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A PERSPECTIVE OF R & D IN DEFENCE SECTOR AND THE CHALLENGES

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ABSTRACT

R & D in a country is essential for self-reliance in many fields and defence sector is a major participant in it. India is highly dependent on foreign countries for its defence weapon system needs and is a major importer of arms. The paper discusses in detail the R&D environment in India compared to global trends and what needs to be done to improve the situation so that the country becomes self-reliant to a large degree on its weapon needs.

KEYWORDS—R&D, Patents, DRDO, Defence

I. INTRODUCTION

Defence Research and Development Organisation (DRDO) was formed in 1958 under the Ministry of Defence with the aim to advise and assist the armed forces on scientific developments and indigenous weapon system development and to undertake research in the areas of weapon system and requirement of the armed forces. It was set up with the mandate of carrying out research in cutting edge technologies leading to production of state of the art sensors, weapon systems, platforms and allied equipment to the defence services. In 1980, the Department of Defence Research and Development (DDR&D) was formed to improve the administration efficiency. DRDO today has 46 laboratories across the country. Based on the type of R&D work carried out by the 46 laboratories, they are grouped into seven clusters namely Armament and Combat Engineering Systems (ACE), Aeronautical Systems (AERO), Missiles and Strategic Systems (MSS), Naval Systems and Materials (NS&M), Electronic and Communication Systems (ECS), Micro Electronic Devices and Computational Systems (MED &CoS) and Life Sciences (LS).[1] In addition there are four Research Boards with funding provided by DRDO which carried out basic research in areas of strategic importance with the academia. The organisation is headed by Scientific Adviser to RakshaMantri (SA to RM) who is also the DG R&D.

The Department of Defence Production (DDP) was set up in 1962 with the aim of developing production infrastructure to produce various weapons, systems etc required for the armed forces. The DRDO in India maintains partnership with about 40 premier academic institutions, 15 National Science and Technology (S&T) agencies, 50 Public Sector Units (PSU's) (which include the nine Defence PSU's (DPSU's), 39 Ordnance Factories (OF's) and 1000 plus private sector industries.[2] This forms the main machinery in the R&D network for the defence.

In order to achieve self-reliance in defence technology it has resulted in creation of huge establishment with many entities to provide the state of the art weapon system for the armed forces. However, the capability of DRDO to provide the cutting edge technology what the services ask is far from satisfactory and also many of the projects have taken too long to fructify. This has resulted in import of the various weapon system for the armed forces. According to Stockholm International Peace Research Institute (SIPRI), India ranks No. 1 in the international arms transfers with arms worth US $ 23022 million was imported by India. This is a whopping 13.9% of the total international arms transfer.[3]

II. GLOBAL TRENDS IN R&D

Being the leading country in arms import, let us look at the global noise in R&D. The global trends in the R&D activity has a bearing on the R&D activity in the country. There is a very important relation between research and development and economic growth. The US is the dominant figure in R&D spending followed by China. The role of Asia is increasing in R&D spending with China and Japan taking the lead.

China is continuing its economic growth as well as continued increase in R&D spending. At the current rate of growth and investments China is likely to surpass in R&D funding to that of US by 2022. Table 1 given below gives the R&D investment of 10 countries. From the Table it can be seen that United States continues to be the top spender on R&D with about 2.8% of GDP being spent. India has been spending about 0.85% of GDP on R&D.

The Gross Expenditure on Research and Development (GERD) as per PPP figures forecast 2016 globally is about US $ 1947.75 billion[4]. Therefore it can be seen that the money spent on R&D by India is very small compared to the other major players in the world. The R&D expenditure as % of GDP for a few selected countries is shown in the Fig 1below. The R&D expenditure per capita is PPP$ 26.2 in India whileit is US $1494 in Finland and US $ 115.5 in China for the year 2009.[5]

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Forecast Gross Expenditures on R&D

		2014 Actual			2015 Estimated			2016 Forecast		
		GDP PPP Bil, US$	R&D as % GDP	GERD PPP Bil, US$	GDP PPP Bil, US$	R&D as % GDP	GERD PPP Bil, US$	GDP PPP Bil, US$	R&D as % GDP	GERD PPP Bil, US$
1	United States	17,460.0	2.78%	485.39	18,001.3	2.76%	496.84	18,559.3	2.77%	514.00
2	China	17,630.0	1.95%	343.78	18,828.8	1.98%	372.81	20,015.0	1.98%	396.30
3	Japan	4,807.0	3.40%	163.44	4,855.1	3.39%	164.59	4,913.4	3.39%	166.60
4	Germany	3,621.0	2.85%	103.20	3,678.9	2.92%	107.42	3,741.4	2.92%	109.25
5	South Korea	1,786.0	3.60%	64.30	1,844.9	4.04%	74.53	1,909.5	4.04%	77.14
6	India	7,277.0	0.85%	61.85	7,822.8	0.85%	66.49	8,409.5	0.85%	71.48
7	France	2,587.0	2.25%	58.21	2,618.0	2.26%	59.17	2,657.3	2.26%	60.05
8	Russia	3,568.0	1.50%	53.52	3,432.4	1.50%	51.49	3,396.6	1.50%	50.95
9	United Kingdom	2,435.0	1.81%	44.07	2,500.7	1.78%	44.51	2,558.2	1.78%	45.54
10	Brazil	3,073.0	1.21%	37.18	3,042.3	1.21%	36.81	3,072.7	1.21%	37.18

Table 1:Gross expenditure on R&D
Source:'R&D 2016; Global R&D funding forecast winter 2016'accessed at www.iriweb.org on 03 Mar 17

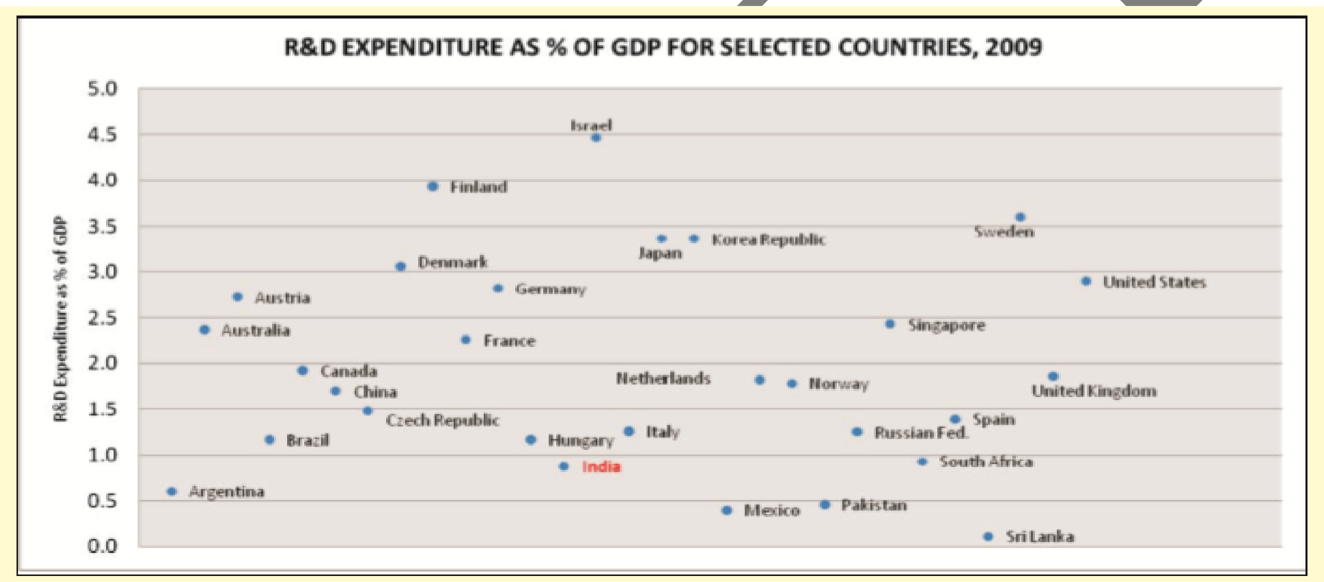

Fig 1: R&D expenditure as % of GDP of few countries
Source: Department of Science & Technology, Govt of India

III. STATE OF INDIAN R&D

The R&D in DRDO or defence related industry forms a part of the larger R&D system of the country because a large number of innovation and R&D has dual use in both civil and military especially R&D related to information and aviation sector. Therefore they are interlinked and have a bearing on each other. Also, the research carried out by the academic institutions have a relation with the requirement of the defence forces by way of contribution of human skills. The state of Indian R&D had no doubt shown remarkable progress in the years and has achieved international recognition. This is evident on multiple parameters in the field of R&D like increase in the number of scientific papers published by Indian researchers, the number of patents filed by Indians, the growing participation of Indian scientists in international scientific events. From 2006 to 2010, the contribution of Indian scientists in 16 major scientific journals have gone up by 12 % average totalling to 65487 research papers while the worlds average increase was 4 %.

The growth in the science publications has also improved India's global ranking to ninth place in 2010 compared to 13th place in 1996. The quality of Indian scientific publications as measured in terms of citation impact, has also improved at 0.68 which is higher than Russia and China.[6] The Indian space industry is also highly recognised for its capability in design and manufacture of satellites. Compared to defence sector R&D, the space industry has proved its capability to adopt latest scientific technology and is much more self-reliant.

The domestic industry provides around 70 % of the total technology content in the space sector.[7] Notwithstanding the achievements of India in the field of science and technology, compared to the global standards, it is far below the standards. The measure of inventiveness in basic sciences given by the creation of Intellectual Property is far below countries like US, China, Japan and South Korea. China has increased its R&D investments continually for the past 20 years and is likely to surpass US by 2026[8]. It is increasing investment heavily to create innovation infrastructure to help it to develop, manufacture, commercialise advanced technology products moving away from the image of producing low technology products.

Table 2 gives the patent trends of four countries between 2010 and 2015.[9] In 2010, the number of patents granted to India was 5.3% % that of China and by 2015 this has reduced to 1.7%. Also, the resident category of patents are more than non-residents category in China while in India the non-resident category of patents are much more than resident category of patents.

Year	China			India			Japan			USA		
	Resident	Non-Resident	Total	Resident	Non-Resident	Total	Resident	Non-Resident	Total	Resident	Non-Resident	Total
2010	79767	55343	135110	1208	5930	7138	187237	35456	222693	107792	108626	216418
2011	112347	59766	172113	776	4392	5168	197594	40729	238323	108626	115879	224505
2012	143808	73297	217105	722	3606	4328	224917	49874	274791	121026	132129	253155
2013	143535	64153	207688	594	2783	3377	225571	51508	277079	133593	144242	277835
2014	162680	70548	233228	720	5433	6153	177750	49392	227142	144621	156057	300678
2015	263436	95880	359316	822	5200	6022	146749	42609	189358	140969	157438	298407

Table 2: Patents granted to four countries taken from ipstats.wipo.int

From the above table it can be seen that from 2010 to 2015, the total patents granted in China has increased 2.65 times while that of India has decreased. The trend in grant of patents in India has been not been impressive compared to countries like China, Japan and USA. Fig 2 shows the trends in the grant of patents to four major countries USA, Japan, China and India. It is seen that there was a steep raise in grant of resident patents in China from 2010 onwards.

The patent grants for resident Indians during the period 1999 to 2013 had reduced from 633 to 594 except for intervening period between 2005 and 2010 when it crossed 1000 mark, and has shown marginal increase in 2014 and 2015.Whereas patent grant in non-resident category during the period 1999 to 2013 had increased from 1527 to 2783 with maximum reaching 13520 in 2008. In 2015 the patent grant in non-resident category was 6.32 times the resident category in India. Compare this with China the patents granted in resident category during the period from 1999 to 2015 has shown an increase from 3097 to 263436 which is about 85 times and in the non-resident category it showed an increase from 4540 to 95880 during the same period which is about 21 times[10].Fig 2 below shows the graph of patents granted in resident and non-resident category of four major countries from 1999 to 2015. "This is a worrying situation for an economy like India's, which is striving to grow multi-fold in the near future and aspiring to become a knowledge-driven economy."[11] Although there has been a marginal increase in grant of patents in resident category in 2013-2015 from 594 to 822 but the non-resident category also has shown an increase from 2783 to 5200 during the same period.

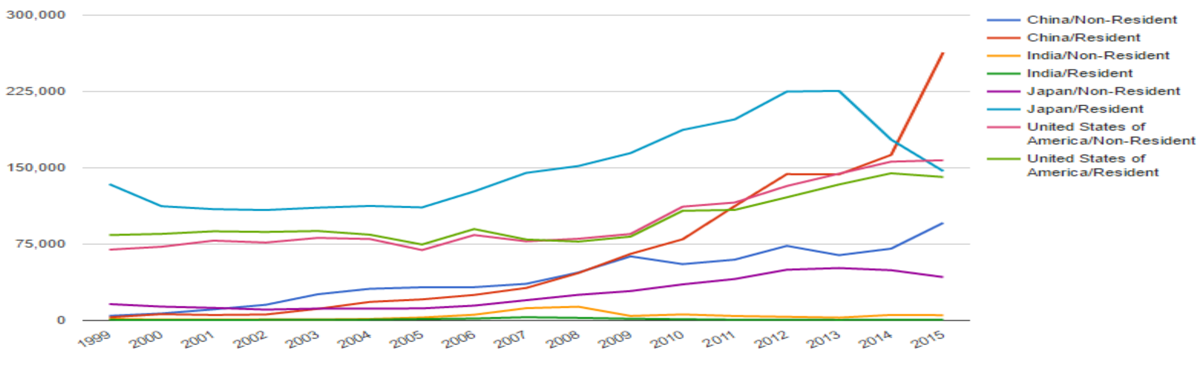

Fig 2: Patents granted from 1999 to 2015
Source: www.ipstats.wipo.in

On 12 May 2016, GoI adopted the IPR policy with an aim to make Indians recognize their own IPs, as also respect others' IPs. The Vision Statement envisages an India where creativity and innovation are stimulated by Intellectual Property for the benefit of all; an India where intellectual property promotes advancement in science and technology, arts and culture, traditional knowledge and biodiversity resources; an India where knowledge is the main driver of development, and knowledge owned is transformed into knowledge shared[12].

Researches are key to innovation and R&D in any country. The availability of researchers drives the R&D capability of the country and advancement in science and technology. India has one of the lowest densities of R&D personnel. The number of researchers per million population in India is 157 compared to 8282 in Israel, 5201 in Japan, 1089 in China, 4055 in UK, 4153 in France and 4019 in USA.[13] "The shortage of qualified scientists and engineers, something HomiBhabha had warned about when he put together the nuclear establishment in the late 1940s, has come to haunt Indian R&D and industry." [14]

The R&D funding in India is mostly by the Govt. The share of various sectors in the total R&D expenditure in India is shown in Fig 3. The major contribution for R&D is form the central Govt which accounts to 55% and the private sector contributes 29%. The industrial sector contributed 6.1% of the total defence R&D expenditure in India during 2009-10. The industrial sector includes PSUs and private sector put together. Out of the total national R&D budget, 31.6% goes to DRDO which is 18.4 % of the share of national expenditure on R&D.[15]In comparison, industry contributes 72 % in the US and the federal govt spends just 8 % on R&D with academia spending 15 %.[16] The contribution of private industry in defence R&D in India has been particularly very low.

IV. R&D IN DRDO

DRDO is the R&D wing of Ministry of Defence, Govt of India, with a vision to empower India with cutting-edge defence technologies and a mission to achieve self-reliance in critical defence technologies and systems, while equipping the armed forces with state-of-the-art weapon systems and equipment.[17] DRDO is the main arm of the defence in the R&D and innovation ecosystem in India. It was created in 1958 by merging the units of Defence Science Organisation with the then Technical Development Establishments of the three services. The organisation started with a cluster of 10 labs in 1958 and has today 46 labs across the country. DRDO's mandate is to provide assessment and advice on scientific aspects of weapons, platforms and surveillance sensors, to carry out research and development of cutting edge technologies leading to production of state-of the-art weapon systems, sensors, platforms and allied equipment for armed forces. In the recent past, the mandate has been widened to support national cyber security architecture which includes testing capabilities, security solutions, networking systems and cyber defence tools. In this process, it has also established national infrastructure, enhanced defence industrial capability and developed committed quality human resources.[18]

DRDO has a total strength of 25,148 employees out of which 7,549 are working in Defence Research and Development Service (DRDS), 9528 in Defence Research and Technical Cadre (DRTC) and 8071 are admin and allied cadre. DDR&D was allotted Rs.14358.49 crores in the year 2015-16 and 58 new projects costing 1591.10 crores have been sanctioned. The projects on which DRDO works can be classified into five categories; Mission Mode (MM). Technology Demonstrator (TD), Science & Technology (S&T), Infrastructure and Facilities (IF) and Product Support (PS).

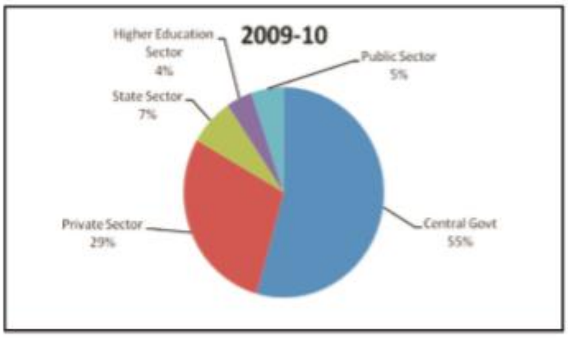

Fig3: Share of various sectors towards R&D
Source: www.dst.gov.in

DRDO currently has around 278 ongoing projects costing around Rs 46840.76 crores. Some of the high value and flagship projects of DRDO are Light Combat Aircraft (LCA) for Air Force and Navy, Long Range Surface to Air Missile (LRSAM), Medium Range Surface to Air Missile (MRSAM), Airborne Early Warning and Control Systems (AEW&C), Kaveri Engine, Airborne Warning and Control System (AWACS). The production value of DRDO developed systems is around 1,74,800 crores which has increased from around 6000 crores in the eighties.[19]

From the time DRDO was formed in 1958, the organisation has evolved and the production value of the systems developed by DRDO has increased. Over the years the organisation has made significant progress and contribution in the missile system which is evident from the development and successful trials of Nag, Prithvi and Agni missiles. Also, more than 300 items of arms and ammunition worth over Rs 1,20,000 crores based on DRDO technologies have been inducted or under induction in the services. The quality of the product design of some of the products/technologies compares favourably with the best in the world. Some technologies like illuminating ammunition, FSAPDS shots, and gun/rocket/missile propellant even surpass the performance of the contemporary design in many respects.[20]Being the premier research agency in India for defence, DRDO is not only judged by what it designs and produces but also the indigenous content in the products it produces.

In 1992, the self-reliance committee under the chairmanship of Dr APJ Abdul Kalam, the then scientific adviser to the Defence Minister, had visualised that the percentage share of domestic procurement in total procurement expenditure, a measure of self-reliance would progressively increase to 70 % by 2005.[21] But as on 2015 that target has not been met and is far from reaching it in the near future. Although the exact measure of the self-reliance index is not known there are various statements regarding extent of self-reliance. As per the report by the Standing Committee on Defence submitted to Parliament in April 2012, the chief of DRDO had claimed that the self-reliance had gone up to 40-45 %.[22] According to Defence analyst G Balachandran, the self-reliance index for the seven year period between 2001-2008 was 55 %.[23]

The DRDO being the only agency for R&D in defence with miniscule participation by private industry has come a long way in providing the weapon system for the armed forces. During the early 1960s the DRDO was responsible for achieving self-sufficiency in non-lethal weapons of the armed forces. However, DRDO has always been accused of not being competitive, project cost over-runs, inordinate delay in delivery of system, lack of innovation amongst the personnel. This has inevitably led to import of arms and denial of cutting edge technology to the armed forces. India today is the No 1 arms importer in the world and imports almost 70 % of its requirement from abroad.

The technological gaps has led the organisation to take on as many projects as possible and resulting in non-deliverables of the technology within the allotted time and cost. This has also led to closure of few projects as either the armed forces does not need it or due to the security scenario, the system was imported from abroad. A 1989 review of all the projects undertaken by DRDO had led to closure of almost 618 projects out of 989 projects.[24] Although lack of funds was the reason given for short closure of the projects, it was evident that the organisation lacked the capability of develop technologies it had pursued. The Comptroller and auditor General of India was critical in the manner in which projects are sanction in his report of 2012-13.[25]

Almost all the flagship projects of DRDO has ran into time and cost overruns. Also, the user satisfaction and the confidence in the products developed by DRDO is very low. The cost over-run of MBT Arjun was a whopping 1884 % and despite taking two decades, the production numbers as ordered by Indian Army is very low which indicates users lack of confidence. Similar is the fate of Light Combat Aircraft (LCA) which has taken three decades for development. This was supposedly the replacement for MiG series of aircraft which were aging and obsolete. The delay in developing LCA has led to depletion in the strength of the squadrons in IAF and has led to the Air Force pitching for MMRCA from abroad. This has a great effect on the defence preparedness of the country. The inability of HAL to develop the indigenous Intermediate Jet Trainer (IJT) aircraft even after 15 years, which has still not achieved the Initial Operational Clearance(IOC), has led the IAF to think of using the Basic Trainer Aircraft (BTA), Pilatus 7 Mk-II for the intermediate stage training which is now being done on Kiran Mk-II aircraft.[26] The Kiran aircraft are aging and are flying with extensions. The inability of HAL to develop HTT-40 BTA has led to additional procurement of Pilatus Mk-II from abroad.

The delay in the successful development of weapon system not only results in importing from abroad, it leads to adverse effect on the op-preparedness of the service. Once the weapon system is imported, the users cancel their requirement which is waste of expenditure in developing the system.

High end technologies and system are procured from abroad under the transfer of technology route for licensed production by DPSUs. However, technology transfers does not happen in true sense as the OEMs never part with the critical technologies and those of strategic importance. So the Armed Forces are continually at themercy of OEM where at any point in future the OEMs can deny or may come at a high cost. Also, technology transfers have not been able to foster R&D in DRDO since technology transfers needs adaptation of skills, cultural change and organisational change. The R&D personnel needs to adopt the technology of the foreign countries which is difficult due to differences in the skills of the people involved. This results in just assembly of the parts procured from abroad.

V. WHAT IS THE WAY AHEAD

The existing system of R&D in defence with little participation from the private industry and academia does not augur well for a nation like India. The services make a Long Term Integrated Perspective Plan spanning three Five Year Plan which are reviewed regularly. These are made based on threat perception, doctrine of the Armed forces, obsolescence of existing system, strategy of the armed forces and adversaries capabilities and ways to neutralise them. The DRDO then prepares its own Long Term Technology Perspective Plan (2012-2027) which coincides with the Five Year Plan. The LTTPP of DRDO highlights the expected new technology developments in various areas. It is incumbent that all stake holders like DRDO, DPSUs, CII, representatives of Industry, representatives of Armed Forces need to make a combined perspective plan for the next fifteen years based on the requirement of the Armed Forces.

The stake holders based on their core competency have to commit the time frame for development of the technology. The formulation of the Plan in isolation and the expectation of the services that it would be delivered by DRDO is a tall order. The projects can then be categorised as Mission Mode, Technology Demonstrator, strategic projects etc. Development of any new technology take lot of time and effort. The following are the proposals for improving the R&D environment so that the stake holders like defence services can benefit and the R&D agencies can deliver cutting edge technology weapon systems in time and with the required quality.

A. Formation of Technology Development Agency

Many committees formed by the Govt over the years have recommended the formation of a centralised agency to formulate, coordinate, and monitor the R&D and production of defence systems in India. The R&D and the technology development today is fragmented with armed forces making a wish list in the form of Long Term Perspective Plan (LTPP) and the DPSUs framing the Technology Perspective Capability Roadmap (TPCR) and the DRDO making the Long Term Integrated Perspective Plan(LTIPP) based on the services requirement. There is no single agency to coordinate and monitor the development of systems of various agencies. The services make a LTPP based on the specification of latest system available across the world hoping that the DRDO would be able to provide in the shortest possible time. DRDO on the other hand takes too much than it can chew with unrealistic projection of resources and time frame.

A central agency needs to be formed which should have members from the armed forces, paramilitary forces, PSUs, private industry, CII, scientists from academia, S&T department. The SA to RM who heads the DRDO should be relieved of the duties of head of R&D as it is too big a task to be left as a part time job. The LTPP of the services should be discussed thread bare by the board members and a five year plan is to be formed with firm time lines. The participation of the private industry needs to be increased especially now with the Govt emphasis on Make in India. The progress needs to be monitored regularly and the aim should be to progressively increase self-reliance to 75 % of the requirement.

B. Transfer Of Technology Vs Self Reliance

India has been importing weapons since the last six decades under the ToT scheme. However, no country would transfer the critical technology know how. For over 50 years India had buyer-seller, patron-client relationship with Russia manufacturing weapon system including fighter aircrafts, tanks under license but no technology transfer has taken place. So far no technology has been transferred by US despite $10-12 billion worth of weapon acquisitions.[27] Even after so many years after procurement of Su-30, the country had to go back to Russia for upgrade where they held HAL to ransom. Therefore the LTPP should be broken down to five year plans for mission mode implementation where technology is already available in the Indian market and can be bought from the private players. The long term vision spanning next 15-20 years needs to be put into action mode for development by Indian players. It is already seen that after the issue of DPP-2013', the share of "Buy (Indian)' and 'Buy and Make (Indian) has increased manifold. Table 3 gives the figures.

The self-reliance of the country in defense system has been very poor despite the recommendation of the committee headed by Dr APJ Abdul Kalam, then Scientific Advisor to RakshaMantri recommending that the self-reliance index should be ramped up from 30% (1995) to 70% (2005). Table 4 gives how the index has remained still at 30%.

Although the Defence Production Policy (2011) had recommended achieving substantive self-reliance in development, design and production of critical systems through the route of consortia, Joint Ventures by involving academia and R&D institutions and setting up of a Defence Technology Fund to support public, private sector, academic andscientific institutions for pursuing high-end research, there is littleprogress to show. Allocation of Rs. 100 crore towards Defence Technology Fund has hardly evinced any interest from the private industry which wants to have a major say in the management of manufacturing. The reason for the poor participation of the private industry both large and medium scale is the veil of secrecy behind defence technology. The industry is not aware of the long term plan, the scale of manufacture, uncertainty in the long term sustenance of the contract, poor economic support from the Govt. Despite the promulgation of the offset policy in 2005 and contracts worth $4.8 billion, there is hardly any benefits in terms of FDI inflow, high end technology, exports and reduction in dependence on arms import.

Year	Buy (Indian)	Buy & Make (Indian)	Make (Indian)	Buy & Make	Buy (Global)	Total
2010-11	60835	16710	15845	19450	40547	153387
2011-12	28561	2032	0	5747	20500	56840
2012-13	18689	385	1004	13460	27114	60652
2013-14	21001	2733	0	3504	371	27609
2014-15	38318	72750	0	0	6759	117827
Total	**167404**	**94610**	**16849**	**42161**	**95293**	**416317**

Table 3: Category wise Acceptance of Necessity (Rs in Crores)
Source: "Make in India in Defence Sector" An overview of Dhirendra Singh Committee Report by Laxman k Behera published in IDSA

C. Govt Regulations

The 'Make in India' has laid emphasis on Indian manufacturing and indigenization in all fields of technology. However, a lot needs to be done to attract private industry participation in defence R&D and manufacturing. The mistrust between Ministry of Defence and the private industry needs to be tackled by reducing the barriers for entry to defence sector. Unlike other important sectors where there are clearly defined policies, defence R&D does not have a clearly stated policy by MoD. The Defence Production Policy (2011) makes a passive reference to "broaden the defence R&D base of the country"[28] The Defence policy is also not supported by a concrete manufacturing plan- a key weakness highlighted by the Economic Advisory Council to the Prime Minister (PMEAC).[29] The Technology Perspective and Capability Roadmap (TPCR) which was announced in April 2013 provides an overview of the capabilities required by the defence forces, but it does not quantify the requirements in the long term to enable the industry to translate into viable business opportunities. Rather it shifts the entire risk to industry and with no commitment from the Govt. This is best described by the disclaimer in TPCR which says that the participation of the industry is solely at its own discretion and Govt of India is not responsible for any loss by the industry whilst complying with the stipulation in this document or with changed requirement due to any reason. This becomes a dampener for the industry as technology development is as much the responsibility of the Govt as of the industry. This creates an uncertain environment for the industry to take long term business decision.

The Govt also needs to relook into the approach of the procurement system in the case of single vendor system which is a reality. The capability of development of a lot of high technology systems does not exist with many players in India yet. The approach towards the single vendor system ultimately delays the entire process and may result in the vendor losing interest in the project.

The Govt needs to make exclusive Defence Economic Zone (DEZ) on similar lines as SEZ for setting up production facilities with economic incentives like tax holidays, percentage of expenditure to be shown as R&D expenditure, and permission of dual use of the technology developed by which the industry can recover the expenditure incurred by utilising it for making products for civilian use. This would bring down the cost of development and enthuse interest in the industry for higher participation in defence sector. The Make In India policy has provided many incentives for participation of private industries in defence manufacturing with contractual offset obligations worth around $ 4.53 billion in the next 5-6 years. The revised DPP of 2016 provides a new category of capital procurement namely Buy Indian-IDDM (Indigenously Designed, Developed and Manufactured) which provides incentives to make in India with strategic tie up with foreign equipment manufacturers under offset policy.[30]

As per the recommendations of the Rama Rao committee, DPSUs and Ordnance Boards are to be shortlisted in stock exchanges so that the corporate culture is brought into the organisation. This would also improve the accountability of the organisations and increase transparency in the functioning.

D. Reforms in R&D

The R&D environment needs to reform in the way it functions. Although the R&D has achieved a lot in all these years, yet it falls short of the standards expected of a R&D organisation. Various labs of DRDO are working on different technology development without inter-discipline interactions. The organisation should form core teams for each project rather than assigning to a lab. The core team should have the autonomy to choose the team members not only from the organisation but from any organisation or industry and have the autonomy to spend money on the research. This would give more flexibility and autonomy to the scientists in carrying out research and development.

The organisation should be more kind towards failure. R&D cannot guarantee success all the time. Innovative ideas can come up only when there is no fear of failure. The present ecosystem in R&D does not foster innovation and creativity. Even agency like DARPA of the USA, as per one of its Chief, 80-85 % of its projects fail to meet its objectives.[31]
There is too little interaction of the scientists with the users of the technology. The scientists working on various projects need to have more interaction with the users and vice-versa is also applicable. The users need to interact more with the labs right from the start till the end. The users generally are brought in the end during user trials of the system by when the individual would have changed and a whole new perception sets in. The armed forces also should make core teams which would permanently interact with the lab core team wherever they are posted till the project is concluded. This will ensure continuity of the user representatives during the entire duration of the project so that there are no perception changes due to change of individuals. Changes may become essential due to change in technology/alternate technology, but that need to be taken into account by all stakeholders in the project.

DRDO despite having extensive field of R&D has around 7700 scientists compared to around 8000 scientists in ISRO which has fewer fields in R&D. [32] Also, the educational profile of the scientists in DRDO is poor and is cause for concern. The Rama Rao Committee had brought out its concern by the predominance of first degree holders in the scientific cadre of DRDO with 60 % of its scientists are diploma holders, engineering or science graduates, or masters in arts or science. The committee found that only 10 % of the total scientific personnel were PhDs. This severe constraint of qualified research scientists does have an adverse effect on the capability of the organisation. ISRO having faced with a similar situation set up Indian Institute of Space Science and Technology in 2007 which*h offers graduate, post-graduate and doctoral programme in space science and technology. The DRDO has Defence Institute of Advanced Technology which just trains in-house scientists for a period of 20 weeks. The choice of DRDO for an engineering or post graduate student is not at all attractive and is the last choice. That too he joins the organisation for getting experience and wait to jump to greener pastures at the first opportunity due to remuneration in private industry, mobility. The DRDO should make the job more attractive and stimulating rather than like any Govt set up. The bureaucracy in the organisation stifles innovation and creativity which is an essential ingredient in R&D.The scientists need to be incentivised for successful completion of projects. DRDO is still in nascent stage in implementation of IPR regime. Though being a premier defence organisation it has hardly any patents worth describing about. The DRDO needs to put in a clear IPR regime and scientists need to be made co-owner of the IP.

DRDO needs to set up a national network for sharing of resources amongst scientists. All the research activities should be documented and a repository of the same needs to be made for access by any scientist for his use. This can help in avoiding duplication of work and sharing of knowledge.

DRDO needs to take help of professional in formulation of a R&D strategy. Various scientific tools need to be used and a Technology Road Map (TRM) for R&D needs to be made for every project with input from all stake holders. The TRM should result in an Implementation Strategy which should be strictly followed. In fact the formulation of LTPP and TPCR should utilise scientific tools so that they are realistic and implementable.

The world is witnessing IT revolution and so is India and its armed forces are also affected by it. People from this country have made great inroads in IT across the world. The armed forces is shifting to Network Centric Warfare and the use of IT is all prevalent todays weapon systems. DRDO should leverage the IT potential of this country and carry out more development in IT systems for use in technology development. Despite contributing enormously in development of IT, the armed forces still are dependent on foreign countries for development of IT in the weapon systems. DRDO should formulate an IT strategy and take projects for development and improvements of the IT system in the armed forces.

VI. Conclusion

R&D in research labs of Govt is a subset of the R&D ecosystem of the country. The developments in R&D ecosystem of the country has a direct effect on the R&D ecosystem in DRDO. While DRDO has proved its worth in many areas like IMDP, more needs to be done in terms of time and cost factor. With the Govt's policy of Make in India and Digital India, DRDO needs to formulate a long term and short term strategy for making it a premier R&D institution of the country. While many have recommended that DARPA like agency should be created, it is not essential that it would be successful as yet since the industrial base is not yet ready to develop and manufacture such cutting edge technology. A strong manufacturing hub needs to be created for such radical innovation and disruptive technologies which should make economic sense. Once a strong manufacturing hub is put in place and an ecosystem is created which benefits private industry, scientific community, academic institutions, armed forces, a DARPA like institution may be thought of to provide radical technologies. The Make in India campaign adopted by the Govt of India aims at developing skills, making a strong manufacturing hub in India, providing incentives to MSMEs to participate in defence manufacturing. The recently concluded Aero India show in Bengaluru between 14-18 Feb 17 saw 750 companies from all over the world participate in the event which was aimed at defence, aerospace, civil aviation, defence engineering and airport infrastructure.

This paper therefore has emphasised on the national R&D ecosystem first and derived the way ahead for R&D in India. Unless there is a national impetus for R&D in terms of funds, regulations, ease of doing business, public-private-academic participation in co-creation of technology, research labs on its own cannot produce the cutting edge technology as wished by the armed forces. The bureaucracy in the functioning of R&D has to be reformed as recommended by various committee reports which has not found favour amongst the policy makers.

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