SELF-RELIANCE AND SYNERGY IN AEROSPACE SECTOR: THE ROAD AHEAD

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India is the second major military spender on acquisitions globally[1] (around $ 13 billion annually) and the growth in the acquisition budget over the last ten years is significantly higher than the growth in both central government expenditure and defence expenditure. The aerospace sector accounts for 50 percent of our modernisation budget. Though we have acquired substantial military manufacturing capability in the aero sector through technology transfer during (1963-2006), we are still critically dependent on imports for aircraft and their propulsion, sensors and weapon systems, with weak synergy between the design agencies and production houses, and an unedifying record in terms of design capability of fighters and transport aircraft and engines.

This paper seeks to provide an indication of the gaps in critical technology that is contributing to our low Self-Reliance Index (SRI) (around 30 percent) and tries to provide a roadmap in terms of policy and partnerships to improve military industry capability and self-reliance.

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1. *SIPRI Yearbook* 2010.

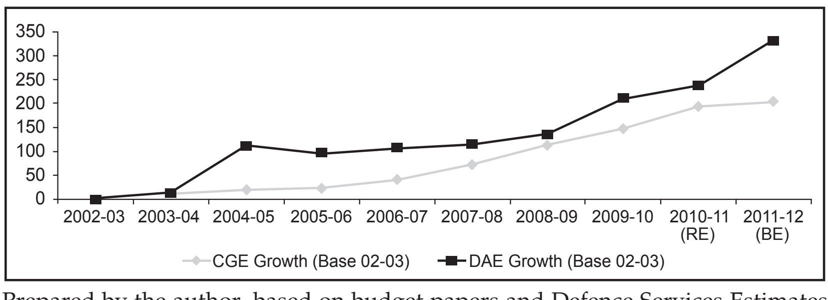
MILITARY MALTHUSIASM

The increased focus on modernisation of the defence forces is evident from the faster increase in the acquisition budget in comparison to total Central Government Expenditure (CGE). Between 2002-03 and 2011-12, the acquisition budget has been increased by nearly 330 percent, in comparison to 203 percent growth for CGE—a phenomenon known as 'Military Malthusiasm' where increase in acquisition outstrips increase in CGE. In terms of inter-Service escalation in annual acquisition of platforms and systems, the aerospace systems and products are likely to be of the order of 30 percent, far outstripping the expected annual escalation of the Navy (20 percent) and Army (15 percent).

Table 1: Trend of CGE & Defence Acquisition (in Rs. crore)

Year	CGE	CGE Growth (Base 02-03)	Defence Acquisition Expenditure	DAE Growth (Base 02-03)
2002-03	4,14,162	0	12,939	0
2003-04	4,71,368	13.81	14,584	12.71
2004-05	4,97,682	20.17	27,209	110.29
2005-06	5,06,123	22.20	25,491	97.01
2006-07	5,83,387	40.86	26,900.44	107.90
2007-08	7,12,671	72.08	27,903.42	115.65
2008-09	8,83,956	113.43	30,614.64	136.61
2009-10	10,24,487	147.36	40,367.72	211.98
2010-11 (RE)	12,16,576	193.74	43,799.21	238.51
2011-12 (BE)	12,57,729	203.68	55,604	329.74

Graph 1: Trend of CGE & Defence Acquisition (in Rs. crore)



Source: Prepared by the author, based on budget papers and Defence Services Estimates.

INDIGENOUS DESIGN AND PRODUCTION OF AIRCRAFT AND WEAPON SYSTEMS

Herbert Wulf, while examining defence industrialisation in the developing countries, mentions five major stages that they have to traverse. As shown in Table 2 below, the process proceeds from off-the-the shelf purchase to co-production to licensed production and, finally, indigenous design and production of weapon systems.

Table 2 : Stages of Defence Industrialisation[2]

Import of equipment for repair, maintenance and overhaul of imported weapon systems. Foreign suppliers export technological skills by training personnel.
↓
Assembly of imported arms, components, sub-systems and unassembled kits of particular weapon systems.
↓
Local production of simple components under licence, though sophisticated and more expensive parts continue to be delivered from abroad. Licensed-produced and imported components are then assembled domestically.
↓
Indigenous design and production of weapon systems. This stage can be initiated, at least for technologically advanced weapon systems, on the basis of many years of production experience and when sophisticated and diversified R&D facilities are set up. Design and production are often still dependent on know-how and technology inputs from producers in the industrialised countries.
↓
Licensed production of near complete weapon systems. While the number of imported parts is reduced so that the weapon is produced domestically, many sophisticated components still have to be imported.

2. Herbert Wulf, "Arms Production in the Third World", in *SIPRI Yearbook 1985* (Oxford: Oxford University Press, 1985), p. 330.

India's Defence Industrial Base (DIB) has gradually progressed from stage 1 to stages 2 and 3, with the assembly of armoured vehicles and local production of certain automotive and aerospace components. However, the country's defence industrial capability is limited in stage 4 and almost non-existent in stage 5 i.e. complete indigenous design and production of weapons. The two substantially indigenous platforms viz Light Combat Aircraft (LCA) and Main Battle Tank (MBT) are, however, dependent on imports for their propulsion systems and weapons.

The areas in which there are critical gaps in technology are as given in Table 3 below:

Table 3: Critical Technology Gaps[3]

Sr. No.	Systems	Gaps
1.	Gas Turbine Engine	Single crystal and special coating in turbine blades FADEC
2.	Missile	Uncooled FPA seekers
3.	Aeronautics	Smart aerostructures Stealth technology
4.	Material	Nano material, carbon fibres
5.	Sensors	AESA, radar, RLG, INGPS
6.	Communication	Software defined radio
7.	Avionics	Gen III, II Tubes
8.	Surveillance	UAVs, satellites
9.	Weapons	Air-to-air missiles, ATGM

The major technologies in defence platforms are the **seeker, Focal Plane Array (FPA), Active Electronically Scanned Radar (AESR), Ring Laser Gyro (RLG), stealth technology, seekers and single crystal blade, and they cut across the requirement of all the Services.**

A brief overview is of each technology is given below.

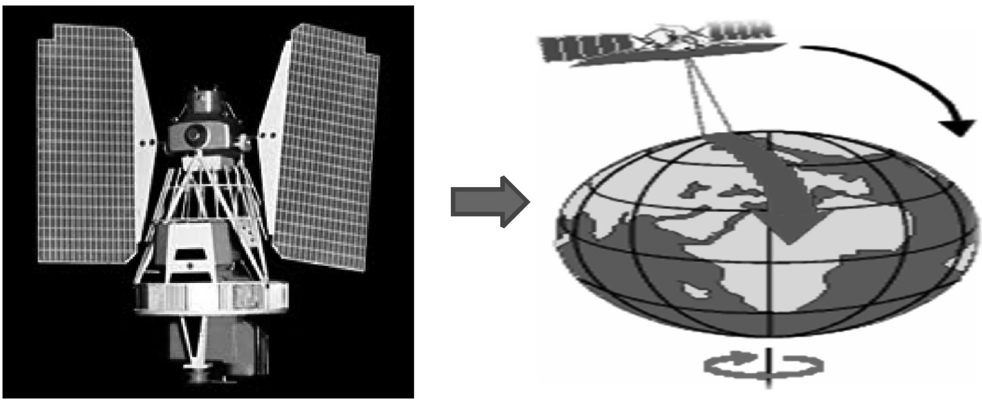
3. Based on discussions with DRDO scientists.

Focal Plane Array (FPA)

Focal Plane Arrays (FPA) are detectors which consist of a linear or two-dimensional matrix of individual elements. They are used at the focus of imaging systems e.g. satellite imagery, etc.

FPAs are used in astronomical imaging, aerial reconnaissance, aerial mapping, spectrographic analysis, star tracking, machine vision, X-ray diffraction and measurement applications. They can be visible, near Infrared (IR), mid IR and far IR. The linear array consists of a single line of pixels and the area array consists of rows and columns of pixels.

A pictorial diagram of the FPA is as under:



AESA Radar

The AESA radar is a type of phased array radar whose transmitter and receiver functions are composed of a number small solid state TR (Transmit/Receive) modules.

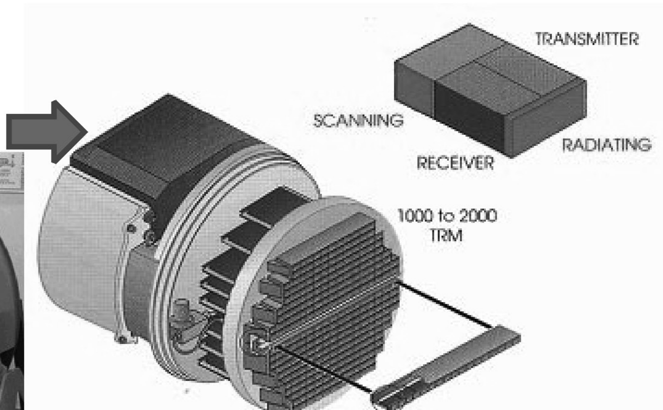
AESAs aim their "beams" by broadcasting radio energy that interfere constructively at certain angles in front of the antenna. They improve on the older passive electronically scanned radars by spreading their broadcasts out across a band of frequencies, which makes it very difficult to detect over background noise. AESAs allow ships and aircraft to broadcast powerful radar signals while still remaining stealthy.

The advantages of AESA radars are low probability of intercept, high jamming resistance, replacing a mechanically scanned array with a fixed AESA mount which can help reduce an aircraft's overall Radar Cross-Section (RCS).

Presently, Northrop Grumman/Raytheon use it for the F-22 Raptor, Falcon F-35.

A pictorial diagram of an AESA radar is given below.

Assembled AESA Elements



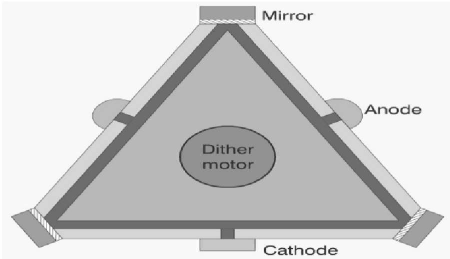
Sections view

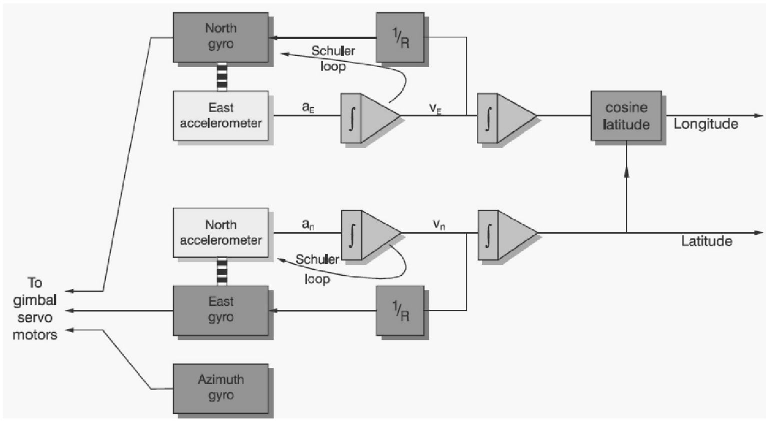
Unmovable Eye of Platform to cover more than 300 km in all weather conditions

Ring Laser Gyro

An RLG consists of a ring laser having two counter-propagating modes over the same path in order to detect rotation. It operates on the principle of the Sigma effect which shifts the nulls of the internal standing wave pattern in response to angular rotation. Interference between the counter propagating beams, observed externally, reflects shifts in that standing wave pattern, and, thus, rotation.

A schematic diagram is placed below.





Stealth Technology

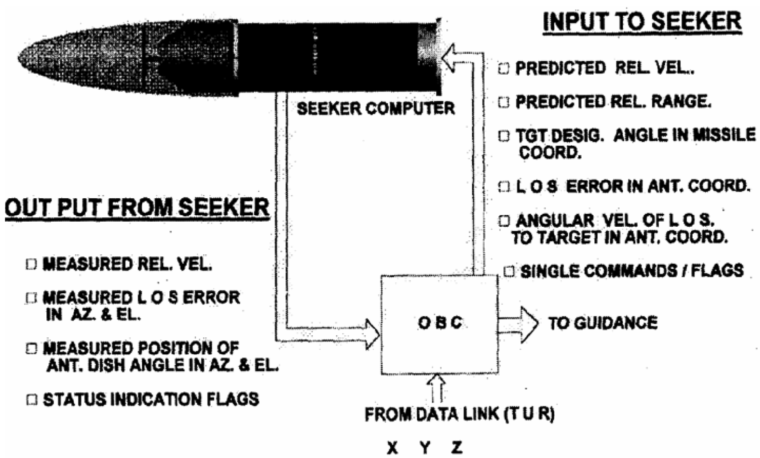
It enables an aircraft to be partially invisible to radar or IR signature. In simple terms, stealth technology allows an aircraft to be partially invisible to radar or any other means of detection. This doesn't allow the aircraft to be fully invisible on radar. Stealth technology cannot make the aircraft invisible to enemy or friendly radar. All it can do is reduce the detection range of an aircraft. This is similar to the camouflage tactics used by soldiers in jungle warfare.

The principle of reflection and absorption makes a vehicle "stealthy", deflecting the incoming radar waves into another direction and, thus, reducing the number of waves, which return to the radar. Another concept is to absorb the incoming radar waves totally and redirect the absorbed electromagnetic energy in another direction. Whatever may be the method used, the level of stealth a vehicle can achieve depends totally on the design and the substance it is made of. The technology used is reflected waves, infrared (heat), wavelength match, Over-The-Horizon (OTH) radar and special coating.

Presently, the F-22 Raptor, F-35 are using this technology. This is also under development as the Fifth Generation Fighter Aircraft (FGFA) programme by India Sukhoi in collaboration with the Design Bureau.

Seeker Technology

Seekers are the eyes of the missiles which help in guiding them towards targets. A seeker has a transmitter, radome, antenna, stabilisation system, waveform design, receiver and signal processing unit. Seekers can be semi-active, active or passive. The type of seeker varies with the mode of operations which can be air-to-air, air-to-ground, ground-to-ground, and ground-to-air. It can be either X-band (monopulse), Scene Correlation Area Navigation (SCAN) and multi-spectral. The seeker operates with an onboard computer.



Single Crystal Blade Technology

In the late 1990s, single crystal blades were introduced in gas turbines. These blades offer additional, creep and fatigue benefits through the elimination of grain boundaries. The transverse creep and fatigue strength is increased, compared to equiaxed or Directionally Solidified (DS) structures. The advantage of single-crystal alloys (SX) compared to equiaxed and DS alloys in low-cycle fatigue life is increase by about 10 percent. In the case of the single crystal, a single grain occupies the whole component space. This casting process goes one step further by completely eliminating all weaker grain boundaries. In single-crystal material, all grain boundaries are eliminated from the material structure and a single crystal with controlled orientation is produced in an airfoil shape. By eliminating all grain boundaries and the associated grain boundary strengthening additives, a substantial increase in the melting point of the alloy can be achieved, thus, providing a corresponding increase in high-temperature strength. The transverse creep and fatigue strength is increased, compared to equiaxed or DS structures.

The advantage of single-crystal alloys compared to equiaxed and DS alloys in low-cycle fatigue (Lef) life is increase by about 10 percent. This process has made it possible to cast a complete turbine airfoil in a single crystal super alloy. SX turbine blades have been used as replacement for DS alloys for the past 20 years due to their higher creep strength and thermal and mechanical fatigue tolerance. Using the SX casting, the metal temperature can go up to 1,150ºC and with Thermal Barrier Coating (TBC), the metal temperature can go up to 1,250ºC.

ROADMAP FOR BOLSTERING INDIA'S DEFENCE AEROSPACE MANUFACTURING CAPABILITY

R&D Capability

For bolstering manufacturing capability in defence, the critical areas would be our R&D policy and design capability. Our weaknesses in core technology areas are clearly known. A coordinated effort needs to be made to bolster R&D

investment by both the private and public sector players and Defence Research and Development Organisation (DRDO) to at least 10 percent of their sales[4]. This will facilitate quicker absorption of high end technology.

The military spending on R&D of a few countries reveals a significant positive correlation between R&D spending and equipment capability. Dr. Rama Rao (2011)[5] contends that private industry's share in R&D in India is only 23 percent, which is far below that of the advanced countries like France and the USA. The R&D spending of India, China and USA would show that while India spends less than 1 percent of Gross Domestic Product (GDP) on R&D, China and the USA spend around 2 and 3 percent respectively.

The following table would show the military R&D expenditure incurred by the developed countries and India (Table 4).

Table 4: Defence R&D Expenditure: Global Trend[6] ($ billion)

Countries	R&D Exp.	% to Total Mil Exp
USA	90	(14%)
RUSSIA	7	(11.5%)
FRANCE	6.1	(11%)
UK	4.7	(9%)
INDIA	2.0	(6%)

Further, Table 4 would show global leadership in terms of various parameters of R&D.

Table 5 : Global Leadership Against Various Parameters of R&D

Sl. No	Parameter	1st	2nd	3rd	4th
1.	R&D Exp % GDP	Israel	Sweden	Finland	France
2.	Skilled Labour	Denmark	Iceland	Israel	Austria
3.	Qualified Engineers	India	Finland	Israel	Japan

4. Recommendation of the Parliamentary Standing Committee on Defence (2009-10).
5. Seminar in the College of Defence Management, Hyderabad (January 2011).
6. Keith Hartley, "Defence R&D: Data Issues", *Defence and Peace Economics*, vol. 17, no. 3, June 2006, pp. 169-175.

4.	Technology Readiness	Israel	USA	Finland	Sweden
5.	Quality of Scientific Institution	USA	Sweden	Israel	Finland
6.	Utility Patents	USA	Japan	Taiwan	Israel

It would be seen from the above that the USA leads in terms of quality of scientific institutions, patents and technology readiness, while Israel is a frontrunner in terms of R&D expenditure. **Interestingly, India is the global leader in terms of qualified engineers**. However, to realise the preeminence enjoyed by countries like the USA, Israel and Finland, we must invest handsomely in R&D and improve the quality of our scientific institutions so that our technological readiness is at a higher level.

No single country can contend with the demand of R&D and high technology system development. Fusion energy and human genome development are, therefore, multi-country projects. Finland, a small country, which was largely a forest-based economy, has become a technology powerhouse by spending 1 percent of its GDP on R&D related production development of Nokia, and the results are there for all to see. In the area of design and development, the challenge would include multiple options like creation of a "National Technology Fund" to support the private sector and academia, joint R&D initiatives with reputed design houses abroad, setting up of design institutes and fostering national R&D, as countries like Israel and France have done.

India's experience in the case of design and development of major programmes like the LCA and MBT clearly reveals our inadequacy to develop critical systems. The engine and radar for the LCA are sourced from the USA and Israel. The engine for the MBT is sourced from Germany. The FCS (Fire Control System), GCS (Gun Control System) and Night Vision Devices (NVDs) are sourced from abroad in the case of the MBT. National commitment to R&D, joint technology development and higher R&D investment by the private sector will be needed to bolster self-reliance in critical sub-systems.

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A Defence Technology Fund should be created which will provide the funding needs of Defence Public Sector Units/Ordnance Factories (DPSUs/OFs) private sector, academia and lab(s). The recommendations of the Defence Production Policy (2011)[7] must be operationalised early.

Concurrently, a **Defence Modernisation Fund** needs to be created in the Ministry of Defence to support the infrastructure and capacity build-up requirement of the DPSUs/OFs/private sector. Such initiatives would particularly help the shipyards that are in acute need of modernisation and upgradation of facilities. Areas for investment in technologies are summed up in the table below (Table 6).

Table 6 : Areas for Investment in Technologies[8]

- Intelligence Terminal Guidance
- Supersonic and Hypersonic Propulsion
- Hydrodynamics
- Ceramic and Metal Matrix Material
- Sensors
- Lasers
- Radars for Stealth Detection
- Active Arrays
- Fibre Optics
- Heavy Particle Beams

Synergy Among Design Houses, Production Houses and Users

Air Cmde Jasjit Singh (Retd) brings out (2011)[9] how the aerospace power of Russia is largely due to the design house being in charge of the production plants and ensuring realisation of technology. A committee under Subramaniam in the 1960s had also recommended, in the context

7. See Ministry of Defence website www.mod.nic.in.
8. Discussion with members of the Self-Reliance Committee (1993).
9. Jasjit Singh, *Indian Aircraft Industry* (New Delhi: Knowledge World, 2011).

of the gas turbine engine for the fighters, that the production agency should be in charge of design and development. Sadly, such recommendations merely gathered dust in the corridors of power. The Rama Rao Committee (2008) also made similar recommendations in the context of the design, development and production of the engine for the LCA.

The government has to play a pivotal role in bringing to the table each major stakeholder viz. the Ministry of Defence (MoD), Services, DPSUs/OFs, DRDO, private sector and Original Equipment Manufacturers (OEMs) and Ministry of Civil Aviation.

The serious hiccups in the Kaveri gas turbine engine programme in the LCA are largely attributable to the lack of synergy between the engine designers in GTRE and the production agency (HAL) and lack of foresight to have a partnership with engine majors abroad. On the other hand, missile programmes like the Prithvi have seen success due to proper synergy between DRDL, the development agency, and BDL, the production agency.

Though the issue of putting the design agency under a production agency is a sensitive policy issue, it has to be addressed, and single point accountability brought in. Given the plethora of aircraft programmes in the pipeline like the MLH, FGFA, MRTA, MCA, RTA and SARAS, it is high time that all the aerospace sector related laboratories like GTRE, LRDE, DARE, ADE, NAL and ADA and production agencies like HAL are brought together under one umbrella/agency, with overall accountability in terms of major deliverables.

The government has to play a pivotal role in bringing to the table each major stakeholder viz. the Ministry of Defence (MoD), Services, DPSUs/ OFs, DRDO, private sector and Original Equipment Manufacturers (OEMs) and Ministry of Civil Aviation that have a tendency to indulge in the blame game. Achievement of self-reliance in design, development and production of major sub-systems and platforms has to be a concerted national effort.

FDI Policy and Technology Transfer

There is an urgent need to review the Foreign Direct Investment (FDI) policy in defence and upscale it to at least 50 percent from the present cap of 26 percent. Successful Joint Venture (JV) models like the Brahmos buttress such suggestions. It would be interesting to recount China's experience with a liberal FDI policy. FDI moved into China in a big way from the early 1990s ($5.5 billion to $67.3 billion by 2007) and has been directed towards manufacturing, providing capital and technology and skills.

Some of the FDI has been centred on high technology operations such as semi-conductors, telecommunication, optic fibres, Information Technology (IT) and aviation. FDI has been viewed as far more important than portfolio capital, venture capital or commercial bank finance.

At the heart of policy efforts to promote FDIs were the Special Economic Zones (SEZs) which provided an open economic environment conducive to business. Intellectual Property Rights (IPR) projections remain a challenge, but World Trade Organisation (WTO) membership ensures that the authorities are committed to strengthening measures to protect IPR.

Hand in hand with such liberalisation has been the changing structure of FDI – i.e. moving from contractual JV operations to joint development projects to equity joint ventures providing a template for long-term relationships/partnerships. This has encouraged greater access to foreign technology. With more market-based structures, the policies have promoted FDI in wholly owned subsidiaries of foreign corporations.

The downside of FDI is that the foreign enterprise exploits the host economy's markets, promoting little in the way of skilled labour and sub-contractor's value.

China joined the WTO in 2001, by embracing globalisation. Since then, it has attracted a cumulative $ 400 billion in FDI of which 5l percent is in manufacturing, followed by real estate (21 percent). Currently, China accounts for 8.4 percent of total manufacturing and has concentrated on export oriented manufacture. Its share in global exports has increased from 3.9 percent in 2000 to 9.7 percent ($ 1,202 billion) as against only 1.4 percent by India.

Similarly, technology transfer has to be part of the offset policy and suitable multipliers applied to key technology. Dual use technology in areas like cryptology, robotics, artificial intelligence, sensors, nano technology, and strategic defence electronics should be our thrust areas. There should be a single point agency to monitor inflow of new desirable technologies and an appropriate mechanism put in place to check the quality and value of the technology being transferred.

It would be useful to look at the successful technology transfer experience in the case of the Embraer aircraft and Agusta Westland helicopter, as given in Tables 7 and 8 below.

Table 7: Successful Technology Transfer: Embraer Aircraft[10]

- Formation of Embraer as an aircraft manufacturer (1969)
- Licence for the Aermachhi, Italy-produced Xavarite Armed Trainer (1971)
- Licence from Piper, USA production of Seneca Light Planes, EMB 312 (1978)
- Government encouraged JVs between overseas arms companies and local companies and technology transfer.
- Strong foundation on R&D
  - Financial support for R&D
  - Recruitment of research staff of aviation technology centre
  - Tax for companies buying Embraer's shares
- Encourage civilian industrial base

Table 8: Successful Technology Transfer : Agusta Westland Helicopter[11]

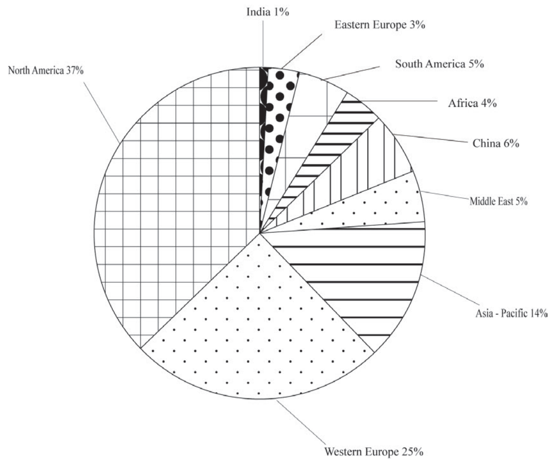
- Licence to build the S-51 helicopter (Westland Dragon Fly) in the UK (1947)
- Further licence to build the S-61 (Seaking) (1959)
- Sold to the UK armed forces and substantial exports
- Company build D&D capability in helicopters (1967)
- Three types of helicopter developed
- Became equal partner with Agusta (Italy) EH 101 Merlin Helicopter
- Westland selected to build Boeing Apache helicopter (1995)
- Collaborated with Rolls Royce for the engine
- Agusta Westland merged – presently world class helicopter company

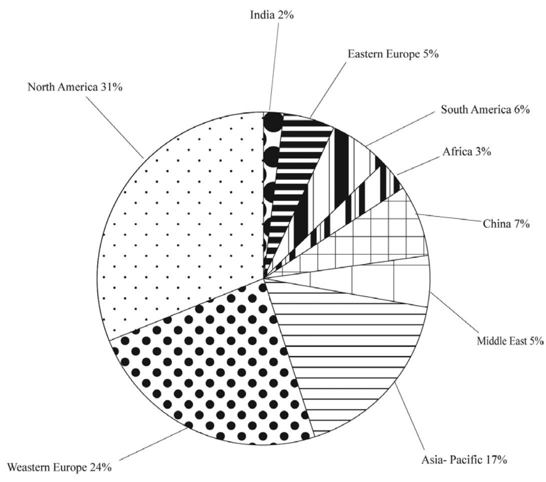
10. Sam-Perlo Freeman, "Offset and Development of Brazilian Arms Industry", 2004.
11. Table prepared by the author, based of the study on effect of offsets on development of EDA and market, 2007.

Providing Capability to Maintain, Repair And Overhaul

The Kelkar Committee (2005)[12] had identified acquisition of deposit maintenance technology as a thrust area. Maintenance, Repair and Overhaul (MRO) constitutes a $40 billion global market. More is spent by an organisation on MRO than on manufacturing. It is critical for facilitating life-cycle extension of an existing fleet and keeping operational costs in check.

The market is currently dominated by North America and this trend is likely to continue in the near future, though with a smaller market share.





Source: The Global MRO Forecast A Look Forward, 2007-17.

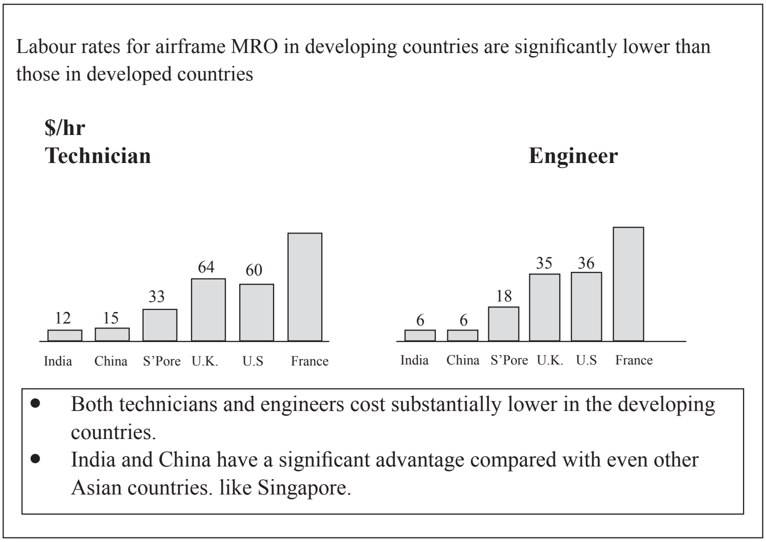
12. Towards Strengthening Self-Reliance in Defence Preparedness, April 2005.

There are four key factors for building a successful airframe MRO business:

1.	Significant technical capability	• Significant technical expertise is needed to get the certifications required for setting up an airframe MRO • Turnaround time is the most important criterion used by airlines for selecting an airframe MRO service provider and it depends on technical expertise.
2.	Robust talent pipeline	• Airframe MRO demands a strong pipeline of skilled manpower. • This industry is characterised by high attrition* rates as a result of a globally mobile workforce.
3.	Sustainable cost advantage	• Airframe MRO is a relatively commoditised business and, therefore, having enduring cost competitiveness, is the key to attracting and retaining customers.
4.	Assured baseload	• Non-sticky customers and high fixed costs make locked-in demand essential to de-risk the business.
* High attrition is a phenomenon witnessed only in the developing countries, with dynamic labour markets; in the developed countries, it is often a career choice and attrition rates are low		

Globally, labour accounts for 70 percent of the cost of airframe MRO and countries like India have a substantial cost advantage in terms of labour rates, despite lower productivity (around 50 percent) compared to the Western countries.

Fig 1: Cost Advantage in MRO for India



Sources: Watson Wyatt, Global Remuneration Planning Report, growth adjusted (2004); U.S. Social Security Administration; expert interviews

The offset policy introduced in 2005 by Malaysia has facilitated development of local maintenance, repair and overhaul capacity. Out of the offset contracts concluded so far, there are three contracts viz. MiG-29 upgrade and VVIP helicopters and Globemaster where HAL and other private sector players will benefit in terms of MRO capability.

The position is as under:

Table 9: Offset Credit for MRO

	Acquisition	Contract Value	MRO Credit
1.	Upgrade of MiG-29	3,856 crore	235 crore
2.	Medium refit helicopter	5,600 crore	585 crore
3.	VVIP helicopter	4,227 crore	1,268 crore

Source: Collected by author from DOFA, MoD.

This will ensure that for periodic repair and overhaul of aircraft, India does not have to go to OEMs and would be able to do ROH in a cost effective manner. HAL can be a frontrunner in acquiring such technology as it has done for ROH for MiG services, aircraft and engines. There is a huge opportunity for MRO for both the civil and military aircraft as they have to be overhauled at least four times during their life-time.

Public-Private Sector Partnerships

Public-private partnerships would need to be consciously nurtured. It has been a very successful model in the national highway programme. Partnerships between HAL and Tatas for aero-structures and Unmanned Aerial Vehicles (UAVs), OFs with Mahindra and Mahindra for the FICV, 155 mm guns, MDL and GRSE with Pipavav, L&T and ABG for patrolling vessels, and frigates should be forged.

To fill in the capability gaps, suitable OEMs should be identified for JV arrangements for both design and development and manufacturing. The government must encourage and enable creation of Tier I and Tier 2 companies in the country. In critical areas such as flight controls, landing gears, composites, support for formation of JVs with established industrial players in Europe and North America would be extremely beneficial.

In the field of aviation, these facilities are expensive and would need regular calibration, upkeep and upgradation. Most of the Small and Medium Enterprises (SMEs) cannot afford to own these facilities in-house. It is suggested that these costly facilities are established through government funding but managed on the GOCO (Government Owned Company Operated) principle and made available for industry's use. These test facilities should be approved not only by internal agencies such as CEMILAC/DGAQA/DGQA but also by major outside OEMs such as Boeing/Airbus and certification agencies such as FAA/EASA. Availability of certified facilities will help the industry to provide fully tested products to the indenting agencies in India and abroad, enhancing the value of the products supplied and reducing the time cycle for delivery.

A number of Indian engineering service providers have undertaken design and engineering services for manufacture of components. Most of the sub-contractors were SMEs. Big industries such as L&T and Godrej have participated but purely as sub-contractors. In the sphere of aviation

China is targeting itself as a major supplier of wings, landing gear and composite structures and is a first tier supplier of fuselage sections.

in India, there are no Tier 1 and Tier 2 companies with adequate strength in design, development and manufacture, and willingness to be risk sharing partners. Industries such as TCS, HCL, Infosys, Wipro, and Mahindra Satyam have entered the engineering services domain in the last one decade and have done engineering tasks for OEMs/Tier 1/Tier 2 manufacturers of Europe and North America. These companies, along with their sister companies, are trying to enter the engineering and manufacturing domains to meet the changing requirements of customers who are now demanding not only design and engineering services but also manufactured parts. However, their experience, expertise, systems and processes are inadequate.

The SMEs have experience of manufacturing mechanical, structural components, electrical looms/connectors/LRUs to a specified drawing. As regards avionics equipment, a few of the industries have developed the capability to develop equipment to a given specification. None of these industries have heat treatment/other process facilities and are dependent on OEMs for these facilities. Similar partnerships are possible in the shipbuilding sector and defence electronics also.

Partnerships Between Public Sector Entities

The DPSUs, despite enormous complementarities in their production capability, rarely synergise. For instance, HAL and BEL can be very effective partners in the areas of communication, defence electronics visual display devices, radars, software defined radio. Synthetic aperture radars and various payloads like the FLIR for UAVs and the airframe for UAVs and integration thereof can be excellent areas of cooperation among HAL, BEL, DRDO and OEMs. Presently, we are dependent on M/s IAI, Israel, for all our requirements of UAVs by the three Services.

Similarly, Mishra Dhatu Nigam (MIDHANI) can be a major source of supply for super alloys like titanium steel which can be used for engine components manufactured by HAL, as MIDHANI has already absorbed the technology successfully from Russia. Ironically, these components are being sourced from Russia. MIDHANI's capacity can be ramped up which will reduce the import dependence of HAL substantially.

Joint Ventures and Joint Technology Development

Given the enormous gaps in indigenous manufacturing of major systems and design capability gap vis-à-vis reputed global majors, the most viable option to leapfrog is not by reinventing the wheel but by forging partnerships with global companies. Brahmos, in which we have a 50: 50 JV partnership with Russia for manufacturing cruise missiles, is a major success story. There are major partnerships in the offing with Russia for the design, development and production of a stealth and transport aircraft. With the French also, such co-development arrangements are in the pipeline for short range and medium range missiles. However, the process of selecting the OEM/design house as a partner should be through a process of due diligence.

China is targeting itself as a major supplier of wings, landing gear and composite structures and is a first tier supplier of fuselage sections. In comparison, India's exports are limited to the supply of doors to Airbus, wiring harnesses, uplock boxes and detailed engineering drawings. In order to graduate to a higher level of presence in global aerospace, China's aviation major Aviation Industry of China-I (AVIC-1) is having an alliance with Bombadier on the ARJ 21 and with Airbus for the final assembly of the A320. Similarly, though Russia has considerable design and production capability of fighter and transport aircraft, its major design house, NPO-Saturn, is having a JV with France's Safran for building an engine for the regional jet (SAM 146) in competition with GE. These are major lessons for India's aviation majors like HAL that are engaged in export of small items like doors, wiring harnesses and uplock boxes.

NATIONAL MANUFACTURING POLICY AND MILITARY INDUSTRY CAPABILITY

The following recommendations were made by the Prime Minister's (PM's) group (2008)[13] on the growth of the Indian manufacturing sector.

- Promote competitiveness
- Domestic value addition as a core endeavour
- Private sector main driver of manufacturing growth.
- FDI policy to encourage development of domestic technological capability for long-term growth.
- Priority treatment to be given to strategic manufacturing sectors viz. aerospace, shipbuilding, IT and electronic hardware, capital goods and solar energy.
- Create Technology Acquisition Fund for use by SMEs.
- Identify technology from general technological development and strategic view-point.
- Identify specific areas of technology where FDI should be attracted, including Transfer of Technology (TOT). It should be designed to leverage the huge domestic market available for foreign companies.
- Offset policy should mandate technology transfer in addition to manufacturing.
- Create strong industry-science linkage to facilitate commercialisation of scientific advancement.
- Establish linkage with technologically advanced countries through trade and investment to pass on the benefits of innovation, upgradation.
- Invest heavily in research in future technologies like nano manufacturing, solar and hydrogen technologies and intelligent manufacturing technologies.

There is an urgent need to dovetail the military industry capacity and capability with national manufacturing policy. Though the share of the manufacturing sector in the Gross Domestic Product (GDP) has gone up in India from 15 percent in 1950-51 to 26 percent now, it is still substantially lower than in countries like China (40 percent), which has become a global manufacturing hub for consumer goods, aerospace and shipbuilding.

13. Measures for Ensuring Sustained Growth for Indian Manufacturing Sector, September,. 2008.

The share of different sectors since the First Plan is as under:

Table 10: GDP Share : Major Sectors[14]

	Agriculture	Industry	Services
1950-51	56	15	29
1990-91	33	25	42
2009-10	17	26	57

China's substantive manufacturing capability and cost-effectiveness have ensured a substantial share in exports globally (9.7 percent) as against India, whose share is 1.3 percent only. Redeemingly, the new manufacturing policy (2011) seeks to increase the share of manufacturing in GDP to 35 percent and create 100 million new jobs by 2022. This is a welcome development. The defence industry capability plan must be a sub-set of the national manufacturing plan as they are closely interlinked. Many sectors like aerospace, shipbuilding, electronics, avionics, and telecom have a lot of commonality in terms of components, material used and sub-systems. The offset policy, by including all these sectors, can have a significant impact for such capability build-up.

As a definite step during the 12th Plan (2012–17), if our import content is reduced to 60 percent i.e. a modest reduction of 10 percent from the present level, additional indigenisation procurement would be to the tune of about $ 2 billion and create an additional employment opportunity of1.3 lakhs every year, as per the table given below.

Table 11: Impact of Reduction in Imports on Domestic Defence Production and Employment: A Projection[15]

Year	Acq. Budget (Rs. crore.)	Import Content (% to Acq)	Indigenous Procurement (% to Acq)	Addl.Indigenous Procurement (Rs.crore)	Addl. Employment
2011-12	46,000	32,200 cr (70%)	13,800 cr. (30%)	–	–

14. *Statistical Outline of India 2009-10 Tata Services Ltd.,* Department of Economics and Statistics
15. Based on calculation by the author, from inputs from Indian industry associations.

2012-13	53,000	34,450 cr. (65%)	18,550 cr. (35%)	2,550	36,000
2013-14	60,950	39,617 cr. (65%)	21,332 cr. (35%)	3000 .	43,000
2014-15	70,092	42,055 cr. (60%)	28,036 (40%)	7036	98,000
2015-16	80,606	48,363 (60%)	32,242 (40%)	8242	1,20,000
2016-17	92,697	55,618 (60%)	3,70,788 (40%)	10,000	1,30,000

Some of the policy issues that also need to be addressed are licensing, export and removing the protectionist bias towards DPSUs/OFs.

(a) Rationalising Licensing Requirement

The present process for issuing an industrial licence is complicated and does not give any advantage to effectively assess the suitability of an individual company for meeting the technical requirements of the products of an overseas buyer company. It is only after multiple on-site assessments by the specialists that an overseas company approves an Indian firm as a potential candidate for receiving outsourced work for offsets. Since it is the responsibility of the overseas company to pick up the right partners who have adequate means to produce items for export as defence offsets, the responsibility is more on them to select suitable and capable partners.

At present, the MoD maintains a list of licensed companies for offsets. Many of the overseas representatives feel that it is misleading, limiting and lacking in clarity. Further the Industrial Licensing Policy does not have any clear definition of defence equipment. Industrial licensing requires a National Industrial Class (NIC) code but it has no specific entries in defence equipment, thereby necessitating clarifications from the Ministry of Defence, with inherent delays. Companies engaged in IT require industrial licences and are subject to an FDI cap of 26 percent. This is not only retrogressive but discriminatory. The industrial licence granted under the IDI Act, 1956, applies to manufacturing and not to services like IT: 100 percent FDI on the automatic approval route is available to IT which has made it a global powerhouse. The licensing requirement for IT products and 26 percent FDI cap for IT companies will seriously hamstring the IT sector. The Department of Defence Production has circulated a list of dual use products. This will roll back liberalisation as it seeks to reintroduce the Licence Raj. Ironically, it includes items like uniforms, ready to eat foods, etc. instead of including items based on lethality.

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(b) Export Policy

While the offset policy envisages a surge in defence exports, the export policy for defence goods is mired in red tape, and is cleared on a case to case basis. There is no clarity about which products and to which countries are restricted. This anomaly would need to be resolved. The Kelkar Committee (2005) had also called for a relook into the negative list maintained by the Ministry of External Affairs (MEA) and evolving a product strategy for exports. India's products like the Advanced Light Helicopter (ALH), Brahmos and small arms have immense export potential and must be actively pursued with countries that are on the look-out for cost-effective exports.

(c) Removing Protectionist Bias Towards DPSUS/OFs

The present arrangement of the Department of Defence Production (DDP) overseeing the interests of both public and private sector entities is flawed as there is a built in bias to protect the interests of the DPSUs/OFs to ensure their capacity utilisation. This is often at the cost of economy, quality and timely delivery. It has been amply demonstrated in the case of patrol vessels that an upcoming shipyard like Pipavav sells deliverables at a much lower rate, given an opportunity to compete, which DPP-2011 now provides.

The infant industry argument would no larger hold water for DPSUs/OFs and they would need to be time-compliant and cost-effective. In many cases, they can be Tier I partners to the DPSUs/OFs. For low technology items like clothing and shoes, there appears to be no justification to carry on with the present arrangement of producing them through the OFs. Also

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in the 'B' vehicle segments' continuation with the existing arrangement of VFJ without much value addition does not make any sense. The Nair Committee (2000) had strongly recommended privatisation of these items to ensure quality, cost-effectiveness and timely delivery. There is a strong case for greater private industry participation in the categorisation mechanism of the Ministry of Defence. This is a long standing demand by various industry associations.

CONCLUDING THOUGHTS

There are no easy shortcuts to fill up capability gaps in design and manufacturing of aircraft and their systems. In an oligarchic market, with a handful of design houses, and IPR hiccups, governmental policy and mentoring would be critical for fostering joint technology partnerships, joint ventures in manufacturing and public-public and public-private partnerships. All stakeholders, including the private sector, must upscale their R&D allocation substantially as technology transfer of key systems will be hard to come by.

Liberalisation in defence is still mired in prevarication and red tapism. Both in terms of policy facilitation and implementation, we need to take a leaf out of Brazil's successful tryst with Embraer Aircraft and China's preeminence in the manufacturing sector. The temples of modern India viz, the Indian industry, must rise to this challenge in a globally networked environment.