SYNERGY

Journal of the

CENTRE FOR JOINT WARFARE STUDIES

CENJOWS
(Established : 2007)

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Synergy is a bi-annual Journal that is published in June & December every year. It is supplied to the members of CENJOWS. Articles, Book Reviews, abridged version of Research Papers and Dissertations may be sent to the Editor as per the guidelines contained in the Journal. Advertisment enquiries concerning space and charges may also be sent to the Editor.

Indian Defence Research and Development (R&D):Transitioning from "Make in India" to "Made in India"

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Abstract

Currently about 60% of India's defence equipment is procured from abroad. There are imminent risks of such a situation to India's national security as seen during the 1965, 1971 Indo-Pak Wars and 1999 Kargil conflict. The success of the "Make in India" programme is critical to increase the share of defence equipment produced within the country. International arms suppliers are however unlikely to undertake complete transfer of technology especially in critical materials and technologies. The article argues that in the long term, there is no alternative to strengthening domestic defence research and development (R&D) if the larger objective of increasing self-reliance in defence has to be met. The article flags three bottlenecks which need to be done away with in order to strengthen India's domestic R&D efforts. These include adequate long-term funding for research & development; augmentation of national capacity and capability to support R&D efforts; and compressing development timelines and ensuring quicker induction of the platform into the Services in large numbers.

Introduction

The Indian government led by Prime Minister Narendra Modi launched the "Make in India" programme in September 2014. The visionary initiative is aimed

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at increasing the share of manufacturing sector in India's economy from a little over 16% in 2014-15 to 25% of the GDP by 2022 which is expected to create an additional 100 million jobs. The programme focuses on 25 sectors ranging from Automobile to Biotechnology to Defence Manufacturing to Electronic Systems.[1]

In the area of defence manufacturing, the "Make in India" initiative - with a focus on increasing domestic manufacturing of defence equipment by the public and the private sector - becomes all the more significant. Given that the government in the form of the military and security forces is the only consumer for defence equipment, the 'Make in India' programme is largely fashioned by the defence procurement policy.[2]

Importance of Self Reliance in Defence

India has the third largest standing military in the globe and is situated between two inimical neighbours - in Pakistan and China - with whom India continues to have unresolved border disputes. India's bilateral relationship with India and China is unlikely to change in the short term. This in turn necessitates a military which is modern, well equipped and fighting fit. Though the Indian political and military leadership have been working towards inducting modern equipment into the Indian military forces; a large percentage of such procurements have come from abroad.

Over the past few years, India has become the world's largest arms importer with an estimated 60% of our defence equipment being procured from abroad.[3] This situation is not a new phenomenon. A March 2014 report by the Stockholm International Peace Research Institute (SIRPI) had stated that the volume of Indian weapons imports had risen by 111 percent between 2004–08 and 2009–13.[4] More recently, in March 2015 the SIPRI reported that India continued to occupy the position of the world's largest importer of major weapons between 2010 and 2014 followed by Saudi Arabia and China with a 15% share of international arms imports during the same period.[5] It is also important to remember that apart from direct imports/capital acquisitions an equally vast sum of money is spent every year for the purchase of parts, components, and consumables from foreign sources by the Services and various state-owned enterprises or Defence Public Sector Undertakings (DPSUs).

It is quite apparent that the current situation is fraught with obvious risks. In addition to being a drain on the country's financial and foreign exchange reserves;

the continuance of the situation poses a direct national security risk. In a recent interview with *Times of India*, former Chief of Army Staff (CoAS), General V.P. Malik stated that dependence on foreign partners for critical defence equipment and spares resulted in a serious crisis during the 1999 Kargil conflict. During the Kargil conflict, the Indian military was running short of spares for critical Bofors artillery guns and naval helicopters which hampered the optimum utilisation of these platforms. As a result of the sanctions which had been imposed on India following the May 1998 nuclear tests, many countries refused selling much needed equipment and spares during the Kargil conflict.[6]

It is important to recall that Kargil was not the first instance of using supply of essential military spares and equipment to exercise their influence in the region especially during conflict situations. During the 1965 Indo-Pak War, the United States and the United Kingdom had stopped supply of all military equipment to India and Pakistan in order to force both parties to end the conflict.[7] During the 1971 Indo-Pak War, the American administration under President Nixon tilted completely in favour of Pakistan. In addition to diplomatic support at the global stage, the US directly and indirectly supplied Pakistan with much needed military equipment. Despite the embargo on military supplies to Pakistan imposed by the US Congress, the Nixon administration supplied Pakistan with F-5 and F-104 fighter aircraft via Iran and Jordan.[8] Recent US declassified documents bring out the fact that American Secretary of State, Henry Kissinger in a meeting with the then Chinese Ambassador acquiesced to China providing Pakistan with military supplies at a meeting in Paris.[9]

It is therefore very much possible that in future crisis or conflict situations, foreign countries supplying weapons and spares to India could either delay or deny essential weapons for purely commercial, political or other simply in pursuit of their strategic interests. Therefore reduction of dependence on foreign suppliers for defence equipment is an important national goal. It is in this context that the Indian government's 'Make in India' programme and the push for greater production of defence equipment in India by public and private sector becomes so critical.

Transition from "Make in India" to "Made in India"

It is imperative that the Indian political and military establishment should seek a 'golden mean' which lies somewhere in between the current situation of over-reliance on imports for meeting our defence needs and a situation where the

country strives for complete indigenisation. The latter situation might neither be achievable nor desirable. However, to give a concerted push to our domestic defence industry, it is critical to make investments into defence research and development (R&D) and that too over a sustained period of time. Though producing a larger share of defence equipment in India under the Make in India programme is desirable, it should go hand in hand with an increased focus on R&D efforts. Only domestic R&D efforts will enable the country to transition from 'Make in India' to 'Made in India'. It is imperative that such efforts receive adequate funding and human resources even if initial efforts face setbacks and do not garner immediate results. Such support is vital given the fact that defence R&D projects by definition involve overcoming complex technological challenges and have long gestation timescales.

The hard truth is that there is no alternative to building domestic capacities and capabilities in critical materials and technologies like titanium casting, forging and machining; aero engines; single crystal turbine blades; composites; gyroscopes; Nanotechnology and MEMs-based sensors; miniaturised Synthetic Aperture Radars (SAR) and ISAR; fiber laser technology etc. Though international arms suppliers are glad to sell complete systems, spares and set up maintenance, repair and overhaul (MRO) facilities; they have historically been reluctant to share their technological expertise and engage in transfer of technology.

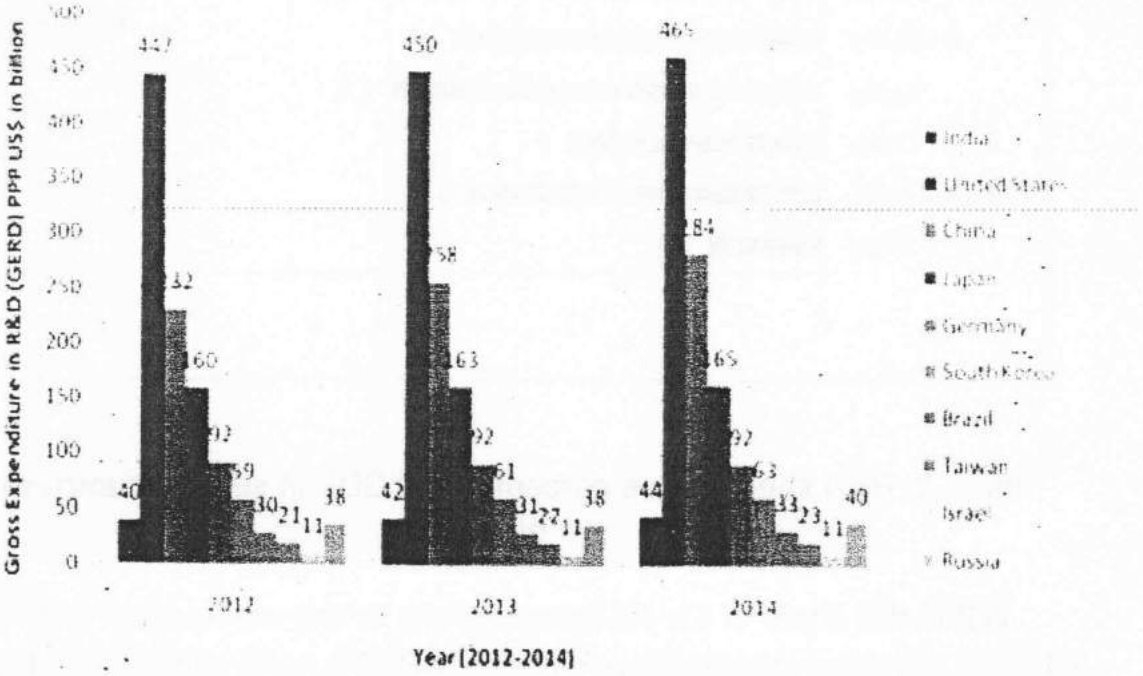
This fact is brought out by the fact that despite increase in Foreign Direct Investment (FDI) limit into the defence sector, the country has seen an influx of only Rs 56 lakh into Defence industries between October 2014 and September 2015. The figures for the current financial year (March 2015 to September 2015) amounts to a measly Rs 8 lakh.[10] As Jayant Sriram argues in *The Hindu*, the slow trickle in foreign investment is largely the result of the foreign companies' anxiety over control of technology and unwillingness to transfer high-end technology if the FDI cap is not raised over 50 percent.[11]

The situation thus cannot be remedied by simply relying on foreign companies to invest in the defence manufacturing in the country either individually or by way of joint ventures with Indian public and private defence companies as envisioned in the Make in India programme. A larger share of indigenisation in defence equipment is only possible only when enough financial and human

resources are pushed into domestic R&D with a long term perspective in mind. This is very important because of the multiplier effect that investment into R&D can bring about in the socio-economic situation. When compared to the global situation, Indian investment into overall R&D and in particular into defence R&D has largely been below par.

As per the latest figures released by Battelle in its 2014 R&D Global R&D Funding Forecast states that GERD in India has increased from PPP$ 40 billion to PPP$44 billion between 2012 to 2014. This is compared to the global GERD expenditure which has gone up from PPP$1,517billion to PPP$1,618 billion in the same period.[12] Figure 1 below shows the gross expenditure in R&D (GERD) of select countries between 2012 and 2014. In India, as per estimates put out by the NSTMIS, Department of Science and Technology, the government sector ploughs in close to 55% (55.4%) of national expenditure into R&D with the private sector spending close to 29%.[13]

Figure 1: Gross Expenditure in R&D (GERD) in Select Countries (PPP US$ billions)



The need for greater investment into R&D becomes comes out more starkly when one compares R&D investment as percentage of GDP in India and other select countries. During the Eleventh Five Year Plan period, India allocated about 0.88% of its GDP into R&D. For 2014, the R&D investment as percentage of GDP for India is 0.9%. This is compared to 2.8% by the United States, 2.0% by China, 3.4% by Japan, 1.5% by Russia, 1.3% by Brazil, 2.4% by Taiwan and 4.2% by Israel. In order to catch up with the global leaders, Indian spending on R&D should move closer if not exceed the global average of 1.8% of GDP and this level of investment should be sustained over the next decade or more. Figure 2 below brings out the R&D expenditure as percentage of GDP in select countries.

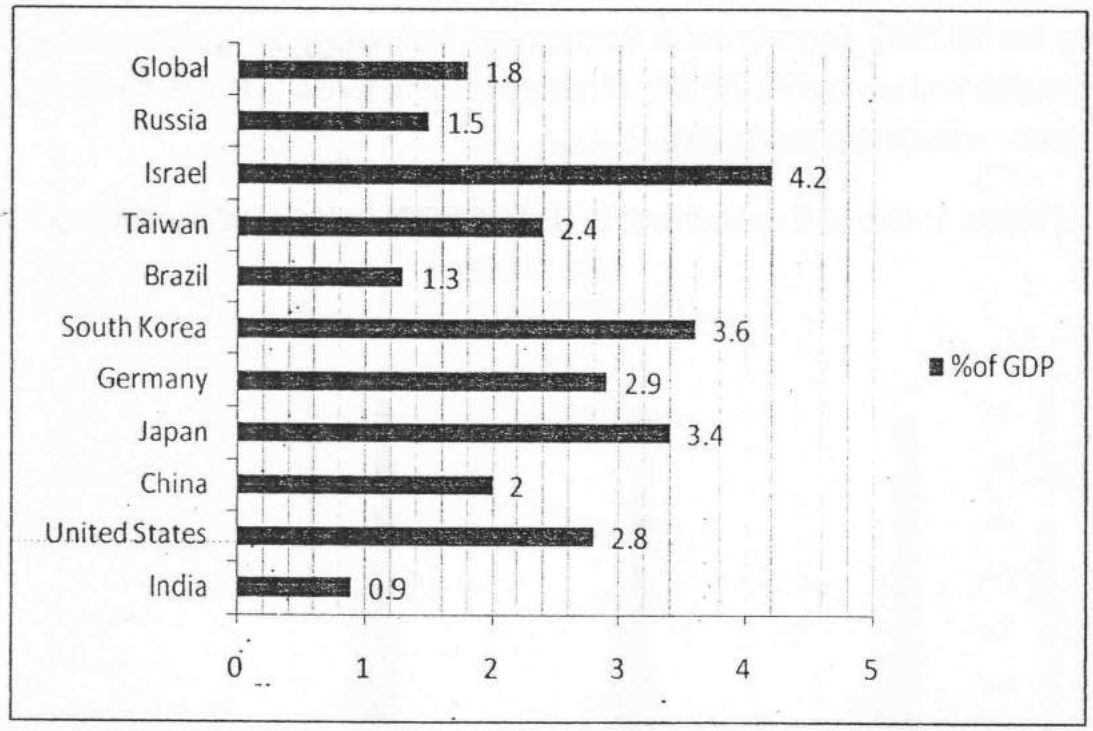


Figure 2: R&D spending as percentage of GDP in select countries in 2014

Within this share of the R&D expenditure for the entire country of PPP$ 44billion, the share of expenditure on defence R&D is much smaller. In India, the defence R&D is largely concentrated in the Defence Research and Development Organisation (DRDO). Between 1961 and 2015, the DRDO has historically received on an average 4.6% of the Indian defence budget.[14] In the last two defence budgets, 2014-15 and 2015-16, the DRDO's share has increased a little

bit and has increased to 6.05% and 6.27% of the defence budget. If estimated at the current US$ exchange rate of (US$66.24), the total defence expenditure 2015-16 amounts to Rs.229000 crores (US$ 34.571 billion) and the R&D budget amounts to Rs. 14358 crores (US$ 2.16 billion).[15]

In order to increase the share of indigenisation, two other bottlenecks in addition to hiking gross defence R&D expenditure have to be addressed. The first is the induction of fresh recruits into the DRDO. In the recent past, the tasks assigned to the organisation have increased manifold but the recruitment has largely continued at the same level sanctioned by the Indian Cabinet in 2001. This has resulted in a situation where the organisation is short by over 2700 scientists.[16] Former Director General DRDO, Dr. Avinash Chander in an interview to the *New Indian Express* stated that close to 70 fresh scientists and engineers are recruited into DRDO as opposed to an annual requirement of 370 scientists.[17] Hopefully, the current state of affairs will change with the Indian cabinet considering a move to sanction an additional 4,966 posts, including 2,776 posts of scientists in the DRDO.

The second bottleneck is the lack of adequate money available for capital expenditure in the defence budget. As Lakshman Behera points out, between the Budget Estimates (BE) and the Revised Estimates (RE) of the 2014-15 Defence Budget, the money allocated for capital expenditure was actually reduced. Further, the share of capital expenditure as part of the 2014-15 and 2015-16 defence budget has actually shrunk from 41.3% to 38.3%. Despite augmentation of the defence budget, there has been nil growth in capital expenditure between the two budgets.[18]

The lack of adequate allocation for capital expenditure is very worrying because of the fact that about 93% of the money budgeted for capital expenditure in 2014-15 defence budget is already allocated towards committed liabilities with a paltry 7% available for any new acquisitions. This leaves precious little with the Services for acquiring any new defence equipment developed under the 'Make in India' programme by Indian companies or DPSUs.[19] Without increased allocation for capital expenditure by the Services, the Make in India programme is unlikely to succeed in strengthening the domestic defence industry and as a result increasing the indigenous content in the military's defence equipment.

Need for Shorter Development Timelines and Faster Induction

In order to catch-up with the modern technologies and induct them into the military, the timeline for a platform to transition from the laboratory-scale to actual induction into the Services should be compressed to a matter of few years not decades. Given the absence of a domestic defence industry ecosystem and lack of competition between defence industry players; platforms developed within the country have historically suffered from long development timelines and delayed induction into the Services. Time and again the delays in development timelines of the Light Combat Aircraft (LCA) *Tejas* and the Main Battle Tank (MBT) *Arjun* have been cited as examples of this bottleneck. It is crucial to remain cognizant of the fact that many of these projects involve complex technologies. Also, when the country began pursuing these projects there was a lack of a domestic ecosystem to support the efforts. Thus, in addition to developing the platforms, the developers had the added task of creating and nurturing a nascent domestic defence industry ecosystem which was essential to support future projects.

Another point largely ignored is that the development timeline of the LCA-*Tejas* is comparable to the time taken for other global fighter aircraft. The LCA project began in earnest in 1993 when it received funding to the tune of Rs. 1600 crores. Taking this as the start date, the first flight of the LCA took place in 2001. If the LCA receives its final operational clearance (FOC) in 2016, the entire development timeline would be a little over two decades.[20] As Maggie Marcum writes, Russia and the United States despite their advanced technological know-how, experience and thriving defence industry ecosystem took an average of 12 years to go from the study to the delivery of their fourth-generation fighter aircraft like F-15 and Mig-29. Late entrants with inferior technological capabilities like China have taken close to 25 years with the J-10.[21] Given that the LCA-*Tejas* was the first of its kind and began without any domestic capacities or capabilities to support the project, it is not surprising that the LCA project has taken longer.

Coordination between Stakeholders: That having been said, it is crucial to compress the development timelines to ensure faster induction of new platforms into the military. An essential element for this to materialise is increased coordination between various stakeholders: viz. the Military, the development agency (DRDO) and the production agency (BDL, BEL, DPSUs etc). Such co-ordination must begin with the phase of formulating the Qualitative Requirements

(QRs) by the Service Headquarters. Apart from formulating QRs on the basis on current and future requirements of the military, this interaction will ensure that any future development bottlenecks will be ironed out at this stage, thereby shaving off crucial months from the development timeline. Such an approach has been applied in the Advanced Medium Combat Aircraft (AMCA) wherein the ADA, the Air Force and the HAL have worked together to finalise the specifications including avionics, on-board weapons before the freezing of the blueprint of the aircraft.[22]

Mechanism for Coordination between the R&D and Production Agency: In addition to this, it is crucial that the Services take ownership of the development of the platform and station their best personnel at the development agency during the design, development and testing phase. This will ensure that a mechanism is created for coordination between the User Service and the development agency thereby ironing out issues as they arise without waiting for quarterly or other such periodic review meetings. One of the best examples of such a strategy can be seen in Commodore C.D. Balaji, current Director of the Aeronautical Development Agency (ADA), Bangalore who was among the first officers to be deputed by the Indian Navy for leading the Naval version of LCA project in 2002.[23]

Experience will result in shorter development timelines: The Naval version of the LCA received formal sanction from the government in March 2003. Less than a decade later, the first flight of the LCA-Navy successfully took place on April 27, 2012. Three years later the aircraft conducted a Ski-jump from a Shore Based Test Facility (SBTF) stimulating take-off from a carrier aircraft on December 20, 2014.[24] The direct involvement of the Indian Navy personnel backed by the experience gathered from the development of the LCA-*Tejas* resulted in the short development timelines achieved by the LCA-Navy aircraft which has received all round praise.

The initial steep learning in the Light Combat Aircraft-*Tejas* (LCA-*Tejas*) project has built up national capacity and capability in addition to creating trained manpower in the country. This experience has resulted in shorter timelines during the development of the Intermediate Jet Trainer (IJT)- *Sitara* / HJT-36 which was to replace the ageing Basic Jet Trainer *Kiran* (HJT-16). The Sitara IJT received project sanction in July 1999, the layout was frozen in April 2001, manufacture of parts began in June 2001 and first flight of the prototype took place in March

2003. Yogendra Kumar, former Director (LCA) in Hindustan Aeronautics Limited (HAL) notes, the first flight of the *Sitara* intermediate trainer took place a mere 20 months form first metal-cut.[25] It is therefore important to appreciate the fact that the pioneering effort whether in form of the LCA-*Tejas* or the MBT-*Arjun* is bound to take more time and suffer from niggling issues. However, the experience gained from the project is invaluable and should not be lost. The capacity and the capabilities so acquired - as seen in the examples LCA-Navy and the Sitara IJT - will result in shorter timelines in subsequent projects.

Concurrent Engineering: In July 1983, when the Indian government sanctioned the Integrated Guided Missile Development Programme (IGMDP), it put in place a three tiered management structure comprising of the Guided Missile Board (GMB), the Programme Management Board (PMB) and five Project Management Boards (PJB). In addition, it established the Production Management Committee (PMC) under the chairmanship of the CMD, Bharat Dynamics Limited (BDL), which was the lead production agency for the IGMDP project. Representatives from the BDL were part of the five Project Management Boards. This structure ensured that concurrent engineering practices were adopted and involvement of the User Services and production agency in all phases of the project right from design, development to testing and production phases of the product.

Adoption of such a mechanism in domestic research and development projects is likely to achieve similar results. In fact, such synergy between the User Service, the development and the production agency (ADA and HAL) is being seen in the Advanced Medium Combat Aircraft (AMCA).[26] It is also crucial that the development agency works with the production agency - whether BDL, HAL, or the Ordnance Factories (OFs) - to ensure smooth transition into production. This can be ensured by preparing proper documentation and some hand-holding of the production agency in the initial production phase to tide over the initial teething problems.

Induction into Service along-with Flight Testing by User: In 2004, then serving Chief of Air Staff, Air Chief Marshal S. Krishnaswamy speaking to journalist Shiv Aroor is reported to have stated, "I feel we should simply induct the *Tejas*. Once it is in service, a sense of ownership will come. And we can progressively improve it jointly along with the developers. The aircraft needs to get out of test and into squadrons. That is the only solution."[27] Eleven years

have passed and the LCA is yet to be inducted fully into the Air Force. In January 2015, an important milestone was crossed with the HAL handing over the first series production version of the LCA to the Air Force.[28]

Given that any such technologically complex system is bound to have issues; is not possible to induct the platform into the User Service as Air Marshal Krishnaswamy suggests. The aircraft can continue to undergo testing along with active squadron service. This has been the practice globally as seen in the case of the American F-35 fighter aircraft. The User Service could look at whether they can actively test other future weapon systems (without compromising preparedness of the Service) so as to provide faster feedback which will assist the development and production agency in ironing out the issues and improving future variants of the platform.

In an important statement, the current Chief of Air Staff, Air Chief Marshal Arup Raha has said that the Air Force would induct the *Tejas* Mark-1 in large numbers if some of the features are upgraded and will not insist on Mark2.[29] Though such an aircraft might not meet all the specifications outlined by the User Service, it will help, as Shiv Aroor notes, in building up of a sense of ownership in the platform and provide crucial feedback to the development and production agency for improving future variants.

Augmentation of Capacities and Capabilities

In order for the "Make in India" programme to succeed, it is imperative that Indian R&D establishments as well as defence PSUs augment their capacity and capability. One major area where there is a crucial capacity gap is in supersonic wind tunnel testing and other flight testing facilities within the country. As Ajai Shukla writing in the *Business Standard* notes, the lack of flight testing facilities in the country necessitates Indian developers to ship the *Kaveri* engine to the Moscow-based Central Institute of Aviation Motors for simulated flight testing up to 15 kilometres.[30]

In an important move, the government recently opened up the existing testing facilities with the DRDO, the three Services and other public sector establishments to Indian private sector defence companies. This move will go a long way in furthering defence production in the country as the lack of such capacity imposes financial and time constraints on domestic testing and production efforts.

A more important bottleneck is the need for serious augmentation of national capacities by Defence PSU's and Ordnance Factories to ensure that the defence equipment is produced and inducted into the Services quickly in large numbers. One area which needs augmentation of capacity on a war footing is the domestic shipyards. As a result of the Indian Navy's modernisation programme, the public sector shipyards have large backlogs in their order books. Defence journalist Nitin Gokhale writes that the Mazagaon Docks Limited has an order backlog of approximately Rs 70-80,000 crores vis-a-vis its current capacity of spending of about Rs 5,000 crores per anum.[31] The current situation is the result of multiple factors ranging from lack of investment to augment capacities, absence of a competitive environment, poor inventory management. This situation is further compounded by limited financial and operational decision-making powers which cause further delays in projects. In addition, lack of investments into R&D and a shortage of trained naval architects and engineers have resulted in dependence on foreign design companies.[32]

The Indian government seems to be seized of the issue and has recently announced a 4,000 crore package for ship builders that includes infrastructure' status for shipbuilding and ship repair industry which would enable them easier access to finances.[33] Shipping Secretary, Rajive Kumar has recently stated that the government has planned investments of around Rs 50,000 crore in 35 projects for the port sector under public-private-partnership (PPP) model.[34]

In the case of the Light Combat Aircraft, the *Tejas* division of the Hindustan Aeronautics Division which was launched in 2002 and upgraded to a full HAL division in April 2014 is currently manufacturing the first of the series production (SP) aircraft at its Bangalore facility.[35] The facility is aiming to ramp up production from to the existing 8 to 12 *Tejas* aircraft per year. Reports also indicate that the government is planning to sanction a second *Tejas* production line and/or look at setting up joint ventures with major international players like Boeing, Lockheed Martin, and Eurofighter consortium.[36] Though ramping up domestic production is the preferred route, the HAL is roping in private Indian defence players to make modules of the aircraft so as to meet the orders of about 200 *Tejas* aircraft in the shortest possible time.[37]

Recommendations

- In 2014, India spent close to 0.9% of its GDP or (PPP US$ 44 billion) in R&D sector. As for the defence R&D sector the spending in 2015-16 was US$ 2.16 billion. At a minimum, the spending on R&D sector needs to double to match the global average of 1.9% of GDP. This increase should be sustained for the next decade or more.

- In order to provide economies of scale and to ensure long-term sustainability of the domestic aerospace sector, it is essential to end the separation between the civilian and the military in the aerospace sector with two different ministries in the Ministry of Civil Aviation and the Ministry of Defence shaping national policies in their respective domains with little coordination or synergy.

- To foster discovery and integration of modern technologies into the three Services, the Indian military should consider establishing their research own research laboratories. These establishments could be on the lines of the US Army's Research Laboratory (ARL), US Air Force Research Laboratory (AFRL) and the Office of Naval Research (ONR).

- To avoid duplication of existing capacities, the three Services could assume the responsibility of managing and outlining priorities for existing defence R&D labs in the country. The three Services would assume executive responsibilities of laboratories in their domain and closely work with the parent development agency on current and future development projects in order to meet the Services' requirements.

  - **Indian Air Force**: Aeronautical Development Establishment (ADE), Centre for Air Borne Systems (CABS), Aeronautical Development Agency (ADA), Defence Avionics Research Establishment (DARE), Gas Turbine Research Establishment GTRE).

  - **Indian Army**: Armament Research & Development Establishment (ARDE), Combat Vehicles Research & Development Establishment (CVRDE), Vehicles Research & Development Establishment (VRDE).

  - **Indian Navy**: Naval Physical Oceanographic Laboratory (NPOL),

Naval Science & Technological Laboratory (NSTL) and Naval Materials Research Laboratory (NMRL)

- Critical technologies and spares should be identified jointly by the development and production agency in consultation with the Services. Coordinated national effort involving both the public and the private sector should be initiated to indigenise these items in the medium to long term depending on the item's complexity.
- In order to compress development timelines and ensure faster induction into the Services, weapons systems should enter into active military formations to undergo active testing once all requisite certification is completed.

Conclusion

The "Make in India" programme is targeted at reducing reliance on imports for military equipment. However, the programme should be seen as a stepping stone for the long-term objective of transitioning from "Make in India" to "Made in India". For such a transition, it is important to overcome the existing bottlenecks like lack of adequate long term financial support to augmentation of national capacity in crucial areas ranging from material to testing facilities. Compressing development timelines and ensuring faster induction of the developed platform into the User Service in large numbers is crucial in building confidence between the Services, the development and the production agencies. There is however no silver bullet given that many of these problems are symptomatic of larger structural issues. The only prescription for overcoming these ills is sustained efforts with a concerted push from the country's political and military leadership.

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