It is a good way to incorporate cross-functional cooperation in planning and managing TT projects and also ensures that important activities are not forgotten or carried out carelessly.
- A single empowered team is responsible from start to finish. This avoids turf wars.
- All projects may not have to go through all the stages. Low risk projects may go quickly to the latter stages.
- The approach must not be seen as a bureaucratic system. It actually facilitates the development of a streamlined system with clear agreed upon, and visible, road map.

Clearly the success of the approach will depend upon the skills possessed by the managers involved in the TT project to carry out the activities effectively at the stages and gates. Thus, organisations that are serious in competing in today's global business setting must develop such skills on a priority basis.

Note

1. This annexure is drawn verbatim from part of a paper by Dr. K. Ramanathan, Head of APCTT, titled 'An Overview of Technology Transfer and Technology Transfer Models' at http://tto.boun.edu.tr/files/1383812118_An%20overview%20of%20TT%20and%20TT%20Models.pdf, accessed on September 16, 2018.

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In recent years, transfer of defence technology to India, as an alternate route to indigenous development, has been frequently brought up with widely varying views from the Indian defence technology fraternity. Some lament its failure to help India achieve self-reliance, while others suggest it can enable India to leapfrog ahead. While it has been paradoxically, often found to be more expensive than outright purchase of defence systems, there are indications that countries such as Israel, South Korea and China have gained immensely from it. While there has been a flood of ToT proposals from foreign OEMs after the launch of the Make in India initiative, there have been few proposals which have materialised and a miniscule number successfully implemented. Acknowledging the need to unravel these mysteries, this book attempts to throw light on the entire range of connected aspects from a brief historical perspective to an understanding of its fundamentals and nuances, to how ToT should be aligned with national goals and there on to its implementation issues. Initially addressing the most conventional mode and its complexities, it expands to touch upon the other modes, then the unconventional ones, the facilitators such as offsets and finally the transaction in its widest sense. Thus enveloping the complete spectrum, it brings its insights together to converge on a possibly successful arrangement for India. Written in an explorative, questioning style, this book will intrigue interested readers and propel the Indian defence technology community to dwell on its findings and suggestions for the formulation of a cogent way forward.

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₹ 980.00

KNOWLEDGE WORLD

KW PUBLISHERS PVT LTD

www.kwpub.com

ISBN 978-93-89137-17-0

9 789389 137170