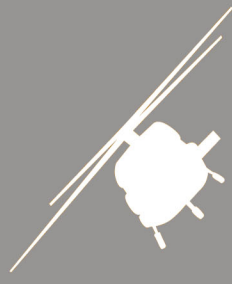
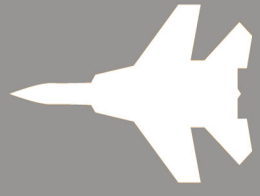
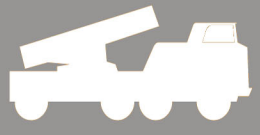
VIF Task Force Report - Part II







Achieving Self Reliance through Indigenous R&D by DRDO/Industry

Vivekananda
International Foundation

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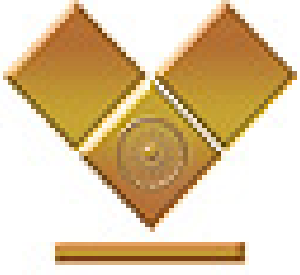

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Task Force Members

1. **Vice Admiral Raman Puri (Retired)** is currently a member at the National Security Advisory Board.

2. **Brig Dr Anil Sharma (Retired)** is currently the Additional Secretary cum Principal of Yogoda College, Ranchi University.

3. **Rear Admiral Dr. Sanatan Kulshreshtha (Retired)** superannuated from Indian Navy as Director-General of Naval Armament Inspection (DGNAI) and is currently a Member of the Safety, Testing and Evaluation Panel of the Armament Research Board of the DRDO.

4. **Commander Dinesh Singh (Retired)** currently manages the defence business at Tata Consultancy Services.

5. **Lt. Gen. A.V. Subramanian (Retired)** superannuated from the Indian Army as the Director-General of Weapons and Equipment at IHQ (Army).

6. **Shri Amit Cowshish (ex- FA Acquisition)** is a former Financial Advisor (Acquisition), Ministry of Defence.

7. **Dr. Kota Harinarayana** is currently a SERB distinguished fellow at CSIR-NAL and founder chairman, General Aeronautics pvt ltd (A startup incubated by IISc ,Bangalore).

Foreword

The global pandemic Covid-19 has taken a huge human and economic toll on India. The country is likely to face severe resource crunch in the years to come. The affordability of the import of high technology weapon systems from abroad will become uncertain. In this backdrop, indigenisation of defence production assumes great urgency. This is the time to give a big push to the indigenisation of defence production by building on achievements so far and carrying out radical reforms of our planning processes, procurement procedures, and augmenting indigenous research and development, creating intellectual property and building new systems engineering capabilities based on emerging technologies. This is the time to reduce overwhelming dependence on imports of weapons systems.

The Vivekananda International foundation is committed to the cause of indigenous defence production. In 2019, we had published a report on Make In India in the defence production sector. The report was released by the then Hon Raksha Mantri Smt Nirmala Seetharaman. We take great pleasure in publishing Part 2 of the report prepared by a task force of experts led by Vice Admiral Raman Puri (Retired). The team members have decades of experience in different facets of defence production.

Part one of the report had brought out the shortcomings in the Long-Term Integrated Perspective Plan (LTIPP) document, which lacked a long term vision of technological capability enhancement in the country. Similarly, the defence acquisitions based on a system of Service Qualitative Requirements (SQRs) and Preliminary SQRs (PSQRs) requires a major reform to promote Indianisation. The report looks into this aspect carefully and makes several suggestions

Part 2 of the report examines in detail the reasons why India's progress in indigenisation of defence manufacturing has been slow despite several outstanding achievements of the past. The reliance on imports of high-tech weapon systems has been addictive. This has impacted the indigenous effort adversely. The report goes into the detail of indigenous technology development, prototype making, trials and evaluation, production and postproduction phases of indigenous weapon systems, identifying the gaps in the prevalent institutions, mechanisms, procedures et cetera.

Another important recommendation the task force report makes is that there ought to be a pre-technology development phase before a project is undertaken. The reform of the trial and evaluation method needs a complete overhaul because that is a major source of delays in indigenous production.

Except for a few exceptions, the involvement of the Indian private sector in defence production is limited even though defence manufacturing was opened to the private sector for some years now. The report It makes several recommendations about enhancing the role of the private sector in defence production through long and enduring partnerships.

Based on the lessons learned from successful examples of Indianisation in the past, the report assesses that "no further imports are required for most of our fighters and helos, ships/ submarines/ artillery systems, armoured fighting vehicles both wheeled and tracked, missile systems, radars, EW systems and C3I systems, software-defined radios, other communication systems and most of the electro-optical systems."

Defence Research and Development Organisation (DRDO) is the apex organisation in the country for R&D. It has several achievements to its credits but it has also been criticised for delays. The report examines at length why this is the case. It pinpoints several areas in which the DRDO needs to be strengthened, particularly concerning its human and financial resources. Research and Development Organisation also requires a certain flexibility in its working. The task force report reiterates an earlier recommendation that the DRDO should be transformed into a Defence Technology Commission with a due autonomy, just as the Space Commission and the Atomic Energy Commission have. This will go a long way in reforming the institutions and mechanisms and procedures that are essential for promoting Indianisation.

Keeping in mind the changing security environment and the emergence of new technologies, the task force report recommends that the country should launch certain indigenous programs which would be vital for India. Their recommendations include the launch of the conventional submarine and nuclear attack submarine programme, hypersonic missile systems, integrated ballistic and cruise missile systems, fifth-generation manned fighter technology, development of gas turbines for various platforms, transport aircraft programme for civil and military requirements, unmanned combat aircraft, unmanned ASW surface vessels etc. The LTIPP should include these technologies in its vision. Development of these programs will help the country to become self-reliant in key strategic technologies and also give a fillip to indigenous research and development, production et cetera.

I would like to thank Vice Admiral Raman Puri, PVSM, AVSM, NM, VSM (Retired) – Chairman, Brigadier (Dr.) Anil Sharma (Retired), Lt. Gen. A.V. Subramanian (Retired), Shri Amit Cowshish (ex- FA Acquisition), Rear Admiral Sanatan Kulshreshtha (Retired), and Commander Dinesh Singh (Retired) and Dr. Kota Harinarayana for their hard work stretching over two years in the preparation of these reports. I would also like to put on record my appreciation of Radhika Daga's valuable help to the task force in its work.

I hope that the report will be read with interest by policy makers as well as others who are interested in the subject

Dr. Arvind Gupta
Director,
Vivekananda International Foundation

New Delhi
6 May 2020

List of Abbreviations

AAP	Annual Acquisition Plans
ADA	Aeronautical Development Agency
AEC	Atomic Energy Commission
AFV	Armoured Fighting Vehicles
AHSP	Authorized Holder of Sealed Particulars
AI	Artificial Intelligence
AJT	Advanced Jet Trainer
ALH	Advanced Light Helicopter
AMCA	Advanced Medium Combat Aircraft
AON	Acceptance of Necessity
APAM	Anti-Personnel Munition
APS	Avtomat Podvodny Spetsialnyy
AR&DB	Aeronautics Research and Development Board
ARRV	Armor Repair and Recovery Vehicle
ASLV	Augmented Satellite Launch Vehicle
ASR	Air Staff Requirements
ASW	Anti-Submarine Weapon
ATGM	Anti-tank Guided Missile
ATP	Acceptance Test Procedure
ATVP	Advanced Tactical Vessel Program
AUCRT	Accelerated Usage Cum Reliability Trials
BDL	Bharat Dynamics
BEL	Bharat Electronics Limited

BEML	Bharat Earth Movers Limited
BFSR	Battle Field Surveillance Radar
BLT	Bridge Laying Tank
BOM	Bill of Material
BPC	Bulk Production Clearance
CDR	Critical Design Review
CEMILAC	Centre for Military Airworthiness & Certification
CFA	Competent Financial Authority
CMM	Capability Maturity Model
CONOPS	Concept of Operation
CVRDE	Combat Vehicles Research and Development Establishment
DA	Development Agency
DCPP	Development cum Production Partner
DDP	Department of Defence Production
DGPP	Directorate General of Perspective Planning
DGQA	Directorate General of Qality Assurance
DPP	Defence Procurement Procedure
DSIR	Department for Scientific & Industrial Research
DTC	Defence Technology Commission
EMC	Electromagnetic Compatibility
EME	Corps of Electronics and Mechanical Engineers
EMI	Electromagnetic Interference
EPP	Enhanced Performance Parameters
EW	Electronic Warfare
FB	Failure Board
FCS	Flexible Complementing Scheme
FDR	Final Design Review
FET	Field Evaluation Trials
FICV	Futuristic Infantry Combat Vehicle
FMBT	Future Main Battle Tank
FMEA	Failure Mode Effect Analysis
FMS	Foreign Military Sales, US

FMV	Swedish Defence Materiel Administration
FOPM	First of Production Model
FPGA	Field-Programmable Gate Array
FRCV	Future Ready Combat Vehicle
FTA	Fault Tree Analysis
FY	Financial Year
FYAP	Five Year Acquisition Plan
FYP	Five Year Plans
GAETEC	Gallium Arsenide Enabling Technology Centre
GAO	Government Accountability Office
GFR	General Financial Rules
GSLV	Geosynchronous Satellite Launch Vehicle
GSQR	General Staff Qualitative Requirement
HAL	Hindustan Aeronautics Limited
HVF	Heavy Vehicles Factory
IAC	Indigenous Aircraft Carrier
ICV	Infantry Combat Vehicle
IDDM	Indigenously Designed, Developed and Manufactured
IDS	Integrated Defence Staff
IED	Improvised Explosive Device
IFCOS	Integrated Futuristic Combat Systems
IFDSS	Instant Fire Detection and Suppression System
IGMDP	Integrated Guided Missile Development Programme
ISO	International Standards Organization
ISRO	Indian Space Research Organisation
JPMT	Joint Project Management Team
JRF	Junior Research Fellow
JRI	Joint Receipt Inspection
LCA	Light Combat Aircraft
LD	Liquidated Damages
LOC	Line of Control
LRIP	Low Rate Initial Production

LSP	Limited Series Production
LTE	Limited Tender Enquiry
LTIPP	Long-Term Integrated Perspective Plan
LTTPP	Long Term Technology Perspective Plan
MBSE	Model Based Systems Engineering
MBT	Main Battle Tank
MMIC	Monolithic microwave integrated circuit
MMRCA	Medium Multi-Role Combat Aircraf
MQAP	Master Quality Assurance Plan
MR	Medium Repair
MRL	Manufacturing Readiness Level
NABL	National Accreditation Board for Testing and Calibration Laboratories
NAI	Naval Armament Inspection Organisation
NASSCOM	National Association of Software and Service Companies
NATO	North Atlantic Treaty Organization
NBC	Nuclear Biological Chemical
NCNC	No Cost No Commitment
NRE	Non-recurring engineering
NSQR	Naval Staff Qualitative Requirements
OEM	Original Equipment Manufacturer
OF	Ordnance Factory
OFB	Ordnance Factory Board
OJT	On the Job Training
OSA	Official Secret Act
PDR	Preliminary Design Review
PGM	Precision Guided Missiles
PMR	Project Management Review
PNC	Prices Negotiating Committee
PSLV	Polar Satellite Launch Vehicle
PSQR	Programme Standards and Quality Reports
QAP	Quality Assurance Plan
QC	Quality Control

QCBS	Quality and Cost Based Selection
QR	Qualitative Requirement
QT	Qualitative Tests
RAC	Recruitment and assessment centre
RFI	Request for Information
RFP	Request for Proposal
RLV	Reusable Launch Vehicle
RM	Raksha Mantri
ROI	Return on investment
ROSE	Return on Security Enhancement
ROV	Remotely Operated Vehicles
RPG	Rocket-Propelled Grenade
RUR	Rashtriya Udyog Ratna
SBIR	Small Business Innovation Research
SCAP	Services Capital Acquisition Plan
SDR	Software Defined Radio
SHQ	Service Headquarters
SI	System Integrator
SIPRI	Stockholm International Peace Research Institute
SLA	Service Level Agreement
SLV	Satellite Launch Vehicle
SME	Small & Medium Scale Enterprises
SOC	Statement of Case
SP	Strategic Partnership
SPC	Statistical Process Control
SQR	Staff Qualitative Requirements
SWOT	Strengths, Weaknesses, Opportunities and Threats Analysis
TARB	Technical Assessment Review Board
TASL	Tata Advanced Systems Limited
TEC	Technology Evaluation Committee
TMS	Thyssenkrupp Marine Systems
TNT	Trinitrotoluene

TOT	Transfer of Technology
TRL	Technology Readiness Level
UATT	User assisted trial
UAV	Unmanned aerial Vehicle
UET	User Evaluation Trial
UOR	Urgent Operational Requirement
WESEE	Weapons and Electronics Systems Engineering. Establishment
WPC	Wireless Planning & Coordination Wing

Chapter 1

Introduction

Felt Necessity

India is at the cusp of metamorphosing from a regional player to one with global clout. As India's geo-political and economic ambitions grow, it needs to develop robust indigenous manufacturing capabilities and ecosystem to secure its ambition for self-reliance in the Aerospace and Defence industry.

The current picture however, is quite opposite. India is ranked among the top 10 countries in the world in terms of military expenditure. In 1995-2000, India was the sixth largest arms importer; the bill was $7 billion, which was around 50 percent (in terms of value) of what the largest importer i.e. Taiwan had spent. Compare it to last 5 years (2013-17). As per The Stockholm International Peace Research Institute (SIPRI) reports, India rose to the top, spending over $18 billion, which was more than 12 percent of that of the second largest importer (Saudi Arabia). That is not all. Add the life cycle costs of spare parts, upgrades etc, and seller nations would finally end up earning many times the cost of platforms and systems they export.

From the data available in the Public Domain it can be clearly inferred that building capability through the Buy route is clearly unsatisfactory on grounds of low effectiveness of many of the procured systems in performing to our Mission Needs, especially in the environmental extremes peculiar to our areas of Operations, vulnerability to supply chain breakdowns and high costs both on the Capital and Revenue accounts often leading to sub-optimal investment in Ammunition (including missiles) and other lines of development that make the system effective.

The Buy and Make route where manufacture is sought to be undertaken through TOT- studies clearly shows that 'technology' is far from transferred and what we achieve is just license production with some value addition but dependence remains on critical components, software and so on. The ill effects of outright Buy, to a large extent apply to this route too. The country's economy also suffers on such purchases as the Industry hardly gets any technology infusion that can be horizontally diffused due to end user certification and other restrictions imposed, and export potential cannot thus be possibly exploited. Further, R&D and technology development in the country suffer as we land up paying extremely high R&D costs of other countries (in this very little benchmarking is feasible anyway as many PNC's and subsequent in service negotiations will show) without gaining any 'Technology' infusion.

The net result is that despite numerous revisions and policies, private industry remains pushed to sidelines and imports dominate unabated. Unfortunately, all DPPs tend to reinforce the policy paradigm – more things change, more they remain the same and ultimately we continue in the situation of BUY whatever we can and build only that which we must. This is clearly unsustainable. Ultimately not only the budgeted capital account will not suffice but also the revenue budgets will fall short of the requirements greatly affecting combat readiness. Also with the large diversity in platforms and systems that has resulted from our current procurement process from varied sources makes logistical management an uphill task leading to deficiencies in combat readiness. This phenomenon has already set in.

That we are the only importer of arms amongst global powers, must act as a dampener and reality check for our leaders as no nation in history has ever earned respect, safeguarded its freedom and unyoked its foreign policy on the strength of imported arms and ammunition. The importer countries hold leverage over us, which they would invariably use during geo-political crisis situations, where our vital interests are perceived to be clashing with theirs. Many times in the past our strategic choices had to be recoiled due to such dependencies.

The rapidly changing regional and global security challenges have forced countries across the world to rethink their defence strategies and plans. This is certainly the case in South and South-East Asian regions. Rapid proliferation of dual use technologies, blurring of external and internal security challenges and shrinking of design to production cycle has synergised military and civilian industry to the extent that the leading players in defence capability localisation also lead in industrialisation.

Tapping its globally recognised scientific and engineering talent and harnessing it for indigenisation led, modernisation of armed forces needs to be made a top priority for the government. We should not limit ourselves to 70: 30 ratios etc, but aim for total self-reliance. It is important to flag here that Make in India should imply- conceptualised, designed, technology and prototype development leading to production in India with maximum indigenous contents. It should not be defined by the percentage of indigenous components fitted, which most of the time leads to subjective interpretations and is moreover not a feasible goal.

It is clear from the ongoing arguments that India has to pull out all stops to attain its stated but not successfully pursued goal of developing indigenous defence capability.

Terms of Reference

Keeping the foregoing voids in perspective, VIF setup the Task Force to investigate as to why India continues to be at around the 70 % import level. During the discussions with multiple stake holders many issues that stultify indigenous defence R&D and production were identified. These have been coalesced together into the following key areas proposed for examination: -

- Consider the adequacy of currently available planning documents for formulating meaningful technology and development plans (i.e. Long-Term Integrated Perspective Plan (LTIPP), Five Year Plans (FYP), Annual Acquisition Plans (AAP), and Qualitative Requirements (QR)) based on which R&D and industries are currently required to plan their technology and product realisation plans.

- Development of Technologies and Proof of Concept (PoC) by Academia/R&D organisations/ industries and identifying the challenges and the concomitant way forward.
- Major road blocks and suggested improvements at the stage of prototype development (financial and nomination issues, user and industrial interaction required and conduct of trials leading to user acceptance, issue of timelines in various trials etc).
- Impediments in limited series production and protracted post-production acceptance?
- Entry into service, obsolescence management and mid-life up gradation (attendant role of industry, DRDO and users).
- Inability of procurement procedure to encapsulate costing uncertainties of participating industries associated during R&D.

Essential Issues

Consequent to the discussions and the analysis, the essential issues for study can be grouped under two basic factors.

- How do we set the requirements of the armed forces to achieve our goal of realising their needs through indigenous research, development and production?
- The process to be adopted thereafter to meet these requirements efficiently through indigenous research, development, trials, evaluation and Production.

Chapter 2

Overcoming Voids for Road Ahead

Recapitulation – Part I

R&D Requirement Setting through Strategic Guidance leading LTIPP / LTTP Formulation

Development of indigenous systems requires time for realising the technologies required, establishing adequate critical facilities, developing the human resources and integrating the same into systems. Thereafter, time is required for various trials, evaluations and its production, before inducting the system into service. This timeframe could be anything between 10-15 years and beyond depending upon the complexity of the system and nation's technology readiness levels available.

DPP 2016 enunciates that the proposals for acquisition of capital assets flow from the defence procurement planning process, which will cover the long-term, medium term and short-term plans (LTIPP, FYAP and AAP).

Under Design and Development Cases, SHQs will initiate statement of cases (SoCs) for design and development proposals from LTIPP/FYAP/AAP in consultation with DRDO/DPSUs/OFB (Para 72(a) of Chapter II). However, it will be clear that FYAP and AAP (with limited time span of five and one year respectively), do not provide the required time for development and production of indigenous systems. LTIPP therefore, is the fountainhead from which the military weapon systems requirements must emanate and serve as the basic document for the development of technologies and systems indigenously.

In the sphere of defence planning, the study observes that the main lacunae lie in the lack of an integrated guidance document which would enable the evolution of LTIPP as capability and security enhancement investment program for the next 15-20 years from which, each of the services could draw their schemes/ project programs on long term basis. This would lead to development of technologies and production infrastructure. This has been addressed in Part 1 of the report.

The process to be adopted thereafter to meet these requirements efficiently through indigenous Research, Development, Trials, Evaluation and Production is covered in the subsequent chapters of this report.

Success Story of DRDO under Design and Make in India

DRDO's accomplishments in developing unique technologies and wide range of complex systems, not attempted by any other science agency in the country, deserve to be commended. Wide range of missiles (Prithvi, Agni, Akash, Nag), Radar systems (S-1000, Indra, BFSR-SR, CAR), fighter aircraft [LCA (Airforce), LCA (Navy), Trainer], Main battle tank (Arjun), Rocket system (Pinaka), Underwater systems (APSOH, HUMVAD, HUMSA, USHUS, MAREECH, NAGAN, IAC, VARUNASTRA etc), communication systems, electro optic systems, EW systems etc. have been developed and accepted by armed forces for induction. There is no denial of DRDO's critical role in advancing India's strategic programmes. DRDO has succeeded in developing a large number of private industries (~800 small, medium and large industries) which continue to play a key role in establishing domestic defence industry base in the country. With demonstrated capabilities in niche areas of defence technologies, DRDO is a national asset.

Identifying the Grey Areas

Weakness in Deployable Systems

While DRDO's accomplishments are impressive, there are two areas where DRDO is weak in creating deployable systems. These are airborne sensors and power plants for aircraft and battle tanks. Technology gaps are widening in these areas.

In case of airborne sensors, in the absence of manufacturing base for electronic components such as chips, detectors, MMIC devices, FPGAs, RF components, all these components are imported with attendant denials / delays / restrictions.

In case of gas turbine engines, the country has suffered due to a lack of component test facilities, altitude test facilities and in-flight test facilities. Also, in the absence of manufacturing facilities for heavy forgings and precision castings, DRDO labs and even production units have to depend on facilities abroad, leading to extended time schedules and cost escalation.

Delays in Launching the Process of Productionisation

The DRDO is a development agency. Its work normally stops at successful development and trials of prototypes. Subsequence task of engineering a prototype into a production system needs to be done at production houses by a dedicated design and engineering (D&E) group. Such a group exists in Bharat Electronics for decades whereas other DPSUs and Ordnance factories are creating them now. Absence of adequate D&E support by production agencies lead to avoidable quality and production problems. Converting a prototype to production standards further requires concurrent engineering practices which were followed in the IGMDP programme but with modifications introduced in both the DPP and DPM. This not only results in delays in TOT to the production agency but also additional round of long-winded trials. There is need for urgent reforms in prototype to production processes.

DRDO developed systems such as main battle tank, Light Combat Aircraft, Akash Missile have gone through a long development /production process, leading to delay in their induction into service. It may be noted that the production agencies (OF for main battle tank, HAL for LCA, BDL for Akash missile)

have been accustomed to decades of license manufacture where production tools, processes, equipment are provided by the licensing agency.

However, DRDO being an R&D organisation was able to produce only prototypes. Normally an R&D organisation does not have the expertise in providing **production standard tools, processes and systems.** Dedicated and experienced engineering groups in most of these production organisations, that should undertake the job of converting a prototype to series production system, are either nonexistent or very weak.

As neither DRDO nor nominated production agencies (OFs, BDL, and HAL) have strong production engineering groups, which as stated are now being created, the process of production has been taking long time with suboptimal rate of production.

It may be noted that it is international practice to establish strong production engineering groups at the production agency and not at an R&D organisation.

Technology Development and Pre-Project Activity

Some of the DRDO development projects have gone through large development cycles with time and cost overruns. One of the reasons for escalation in time is that technology developments were taken up only after the sanction of the project in many DRDO Projects. This often led to a situation where technology development took long time with resultant delay in system development. It may be noted that it is a standard international practice to develop technologies and bring them to a level of maturity before project is initiated.

Before project is taken up, considerable pre-project work needs to be done in understanding requirements, identifying technologies, assessing the maturity of available technologies, assessing the requirements of test and manufacturing facilities, understanding the operational environment etc. Quite often enough attention has not been paid to these pre-project activities. This leads to the current flaws in system of formulating QRs. For timely initiation of programmes and projects with the LTIPP, it is essential to achieve these objectives.

Even in ISRO, as part of programme, funds are provided for development of technology, establishment of key infrastructure before taking up project work. Such a practice has not been possible to follow in DRDO except initially with a few programmes like the IGDMP and ATV.

Fabrication (Fab) Facility for Electronics Components

Sensors are vital elements of a weapon system. Electronic components such as MMICs, FPGAs, detectors etc are vital elements of the sensor systems (IR, Laser, Radar etc). DRDO has successfully developed a range of these systems, but there being no manufacturing base in the country, they are dependent on imports for the components. Design and lab scale development done at DRDO could not be manufactured in the absence of fab facilities in the country. Even the fab facilities such as GAETEC were inadequate and could not meet the total requirements. Import of these components was difficult and time consuming due to covert / overt denial regime. **Absence of fab facilities for electronic components continues to be a major cause for prolonged development and production cycles. Our procurement procedures**

requiring global tendering and so on, not only jeopardise confidentiality but also lead to delays and at time denials.

HR Policy – Recruitment, Training, Development and Impact on Outcome

One of the key weaknesses of DRDO is its **HR policy.** There are weaknesses in the processes of recruitment and training of scientific personnel to undertake technology development and systems development.

- Today in DRDO, the average age of scientists has gone up to 47 years and is likely to go up in the coming years. The current recruitment practice is limited to filling the vacancies against retirement. It is well-known that manpower needs to be trained and mentored to make them ready for undertaking responsibilities in advanced R&D areas of DRDO in disciplined areas/ laboratories. While DRDO has been stressing the importance of recruiting well enough, it has not been agreed to, leading to a severe crisis in the human resources available to DRDO.

- The present procedure of DRDO is to select scientists and engineers after completion of their academic qualifications. This is contradictory to the prevalent practice, followed by private industry, which is either through advertisement or campus selection. They select and shortlist suitable students in the beginning of final year and give them an offer, subject to certain basic requirements. Hundreds of industries, including domestic players and MNCs are able to get best of the talent much before the completion of examination. As a result, when DRDO goes to the job market, they are able to source only the best of the rejected lot. This restricts the talent pool in a severe way. Therefore, there is a need to change this process and reach out well before even IT companies and MNCs go to the campuses. Our discussions with some of the institutions reveal that while students are very keen to join organisations like DRDO, since they do not get the opportunities well in time, they are forced to join the other companies. This needs to be addressed without further delay. DRDO may like to study current recruitment practices (e.g. assessment of institutes, seeking first day slot for tests/ interviews, in-house training to bridge skill gaps, On the Job Training (OJT) on live projects, etc.) of large recruiters like engineering/ IT services companies to imbibe best practices on on-boarding best talent.

- After recruiting the scientists and engineers, there is a need for focused post-employment training in areas pertinent to DRDO. As a part of that training, they should also be provided exposure to work done in DRDO and entrusted with project work. This would familiarise them with ongoing work and technologies. Whilst this training method is followed to some extent, there is a greater need for attention in this regard.

DRDO is primarily undertaking **development of systems and system of systems**. This would need an understanding of system engineering concepts and practices, which is not taught in our academic institutions. While the importance is recognised, but no focused training is imparted to the scientists and engineers, either at entry or even at the middle level. This could be one reason for delays in development. Focus must be levied on this area, since it has been recognised world over that the delays occur due to lack of implementation of systems engineering. The concepts of TRL and MRL are also not taught in academic institutions even though they are critical for success of induction of systems developed by DRDO. Hence focused training in these vital should be incorporated.

A multipronged approach is needed to **enhance the overall effectiveness of manpower** of DRDO. It is suggested that an eminent HR professional be hired and he / she should be entrusted with the task of reviewing HR policies, to include practices for improving the motivational level of the scientists and efficiency of the organisation at all levels. The extra ordinary delay in the recruitment process in DRDO is a deterrent for talented people to join the organisation. Absence of a sound system for identifying the aptitudes of the scientists/engineers and providing targeted training to sharpen their abilities is another major weakness. The incentive schemes that would enhance motivation and increase effectiveness are far and few inadequate.

- The development of complex systems would need different engineers and scientists with different capabilities, for example, system engineers who will integrate various disciplines. We need subject matter specialists who will work on discipline areas. We also need managers who can do project management and a few engineers who can integrate the whole system to meet the customer requirements.
- Selection of personnel for these varied disciplines need to **take into account the aptitude**, which is normally done in most of the successful industries. This aspect is not handled in a professional way in DRDO and PSUs. As a result, we do not find the right people to take the responsibility at the right time. This is leading to leadership issues.
- There's a need for **structured training programs** by way of upgrading skills of the existing personnel to equip them with new technology and processes. While such training institutes exist, they are not able to meet the objective.
- The new recruitment to fill the existing vacancies and not planning for future has degraded the capability and capacity of the organisation. **There should be a clear system of recruiting every year, a particular number of scientists and engineers (300 or so)**, so that the continuous inflow of new blood is assured. This will certainly help in keeping the team young and productive. Numbers to be recruited must factor in joining data (versus offers made), attrition rates in new joinees and bench strength required for programmes in pipeline.

While all the above is desirable, we have to recognise the fact that **lack of recruitment in DRDO has created tremendous pressure on the system for delivery of the existing projects and limited the bandwidth available to put their manpower for future projects.**

These lacunae need to be rectified, urgently as the situation is deteriorating each year and will assume alarming proportions in the coming 5-10 years. Long term and short term out of the box measures which gives freedom to employ JRFs without any numerical restrictions, or employment/grant and extensions as recommended by Secretary, DRDO. Lateral induction at scientist D, E and F levels and so on should be seriously considered. Deputation of staff from services and DPSUs (and private sector as well) to DRDO at mid-levels for 3-5 years can help in bringing requisite systems and production engineering knowledge to DRDO. Once back in their respective organisations for higher roles, these officers with a greater understanding of technology and system development processes will be able to take measures for efficient transition of prototypes to production. Thus they would be important links in R&D/ user interface.

Directed Research and Innovation

Directed research and innovation are critical for developing cutting edge technologies and systems. This is far from satisfactory in DRDO. Limited manpower available is engaged in repeated evaluation trials and solving production problems leading to non-availability of highly qualified research personnel in required numbers to guide younger teams on a long-term basis. This pressure on personnel to deal with current project has resulted in lack of urge for acquiring higher qualifications, publishing quality research papers and developing patentable innovations and is an area of weakness and concern.

Funds spent by DRDO for undertaking directed research at its labs and at academic institutions / other research labs / innovative business organisations are quite low. Even though DRDO has setup four research boards and established couple of centres of excellence, the process of sanction of projects and release of funds is very slow. A few years back AR&DB had initiated top-down approach of identifying key technology areas of interest to DRDO and started funding these top down technology initiatives. However, this excellent initiative was stopped recently. This is an unfortunate development. There is a need to revisit and restart this top down approach in crucial technology areas. MoD's recent approach to promoting startups may be dovetailed with DRDO's research boards for optimisation of funding, supervision and better use of end-products/ technologies.

Procurement Process of MoD / DRDO

A slew of policy measures and reforms have been put in place by the Indian MoD since 2014 when the Dhirendra Singh Committee of Experts for Amendments to DPP 2013 including Formulation of a Policy Framework for defence production in India was constituted. In April 2019 the DG Acquisition presented a list of achievements and reforms in the acquisition process which highlighted that issue of Industrial licenses to Private Companies have been speeded up and the DDP has issued 439 licenses covering 264 Private Companies till March 2019. Further, during the last three Financial Years (FY17 to 19) 82% of the AONs accorded by value have Industry oriented categorisation while 61% of contracts (36% by value) in the same period have been signed with Indian Industry.

Notwithstanding the positive trend in shift of the procurement base to Indian Industry, "Make in India" in Defence has not really taken off and we are a long way off from creating a strong Defence Industrial Base in the Country.

In fact, the defence procurement process is biased towards urgent operational requirement (UOR) which translates itself into AAP (two/ three-year need). The AON is given for systems which have been shortlisted by the services in the AAP. This requires a review. As such, whatever is approved as List A in AAP will get operationalised in minimum 5 years and as per past averages, in 10 years or never. For indigenous development under MAKE, MAKE through Mission Mode by DRDO, the AON should be given for systems / platforms needed over next 10-15 years. In addition to this, the responsibility for procurement is dispersed between MoD and SHQ and hence delays. There is no accountability for delays / incorrect projections.

Procurement process in DRDO is one of its major weaknesses. Global tendering process that DRDO adopts for items costing more than 25 lakhs is detrimental to growth of Indian enterprises and achievement of self-reliance. Defence is a strategic and high technology area. The international practice is to identify niche

industries in the country and support them fully. In India, we are doing opposite, by resorting to global tendering. This has resulted in major time delays and retarded the growth of indigenous industry which is essential for success of indigenously developed projects/products and their production and induction into service.

The L1 principle applied in global tendering more often than not inhibits market access and scale for critical material systems developed indigenously. Without large scale that defrays NRE cost over volume, such products are often not cost competitive against imports and lead to shuttering of local industry with technology and vendor base withering away. Technology which is not used is very difficult to sustain and develop further. For example, much of the materials and their manufacturing processes developed at great cost and effort of DRDO and PSUs are imported leading to our continuing to be dependent on critical materials necessary for the manufacture of aircraft engines and others in the country.

Fixed markups on input cost – model applied by DPSUs dis-incentivises them to use local products that are often cheaper and thereby accrue – less profit. Adopting 'import substitution' cost model and allowing SIs to charge higher profit on local products – will flip this scenario in favour of indigenous products. It will also help DPSUs generate sufficient cash from successful products that could be ploughed back in their D&E teams and aid internal R&D. This model will work best for DRDO developed products that are awarded on nomination/ LTE basis to DPSUs/ domestic industry. Assured of higher profits for indigenous products, industry would be able to share R&D expenses as well as pick up slack from DRDO – for further upgrades, thereby freeing DRDO's bandwidth for core R&D.

In many cases there are lacunae in SQRs. Specifications in quite a few SQRs are inconsistent with technology available in the world market. At times, the parameters are unrealistic with regard to actual requirement on the ground. For example, prescribing Remotely Operated Vehicles (ROV) to operate between +50°C to -20°C could not be tested and the possibility of planting of IED in -20°C is remote. In large number of cases, parameters could not be tested during trial evaluation due to lack of testing facilities. Delay in introducing of Bullet Proof Jacket is one such case. One of the parameters specified in SQR for replacement helicopters for Cheetah / Chetak by army was that it should land at 16000 ft, switch off and start. No helipad existed at 16000 ft and hence waiver had to be given at later stage resulting in three years delay and tying up the vital resources of the development agency.

Project Management and Systems Engineering at DRDO

The SWOT analysis has shown that time and cost overruns have taken place in many indigenously developed projects due to;

- Inadequate planning and resource requirement assessment.
- Lack of maturity of technologies required for the project.
- Lack of facilities for testing.
- Lack of eco system / industrial base in the country to undertake the production of materials / components / sub systems.
- Inadequate deployment / availability of trained / skilled manpower.

- Lack of capacity and capability / willingness of production agency nominated.
- Rigid bureaucratic procedures for procurement / project sanction.
- Inability to attract and retain manpower due to slow / irregular recruitment process and inadequate HR policies.

It should however, be noted that in the development of highly technology complex projects, even in very advanced countries with vast experience, large time and cost overruns have taken place. Various measures are taken to reduce cost and time overrun. Key suggestions to reduce time and cost overruns are identified as given below;

- Programme and Project elements
    - In many organisations including ISRO, development has two elements viz. the programme element and project element. For example in ISRO, they have Launch Vehicle programme and various launch vehicle projects such as SLV, ASLV, PSLV, GSLV, RLV etc. The launch vehicle programme would need technologies to be developed, infrastructure to be created, manpower to be recruited and trained, test facilities to be established. These tasks are taken up as programme element ahead of various projects. Funds are provided for the programme before any specific project is taken up. Such an approach is followed by many international organisations.
    - In case of DRDO, there are distinct programmes such as: Missiles, Manned Aircraft, Unmanned Air Vehicles, Underwater Sensors and Systems, EW Systems, Propulsion Systems, Sensors, PGMs, Special materials and processes.
    - Each one of these programmes would consist of various specific projects. In case of missiles, we have surface to surface missiles, surface to air missiles, cruise missiles, long range ballistic missiles, tactical short range missiles etc. The individual projects are launched depending on the requests projected by services and other users. The programme elements need to be launched based on DRDO's LTTPP, overall threat perception, state of available infrastructure in the country and technology forecast.
    - **We recommend funding is provided for programme element ahead of project elements, thereby enhancing the maturity of technologies, enabling recruitment and training of manpower and creation of critical infrastructure.**
- **Systems Engineering – a Key Enabler of Project Success**
    - Over the last 2-3 decades systems engineering as a process has evolved and is applied across the board in all the complex development projects all over the developing world. The benefits of systems engineering have been now well documented. The process mandates **study and capture of concept of operation (CONOPS), requirement capture, concept studies, feasibility studies, system definition, detailed design etc and detailed in depth review at each stage of project development by a stage gate process.**
    - It mandates **application of tools** for each phase of project development. **Feasibility study** is

an important part where system concepts are studied, technology requirements are identified, technology maturity levels are assessed, test, manufacture and other infrastructure requests are assessed, risk levels are identified, risk reduction strategies are indicated, work breakdown structure is worked out, time and cost estimates are assessed. Key technologies whose maturity levels are low are taken up. A thorough review of the output of the feasibility study is done by a cross section of experts, user representatives and top management. This is an important stage to be reviewed and cleared to undertake the next level of project viz. system definition.

- The next major activity in the systems engineering process is **system / project definition**. At the end of this phase, the system definition is completed, technologies are identified based on their maturity levels, requirements are fully defined, and subsystems specifications are worked out. Detailed work breakdown is carried out, partners including production partners are identified, test requirements are worked out, development strategy and production requirements are worked out, detailed cost and time schedules are worked out. Besides technical aspects of the end product, system study also needs to assess operational impact of the product. Simulation tools, rule writing groups and industry is an important stage, the success of which would determine the success of the projects in terms of meeting performance requirements and adhering to time and cost projections. 80 to 90% of the cost is locked at this stage of the project though less than5% of the money is spent. This is a critical stage needing expert support, management attention and user involvement.
- We do consider and strongly recommend that all major DRDO projects follow the systems engineering process. Their stage gates as defined by the process should be compliant to international standards. **Systems engineering groups** should be established in all the System laboratories. However, this approach requires the participation of the users and production agencies with the development agency. And the finalisation of the system specifications as a part of this process. **GSQRs/NSQRs/ASRs as formulated today need a complete overhaul.**

- **Domain Specialisation**
  - Key to success of any complex project is trained and motivated human resource. In a complex project, four types of experts are required;
    - Domain experts (both technical as well as operational).
    - Systems engineers.
    - Technical resources
    - Management experts.
  - A complex project would need people with expertise in all the above four categories. Not every individual is suitable or has aptitude for all these tasks. HR development involves identifying the aptitude of the people and help channelising them in to the respective disciplines. Targeted Training in the respective area is vital. Career progression in the respective areas including cross functional movement, is a must. **Our HR policies should ensure that all four categories have adequate opportunities for career progression.**

- The field of systems engineering would need domain personnel with aptitude for systems engineering. HR organisation of DRDO needs to identify such people and enable targeted training. Indian Navy built Systems Engineering expertise by creating WESEE (in MoD – for better financial support and operational freedom) in 1978 and populated it with their hand-picked technical resources. Duly supported by NHQ with user domain guidance, organisation has owned and executed weapons and sensors integration for every naval ship and submarine ever since. DRDO may like to see if its a model worth emulating across other technology clusters.
- We further suggest that all the young scientists / engineers, in addition to training in domain area, also need to undergo courses in latest quality practices and Innovation to prepare them for work in DRDO. These courses would help to imbibe in them the quest for quality in their work and quest for innovation.
- Subsequently as they progress in their careers, training in systems engineering, technology management and project management needs to be provided by competent experts and experienced systems engineers / project managers, as also using qualities on live courses and also online as available these days.
- For enhancing effectiveness, we recommend mobility of scientists across the labs relevant to their domain, above scientist D level in a planned manner.

- **Test Facilities**
  - These are an important area for the success of any program and must be set up in a holistic manner. For example, Development of Gas Turbine engines is an area where India has not yet come out with a successful product. The Kaveri engine programme is still work in progress needing further refinement in component performance, system reliability and system performance over the full envelope of operation. This would need facilities for testing at a module level (fan / compressor, combustor, turbine, after burner) testing at ground level, testing in high altitude chamber and testing in a flying test bed. Barring the ground level test facility for the full engine, no other test facility is available in the country, forcing the development team to use the facilities abroad. As the development is an incremental process necessitating repeated design, fabrication and testing, absence of test facilities has retarded the development of Gas Turbine engines in the country.
  - **In the absence of a programme and funding, it has not been possible to set up test facilities despite the felt need in the last two decades. We strongly recommend that as part of programme element, the test facilities for module testing, for full scale engine testing in an altitude chamber and flying test bed be funded as a gas turbine engine development programme.**
  - It is now acknowledged that development of a jet engine of this class is going to need technology, of very high order and test facilities as well as engineering skills of cutting-edge nature. Due to this reason there are only four companies (General Electric, Pratt & Whitney, Rolls-Royce and Safran) in the world who have succeeded in making these engines. Another reason for their success is the vast civil aviation engine market that allows for regular funding, large

volumes and commercial incentive. Synergy with civil aircraft development efforts can help India develop similar market for its own aero-engines. Even though Russians have developed very advanced engines for fighter aircrafts, they are not able to compete with the western countries due to limitations of high fuel consumption, low life, high maintenance and higher weight of their engines. Knowing the criticality of this technology, the Chinese government has been investing in the development of jet engines since the last 3 decades to the extent of 20 billion dollars, whereas our investment is about half a billion dollars. It has been the experience all over, that with subcritical funding results are unlikely to be obtained.

- In respect of the Aircraft Development Programme (LCA Mk 1), sufficient funding was provided for creating the facilities for testing the sub-systems. The test facilities created are utilised for not only the LCA programme but all other aviation programmes today. Therefore, we must treat Jet Engine Development as a national programme and provide adequate resources in terms of manpower, technology development, test facility creation and adequate developmental engines and persevere to achieve the end goals.
- We may mention, the development of cryogenic engines by ISRO was an incessant 30-year programme effort within which number of test facilities were created, enormous technology developed and failures experienced. The persevered efforts have led to a successful and matured cryogenic capability. In case of MoD's programmes, such perseverance is not seen other than for strategic programmes.

Services Qualitative Requirements (SQR)

SQRs are essential for DRDO to initiate any mission mode project. The QRs are generated in the service headquarters by staff, which is not particularly trained for this specialised task, as stated above. They are mostly based on marketing brochures/presentations by various foreign companies and tend to include the best technical parameters contained in these brochures.

- QR formulation is a highly specified task requiring staff to clearly state their mission needs, the goals required to be achieved to meet the needs as also the environmental parameters in which the system would need to operate. The staff currently, tasked to evolve QRs is not selected for any demonstrated expertise or competence and thus, is untrained and ill equipped for the job. Also, QR by definition need to only reflect the users requirements, maintenance and logistic support and no RFIs should be necessary for this purpose.
- The detailed systems development thereafter would be undertaken by the development agency, as stated earlier, in consonance with the system engineering practices with participation and full support of the user staff. Currently, services tend to make QRs unrealistic, as has been in the case of the many parameters specified for the LCA. Therefore, it is best to derive the systems specifications, as a result of systems **engineering exercise** through the appropriate stage gates to meet the mission and other needs of the users. Further, the adoption of agile model and concept of spiral development should be incorporated in the development cycle. Build a little, field a little approach, will give users hands-on assessment of gains of R&D and get their buy-in. User feedback at early stages will build stakes within user community and enhance the end product.

- Based on the examination of processes followed in countries such as USA, UK and France, it is recommended that a c**apability development executive be setup and should be supported by an empowered expert group, depending on the system under consideration** with service officers, DRDO scientists and civilian experts. W**e do consider that these recommendations be implemented for speeding up induction of domestically developed equipment.**

Concept of Spiral Development

It may be noted that concept of **"spiral development"** is followed in countries like USA / Russia / France. The first variant of the equipment which meets the basic performance criterion is inducted as Mark I and further variants are inducted in batches with improved performance and other features. A highly successful aircraft such as F-16 of USA has gone through 40 batches of production where each batch had some incremental changes. Similarly, in LCA there has been development of LCA Mk I, LCA Mk IA, LCA Mk II and this leads to continued development of aircraft in defined steps.

- However, this approach is not regularly followed as a structured process, with the user demanding meeting of all the parameters in the very first **user acceptance trials** of the system. This does not help in the development process and retards the achieving of the Make-in-India goals.
- In the first User Acceptance trials, as long as the system performs better than whatever is available in the arsenal today and meeting 75-80% of the mission needs, it should be accepted and inducted. If necessary, it can be inducted in limited numbers.
- It is only though subsequent exploitation of the system that the feedback can lead to improvement. This approach was followed in the Navy for Integrated ASW Computer System for the ships. The first model produced was termed IAC Mod '0'. Today, it has evolved as the standard for all the ships.
- The same approach needs to be followed for LCA Navy project as well. So that there is an incremental development to the twin engine naval fighter requirement.
- **This will also require changes in the rigidity with which QRs are required to be met. These should be reasonably flexible for domestically developed systems and very rigid for systems acquired from OEMs abroad, as explained below.**

It may further be noted that in critical technology areas like jet engine or deck landing aircraft, the nation needs perseverance to succeed. Term like return on investment (ROI) has commercial uses but it must not be applied when dealing with critical technology for national security; instead it should be viewed in terms of **'Return on Security Enhancement' (ROSE)**.

By succumbing to foreign offers, we will put a brake on our ever-developing deck landing aircrafts, after having spent 20 years in coming to a remarkable stage of technology maturation. Such procurements will retard our developmental programmes and degrade our security in real terms.

We strongly recommend "spiral development" approach be followed to enable early induction of domestically developed equipment and weapon systems.

Reforming Trial & Evaluation Process

While the procurement by policy aims to shift from RFPs for Global cases, to those for Indian built equipment, the User trial and evaluation process shows no recognition of this shift.

When equipment that global bidders offer from their product portfolio is sought to be procured, it is appropriate to carry out NCNC trials, evaluate every RFP parameter and avoid any flexibility in evaluation to avoid problems post induction when this equipment are bought and shipped from foreign factories. It may be noted that such an equipment is already developed and productionised in the parent country.

The approach now requires a significant reform with far greater flexibility as procurement is shifting to Indian designed and manufactured equipment with many of the concerns of support and evolution being irrelevant. There are numerous examples of the many challenges faced in the NCNC trial methodology of evaluation as it exists today including ambiguity of the trial directives at the bidding stage.

We recommend that when procurement is from Indian contenders the concept of NC-NC trials should be done away with and either converted to **No Cost with Full Commitment or Development Cost funded with No Commitment as applicable.**

Field Evaluation Trials (FET)

The FET process needs to be simplified and shortened prior to bid opening with reliance on certification and simulation while elaborate trials can be conducted with the L1 and L2 bidders.

Prolonged field trials are often the cause for time delays in DRDO projects. Some of the causes are;

- Omnibus or universal SQRs.
- Trial of new equipment with differing technologies is a highly specialised task. Trial units are often not equipped for the task.
- Trial directives are issued as a matter of routine. Many aspects are not clearly outlined and viewed differently by trial units.
- Trial reports tend to be subjective as per the views of commanders in the hierarchy and couched in generalities.
- Field commanders while giving final recommendations at times incorporate new parameters.
- **Having a designated command for field trials would be in the right direction and need to be considered expeditiously. Such a command while providing oversight could incorporate required specialists and could be a vertical in HQ, IDS.**

Simplification of trial procedure could be as follows;

- **Before Indent**
    - Development trial – required.
    - User assisted trial (UATT) – **not required.** User can participate in development trials.

  - PSQR trials (Summer and Winter) – **not required.**
  - GSQR trials (Summer and Winter) – required. Amendment to GSQR based on trials to be made easy with focus on mission and operational requirements. This will avoid PSQR trials.

- **Post Indent**
  - First of Production Model (FOPM) trials – required to ensure quality of manufacture by the production agency. Production and field trials to be combined. However, where the DCPP route as per para 72 of DPP is adopted these trials can be suitably curtailed as the GSQR trials itself will be from equipment manufactured by the Production Partner through a process of concurrent engineering.
- GSQR and trial directive to be same for all OEMs (including Indian OEMs).

Three case studies on trials: Field Evaluatuion Trials, Futuristic MBT and Arjun Main Battle Tank are given in Appendices A, B and C respectively.

Enabling Production

While converting a prototype to production standard is the responsibility of production agency, designer should aim to design the product for easy production. Many CAD/CAM/CAE tools are available in the market which assist the designer in introducing concepts for manufacturing and assembly (DFMA) at the early stage of the design. Another area of concern to services is related to safety, reliability, maintainability, operability, survivability and supportability ('illities') of the product in the operational environment. Design for illities is important and should be taken into account at the initial stage of design. System safety and effectiveness groups should be created as integral part of systems engineering / quality engineering groups in systems design organisations.

The production organisation must invest resources to firstly reengineer the prototypes developed by the development agencies for serial production. In addition, technologies that enable faster/cheaper manufacturing of components and assembly of the systems for example, traditionally jigs and fixtures are developed for a particular aircraft assembly which is a costly and time-consuming process. Modern assembly technology requires only simple fixtures, conventional robots and laser positioning systems. This process reduces the type specific fixtures enabling cost and time reduction.

Software Development

Embedded software is playing increasing role in weapon systems development. In fact, weapon systems such as fighters, UAVs are becoming cyber physical systems. Development and configuration control of embedded software needs to meet the safety requirements. The software industry adopts structured process in developing the safety and mission critical software. The hardware industry gets certified for ISO standards whereas the software industry gets certified for CMM levels. CMM level 5 is the highest standard. As the software developed by DRDO labs/PSUs will be used by production agencies on "as it is basis", it is prudent that concerned system labs / application labs strive to get "CMM level" certification and follow the structured process of software development.

Application of model-based systems engineering (MBSE) helps in developing the correct logic and algorithms and in developing quality software. **MBSE process needs to be adopted to produce quality systems and software.**

Support to Small & Medium Scale Enterprises (SMEs)

SMEs have been the back bone of DRDO projects. Around 800 SMEs have participated in various DRDO projects. They are very innovative, agile and are ready to accept challenges. But they are severely resource constrained and depend on DRDO / PSUs for test facilities and process shop facilities. These facilities are of high value and beyond the reach of SMEs/ start-ups. Creating dedicated facilities and making them available to SMEs and start-ups would go a long way in cutting down time delays.

I**t is strongly recommended that MoD funds establishment of these facilities on priority at key locations such as Bangalore, Hyderabad, Pune and Dehradun.**

Small Business Innovation Research (SBIR)

The importance of leveraging the innovation and entrepreneurial spirit of SMEs/ Start-ups has been flagged by many committees of Government of India. We are happy to note that SBIR programme has been launched recently by MOD. It is recommended that adequate resources be provided to this programme along with simplified approval processes, as success **of this programme will result in cutting edge technology development, industrial growth, manpower training and enhancing the indigenous content of defence procurement.**

Interfaces with Academia

While DRDO has established a few of centres of excellence at academic institutions and established four R&D boards, the funding levels are low. There is a need for increase in funding of DRDO's R&D budget and establishment of more centres of excellence. As also simplify the approval and implementation processes.

Defence Technology Commission (DTC)

To give greater thrust to innovation, flexibility of operation and achievement of desired levels of self-reliance, Rama Rao committee and Ravindra Gupta Committee recommended that DRDO be reconstituted as " Defence Technology Commission " (DTC) on lines similar to AEC and ISRO. We firmly believe that this step is essential and should be done without any further loss of time.

Procurement Procedures of OFs, DPSUs

These are adding to delays and quality problems.

- In case of OFs, as per the recent change to their procedures, orders for only 80% of the production requirements can be placed on DRDO identified vendors and for the rest of the 20%, open tender needs to be resorted. However, given this welcome step of increasing the percentage from 50 to 80, has not resolved the problems totally, as the OFs now find that in many cases 20% of the

order quantity is not attractive enough for the industry to setup the required infrastructure. As the equipment/components being procured are of specialised nature needing skill and technology which are not easily available in general market, this process leads to quality problems and delays.

- HAL, for example, f**loats global tenders even for materials developed within the country and selects supplier on L1 basis**. The result is that indigenous supplier; due to lack of orders, closes the production line and expertise gained is lost. We understand that this is an MOD requirement as per the DPM. Indigenisation today is greatly suffering due to such procedural requirements.

Role of Private Industry

In the international scenario, there is a structured defence industrial complex with prime industries, system integrators like HAL and BEL for complex system have Tier1, Tier2, Tier3 industries and general suppliers. In India we have OFs/DPSUs (system integrators) and large number of small vendors. Until recently there is no eco system in the country in defence production. Thanks to EW, LCA, Brahmos, ATVP and Akash projects, large industries such as L&T, TASL, Bharat Forge and medium scale industries such as Alpha Design, Dynamatic technologies, VEM technologies, Quest Global etc have entered Aviation & Defence (A&D) domain of manufacturing at tier 1/2/3 levels. This is a welcome development that needs to be nourished and strengthened with system integrators like OFs/DPSUs/Competent large private industries.

Defence Exports

- Defence exports are negligible and form very small percentage of total turnover of our defence industry. This is an area of concern. It is often the export that enables indigenous products to become cost competitive with consistent quality and product support. Most foreign countries have dedicated arms only for export promotion and ploughing back profits in domestic arms industry (e.g. FMS/ US, FMV/Sweden, Rosboronexport/Russia etc.). Export enables bench marking of Indian products vis a vis international competition and with the attendant improvement in cost, quality and product support. The Government's simplification of Defence Export procedures, speedy clearances and clear encouragement of Defence Industry to collaborate and export has led to a significant growth in exports from about 1500 Cr in FY17 to 10,750 Cr in FY19 led mainly by growth in the Private Sector contribution by taking up upgrades and component level exports. Equally importantly the Government has facilitated some of these export opportunities by opening Line of Credit to various South East Asian Nations as part of its "Look East" foreign policy. Extending unused LOC extended to various friendly developing Nations for Defence products needs to be pushed to sustain this growth in the Defence exports market.

- **It is strongly recommended that export of A&D products should be supported as a state policy with incentives and targets. To enable export of larger systems manufactured in the country, priority must be given for development of those subsystems and components which are subject to export restrictions.**

- At the cost of repetition, it is stated that most of the raw materials, consumables, equipment continue to be imported even after years of license production by OFs and DPSUs. **Raw materials and consumables form a small percentage of total cost but are critical for self-reliance.** Hence a policy of sourcing from within the Country even at higher cost should be adopted. A country like

Russia, sources its engines and avionics etc for fighter aircraft from within the country even though their performance is inferior and better products are available in the international market. The QRs are tailored to enable deployment of indigenous systems. Self-reliance in this field is too important for national security to depend on imports. Also the ability to design and owning the IP as also the ability to service the systems exported, is a necessary condition for exports to take place and to be sustained.

Strategic Partnership Model

The Dhirendra Singh Committee constituted in 2014 on Defence Procurement Policy reforms recommended setting up a task force to suggest how private sector participation in Defence manufacturing could be increased. The VK Aatre Task force set up for this purpose suggested the Strategic partnership (SP) model and emphasised the need for SPs that are system of system integrators and drew up a clear outline to build an Indian Defence Industrial Base and ecosystem. Backed by the then RM Manohar Parrikar, the recommendations of the Committee thereafter struggled to gain acceptability within the system and finally got converted to policy and found a place in the DPP 2016, by May 2017. In this troubled journey the policy redefined itself and got converted from a bold idea to one more procurement process for foreign OEM products through Indian Companies and manufacturers; thus, defeating the very purpose for which it was conceptualised. The committee observes that in all major areas defined in SP model at present, design and development capability exists in the country and productionisation of these systems does not require us to adopt the ToT route and license production from foreign OEMs. However, within this broad framework there are, at equipment/component/material levels, where imports are still being done. But these imports do not justify our procurement of the total system through the ToT route. In addition, indigenisation of such equipment/component/material which are still being imported can be progressively undertaken only when we hold the design knowledge(know-why) of the system and should be incentivised for the same. However, it should be noted that for the items that have been so indigenised should not be subjected to global tendering process.

Revitalise Make Process through TRL (Technology Readiness Level Assessment)

Induction of indigenously developed defence products and systems also happens when the Service Headquarters (SHQs) initiate the Statement of Case (SOC) for Design and Development Projects undertaken by DRDO / DPSUs / OFB, resulting in, post completion of Development Trials / User Assisted Technical Trials (UATT) and freezing of SQRs, issue of a RFP under Buy IDDM to the Industry development partner / DPSU concerned or placement of an Indent on OFB. While many indigenous weapon systems and equipment have been inducted through this route, notably Pinaka, Akash, BMP2 Fire Power upgrade, etc., the process has been a long drawn one with decades of lag between development of the technology and induction of the equipment. Post RFP issue the equipment undergoes User trials and / or Bulk Production Clearance or First of Production Model clearance.

- The entire process has large implementation problems leading to unrealistic timeframes. The Concept Development to Prototype stage is plagued by lack of involvement of a lead Industry partner and lack of involvement of the User. The Prototype to Trial phase is again an extended one with the User looking to resolve both essential and desirable parameters through protracted rectification and re-trials spread over long waiting cycles for extreme environment condition. A typical case in point

Development Project Pinaka taken up by DRDO	1987
Development order for Pinaka Multi-Barrel Rocket Launcher by DRDO on 3 Industries	FY89
Prototype Launchers delivered followed by development trials	1995-1999
Technology Trials and UATT	1999 till 2001
Induction by User (planned in 2001) post trials	commenced in 2003
RFP for two regiments	FY05
Contract for first two regiments	FY06
User Trials of first 2 launcher systems	Dec 2008-Jan 2009
Completed induction of first regiments	FY10
RFP for 3rd & 4th regiments	FY10
PNC concluded	Jan 2011
Contract signed (price levels as negotiated in 2011)	Nov 2016
Systems realised	Mar 2018, Nov. 2018
Firing trials (non-availability of ammunition/ ranges)	Dec. 2018 to Feb. 19
JRI completion in progress and **likely to be completed**	by Aug. 2019 end
Repeat Order RFP for Regiments 5-10	May 2017
Contract for Regiments 5-10 **likely to be signed**	Sept-Dec 2019

is the NAG missile program where development for a Fire & Forget 3rd Generation ATGM began in the mid-eighties and thirty-five years on, and many exhaustive summer trials later, the system appears to being readied for limited series production. The system in its current configuration has been on UATT year on year, every year, for the last ten years.

- An equally excruciating example is of the Pinaka Multi Barrel Rocket Launcher System where the milestones of the 30 year journey from development to induction of regiments are tabulated below.

There are a series of critical reforms which need to be implemented (and some are being implemented or are work in progress) to enhance the efficacy of this system. These include:

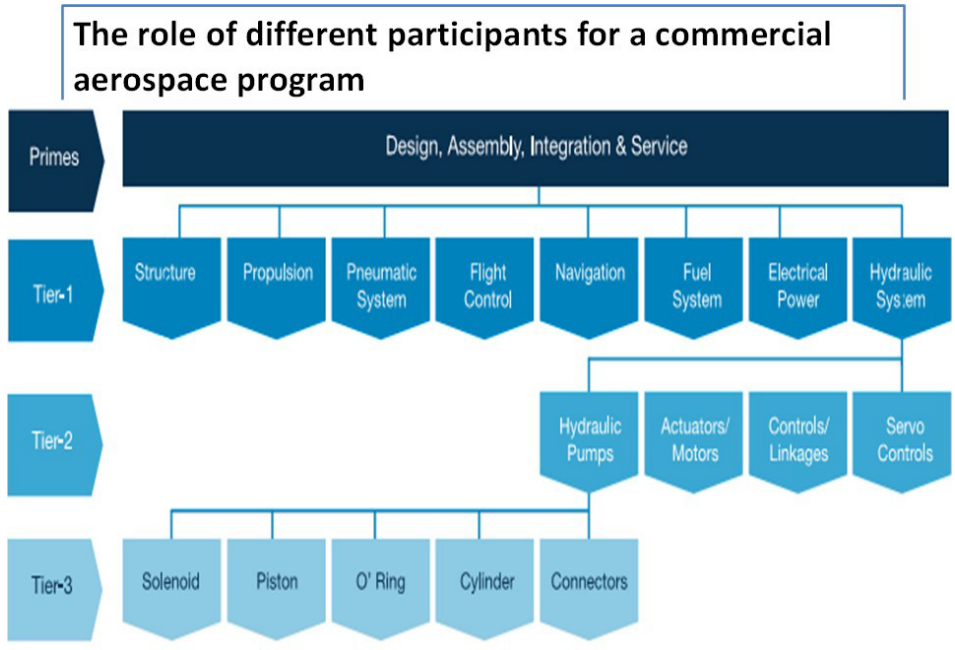
- Review of **the process for obtaining the approval of AONs by the services** should be based on an understanding of the TRL levels for systems/equipment available in the country. Where this TRL is 4 and below, the timeframe for induction after grant of AON could range from 10-15 years, depending

on the complexity of the system. However, where TRL is 5 and above, it could be 5-10 years. Less than 5 years, should contain cases where only incremental improvements and upgrade of systems are envisaged. This will require that the LTIPP is drawn up, taking into account the TRL levels of the equipment or systems they require when formulating the same. Also, it may be mentioned that the Long Term Technology Perspective Plan (LTTPP) drawn up by the DRDO where in, the TRL levels of various equipment/system/technology indicated at the current level and the plans for developing the same for next 5-15 years are indicated. Currently, the LTTPP of the DRDO is drawn up based on the projections on the LTIPP of the armed forces. However, to achieve the above objective, these two documents need to be drawn in conjunct with each other with considerable interaction between the armed forces and the DRDO.

- Advanced technology programs which are at TRL3 or lower need to be taken up as National technology missions by DRDO in conjunction with Academia and other R&D institutions. Programs which are at TRL 4 or TRL 5 need to be taken up by DRDO with an Industrial Development cum Production Partner (DCPP) or lead system integrator, or through local Industry working closely with niche technology partners through the Make I route of the DPP. User involvement through funding and Technical and Ops team assignment is crucial for the success of these programs, as explained in our discussion on systems engineering, evolved system specifications. A crucial step forward in this direction is in defining a DCPP policy which involves selecting a capable industry upfront in a complex program as a risk sharing development partner, lead integrator and future production agency. Para 72 of the DPP provides a useful framework for such a policy and needs only marginal changes. Also, such a partner should be our strategic partner in future as well for a reasonable period of time.

- While such a policy will be a major enabler, the implementation methodology is not clear. How will the program select a capable DCPP? Time and again policies, involving selection based on qualitative parameters, have failed because the power to judge and discriminate and take a decision which is the best at a point in time is subject to scrutiny and challenge in hindsight and can be penalised. We should be ready to overcome the trust deficit, take a leap of faith and contrary to GFR requirements say that any decisions taken by a Committee for choosing a domestic DCPP partner in this matter should not be retrospectively questioned or penalised. It may be audited, guidelines for making better decisions with the benefit of hindsight be drawn up but the decision cannot be questioned or penalised unless there is conclusive evidence of direct mala-fide in the case. Such a change in mind-set and approach would be a vital enabler for decision makers and a game changer for crucial processes such as the DCPP and Make I. Other processes like Make II being attempted are unlikely to succeed for creating system of system integrators and can at best be useful for certain force multipliers (at Tier II/III level).

The present defence production setup has not been successful as is evident from poor self reliance index. We, the committee members, are firmly of the view that there is a need for a paradigm shift wherein the entire national capabilities are leveraged. Self-reliance should be adopted as an explicit MOD doctrine. This should be responsibility of all stakeholders like, MOD, Services, defence production organisation and not limited to that of DRDO alone.



Source: PricewaterhouseCoopers' Globalisation in Aerospace and Defence (30 January 2008)

Multi-Tiered Eco System

Aviation and defence systems necessarily incorporate high level of technology needing best of R&D and production technologies. Defence industry, world over is a niche industry that needs an eco system to be developed and constantly nourished and nurtured. A mature aviation industry has a prime system integrator supported by Tier1, Tier2 and Tier3 partners.

At Tier1 and tier 2 level, in each of the specialised area (structures, propulsions, flight controls etc.) only 2-3 industries should be nurtured.

- In Aviation & Defence industry, the number of systems produced (aircraft, missiles, tanks, submarine) are small and embed with high level of technology. As a result, only small number of specialised industries could be sustained. So tendering is limited to small number of approved competent industries to keep them technologically and commercially viable.
- Maruti Udyog Limited, which was a public sector joint venture, even though it is an auto industry with much larger volumes, followed similar philosophy. In each of the specific areas, it nurtured normally not more than two industries and enabled creation of a world class auto component industry complex in India. Thanks to this eco system, Indian Auto industry became a major exporter and is a success story in Indian manufacturing sector. We need to create such an eco-system for Aviation and Defence Industry in the country. We should limit the system of system integrators (primes) to one for most of the complex systems and also create Tier 1/2/3 industries as described above with competent private sector participation in a big way.

Such a strong defence eco system is essential for undertaking production of domestically developed equipment and systems. These industries should be able to absorb the technology, introduce efficient production methods and undertake product upgrades without undue dependence on the development agency.

Maximise the Potential of Para 72 of DPP 2016

The Proposed Amendments to Para 72 of Chapter 11 of DPP 2016, are given below:

a. DRDO/DPSU/OFB along with concerned SHQ(s) should jointly identify potential Design & Development (D&D) cases from LTIPP/SCAP/ and initiate Statements of Case (SoCs) based on feasibility study undertaken by the development agencies For force multipliers such a study could be with the SCAP inputs.

b. To facilitate spiral development, the SHQ should indicate Mission needs, goals to be achieved and environment for deployment of the system developed. The systems analysis and engineering thereafter should be followed to arrive at system specifications test and trial requirements and feasible timelines.

c. To associate 'Development' with 'Procurement', and to ensure that development timelines do not inordinately deny the services of critical capability, the SoC will inter alia include, top level requirements with indication of the quantity required which can be exclusively committed for systems engineering process to be adopted to progress the project. In case of delay over projected time, MoQ for import may be indicated for the interim period. However, the development effort thereafter should be pursued following the ADA/IGMDP model.

d. Design and Development of prototype by DRDO/DPSUs/OFB will be done as per their internal procedures. Wherever applicable, Development-cum-Production partner (DcPP) or the Production Agency(s) (PA) should be selected by the developmental agencies right at the initial stage of development, so as to ensure seamless transfer of technology as well as lifecycle support.

e. To reduce timelines and enable timely correctives at the developmental stage, representatives of QA and other agencies responsible for EMI/EMC checks may be co-opted in the JPMT, so as to complete majority of their trials/checks during the Developmental/User Assisted Technical Trials (UATT) itself. Para 72 of the DPP provides for this.

f. Once the prototype based on the system specifications successfully completes Developmental/User Assisted Technical Trials (UATT), the Minimum Order Quantity of equipment should be inducted into the Service as Limited Series Production (LSP) for 'User Exploitation' trials. These LSP should be designated as Mark-1 of the product.

g. Shortcomings observed or improvements suggested in the Mark 1 (LSP Model) should be addressed following the spiral development model as Mark II and so on.

h. Commercial order should be issued to Development-cum-Production partner, (i) In cases where the quantities are limited and production by industry is not feasible, production could be undertaken by the development agency itself. Also for major systems the Production development partner be designated as the strategic partner.

Development to Production: Transition Facilitators

Following are the suggested actions needed to facilitate smooth productionisation of indigenously developed equipment and weapon systems, as discussed in this report.

- The DCPP model, as per para 72 of DPP, should be mandated for all systems as discussed in this report.
- Competent **design and engineering groups** need to be established in OFs/DPSUSs/Private Industry in their niche areas who would be responsible for interfacing with DRDO and convert prototype drawings/Processes to series production standards. Bharat Electronics has such teams located at their production centres and thus enabling production of large number of DRDO developed equipment and systems. This needs to be adopted by other DPSUs and OFs.
- Purchase procedures of OFs and DPSUs should be updated to enable procurement from DRDO developed vendor / partner. OFs and DPSUs should take steps to enable the vendor to enhance his production capacity and technology base as required. Long term contracts should be planned to ensure continuous work load and economic viability.
- Global tendering should be attempted only when indigenous design and development capability does not exist. However, in such cases, expeditious action should be taken to establish requisite capability and capacity with in India either at private or public sector.
- MOD should change the tendering guidelines to enable India first policy. As defence is a strategic industry, indigenous sourcing policy will not be in conflict with any international agreements.
- OFs and DPSUs must have the target to enhance production of indigenously developed systems. It may be noted that only 12% of production volume of OFs are DRDO developed products. Enhancing from 12% to 80% in the next 10 years should be joint responsibility of OFB and DRDO. Similar targets are required in case of DPSUs.
- OFs and DPSUs and RURs/designated SPs should be judged **by the extent of sourcing from Indian industry and by the level of export achieved.** Specific targets should be set. In order to achieve these targets, they should be encouraged and enabled to tie up with DRDO and private industry.
- **OFs** as they are structured now, do not have adequate flexibility to enhance their manpower or jointly fund and undertake upgradation of existing weapon or development of new weapons. Also the delegated power of OFB appears to be too low to enable speedy decision making. While corporatisation of OFB as recommended by Kelkar and others committees would be the permanent solution, in short term, authorisation from MOD in terms of manpower, funds and enhanced delegation of power would increase their effectiveness.
- Industry (OFB / DPSUs / Private Industry) should be encouraged to participate in development projects of DRDO, by contributing even a small percentage of development cost. This would help in ensuring their commitment to the success of the project and its productionisation.

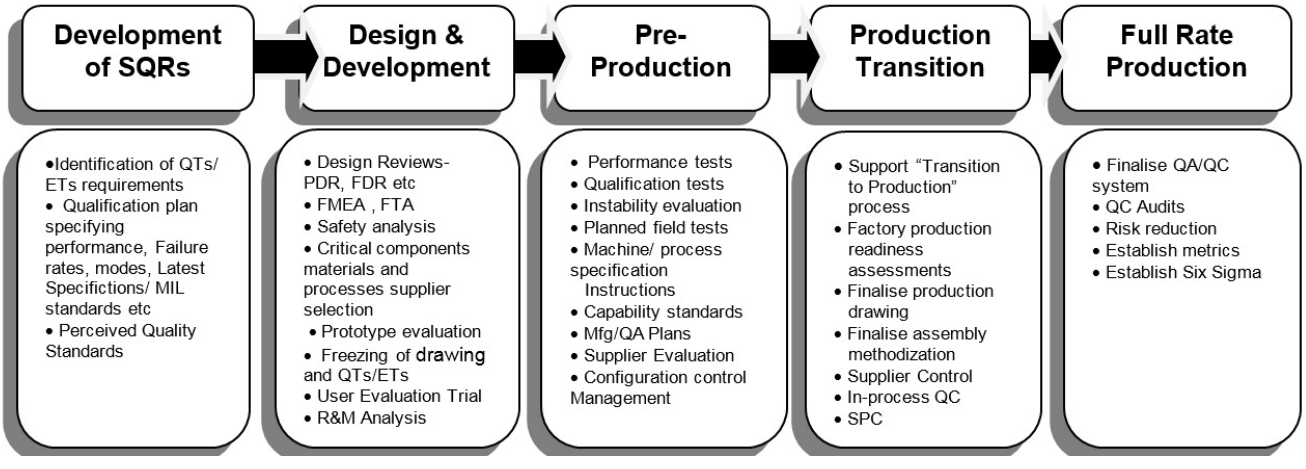
- The eco system can be best created through major national project such as LCA Mk I A.

The following example of LCA Mk I A which is a very important national project could be the vehicle on creating the eco system required in the country.

- IAF is very keen to acquire LCA Mk II. They have planned to induct more than 100 LCA Mk II aircraft. Deliveries must be critically planned. ADA, the developing agency of LCA Mk IA has come out with an improved design solution. This will help in equipping at sub-assembly stage. At present, laying of cables, piping and equipping are done after final assembly of the full aircraft structure. The new design change envisaged by ADA, will help in outsourcing each sub-assembly (fully equipped) from the selected private industries.
- HAL will be the nodal agency for final assembly, flight testing and sale of the aircraft to IAF. This exercise will almost double the production rate and consequent increase in sales and profit of HAL. Not only, Airforce's projected requirements will be met but also HAL will be able to export this modern aircraft, for which there will be global demand. The most important intangible benefit will be regaining the trust of the customer.

This process needs to be followed for projects such as LCA MKII and AMCA, Transport aircraft and must also be implemented with greater vigour and sense of urgency. The role of **Department of Defence Production (DDP)** is of paramount importance as a Process leader. Changes are needed in the structure of DDP

- Secretary Defence Production should be assisted by two Additional Secretaries. One will exclusively look after the Defence PSUs and Ordnance Factories and the other the private sectors. This will provide focused attention and support to both public and private industries and help in realising the dream of building a **"National Defence Manufacturing Capacity"**, an essential "eco-system" for defence production.
- The present Secretary Defence Production may be designated as **"Secretary Defence Industry"**. He will achieve the goal of meeting the needs of armed forces by getting the products, manufactured from all the capable Indian industries. In due course, he will be able to generate substantial wealth for the nation through export of Defence products, an avenue being followed by almost all the developed countries for wealth creation.



QA Criticalities

Quality is an important attribute of any product and is required to be assured in all the phases of product life cycle. The various stages involved in the realisation of weapon system in form of primary tasks and the role of QA role are as shown below: -

Product Life Cycle – primary tasks and role of QA

(Abbreviations: QTs / ETs: Qualitative Tests / Environmental Tests; PDR: Preliminary Design Review; FDR: Final Design Review; FMEA: Failure Mode Effect Analysis; FTA: Fault Tree Analysis: QA: Quality Assurance; QC: Quality Control; SPC: Statistical Process Control; SQR: Staff Qualitative Requirements; R & D: Research & Development: CDR: Critical Design Review; PMR: Project Management Review; FB: Failure Board; R & M: Reliability & Maintainability; BOM: Bill of Material; MQAP: Master Quality Assurance Plan; ATP: Acceptance Test Procedure; LRIP: Low Rate Initial Production; UET: User Evaluation Trial; TARB: Technical Assessment Review Board)

Towards this, presently Naval Armament Inspection Organisation (NAI) is involved at all the phases of the product life cycle starting from development of SQRs till disposition of article from services. This model needs to be followed by the Air Force and the Army for their armament requirements by creating an Armament Inspection authority on the lines of NAI, and develop the ability to certify changes as done by NAI & CEMILAC for airborne systems. DGQA could deal with other stores.

Grey Areas. Following issues are being encountered during various life cycle phases of Weapon development pertaining to QA;

- There is no single agency available for certification of changes to equipment and processes which become necessary in lifecycle of an equipment. This lack of certification impacts indigenisation and obsolescence management. Such an agency needs to be mandated for non-aviation products also.
    - Independent thinking of various Directorates at SHQs results in highly ambitious SQRs lead to long lead time in design & development and production of weapon.
    - QA requirements are not integrated during R&D iterative processes which at times lead to dilution of stipulated standards.
    - R&D process is an iterative process and leads to dilution of stipulated standards as designer tends to do experimentation to get the desired results and overlooks the QA requirements.
    - Noninvolvement of QA reps during various design. Reviews like Preliminary Design Review (PDR), Critical Design Review (CDR), Project Management Review (PMR), Failure Board(FB) etc. These processes need to be followed as is done for aviation domain.
- The documents pertaining to following aspects/quality provisions are generally not available
    - Vendor Quality Assurance System and Procedures.
    - Documentation to be generated maintained and provided by the vendor.
    - Quality measures and standard to be adopted, inspections/tests to be performed by vendor

and documented by vendor at various stages of manufacture. Defect reporting system to be adopted by the vendor also to be documented.

- Inspections and checks to be performed on receipt of bought-out items.
- Test equipment to be used for testing at various stages and requirements.
- Software validation and verification plan.
- Manufacturing / Production process plans, flowcharts at own and vendor premises.
- Explain how quality will be built-in to the product as per design.
- System for Configuration Control.
- Flow chart of manufacturing processes clearly delineating critical to quality aspects/points/ parameters and inspection /test requirements. Parameters to be checked may be elaborated upon in respective unit/assembly test plan.
- Acceptance/Rejection Criteria.
- Work Breakdown Structure from integrated level to assembly, subassembly and component level.
- Incomplete drawings have been observed during mass production taken up by the production.
- Vendors express their inability to procure items mentioned in drawing due to obsolescence of technology. In many cases proprietary vendors identified earlier were not forthcoming to supply the items due to change in their business focus.
- During integration of various items (manufactured by different vendors), the holes and the bolts are not getting aligned due to mismatch in their positions in the drawing.
- It is essential to develop and implement a detailed plan for incorporating documentation changes during the prototype, low- rate initial production (LRIP) and full-rate production phases, and through to the end of life of the program. At a minimum, it must establish the mode of operation and interface relationship among all relative in-house organisations and the subcontractors, and customers (if applicable). Establish a change control board. The configuration management plan should include a documented methodology for establishing the drawing numbers, revision levels, engineering change notices, document release, document effectivity process, signature and review authority, vendor configuration management plan and personnel assigned and authorised for their respective organisations. This is generally absent in most of the indigeniously developed weapons.
- Discrepancies in drawing mentioned in Bill of Material (BOM) of MQAP when compared with ATPs or Incomplete drawings (missing of dimensions/tolerances and other critical features).
- QAPs not formulated.

- Presence of QA personnel at all stages cannot be met due to limitation of manpower and impinges on assuring quality & reliability.

Recommendations

QA Involvement in following would ensure requisite quality & reliability of weapons under indigenous development :-

- All reviews viz PDR, CDR, PMR, Development tests/trials, FB etc.
- Inter Changeability Analysis
- Design changes for bulk manufacture
- Configuration Control Board
- Failure Analysis Board
- Production Stage
- TARB (Technical Assessment Review Board)

However for the above to be undertaken the QA agencies need adequate domain knowledge and expertise on the lines of the Naval Armament Inspection, an organisation which recruits and grooms specialised manpower for the task. For armament to begin with the Army and Airforce could create their service on armament inspection service on the lines of the Naval Armament Inspection Service.

Chapter 3

Design to Print: Post Development Activities – Industry Perspective

Study paper has enumerated steps involved in R&D of complex military systems through TRL model. It clearly lays out importance of involvement of all stake-holders as seen in Indian context (e.g. academia, end users, DPSUs, DRDO and certification agencies), long development lead time, extensive trials and predominance of DPSUs. Previous chapter has discussed probable causes of delays, project over runs (time as well as budget) in indigenously developed projects. It also brought out lacunae in promulgation of QRs, project sanction, technology acquisition road map documents and budgeting. This chapter will cover the emerging Aerospace and Defence scenario specially in light of the following new rules of the game;

- A host of big private sector players with sufficient financial muscle to invest, recruit quality / experienced manpower (primarily from DRDO/ DPSUs stock), influence policy and excite foreign players by way of procedural flexibility and faster decision making
- Government looking at A&D manufacturing as a net job creator and tying up with 'Make in India', Skill development and defence corridors
- Industry clamor of 'level playing field' negating DPSUs advantages and opening up user interest in private sector participation
- A&D offsets moving to private sector (having exhausted absorption capacity of DPSUs) and whetting their appetite for 'new business /profit areas'
- Services centric nature of modern weapon systems opening up A&D sector for IT/ engineering services companies that dominate the world market and have experience of working with global A&D majors (though their engagements are hitherto restricted to civil side of business)
- Greater engagement of India with western geo-political eco-system and its impact on wider candidate suppliers (for users), ease of access to technology, offers for joint-development, G-to-G engagements easing technology denial regime and gains of US pivot to Indo-Pacific

This chapter will lay out 'large industry' view of Aerospace and Defence business and specifically - its own role, goals and constraints. As suggested earlier in report, Tier based organisation /classification of vendors and industry partners akin to the model practiced by western aerospace and defence majors, will pave the way for greater responsibility allocated to those with greater capability. Though applicable

for large industry/ Tier 1 industry partners, these suggestions could be applied across the spectrum with appropriate scaling downwards.

Contractual Issues

Limitation of Liability

Defence R&D based projects in Indian context, are largely DRDO and DPSU driven and controlled. Full know-how and IPs are held by DRDO and rarely parted with, other than 'need to know' basis – a euphemism for 'negligible'. Every stage of product cycle (procurement of components/ customs inspection and clearance, production (part inspection by resident inspectors of GoI), field trials (users), support (maintenance depots and spares organisations) are fully government controlled/ owned. In such scenario, fixing liability of failure and/or deficiencies in performance solely on production partner is neither fair nor justifiable. At the best, production agency may be held answerable for direct liabilities (e.g. delays in production, quality of engineering, breaching SLAs in support phase etc.).

Private sector firms being 'limited liability' companies, tend to be wary of engaging in any business that does not cap their liability (including direct, indirect and consequential liabilities). World over, global A&D majors cover this risk through insurance – sort of solution GoI found to address nuclear trade imbroglio. However, in Indian A&D context (shared development, lack of insurance coverage, minimal control by private sector over product cycle), limiting liabilities to 'direct liability and **capping it to value of goods /services billed will be a good starting point'.**

One-sided Contracts

Most government contracts and specially pertaining to defence business, tend to be one-sided and coercive in nature. Whereas development/ production partner is liable to be penalised with Liquidity Damages for any delays, government bears no penalty (e.g. interest payment) on delays in payments. Delayed payments inter-alia result in 1-2 %/ per month loss in cash terms and negatively impact financial health of a business enterprise including the public sector. **They also devalue office of CFA, by seeking 'discount by other means' on CFA approved price as taken in Discounted Cash Flow with appropriate inflation adjustment, government ends up paying less than what CFA approved.** Similarly, government reserves the right to reduce price – should the business enterprise supply similar goods/ services to any other government entity – it is not applicable other way around. Most clauses on termination, default, stoppage of work, reassignment etc tend to favour government. For example, only remedy available to seller for delays at customer end (e.g. late supply of technical documents, delays in approvals of project documents and test plans, rescheduling of protracted trials due to non-availability of trials platforms/ teams etc.) happens to be 'waiver of LD and corresponding extension of delivery period'. For services sector whose primary expense is billable resources deployed, extension of delivery period is no relief as 'resources' have already been consumed. **Whereas bigger firms can deal with intermittent cash flows and delays, many small firms that help DRDO, PSUs, OFBs in critical components development fold over.** Unfortunately, greater management oversight and financial scrutiny (by auditors, shareholders, mutual fund investors etc.) impedes ability of private enterprise to deploy resources in such contractually uneven field. Primary reason behind our mismatch in economic rise not adding to indigenous defence industry is that the best

who can address technical challenges and take up cash flow slack, do not feel it worthwhile to traverse this contractual minefield called 'defence contract'. Whereas financial and contractual issues tended to be non-issues in MoD/ DPSUs duopoly as 'President of India was dealing with President of India', they need to be addressed equitably to engage private sector. In fact, with creeping private participation in DPSU's equity ownership and rising shareholder activism, one expects public sector boards also facing such scrutiny and concerns as 'commercial' enterprises.

These issues also bedeviled GoI/ IT contracts in so much so that no major project could be launched in last few years due non-participation of IT majors. Sustained discussions between all stakeholders brought current IT systems contracts to somewhat even keel. Some of the improvements include;

- Adoption of Quality and Cost Based Selection (QCBS) model for selecting a bid winner
- Carrying technical evaluation marks at CNC stage.
- Greater play or SIs (as opposed to OEMs).
- Service Level Agreement (SLA) based on measurement of performance.
- Third party audit of delivery linked to milestone payments.
- Fair clauses for arbitration, termination, force major etc.
- Government's commitment on timely payment.

Similar round table between MoD and industry bodies may help bridge this gap fully/ partially. Another precedent MoD will do well to take a note of, can be the practice followed by Maharashtra PWD to balance LD with awards for before time completion. Such practice will not only make the contract even handed; it will speed up execution of defence projects by awarding performers.

While the above improvements are suggested for domestic contracts, it may be mentioned that all foreign contracts are very evenly balanced and, in some cases, in our view, tilted in favour of the foreign OEMs (e.g. protection against FE rate variation, inflation adjustment of quotes, taxation etc.). We believe that a level playing field in this regard is necessary for domestic industry and in fact should be in their favour.

Development and Technical Issues

Two myths plague our Aerospace and Defence ecosystem. One that private sector did not play a role in these strategic sectors. Second – they lack risk appetite. One only needs to remember that aviation sector (both civil aviation and aerospace manufacturing) started in private sector as did nuclear engineering. In fact, our socialist policy tilts muscled private sector out of this turf and very reluctantly, allowed them to participate only as secondary and rudimentary partners of for decades. Wherever allowed (e.g. Pinaka MBRL, Nuclear Submarine, wide area networks of armed forces, host of artillery programmes etc.), their performance has been exemplary. Second myth appears worse as private sector managed to create 150 Bn USD IT industry. They also built the world's cheapest telecom revolution and connected billion plus Indians in a decade. That this energy remains untapped to buttress our A&D self-reliance needs to be reflected upon. Surprising that no tears are shed when this hegemony results in our A&D orders funding global R&D, profits foreign A&D majors and sets up India for arm twisting by foreign powers.

Some of the technical problems associated with development and production could be summed as following;

- Manufacturing /production based contract and inspection regime misses out exploiting independent India's biggest success story- the services. Offsets policy also pushes manufacturing as 'auditors' are not able to cost services properly – as seen in AW case leading to banning of services from eligible offsets. Costing model for services differs from products and NASSCOM could be roped in to share and build requisite costing skills in MoD. It should be realised that other than person- hour costs, there are IP costs in the development of software systems and products.

- As DRDO hitherto is used to retaining all IPs, this model worked, as DPSUs were the only entities that got to deploy these IPs – both owned by GoI. Former retained their primacy as the intellectual brains and latter – got away without any responsibility towards product development/ enhancements on their own. As product cycles get compressed, R&D may not be able to spare efforts towards post-design activities. Earliest involvement of industry both as Development Partners and Production Agency – will help them pick up the slack well. Joint ownership of IPs, as is now possible, will help in formalising this relationship even as addressing security concerns of MoD.

- Defence production process is beset with trust issues with private sector. Their involvement at project definition stage is minimal and restricted at pre-bid/ consultancy/ QR formulation stage. As most of our private sector companies employ armed forces officers (all OSA signatories) in business development/ customer facing roles, MoD may develop a security clearance model at employee level (akin to US). It will allow greater industry inputs at project definition and scoping stage.

- It has been observed that the charter of various arms of MoD run counter to indigenous R&D. ADA developed an indigenous TMS for naval ALH that could be used on any other platform but remains unused. IN's indigenous Data Link solution (incidentally certified by CEMILAC) has been deployed in every naval helicopter/ ship/ submarine for 15 years even as IAF keeps seeking import options for similar systems.

- As cost, complexity and timelines of System Integrator weighs on minds of users as well as acquisition team, indigenous system options are often given a go by. ToT is touted as a viable alternative. Even as DPSUs succumb to the ToT route to retain business, even where there is adequate design and development and Production capability available in the country together with the private sector. **License production not only gives us a technology that's a generation older, it also kills funding for next-gen product through sunk cost argument. This scenario ensures DRDO remains in perpetual R&D mode with shifting goal posts whereas imports continue unabated.**

- Prior to embarking on solution, one needs to debunk one more myth – 'imports' are a faster means of providing capability to end users needing them 'as on yesterday'. Analysis of any major import (e.g. Hawk AJT, Rafale MMRCA and M777 Light Weight Howitzer to name a few) brings out that from the time of enunciation of user need to final systems delivery and their mating with operational doctrines, training and support structure – foreign acquisition takes up to 10-20 years. Given proper QRs and timely funding, indigenous R&D would have delivered such systems in same amount of time. Another way of looking at imports needs to factor the following;

    - We tender for 'developed and proven systems'.

- Systems get export clearance only after prioritisation of local needs .
- These systems have undergone similar inspection and certification cycles in their own countries.
- As technology components and tools move to shorter life cycle (e.g. 5-7 years for electronics and computing), it implies our users get systems that are at the best 2 generations behind, technologically. **Any surprises that DRDO never catches up with the latest (user QRs are often based on systems in use that define a generation or two old technology) and imports flourish.** Systems analysis and engineering in the definition of our users to meet user's mission needs will largely address this lacuna. The process adopted for system's development and indigenisation in the LCA project is a good example of the above case.

Solution to break this cycle (R&D tasking list based on systems in use that were imported after 10-15 years of negotiations) has been found by our strategic submarine programme. **Though this programme imported many foreign systems in the first submarine, they launched parallel indigenisation programmes for subsequent boats. This was undertaken without resorting to ToT. Indigenous Developments Partners was required to meet or exceed performance of imported systems and given sufficient time to develop replacements.** It is a credit to their foresight that the indigenous component is likely to exceed 90 % from third platform onwards. **This technology management approach should be adopted for all major programmes. We should indigenously design and develop (with foreign consultancies if necessary) and import assemblies not available in the time frames set and simultaneously launch an effort for the same with indigenous design and production agencies to meet or exceed the performance of imported systems.**

AON to Contract – Cycle Time

In May 2001, the defence sector, which was hitherto reserved for the public sector, was opened up to 100 per cent for Indian private sector participation, with FDI up to 26 per cent.

In these two decades Private Sector share in the country's defence production has grown to about **Rs 17,000** crores, whereas the 41 ordnance factories (OF) and nine defence public sector undertakings (DPSU) contribute about **Rs 58,000** crore to defence production every year. While the Government continues to support DPSUs and OFs to expand their activities, and nominates them for large programs, the department of defence production has issued **439 licenses** covering **264 private companies** till March 2019.

Issue of Industrial Licences have been speeded up and licenses are being issued for the manufacture of tanks and other armoured fighting vehicles, defence aircraft, spacecraft and allied items of defence equipment. Also, for a large number of defence components, no license is required.

During the last three Financial Years (FY17, FY18, FY19), **160 AoNs** worth about 3.08 trillion rupees were accorded. Out of these, **111 AoNs** (69%) worth about 2.53 trillion rupees have Indian Industry oriented categorisation. In terms of procurement cost, in the last 3 FYs, 82% of AoN cost pertained to AoNs favouring Indian Industry Participation.

Notwithstanding these positive indicators and trends of increasing number of contracts with indigenous industry, reflecting an impetus to domestic industry in keeping with emerging indigenous capabilities, the **large scale of nominations to DPSUs and OFB continue**. It is the current reality that "Make in India" in Defence has clearly not taken off and yielded dividends as anticipated. The Defence Industrial Ecosystem has not yet been built and put to test despite large number of private industries having entered the sector and having made investments in plants and infrastructure. The **cycle time from AON to Contract is 4-10 years in the Indian Defence procurement system and going by the numbers listed above it would take 5-7 years for about 65-70% of procurement contracts to be placed on Indian Industry.**

To achieve even this goal would call for shortening the AON to Contract cycle, strengthening the capability of the Industry to develop and realise systems indigenously to address this opportunity and building of an entire Defence Ecosystem to enable and sustain the growth in indigenous production.

Recommendations

- Policy on joint IPs, ownership, monetisation, export controls and use for non-defence business.
- Parallel projects to be launched for development (along with last import).
- Services to be sensitised clearly that further 'imports' would not be resorted to in future.
- MOD should;
    - set a last import date for all major systems based on current capability and analysis and weeding out cases that are no longer relevant/ required of pending AONs.
    - In our assessment, no more imports are required of fighters/ most of the helos, ships/ submarines/ artillery systems, missile systems, radars, EW systems, C3I systems and armoured fighting vehicles.
- The current postulation that Strategic Partnership should use ToT from OEMs as means of design development capability in private sector is a fallacy as no license production builds this capability. In our view, Strategic Partnership should take into consideration, the most capable Indian players from private or public sectors. For example: In case of guns, it could be between OF, TASL and Bharat Force. In case of Conventional Submarines Mazagon Dock would be a natural partner, while L&T will fit for Nuclear Submarines. And in case of Helicopters, it will clearly be HAL. For fighter aircraft, it would be HAL.
- Parallelly for each major platform, the chosen system integrator should ideally (acc to para 72) become a design cum product partner. Further, in the choice of number of system integrators, it would be necessary to see the market size. In Europe for all helicopters it is Airbus and Agusta Westland. For Fixed Wing Combat Aircrafts, it is Dassault and Saab. On the other hand, in the US, it is a two horse race between Boeing and Lockheed Martin.
- In India's case, we can reckon we can have 1 or at max 2, considering our defence market size, available budget and our nascent steps towards exports are largely in terms of components and sub-systems.

- Similar analysis is to be done for each major system/sub-system components as to Tier 1/2/3. We should develop to ensure the volume to be offloaded are able to sustain the industries profitably.
- Modifications to DPP by bringing about **c**hanges to categorisation system;
    - Indigenous Design Development and Production: Criteria should be the design and IP of the system, not necessarily as a percentage of indigenisation. In the ATVP project, for example as we held the design, indigenisation is expected to reach from 30% to 70% by the second boat, and to 90% in the third boat. Western OEMs insist on maintaining the indigenisation ratio as per contract and specify foreign vendors even for items not manufactured by them. All other procurement process are generally Buy & Make.
    - Other major issues are combined in the execution of Para 72.

Chapter 4

Conclusions and Recommendations

Conclusion

Defence of India is critical to our survival as a nation state. Even today India continues to face threats/ insecurities from countries that have gone to war against us. Internal security environment faces concerns from left wing extremism, separatism and proxy wars like terrorism. Security tasks include challenge of securing our energy/trade interests.

Realising this the Government invariably continues to allocate large chunk of funds in its kitty to Defence. In the current budget, defence has got approx. rupees 337000 crores, which although largest of the allocation (16%) made in the budget, is only 1.5% of its GDP. This is considered woefully short to take care of the needs of the armed forces. For capital outlay Rs 111800 crores is laid out which is nearly half of the revenue outlay.

In the future the shortfall will continue to grow, if we continue to import nearly 70% at exorbitant prices, and thereafter have to rely to a considerable extent for longtime logistics support from the OEMS and their subsidiaries/vendors.

The ongoing study both Part I and II has carried out an in-depth analysis through case studies and round-table discussions with various stake-holders, consequently, the essential issues for study can be grouped under two basic factors as follows;

- How do we set the requirements of the armed forces to achieve our goal of realising their needs through indigenous research, development and production?
- The process to be adopted thereafter to meet these requirements efficiently through indigenous research, development, trials, evaluation and Production.

The comprehensive recommendations evolved post study as an effective way forward, are given section wise in the succeeding paragraphs.

Section 1 : Gap Analysis and Recommendations From Part-I

The gap areas and recommendations of part I of our study are summarized in the succeeding paragraphs.

Gaps Areas

Lack of Institutional Mechanisms to Create Strategic Guidance Documents

The entire chain of guidance documents governing the indigenous technology development and production process and provisions in the defence procurement procedures and procurement manual ultimately leads to our resorting to RFI and RFPs for foreign procurement.

Strategic documents needed to arrive at the LTIPP need to be institutionalised. This would also require substantial changes in the existing defence planning process.

The 15-year LTIPP in its present form provides inadequate guidance for the purpose of planning for indigenous design, development and production. Based on our discussions on the essential process required to arrive at the LTIPP based on which R&D /industries organisations can formulate meaningful Technology and Production Capability Development Plans and follow it up with effectual development process.

Delay in PSQRs. Prototype development cannot currently commence unless PSQRs are released well in advance. Much of the delay occurs due to the absence of PSQRs/ QRs, which is generally finalised largely by the time AONs are accepted. Therefore, AONs must be released well in time for the development, production and processes to bear the fruit. There other issues at this stage as well like financial and nomination issues, conduct of trials leading to user acceptance and so on.

Delay in Production of Indigenous Prototypes. The industry's failure to productionise domestically developed prototype to the scales and quality required in many cases. As a result domestically developed equipment that has qualified after intense user trials often fails to meet the standards post production. Thus, scaling up of production to meet the armed forces requirement becomes difficult.

Lack of a system to encapsulate the positive **lessons learnt** from successful projects across the board.

The **relationship between the users and the developers** in the system is more of a buyer-seller. The need to treat the developer as a partner in capacity development is acutely felt.

Recommendations

Reform the Defence Planning Process and restructure higher defence organisation and institutionalise the system of generating strategic guidance documents to evolve a meaningful LTIPP and LTTP which alone can form the basis for developing the required programmes and projects resulting in indigenous defence capability.

Program Management Process to be same in Strategic Sphere and Conventional Sphere.

- It is seen that sensitive programs managed in the strategic sphere are executed with synergy to focus on the indigenous effort. The technical and financial decision-making processes are effective and timely.
- In the conventional sphere, procedures are cumbersome and decision making is slow. Conventional programmes also have high strategic value to create the required deterrence. There is, therefore, an urgent need to bring the intensity of focus practiced in strategic programs to be applied to key indigenous defence programs.

Programs and Technologies as part of LTIPP

- LTTPP (Long Term Technology Perspective Plan) must include programs and constituent technologies that need to be developed and owned by the country.
- Development of these technologies, infrastructure creation must be funded as a Program element ahead of the project sanctioned as is now practiced by ISRO.
- Developing the LTIPP and the concomitant LTTPP as discussed in this report will necessarily take time to implement. The study group is, therefore, of the opinion **that following programs be launched in view of their criticality.**
    - Conventional submarine and Nuclear attack Submarine.
    - Hypersonic missile systems.
    - Integrated Ballistic and Cruise Missile System.
    - Aviation programmes.
    - Fifth generation manned fighter technology.
    - Development of gas turbines for various platforms under development.
    - Development of transport aircraft to meet the civil and military requirements.
    - Development of surveillance systems to be integrated.
    - AI enabled autonomous systems (Land, Air and Sea) to include platforms like unmanned combat aircraft, unmanned ASW surface vessels.
    - Cyber Security systems for the Armed Forces (Preference only to indigenous solutions, as notified on 2 Jul 2018 Public Procurement (Preference to Make in India) Order 2018 for Cyber Security Products issued by Ministry of Electronics and Information Technology).
    - Programmes to establish electronic and photonic components industry.
    - Development of sensors and seekers for multiple users.
    - The raw materials required for production of critical raw materials both metals, non-metals, composites and functional materials need to be developed. The present efforts are totally

inadequate. A national effort is required in this direction. In case of rare earth, a national implementation plan covering minerals, metals, alloys and downstream products is the urgent need for our self-reliance goals.

Evolving Requirement Specifications

- Operational requirement be evolved by the Services, as a result of system engineering analysis with the active participation of the users.
- All other steps leading to Total Requirement Specifications must be evolved by experts from DRDO and Industry. This document must establish all the essential linkages with the Operational Requirement for the entire satisfaction of the Services, as a result of systems engineering analysis with the participation of the users.
- Total Requirement Specifications must be reasonably rigid for Buy Class of categorisation, but also reasonably flexible for indigenous design, development class of categorization.

Modelling and Simulation

Modelling and simulation should be deployed at all levels of decision making and for system specification and development, as in the Model of Space Commission.

Replicate ISRO Model

The Industrial Policy of Space Commission is a visionary policy that has been supported by focused execution. Similar attempts had been lacking in the defence segment. The following needs to get addressed:

- Buyback Commitments: The DRDO procurement policies could not incorporate this provision as the Defence Forces are operating the DPP which starts treating the DRDO developed products afresh for acquisition and affords limited commitments to development partners and provisions of Para 72(a) of the DPP for various reasons are not used.
- The ISRO industrial policy execution caused a fervent Technology Transfer Groups that functioned in the premises of the industries to ensure effective transfer of technology. Such intense systems are yet to take root in DRDO.
- ISRO funded many private industry technology centers which model be replicated in the defence sector as well.

E-Procurement Exemption for Strategic Systems

- Para 4.15 Electronic Procurement (e-Procurement) of Manual for Procurement of Goods 2017 issued by Government of India Ministry of Finance, Department of Expenditure states "It is mandatory for Ministries/Departments to receive all bids through e-Procurement portals in respect of all procurements. …….. In individual cases where national security and strategic considerations demands confidentiality, Ministries/Departments may exempt such cases from e-Procurement after seeking approval of concerned Secretary and with concurrence of Financial Advisers. ……..

(Rule 160 of GFR 2017)". **This exemption must be invoked for procurements done by DRDO to enable them to maintain the required secrecy.**

- This exemption must also be applied to all the DPSUs and Ordnance Factories, and other Public sector entities involved in procuring sensitive items.

Section 2 : Analysis and Recommendations From Part-II

Recommendations With Respect To DRDO

HR Policy – Recruitment, Training, Development and Impact on Outcome

- There is a need to change the selection process and reach out well before even IT companies and MNCs go to the campuses.
- After recruiting the scientists and engineers, there is a need for focused post employment training in areas pertinent to DRDO. As a part of that training they should also be provided exposure to work done in DRDO and entrusted with project work.
- Focus must be levied on teaching system engineering concepts and practices in our academic institutions. The concepts of TRL and MRL are critical for success of induction of systems developed by DRDO.
- It is suggested that an eminent HR professional be hired and he / she should be entrusted with the task of reviewing HR policies, to include practices for improving the motivational level of the scientists and efficiency of the organisation at all levels.
- The development of complex systems would need different engineers and scientists with different capabilities, selection of personnel for these varied disciplines need to take into account the aptitude, which is normally done in most of the successful industries. This aspect is not handled in a professional way in DRDO and PSUs. The current method of selection by the RAC may be reviewed.
- There's a need for structured training programs by way of upgrading skills of the existing personnel to equip them with new technology and processes.
- There should be a clear system of recruiting every year, a particular number of scientists and engineers (300 or so), so that the continuous inflow of new blood is assured.
- Long term and short term out of the box measures like giving freedom to employ JRFs without any numerical restrictions, or employment/grant and extensions as recommended by Secy, DRDO, should be implemented. Lateral induction at scientist D, E And F levels and so on should also be seriously considered in view of the current manpower situation.

Directed Research and Innovation

- There is a need to revisit and restart a top down approach in crucial technology areas, which the country must own whatever the short term approach we may take, as was done by the Aeronautical Research & Development Board earlier.

Procurement Process of MoD / DRDO

- The defence procurement process is biased towards urgent operational requirement (UOR) which translates itself into AAP (two/three year need). And this requires a review. As such, whatever is approved as List A in AAP will get operationalised in minimum 5 years and as per past averages, in 10 years or never.
- For indigenous development under **MAKE (IDDM)/ MAKE through Mission Mode by DRDO**, the AON should be given for systems / platforms needed at least 7-15 years in advance, depending on an assessment of the TRLs available in respect of the systems/projects.
- In addition to this, the responsibility of procurement which is dispersed between MOD and SHQ leads to delays. Also, **there is no accountability for delays / incorrect projections in setting the requirement (GSQRs etc), which largely occurs due to systems analysis and engineering processes not being followed in setting the requirement to the development agencies. And this requires correction.**
- Procurement process in DRDO is one of its major weaknesses. Global tendering process that DRDO adopts for items costing more than 25 lakhs is detrimental to growth of Indian enterprises and achievement of self-reliance.
- The L1 principle applied in global tendering more often than not leads to critical material systems developed and productionised domestically not being acquired and the materials/products so developed in industry often causes the industry to shut down and the technology withers away.
- **Global tendering requirements should done away with.**

Project Management and Systems Engineering at DRDO

Key suggestions to reduce time and cost overruns are identified as given below;

- **Programme and Project elements**
    - In many organisations including ISRO, development has two elements viz. the programme element and project element. Funds are provided for the programme before any specific project is taken up. Each one of these programmes would consist of various specific projects. Depending on the requests projected by services and other users, while individual projects are launched, the programme elements need to be launched based on DRDO's LTTPP, overall threat perception, state of available infrastructure in the country and technology forecast.
    - We recommend funding should be provided for programme element ahead of project element thereby enhancing the maturity of technologies, enabling recruitment and training of manpower and creation of critical infrastructure.

- **Systems Engineering – a Key Enabler of Project Success**
    - We do consider and strongly recommend that all major DRDO projects follow the systems engineering, their stage gate as defined by the process should be compliant to international standards.
    - Systems engineering groups should be established in all the System laboratories. However, this approach requires the participation of the users and production agencies with the development agency. And the finalisation of the system specifications as a part of this process. GSQRs/NSQRs/ASRs as formulated today need a complete overhaul.
- **Domain Specialisation**
    - Key to success of any complex project is trained and motivated human resource. In a complex project, three types of experts are required;
    - Domain experts.
    - Systems engineers.
    - Management experts.
    - A complex project would need people with expertise in all the above three categories. Not every individual is suitable or has aptitude for all these tasks. HR development involves identifying the aptitude of the people and help channelising them in to the respective disciplines. Targeted Training in the respective area is vital. Career progression in the respective areas is a must. Our HR policies should ensure that all of the three categories have adequate career opportunities.
    - Many other relevant aspects have been explained in details in Chapter 2 of the report.
- **Test Facilities** are an important area for the success of any program and must be set up in a holistic manner.
    - In the absence of a programme and funding, it has not been possible to set up these facilities despite the felt need in the last two decades. We strongly recommend that as part of programme element, the test facilities for module testing, for full scale engine testing in an altitude chamber and flying test bed be funded as a gas turbine engine development programme.
    - We may mention, the development of cryogenic engines by ISRO was an incessant 30 year programme effort within which number of test facilities were created, enormous technology developed and failures experienced. The persevered efforts have led to a successful and matured cryogenic capability.

It may however, be noted that in the development of highly technology complex projects, even in very advanced countries with vast experience, large time and cost overruns have taken place, in most major systems and the US Government (GAO reports) in this regard are very relevant.

Other Recommendations

Delays in the Process of Productionisation

Establish strong production engineering groups at the production agency. Also there is a need to finalise production partner early in the development cycle at TRL 4 and latest by TRL 5.

Technology Development and Pre-Project Activity

Before project is taken up, considerable pre-project work needs to be done in understanding requirements, identifying technologies, assessing the maturity and availability of technologies, assessing test facilities required, manufacturing facilities required, understanding the operational environment etc. Time frame required for this activity must be catered for in the planning process.

Services Qualitative Requirements (SQR)

In addition to the aspects stated in Part-1 of the report, the following issues are important

- QR by definition need to only reflect the users mission needs, maintenance and logistic support, environmental conditions in which the system would require to operate and no RFIs should be necessary for this purpose.
- It is best to derive the systems specifications, as a result of systems **e**ngineering exercise through the appropriate stage gates to meet the mission and other needs of the users. Further, the concept of spiral development should be incorporated in the development cycle.
- It is recommended that a capability development executive be setup and should be supported by an empowered expert group, depending on the system under consideration with service officers, DRDO scientists and civilian experts. We do consider that these recommendations be implemented for speeding up induction of domestically developed equipment.
- We strongly recommend "spiral development" approach be followed to enable early induction of domestically developed equipment and weapon systems as brought out in the report. Concept of spiral development is explained in Chapter 2 of the document.

Reforming Trial and Evaluation Process

We recommend that when procurement is from Indian contenders the concept of NC-NC trials should be done away with and either converted to No Cost with Commitment or Development Cost funded with No Commitment as applicable.

Field Evaluation Trials

- The FET process needs to be simplified and shortened prior to bid opening with reliance on certification and simulation while elaborate trials can be conducted with the L1 and L2 bidders.
- Considerable time and resources are spent in field trials. Prolonged field trials are often the cause for time delays in DRDO projects.

- Having a designated command for field trials would be in the right direction and need to be considered expeditiously. Such a command while providing oversight could incorporate required specialists.
- Simplification of trial procedure could be as follows;
  - **Before Indent**.
    - Development trial – required.
    - User assisted trial (UATT) – not required. User can participate in development trials.
    - PSQR trials (Summer and Winter) –not required.
    - GSQR trials (Summer and Winter) – required. Amendment to GSQR based on trials to be made easy with focus on mission and operational requirements. This will avoid PSQR trials.
  - **Post Indent**.
    - First of Production Model (FOPM) trials – required to ensure quality of manufacture by the production agency. Production and field trials to be combined. However where the DCPP route as per para 72 of DPP is adopted these trials can be suitably curtailed **as the GSQR trials itself will be from equipment manufactured by the Production Partner through a process of concurrent engineering.**
  - GSQR and trial directive to be same for all OEMs (including Indian OEMs).

Enabling Production

- While converting a prototype to production standard is the responsibility of production agency, designer should aim to design the product for easy production. Another area of concern to services is related to safety, reliability, maintainability, operability, survivability and supportability ('illities') of the product in the operational environment. Design for illities is important and should be taken into account at the initial stage of design. System safety and effectiveness groups should be created as integral part of systems engineering / quality engineering groups in systems design organisations.
- The production organisation must invest resources to firstly reengineer the prototypes developed by the development agencies for serial production. In addition, technologies that enable faster/cheaper manufacturing of components and assembly of the systems.

Software Development

- Embedded software is playing increasing role in weapon systems development. Development and configuration control of embedded software needs to meet the safety requirements. The software industry adopts structured process in developing the safety and mission critical software. As the software developed by DRDO labs will be used by production agencies on "as it is basis", it is prudent that concerned system labs / application labs strive to get "CMM level" certification and follow the structured process of software development.

- Application of model based systems engineering (MBSE) helps in developing the correct logic and algorithms and in developing quality software. **MBSE process needs to be adopted to produce quality systems and software.**

Support to Small & Medium Scale Enterprises (SMEs)

It is strongly recommended that MOD funds testing and process shop facilities on priority at key locations such as Bangalore, Hyderabad, Pune and Dehradun. These facilities are of high value and beyond the reach of SMEs and start-ups.

Small Business Innovation Research (SBIR)

It is recommended that adequate resources be provided to this programme along with simplified approval processes, as success of this programme will result in cutting edge technology development, industrial growth, manpower training and enhancing the indigenous content of defence procurement.

Interfaces with Academia

There is a need for increase in funding to 10% of DRDO's R&D budget and establishment of more centres of excellence. As also simplify the approval and implementation processes.

Defence Technology Commission (DTC)

To give greater thrust to innovation, flexibility of operation and achievement of desired levels of self-reliance, Rama Rao committee and Ravindra Gupta Committee recommended that DRDO be reconstituted as " Defence Technology Commission " (DTC) on lines similar to AEC and ISRO. We firmly believe that this step is essential and should be done without any further loss of time.

Role of Private Industry

Until recently there was no eco system in the country in defence production. However, today large industries and medium scale industries have entered Aviation & Defence (A&D) domain of manufacturing at tier 1/2/3 level, though development of complex systems like aircraft and helicopters through domestic research and development largely remains with the DRDO and some other public entities. This is a welcome development that needs to be nourished and strengthened. This aspect is detailed in Chapter-2 of the report.

Defence Exports

Defence exports are negligible and form very small percentage of total turnover of our defence industry. This is an area of concern. It is often the export that enables indigenous products to become cost competitive with consistent quality and product support.

- It is strongly recommended that export of A&D products should be supported as a state policy with incentives and targets. To enable export of larger systems manufactured in the country, priority must be given for development of those subsystems and components which are subject to export restrictions.

Self-Reliance in Critical materials and Consumables

- At the cost of repetition, it is stated that most of the raw materials, consumables, equipment continue to be imported even after years of license production by OFs and DPSUs. Raw materials and consumables form a small percentage of total cost but are critical for self-reliance**.** Hence a policy of sourcing from within the Country even at higher cost should be adopted. Self-reliance in this field is too important for national security to depend on imports.

Strategic Partnership Model

- Strategic Partnership model is providing yet another entry to foreign vendors by diluting the design, development and manufacturing model as well as the strategic partnership model itself as initially envisaged.
- The committee observes that in all major areas defined in SP model at present, design and development capability exists in the country and productionisation of these systems does not require us to adopt the ToT route from foreign OEMs.
- However, within this broad framework there are, at the equipment/component/material level where imports are still necessary. But these imports do not justify our procurement of the total system through the ToT route. In addition, indigenisation of such equipment/component/material which are still being imported should be progressively indigenised with greater thrust, as achieved ATVP and other projects. It should be noted that for the items so indigenised should not be subjected to global tendering process.

Revitalise Make Process

There are a series of critical reforms which need to be implemented (and some are being implemented or are work in progress) to enhance the efficacy of this system. These include:

- Review of the process for obtaining the approval of AONs by the services should be based on an understanding of the TRL levels for systems/equipment available in the country. Where this TRL is 4 and below, the timeframe for induction after grant of AON could range from 8-15 years, depending on the complexity of the system. However, where TRL is 5 and above, it could be 5-10 years. Less than 5 years, should contain cases where only incremental improvements and upgrade of systems are envisaged. This will require that the LTIPP is drawn up, taking into account the TRL levels of the equipment or systems they require in formulating the same and AONs granted in time to cater for a development and trials period required.
- The Long Term Technology Perspective Plan (LTTPP) document by the DRDO where in, the TRL levels of various equipment/system/technology indicated at the current level and the plans for developing the same for next 5-15 years are indicated. Currently, the LTTPP of the DRDO is drawn up based on the projections on the LTIPP of the armed forces. However, to achieve the above objective, these two documents will need to be drawn in conjunct with each other with considerable interaction between the armed forces and the DRDO.

- Advanced technology programs which are at TRL3 or lower need to be taken up as National technology missions by DRDO in conjunction with Academia and other R&Ds institutions. Programs which are at TRL 4 or TRL 5 need to be taken up by DRDO with an Industrial Development cum Production Partner (DCPP) or lead system integrator, or through local Industry working closely with niche technology partners through the Make I route of the DPP. User involvement through funding and Technical & Ops team assignment is crucial for the success of these programs. A crucial step forward in this direction is in defining a DCPP policy which involves selecting a capable industry upfront in a complex program as a risk sharing development partner, lead integrator and future production agency. Para 72 of the DPP provides a useful framework for such a policy and needs only marginal changes. Also, such a partner should be our strategic partner in future as well for a reasonable period of time.

- While such a policy will be a major enabler, the implementation methodology is not clear. How will the program select a capable DCPP? Time and again policies, involving selection based on qualitative parameters, have failed because the power to judge and discriminate and take a decision which is the best at a point in time is subject to scrutiny and challenge in hindsight and can be penalised. We should be ready to overcome the trust deficit, take a leap of faith and contrary to GFR requirements say that any decisions taken by a Committee for choosing a domestic DCPP partner in this matter should not be retrospectively questioned or penalised. It may be audited, guidelines for making better decisions with the benefit of hindsight be drawn up but the decision cannot be questioned or penalised unless there is conclusive evidence of direct gratification in the case. Such a change in mind-set and approach would be a vital enabler for decision makers and a game changer for crucial processes such as the DCPP and Make I.

- The present defence production setup has not been successful as is evident from poor self-reliance index. We, the committee members, are firmly of the view that there is a need for a paradigm shift wherein the entire national capabilities are leveraged. Self-reliance should be adopted as an explicit MOD doctrine. This should be responsibility of all stakeholders like, MOD, Services, defence production organisation and not limited to that of DRDO alone.

Multi-Tiered Eco System

- Aviation and defence systems necessarily incorporate high level of technology needing best of R&D and production technologies. A mature aviation industry has a prime system integrator supported by Tier1, Tier2 and Tier3 partners.

- At Tier1 and tier 2 level, in each of the specialised area (structures, propulsions, flight controls etc.) maximum of 2-3 industries should be nurtured, while at the system integrator level 1 and a maximum of 2 in some cases may be possible considering our market size.

Maximise the Potential of Para 72 of DPP 2016

The Proposed Amendments to Para 72 of Chapter 11 of DPP 2016, are important and repeated below for:

a. DRDO/DPSU/OFB along with concerned SHQ(s) should jointly identify potential Design & Development (D&D) cases from LTIPP/SCAP/ and initiate Statements of Case (SoCs) based on

feasibility study undertaken by the development agencies For force multipliers such a study could be with the SCAP inputs.

b. To facilitate spiral development, the SHQ should indicate Mission needs, goals to be achieved and environment for deployment of the system developed. The systems analysis and engineering thereafter should be followed to arrive at system specifications test and trial requirements and feasible timelines.

c. To associate 'Development' with 'Procurement', and to ensure that development timelines do not inordinately deny the services of critical capability, the SoC will inter alia include, top level requirements with indication of the quantity required which can be exclusively committed for systems engineering process to be adopted to progress the project. In case of delay over projected time, MoQ for import may be indicated for the interim period. However, the development effort thereafter should be pursued following the ADA/IGMDP model.

d. Design and Development of prototype by DRDO/DPSUs/OFB will be done as per their internal procedures. Wherever applicable, Development-cum-Production partner (DcPP) or the Production Agency(s) (PA) should be selected by the developmental agencies right at the initial stage of development, so as to ensure seamless transfer of technology as well as lifecycle support. The discussion on choice of system integrator and tier 1/ 2 vendors is very important in this regard.

e. To reduce timelines and enable timely correctives at the developmental stage, representatives of QA and other agencies responsible for EMI/EMC checks may be co-opted in the JPMT, so as to complete majority of their trials/checks during the Developmental/User Assisted Technical Trials (UATT) itself. Para 72 of the DPP provides for this.

f. Once the prototype based on the system specifications successfully completes Developmental/User Assisted Technical Trials (UATT), the Minimum Order Quantity of equipment should be inducted into the Service as Limited Series Production (LSP) for 'User Exploitation' trials. These LSP should be designated as Mark-1 of the product.

g. Shortcomings observed or improvements suggested in the Mark 1 (LSP Model) should be addressed following the spiral development model as Mark II and so on.

h. Commercial order should be issued to Development-cum-Production partner, (i) In cases where the quantities are limited and production by industry is not feasible, production could be undertaken by the development agency itself. Also for major systems the Production development partner be designated as the strategic partner.

Development to Production; Transition Facilitators

Following are the suggested actions needed to facilitate smooth production of indigenously developed equipment and weapon systems, as discussed in this report.

- The DCPP model, as per para 72 of DPP, should be mandated for all systems.
- This will require medium to long term planning of service needs subject to resource availability, as discussed in Part-1.

- Competent design and engineering groups need to be established in OFs/DPSUSs/Private Industry in their niche areas who would be responsible for interfacing with DRDO and convert prototype drawings/Processes to series production standards.
- Global tendering should be attempted only when indigenous design and development capability does not exist. However, in such cases, expeditious action should be taken to establish requisite capability and capacity with in India either at private or public sector.
- MOD should change the tendering guidelines to enable India first policy. As defence is a strategic industry, indigenous sourcing policy will not be in conflict with any international agreements.
- OFs and DPSUs and RURs should be judged by the extent of sourcing from Indian industry and by the level of export achieved. Specific targets should be set. In order to achieve these targets, they should be encouraged and enabled to tie up with DRDO and private industry.
- Industry (OFB / DPSUs / Private Industry) should be encouraged to participate in development projects of DRDO, by contributing even a small percentage of development cost. This would help in ensuring their commitment to the success of the project and its productionisation. At the cost of repetition effective implementation of the DCPP mode at per Para 72 of DPP 2016 will be required.
- The eco system can be best created through major national project such as LCA Mk I A, LCA Mk II AMCA, FICV, FRCV and other major platforms and systems.
- The role of **Department of Defence Production (DDP)** is of paramount importance as a Process leader.

QA Criticalities

Quality is an important attribute of any product and is required to be assured in all the phases of product life cycle. Detailed analysis of the issues encountered during various life cycle phases of Weapon development pertaining to QA have been dealt with in chapter 3.

Section 3 : Design to Print: Industry Perspective Recommendations

Contractual Issues

These issues are highlighted and discussed in Chapter-3 of the report.

Limitation of Liability: In Indian A&D context (shared development, lack of insurance coverage, minimal control by private sector over product cycle), capping liabilities to value of goods /services billed will be a good starting point.

AON to Contract – Cycle Time: There is a need for shortening the AON to Contract cycle, strengthening the capability of the Industry to develop and realise systems indigenously to address this opportunity and building of an entire Defence Ecosystem to enable and sustain the growth in indigenous production. The

DCPP route from para 72 of DPP followed by acquisition as an IDDM indigenously developed product would cut short most of the woes.

One-sided Contracts: Sustained discussions between all stakeholders to bring contracts to somewhat even keel include :-

- carrying technical evaluation marks at CNC stage.
- greater play for domestic System integrators (as opposed to foreign OEMs).
- Service Level Agreement (SLA) based on measurement of performance.
- third party audit of delivery linked to milestone payments.
- fair clauses for arbitration, termination, force major etc.
- government's commitment on timely payment.

In case of foreign contracts, a level playing field in this regard is necessary for domestic industry and as a norm in the favor of domestic industry.

Development and Technical Issues

It is recommended that;

- Policy on joint IPs, ownership, monetisation, export controls and use for non-defence business.
- Parallel projects to be launched for development (along with last import).

Services to be sensitised clearly that further 'imports' would not be resorted to in future.

MOD should

- **set a last import date for all major systems based on current capability and analysis and weeding out cases that are no longer relevant/ required of pending AONs.**
- In our assessment, **no further imports are required** for most of our fighters and helos, ships/ submarines/ artillery systems, armoured fighting vehicles both wheeled and tracked, missile systems, radars, EW systems and C3I systems, software defined radios, other communication systems and most of the electro-optical systems.

APPENDIX A

Case Study I

Field Evaluation Trials - The Challenge to Indigenisation and to Capital Procurement

If there is one challenge in the acquisition process begging for reform it must be the process of NCNC evaluation and User Trials or Field Evaluation Trials (FET).

While the procurement is shifting from RFPs for Global cases to those for Indian built equipment the evaluation process shows no recognition of this shift. When equipment that global bidders offered from their product portfolio was sought to be procured, it was appropriate to carry out NCNC trials, evaluate every RFP parameter and avoid any flexibility in evaluation to avoid any problems post induction when these equipment were bought and shipped from foreign factories. The approach now requires a significant reform with far greater flexibility as procurement is shifting to Indian designed and manufactured equipment with many of the concerns of support and evolution being irrelevant.

Challenges with the existing NCNC trials / FET process

It is pertinent to highlight here some significant challenges faced with the existing FET process with few actual examples to illustrate the point.

1) **Lack of clarity of trial process in the RFP and during pre-bid stage of the Program**

   In the RFP, the Operational Characteristics and Physical Characteristics of the equipment don't explicitly state the requirement/expectation. In most cases the answer given in pre-bid clarifications to vendors seeking details or clarity on these parameters and testing approach is an ambiguous *"as per RFP"* or *"will be clarified during Pre-trial conference"*.

   Such ambiguity leads to difference in understanding amongst all stakeholders (User, DGQA, MET team, EMI/EMC team and bidders) and delays in conduct of trials besides throwing up issues in contract execution. Some amount of clarity being available only post pre-trial conference is too late because by that time the trial prototype would have already been realised based on the bidders' interpretation of requirements and there will be no time available to modify the prototype to address these requirements by the start of trials.

a) Examples

i) For e.g. in a past RFP for the requirement of NBC Protection the RFP simply stated *"To be NBC protected"*. No further details were provided in the RFP.

While the solution offered was discussed and cleared in TEC, during trials and contract execution DGQA has been interpreting this requirement as per their understanding of the past equipment in service and demanding a solution in line with that.

ii) For the requirement of Fire Suppression System, the RFP mentioned *"A fire suppression system for protection of the crew to be provided"*. No further details were provided in the RFP.

However, during trial and execution DGQA demanded performance evaluation based on response time, suppression time etc. while these requirements & parameters were not specified in the RFP.

iii) Typical pre-bid queries and responses for a tracked armoured system RFP:

[Q1]. What is the terrain and soil type (including geological analysis needed to comply with a 60 km in a 24-hour time span demand)?

[A1]. The terrain and other details will be briefed during pre-trial conference.

[Q2]. During endurance trials what is the total travel distance and how many rounds will be fired during the trial.

[A2]. Details will be clarified during Pre Trial conference

[Q3]. Please specify the EMI/EMC Standard/tests to be followed?

[A3].The details will be clarified during pre-trial conference

b) Recommendation

i) The RFP or pre-bid clarifications should bring out trial acceptance process and parameters.

ii) If the RFP, for whatever reason, chooses to leave certain aspects open for bidder interpretation and design, then systems designed and offered by bidder should not be questioned, as long as the same are meeting the stated requirement of the RFP.

2) Issues relating to FET, MET & DGQA trials

a) FET

Lack of clarity of trial methodology leads to arbitrary (trial officer dependent) conduct of some tests.

i) Examples

(1) RFP is silent on what zone of charge will be used for Direct Firing of Artillery Gun. This aspect is not covered in pre-trial conference either. It was left to the Trial OIC and the Bidders to arrive at a mutually acceptable solution at site.

(2) RFP is silent on how gradient test will be conducted. Not covered during pre-trial conference. It was left to the Trial OIC and the Bidders to arrive at a mutually acceptable solution at site.

(3) How mountain mobility will be conducted or what will be criteria for 'Passing the trial' is not defined in the RFP. Not even during Pre-trial conference. Trial team devised a method which was not disclosed till end of trial

ii) Recommendations

Trial Directive should be part of the RFP. In case there is an issue with incorporating Trial Directive in the RFP as-is, at least the essential aspects of Trial Directive affecting the preparation of trial prototype should be made part of the RFP.

b) MET

RFPs do describe in great detail the concepts of Field Level Maintenance and Depot Level Maintenance. However, they do not indicate which system needs to be maintainable at Field Level and which system needs to be maintainable at Depot Level.

This causes a conflict during MET. As per bidder's understanding/practice in OEM country, a particular assembly may be repairable at Depot Level; but MET team demands that item to be maintainable at Field Level, thus making the deliverable quantities of the particular item going up. Since price bids are already submitted, bidder has to absorb such costs.

The sufficiency clause is often invoked during MET and deviations in MET team recommended spares and spares included in the bid. Bidder is expected to offer these additional spares free of cost under the sufficiency clause of the RFP.

i) Recommendations

(1) EME should indicate, at least in generic terms, as to which system needs to be maintainable at Field Level and which system needs to be maintainable at Depot Level

(2) EME should conduct a detailed separate session as part of pre-bid meeting and formally clarify to bidders their expectations in detail.

c) DGQA Trials

Bidders are not clear about DGQA evaluation like applicable Tables of JSS55555 etc. Also for EMI/ EMC trials bidders are not informed about the required values, obtained values, result etc.

i) Recommendations

(1) Similar to the suggestion to EME, a separate session must be conducted by DGQA to apprise bidders in detail about the entire process of evaluation, decide with each bidder in one-on-sitting as to what all systems of each bidder will undergo evaluation etc.

(2) Wherever bidder is able to furnish certificate from NABL accredited labs, DGQA should accept the same and should not demand to test again.

(3) EMI/EMC team should conduct a detailed session with bidders and apprise them about the method of evaluation as to what will be tested, how it will be tested, reference values at pre bid stage

(4) At the time of evaluation bidders should be informed of observed values vis-à-vis reference values, if their equipment has passed the evaluation or not

d) Post Contract trials – BPC / FOPM

i) Various RFPs call for trials post Contract either to obtain Bulk Production Clearance (BPC) or to test the First of Production Model (FOPM). Despite long and protracted FET, a comprehensive test of the equipment is once again carried out post contract to validate parameters tested pre-contract and to close out any untested parameters or undertaking by the vendor for rectification / modification / improvement / enhancement given during the course of the FET.

BPC phase often takes a long time over satisfying various User and QA agencies. This disrupts all Contractual timelines and the Contract doesn't provide the vendor any relief for the time consumed in such evaluation.

Example

The most startling example of this is the Sarvatra Mobile Bridging System, a DRDO Design & Development project which was procured from BEML as the nominated DPSU Production Agency under Para 72 of DPP. After over 10 years of development by DRDO with the assistance of Industrial Partners and 2 years of User Assisted Technical Trials a LSP quantity of 5 numbers was procured and evaluated over a period of 4 years. After carrying out further improvements on these 5 bridges based on various deployment feedback for a period of about 4 years a MoD Contract was placed. Soon after, the order was placed on hold & modifications to the hinge of the foldable bridge were carried out by DRDO to cater for reported field cracks in the hinge. After life evaluation of this modification, clearance was accorded for proceeding with FOPM. The BPC phase has extended for over 2 years as the User identified new issues with water ingress in the bridge piers and asked for a design change to enhance sealing as well as realised that with these series of modifications the truck platform had a lower power to weight ratio than specified in the GSQRs. So more than twenty years on a Contract for

production of these bridges have been placed during FY12, advance has been paid to a DPSU, no production has commenced till date, and the supply chain of industries is in wait mode after buying material for production with no advance or compensation paid to them, even when the delayed timeframes are not attributable to the industry participants.

ii) Post Contract phase, DGQA often extends its brief to interpretation and enhancement of Contractual requirements and imposes acceptance procedures & standards followed in one system on another, holds I-Notes till the Vendor complies with these requirements leading to delays in Contract execution and financial burden on the vendor.

Recommendations

1) BPC requirements, methodology and associated timelines should be part of the RFP and the Contract. BPC should be restricted to minor confirmatory tests for enhancements committed during FET. Preferably such testing and any other issues raised by the QA agencies during the trial should be resolved on the prototype equipment itself concurrently with Contract negotiation & finalisation.

2) DGQA establishments should strictly adhere to Contractual provisions and not demand aspects beyond Contract, as DGQA is very much a party to the NCNC trials, joint finalisation and signing of the ATPs, as well as relevant Articles in the Contract regarding Quality during CNC.

3) DGQA should not be permitted to unreasonably hold inspection or issuance of I-Notes as vendor is not contractually obliged to agree to these post contract requirements / demands.

4) Specific and reasonable time frames should be stipulated for each phase of evaluation. In case the evaluation period gets extended due to actions from MoD constituents, appropriate indexing in costs to be provided to Successful bidder with appropriate extension in delivery cycles without imposition of LD

Reforms in the User Trial Process & Way Ahead

Given that the requirements, approach and process of NCNC trials has not evolved with the times to cater for the shifts in procurement strategy and approach a few key reforms are essential in this trial evaluation process for it to be a major enabler for "Make in India" and cater for the prioritisation of the Buy IDDM procurement process either through Make I & II (including suo-moto) or through the Strategic Partnership model route. These are enumerated below and complement the recommendations made in this section above:

1) Where procurement is from Indian vendors only the concept of NC-NC trials should be done away with. If there are No-Cost trials required for large programs, then Commitment to procure after successful demonstration of the Product should be affirmed by the MoD. Alternately, where development costs of the prototype are very high as in the case of complex platforms and systems, the Make-I process should be resorted to with 90% of the funding coming from the Government. For lower development cost programs such as those under the Make II, a seed funding of 30% of

development cost should be paid upfront by the Government against a Bank Guarantee and the bank guarantee returned to the participant Industry if it succeeds in fielding a prototype for trials within the stipulated timeframe. Where no acquisition case is pursued one year after successful completion of trials the full development money should be reimbursed to the Industry concerned. For relatively low value large quantity procurement cases the cost of items that are provided for FET would be reimbursed to the vendors who qualify in the FET as specified in Para 61 of DPP 2016 (Amended).

2) NCNC spending for Defence Programs should be recognised as allowable expenses under the DSIR Industrial R&D scheme and Industries with DSIR recognised R&Ds spending on building trial prototypes should be incentivised by permitting 300% of this expenditure as deduction from their taxable income. This would be another effective way of Government funding the process without MoD needing to make any direct pay outs from their allocated budgets.

3) There is a need to simplify and shorten the FET process. DPP 2016 (Amended) already outlines an intent in this direction through Para 58 which states that *"Parameters which can be evaluated at TEC Stage, based on Documents or Certificates rendered by accredited agencies, may not be included in the field trials"*. Para 59 explicitly states that *"Parameters not specified in the RFP should not be considered for FET"*. Para 60 states that FET will be conducted *"only pertaining to cases where the equipment is most likely to be deployed. In other conditions where the probability of deployment is not high appropriate certifications confirming the functional effectiveness under such conditions may be obtained; in cases where applicable, simulation based testing may be resorted to"*. Increased use of simulation based testing must be resorted to instead of the tedious and time consuming physical testing.

4) In line with the simplification direction of the DPP, it is further proposed that the RFP parameters are classified and FET trials be curtailed and conducted as specified below.

    a) Essential Parameters - A: will include all the essential parameters, functionally required for the equipment / system and will be required to be demonstrated in the User Trials.

    b) Essential Parameters - B: will include the parameters which involve destructive testing or very high testing expenses or long duration environment testing like tropical exposure, etc. or detailed Maintenance Evaluation Tests. These parameters need to be tested only for the L1 bidder.

    c) Enhanced Performance Parameters (EPP): DA(s) claiming EPP will have to demonstrate these parameters before completion of FET and will be awarded a credit score of up to 10%, for evaluation of L1, with each individual attribute not exceeding a credit score of up to 3% as elaborated in Para 10.3 of Chapter II of DPP 2016.

5) Further, in line with the provision of Para 67 of DPP 2016(Amended) for Multi-Disciplinary Technical Delegation abroad catered for in Buy Global and Buy & Make cases (where trials are completed in 1 to 2 weeks in the OEM Country), trials in India involving integration of systems or sensitive equipment be carried out by such a Delegation to significantly shorten and speed up the trial process.

6) Integrated trials plans should be considered wherein all trials (User/MET/DGQA/EMI-EMC) will happen in a time-bound manner. While User Trials and MET are happening parallel evaluation of DGQA and EMI/EMC be considered

7) Trial team members should be part of the TEC for better understanding and subsequent efficient and smooth conduct of the trials. DGQA, MET and EMI/EMC team members should form integral part of TEC so that a unified approach is adopted towards conduct of all parts of the trials.

8) For trials involving Radar Systems, MoD should have the authority to grant temporary WPC license to enable radiation during internal tuning & trials.

9) In repeat order cases the trials should be done away with except for any changes/upgrades

A more flexible obsolescence management process be introduced in Contracts where equipment or components used in FET that have subsequently become obsolete and replaced with more advanced & contemporary equipment available from OEMs be allowed to be upgraded with the quick approval of a Technical Committee comprising experts & the AHSP. This will avoid the User having to live with and support obsolete equipment at high cost because the process for substitution is time consuming, complicated and calls for contract amendments.

APPENDIX B

Case Study II

Futuristic Main Battle Tank

Need for the Next Generation Main Battle Tank

The future warfare will occur not only due to territorial reasons but also due to other factors such as economic strength, geopolitical maneuvering, ethnic issues, political unrest, non-state actors etc. During such ambiguous circumstances, weapons and weapon platforms designed keeping in mind conventional face-offs with adversaries are of little or no use. To overcome this problem, we need to develop weapon platforms keeping in mind the existing and evolving threats along with the technology obsolescence and service life issues of existing platforms.

Threat Perception from Indian Side

Military planners and regional experts envisage four different threat scenarios that are likely to evolve in any future engagement by India. They are traditional threats, asymmetric threats, threats from Rebel Groups and urban warfare. Primarily, the traditional threats such as the enemy tanks, helicopters, aircraft etc., are now not just a weapon platform but also a smart weapon platform integrating many digital systems and artificial intelligence. The technology required to provide this 'smart' effect can either be easily imported such as the case of F-16 sales to Pakistan or a joint R&D collaboration with China such as the development of Al-Khalid or Al-Zaraar. These smart weapon platforms coupled with precision weapons not only provide a deadly combination but also provide a force multiplier effect in the battlefield. In addition, the mountainous North East is likely to emerge as a future theatre of operations, which demands lightweight and powerful weapon platforms capable of operating at such high altitudes.

Secondly, asymmetric threats such as terrorists can transform themselves with latest technologies with the active support of enemy state administration from across the LOC. Strategic planners foresee circumstances where these non-state elements can help regular troops during a full scale war or limited skirmish.

Thirdly, Rebel Groups with the avowed intention of establishing a 'red corridor' pose a great threat to the Indian state. Although they do not possess fighting vehicles but are capable of inflicting great damage on them by the use of IEDs, mines, RPG etc. In addition, the terrain in which the engagement occurs provides natural camouflage in which even IR detection systems are not effective. In case of a skirmish with China, there is remote possibility of these elements opening up a third front thus deflecting our

attention and aiding our adversary.

In the urban scenario such as the one fought by NATO in Iraq & Afghanistan or the one fought by Russia in Chechnya / Ukraine new challenges that need better weapon platforms were the needs of the hour. Although such an eventuality is unlikely to occur in India, in case it happens, many challenging threats can evolve such as close encounters, lesser reaction time, decoys, multiple target engagement and the widespread use of mines, IEDs and RPGs.

Thus, to tackle all the four-threat scenarios a MBT that is light, agile, with high survivability and with improved situational awareness is mandatory.

Present Capabilities

On the Heavy armored vehicle front, Indian Armored Forces have nearly 4000-battle tank of which nearly 50% are latest generation tanks inducted during 2001 viz. T-90 and Arjun MBT and the remaining 50% are of vintage origin namely the T-55 & T-72 battle tanks. In addition, there are nearly 2000 light armored vehicles such as the BMP II from the 1970s vintage. Keeping in view the service life, technology obsolescence and changing scenarios succession planning for Indian armor core is mandatory and the likely induction of newer MBTs is proposed now during 2025. In that time frame, Arjun MBT will be 20 years old, T-90s will be 22 years old and T-72 would be beyond its full life of 40 years.

Working backwards on time with a decent development period (including prototype development, trials and transfer of technology) of 10 years the conceptualisation of Next Generation Main Battle tank (FMBT) will have to start immediately on top priority.

Finally, to win a war, not only meticulous planning but also a host of support vehicles such as Command and Control Vehicle, Infantry Combat Vehicle (ICV), Mine breaching vehicle, Armor Repair and Recovery Vehicle (ARRV), Bridge Laying Tank (BLT), logistic vehicle etc. are required. This demands a whole fleet of these support vehicles to be developed along with the FMBT for battle ready conditions.

Keeping in mind all these aspects, this report explores the feasibility of designing and developing a Next Generation MBT, with all the technology resources available within the country and with novel configurations, so that threat spectrum, weight limitations and transportability requirements are ensured. To replace existing T-72 Tanks by 2025 with a likely service period of 45 years (2022-2067) including overhauls & life extension programs.

Integrated Futuristic Combat Systems Project by Indian Army:

- Based on ARMY PSQR 1997, CVRDE / DRDO initiated a project namely **IFCOS** (**I**NTEGRATED **F**UTURISTIC **CO**MBAT **S**YSTEMS) in 1998 and executed by 2000 with the following activities.
- Formed various teams with all the relevant DRDO LABS for all major subsystems like, POWE RPACK,FCS,GCS,RUNNINGGEAR,ELECTRICAL,ARMAMENT,AMMUNITION,OPTICS, MATERIALS,RADAR ETC
- Organised many interactions with all stake holders including ARMY,EME,DGQA

- Also organised a training program with CRANFIELD UNIVERSITY , UK at Chennai to create awareness about the present and future tank technologies for the future
- Finally CVRDE/DRDO submitted a detailed report with many volumes covering all the technologies, considering the variants of MBT.

Subsequently a draft PSQR with 50 t FMBT was released by ARMY

Draft PSQR (50 t)-extensive deliberations with user, DGQA & other Establishment.

- 1ST and 2nd collegiate meeting conducted by army
- 3rd & 4th collegiate meeting @ ACC&S, Ahmednagar, 2010
- User & DRDO Interaction meeting on FMBT @ CVRDE on Feb 2012
- Draft PSQR-III version (55 t) was issued to CVRDE on 15th Oct 2012
- User & DRDO Interaction meeting on FMBT @ DRDO HQ on 20th Feb 2013
- Draft PSQR-IV version was issued to CVRDE on 27th Sept 2013
- Comments on Draft PSQR given to user on 6th Nov 2013

Finally a new RFI was issued in 2016 which seems to be based on the TI4 Armata MBT, with specifications as under.

- *Crew* : 4
- *Main armament* : 125 mm SB Gun
- *Ammunition* : FSAPDS, APAM, PCB, TB, ATGM (3rd Gen) & HEAT
- *Loading* : Bustle mounted Auto-Loader
- *Gun Control* : All Electric Drive
- *Fire control* : All weather FCS with Hunter-Killer Capability
- *Target tracking* : Automatic Target Tracker
- *Secondary Armament* : 12.7 mm AD Gun 7.62 mm Co-axial MAG
- *Engine* : 1500 hp
- *Transmission* : Automatic
- *Suspension* : HSU with dynamic track tension & attitude control
- *Passive armor* : Modular with ERA
- *Active protection* : Hard/Soft kill DAS
- *Mine/IED protection* :Belly protection, RMDS, Mine plough with MSD & TUSK

- *Camouflage* : Multi-Spectral (MCS)
- *NBC Protection* : Integrated NBC, APU & ECU
- *Fire Protection* : IFDSS
- *Situational Awareness* : Battle Field Management System
- *Communication* : Software Defined Radio (SDR)
- *Navigation* : Advanced Land Navigation System
- *Electrical* : Advanced Battery Management Unit & Fiber Optic RBJ
- Passive Armor protection in the range of 780mm RHA equivalent in the frontal area of Hull
- Passive Armor protection in the range of 650 mm to 1000 mm RHA equivalent in the frontal area of Turret
- Combination of Passive and Active Protection System against C.E projectile in the frontal arc is feasible.
- Armor to defect anti-tank RPG. This requirement can be addressed with Active Protection System
- The belly protection of tank against IED blasts of up to 5 kgs of TNT and additional protection up to 10 kgs can be provided selective area with weight penalty of 2 t.
- Passive Armor protection in the range of 780 mm RHA equivalent in the frontal area of Hull
- Passive Armor protection in the range of 650 mm to 1000 mm RHA equivalent in the frontal area of Turret
- Combination of Passive and Active Protection System against C.E projectile in the frontal arc is feasible.
- Armor to defect anti-tank RPG, This requirement can be addressed with Active Protection System
- The belly protection of tank against IED blasts of up to 5 kgs of TNT and additional protection up to 10 kgs can be provided selective area with weight penalty of 2 t.

Latest status

Indian Army (IA) released a RFI in June 2016, immediately after the demonstration of T14 ARMATA MBT during Russia freedom day, in the name of FRCV- Future Ready Combat Vehicle. IA insisted that only Foreign military equipment supplier can respond for the RFI.

In view of objection in parliament, the RFI was withdrawn

Presently Indian Army is holding the RFI for FRCV under MAKE IN INDIA / Defence procurement procedure program.

Inferences

- Indian MBT, presently, is T 72 which is more than 3 decades old and 2456 nos are available number wise
- Requirement of FMBT was considered in 1997 but till this date there is no progress, whgile DRDO/ CVRDE have developed the system design and realised most of the critical sub systems required as per PSQRs given from time to time, and initiated a 1500 HP engine development programme. Clearly there is a systemic lacunae which needs to be addressed.
- The shifting PSQRs could perhaps be avoided if the DCPP model in para 72 of DPP is followed and the PSQRs/QRs arrived at after a system's analysis and engineering studies undertaken to define the system specifications that would meet the Army's future mission needs.
- When world is focusing on unmanned / 1 or 2, we still seem to specify a 3 or 4 man crew and time delays.
- But IA is always trying to buy Russian T72 / T90 (1000 Nos. are available with IA) with 3 men crew only.
- IA conducted cumulatively more than 50000 km mobility trials and 6000 rounds firing with 11 prototypes and 15 preproduction series in the case of ARJUN MBTs and finally accepted based on AUCRT with 2 tanks and Comparative trials with 14 tanks. There is no system in Indian Army and it is the perception of HEAD WHOEVER Available in chair. Eg: ACCEPTANCE OF ARJUN MBT BY conducting T90 TANK COMPARATIVE TRIALS
- But IA bought T90 tanks just by conducting few days' trials with only 2 tanks and without allowing DRDO as dictated by RUSSIA.
- EME personal trained by spending huge money and time were not posted for the purpose of maintaining ARJUN tanks which is one of the reasons for non operational
- Also HVF have not procured spares and it was also not followed up properly by IA.
- When world is projecting 45t as FMBT, India is projecting 55t plus with 4 men crew.
- IA has been changing QR several times without any objective
- Keeping the present ammunition issues and availability, IA should decide 120 mm SMOOTH BORE but still discussing about 125 mm smooth bore
- IA wants active protection system but it does not want to reduce passive protection
- HVF AVADI always says that they can deliver first batch of tanks within 30 months which never happened
- Perspective planning says fund is not available, even for the present but IA is talking about FICV, FRCV and ARRV Etc.
- When CVRDE / DRDO initiated an Indigenous Engine development program for FMBT, IA was opposing.

- IA was trying to buy RUSSIAN APS (ARENA) by diluting specifications and issuing QR many times for T90, but could not due to genuine objections.
- In spite of spares issue with RUSSIA for T90 tanks, IA is trying to buy further 434 nos of T90 tanks at exorbitant cost. Initially IA procured only basic version of T90 to show that the cost is less but slowly today IA is buying all with exorbitant cost
- IA's requirement for FRCV is such that it wants all available technologies ARJUN MBT MARK II besides many more available in all tanks.

NOTE

FICV project was initiated in 2008 with an objective of involving Indian industries but with an option of allowing them to have partnership with Foreign military equipment suppliers. After receiving response from industries, DGPP objected saying that no clear criteria was given for comparison in the RFP and same foreign company Is considered by many bidders. File is pending with Ministry and IA is thinking of bringing FICV also under MAKE II category

Transfer of Technology

It is the responsibility of OEM / Design agency to provide all the documents required for Production agency, Quality agency, Maintenance agency, User etc including Drawings and Preservation requirements. It includes starting from raw materials to assembly.

HVF/OFB is not capable of manufacturing / assembling with only documents and in almost all cases OEM like industry representatives from Russia in the case of BMP II/ T 72/ T90 and representatives from DRDO for ARJUN MBT, BLT T 72,BMP VARIANTS, used to stay at HVF for years together to provide total support. Mostly they use trainees for inspection and many other functions.

But Private industries absorb technology transfer very fast and with minimum people from OEM and they also consume less time. Recently a private industry executed a contract with CVRDE for fabrication and machining of HULL and TURRET of ARJUN MBT MK II and CVRDE used these and assembled one without any problem/modification. Also the private industry took less time and support from CVRDE.

APPENDIX C

Case Study III

Arjun Main Battle Tank (Arjun MBT)

Prelude

Combat Vehicles Research and Development Establishment (CVRDE), Avadi is a premier establishment of Defence Research and Development Organisation (DRDO). The establishment is functioning with the vision of development of Armoured Fighting Vehicles (AFVs) and its variants for the Armed Forces. True to its vision, CVRDE had developed multiple AFVs and its variants.

Arjun MBT Mk I

The major product emanated from the portals of CVRDE is Arjun MBT Mk I, two regiments of which has been inducted into service. Through this, CVRDE obtained the capability and expertise for development of core technologies and systems for the main battle tank and learnt the finesse of system engineering using multi-disciplined and multiple technology based systems. After extensive validation trials spanning over 70000 km automotive run and about 7000 rounds of firing, Army had placed indent for Arjun MBT Mk I during year 2000. Against Army indent, OFB produced and issued all 124 tanks. Two regiments have been operationalised by Indian Army using these tanks. It is worth mentioning that Arjun MBT Mk I had performed creditably better than T90 during the comparative trials conducted by Indian Army.

Army had indicated issues in the maintenance of these tanks during 2014. Based on the MoD directions and in line with DRDO policy of handholding User towards life cycle management for the products developed by them, CVRDE extensively coordinated and systematically completed operationalisation of all the tanks held by the regiment / brigade. Based on MoD directions, CVRDE undertook the task of procurement of spares for two APR 2014-15 and 2015-16 and the same is under progress for the second tank. CVRDE is also actively contributed and completed Pilot Medium Repair of one tank and the same action is under progress for the second tank. CVRDE is working towards coordinating and ensuring conduct of Overhaul of the Arjun MBT Mk I, when the OH becomes due. CVRDE was instrumental in drafting and obtaining approval for the lifing norms, OH/MR policy and Long Term Sustenance Policies along with Army and other stakeholders.

Arjun MBT Mk II / IA

Bolstered by the performance of Arjun MBT Mk I during comparative trials, Army projected requirement for developing Arjun MBT Mk II with identified major improvements during year 2010. Incorporation of these improvements will lead to development of superior weapon system for Indian Army. First prototype of Arjun MBT Mk II was made within two years by CVRDE and fielded for User trials since Jun 2012. Majority of trials were completedby 2015 and Army has projected a need for integrated User validation trials.

During high level meeting held between Army and DRDO during Mar 2018, a focussed roadmap was laid down for the induction of Arjun MBT Mk II (later renamed as Arjun MBT Mk IA). This led to the formulation and successful conduct of PSQR based trials during Dec 2018 for the 14 major improvements. The prototype had covered more than 7000 kms as part of DRDO and User trials in toto. The trial report indicated that all parameters of 14 major improvements have been validated as per PSQR and recommended the induction of Arjun MBT Mk IA into Indian Army. This led to converting PSQR into GSQR and initiation of Statement of Case towards re-validation of AON for two regiments of Arjun MBT Mk IA consisting of 118 numbers.

Conclusion

As seen above, PSQR trials were successful during Dec 2018. Actions are being taken towards placement of indent. Revalidation of AON and subsequent placement of indent on the nominated production agency (HVF/OFB) need to be done thereafter.

Clearly this brings out that

- We need to go into details of the process of trials and evaluations that domestically designed products have to go through as opposed to procurements from foreign OEMs.
- The reasons for delays that have taken place to complete the trails with the acquisition process still not completed.

Profiles of Task Force Members

Vice Admiral Raman Puri (Retired)

Vice Admiral Raman Puri retired as the Chief of Integrated Service Command (CISC) in 2006 after a distinguished service of 40 years in the Indian Navy. Adm. Puri served in a number of important positions during his career. These include a Destroyer and a Carrier Command, Founder Director of the College of Naval Warfare, Director Staff Requirements (NHQ),the Flag Officer Offshore Defence Advisory Group (FODAG), Flag Officer Maharashtra Naval Area (FOMA), Fortress Commander Andaman and Nicobar Islands (FORTAN), Deputy Chief of Naval Staff (DCNS), and Commander in Chief of the Eastern Naval Command. During his tenure as CISC issues of Defence planning process, Defence acquisition process, Joint Operations, Logistics and Training were dealt with from the Higher Defence and Strategic level perspective. He also served as the Executive Director of the Institute of National Security Studies. He is currently a member at the National Security Advisory Board.

Brig Dr Anil Sharma (Retired)

MMS from Osmania University, PhD (System Dynamics Modeling of National Security Strategy and Force Restructuring), and the writer is Fellow of Army War College. He has been Head of Office of Net Assessment and Professor and Director at University of Petroleum and Energy Studies, Dehradun. He has published more than sixty papers on strategy and security and is former editor of Army War College Journal. He is currently working with Vivekananda International Foundation and is Additional Secretary cum Principal of Yogoda College, Ranchi University. He has evolved integrated NSS model based on system dynamics approach in his PhD as a unique contribution. He has subsequently drafted the NSS while serving MoD.

Rear Admiral Dr. Sanatan Kulshreshtha (Retired)

He superannuated from Indian Navy as Director-General of Naval Armament Inspection (DGNAI) in 2011. He has a Doctorate from 'School of International Studies' at the Jawaharlal National University (JNU) New Delhi. He is a Member of the Safety, Testing and Evaluation Panel of the Armament Research Board of the DRDO. He is also on the Faculty Research Council of Amity University. He is an ardent proponent of self-reliance through indigenisation.

Commander Dinesh Singh (Retired)

Cdr Dinesh Singh (retd) was commissioned in navy's electrical engineering branch on 01st Jan 1986. In his 20 year stint in Indian Navy, he was posted at navy's premier R&D establishment for a decade, working on C3I systems and systems integration of ship /avionics sensors. He was one of the architects of indigenous data link system deployed on IN ships, submarines and aviation platform –both indigenous and imported.

He joined Tata Consultancy Services in 2006 and manages its defence business specially - its support to indigenous defence programmes involving engineering and industrial services. He is an active contributor in various committees of MoD, CII and NASSCOM with specific focus on defence modernisation, offsets and self-reliance.

Lt. Gen. A.V. Subramanian (Retired)

General was a member of the Committee of Experts for amendments to DPP 2013 including formulation of Policy framework. Prior to his superannuation on Mar 14, he was the Director General of Weapons and Equipment at IHQ (Army). He has been involved in indigenous defence technology development.

Shri Amit Cowshish (ex- FA Acquisition)

Amit Cowshish is a former Financial Advisor (Acquisition), Ministry of Defence. He was associated as Distinguished Fellow with the Institute for Defence Studies and Analyses, New Delhi, and as a Partner with Dua Associates, Advocates and Solicitors. A post-graduate in Political Science, he also holds an M Phil and LL B degrees. He has attended the National Security and Strategic Studies course at the National Defence College, New Delhi. He writes regularly on matters concerning financial management in defence, procurement policy and procedures, budget, planning and other related issues.

Dr. Kota Harinarayana

Dr. Harinarayana is the Fellow of Aeronautical Society of India (former President of the Society),Indian National academy of sciences, National academy of sciences and Indian National Academy of Engineering. He was formerly Vice-Chancellor of University of Hyderabad till 15 th July, 2005. He was also chairman of Research councils of CSIO, Chandigarh (CSIR LAB) and Centre for Wind energy Technology, CWET (MNRE Institution) , distinguished visiting professor at IIT,Bombay, Pratt & Whitney Chair professor at University of Hyderabad, Member of UGC empowered committee on Basic research in Science , Dr. D S Kothari DRDO Chair at ADA, Bangalore, INAE Satish Dhawan Chair professor of engineering eminence, Chairman , Board of Governors of IIITDM, Jabalpur , advisor to CSIR-NAL He is at present SERB distinguished fellow at CSIR-NAL and founder chairman, General Aeronautics pvt ltd (A startup incubated by IISc ,Bangalore).

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The defining feature of VIF lies in its provision of core institutional support which enables the organisation to be flexible in its approach and proactive in changing circumstances, with a long-term focus on India's strategic, developmental and civilisational interests. The VIF aims to channelise fresh insights and decades of experience harnessed from its faculty into fostering actionable ideas for the nation's stakeholders.

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