FICCI

Make in India' Paradigm – Roadmap for a Future Ready Naval Force

A Compilation of Papers by Indian Naval Officers for FICCI Seminar

2016

Contents

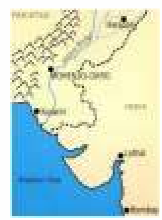
article 1

NAVAL SHIPBUILDING' THROUGH 'MAKE IN INDIA' PERSPECTIVE

(By Cdr Nitin Saxena)

Historical Background

1. Make in India signature in shipbuilding can be traced back to the role Indian shipbuilding played in the creation of the US National Anthem "The Star-Spangled Banner". The lyrics came from "Defence of Fort McHenry", a poem written in 1814 by Francis Scott Key when aboard the Minden, a vessel that was built in India. Minden was built of teak by Jamshedji Bomanji Wadia and launched in 1810 from the Duncan Docks in Mumbai. The Royal Navy came to admire the skills of Indian shipbuilding and dry dock infrastructure, giving Bombay a distinguished place among naval arsenals.



2. India's shipbuilding history is not a matter of chance of casual growth. It is a heritage. Excavations of Lothal, a major port city of erstwhile Harrapan civilisation of India, extending for a period over thousand years from around 3000BC to 1500BC, have unearthed a dry dock used for repairing as well as building ships. So far, it remains the earliest known dry dock in the world, rendering India, as one of the earliest shipbuilding nation.

3. HMS Trincomalee, a 1447 tons 38 gun frigate, was built at Bombay for the British Navy. The keel was laid in 1816 and the ship launched in October 1817. She is the oldest floating British frigate and the second oldest floating ship in the world. Throughout recorded history the world-wide recognition for India's shipbuilding panache was acknowledged and responsible for various naval powers to source their requirement of ships from the different shipyards in India.

4. At the time of industrial revolution in Europe, Indian shipbuilders were at the peak of shipbuilding activities. However, under the British rule India saw the Dark Age in shipbuilding. The arrival of Indian-built ships in Port of London created a sensation among the monopolists. The shipbuilders of the Port of London took the lead in raising the cry of alarm. An obliging Government saw to it that the Indian industry perished. While laying the foundation stone of Scindia Shipyard (now Hindustan Shipyard) in Visakahapatnam on 21 Jun 1941, Dr Rajendra Prasad summarised, 'Indian shipbuilding was thus able to hold on its own till about 1840. But India had to go to wall, in the interest of British shipping'.

Naval Shipbuilding Sector

5. **Indian Shipbuilding**. While the history is replete with numerous examples highlighting sound shipbuilding industry that existed years ago, Indian shipbuilding represents a mere 1.3% of the global shipbuilding share as on date and almost zilch as far as warship export is concerned. India's

present strength include about 10 government owned shipyard and around 50 in the private sector. Eventhough, the Indian government considers shipbuilding industry to have the highest investment and employment multiplier effect, Make in India stamp on global shipbuilding remains invisible. Commercial shipbuilding is confined to tugs etc.

6. **Naval Shipbuilding Share**. Naval shipbuilding is a subset of overall Indian shipbuilding sector. Not just that the Naval shipbuilding holds a scarce percentage (about 5%, Fig 1) in overall shipbuilding matrix of India, also Naval shipbuilding is an unusual industry as 65% of value addition during construction of ships comes from other industries. The growth of the domestic shipbuilding sector, which today imports 45% of its input requirements, can provide a major trigger for large scale indigenisation of heavy engineering products and ancillaries.

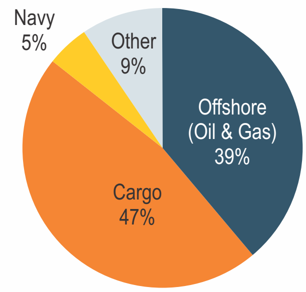


Fig 1. Division of Shipbuilding Share

7. **Indian Shipyards**. Before Naval shipbuilding is discussed, it is important to understand dynamics of shipbuilding industry as a whole and some of its factors which are common in its Naval subset as well. Of the total numbers of shipyards (Table 1), around eight yards account for more than 95% of the Indian shipbuilding order book by value as most of the shipyards are undertaking construction of small vessels for domestic and global markets. Only a small percentage build ships greater than 100m in length and majority of them are Naval ships.

Table 1. Indian Shipyards

PSU Shipyards (02)	DPSU (04)	Govt Shipyard under State Govt (02)	Pvt Shipyards (13)
CSL, Kochi Hooghly Dock and Port Engineers Ltd., Kolkata	GRSE, Kolkata GSL, Goa HSL, Vizag MDL, Mumbai	Alcock Ashdown Ltd, Bhavnagar Shalimar Works Ltd., Kolkata	ABG, Bharti Chowgule, L&T Pipavav, Tebma etc.

8. **Delivery Schedule**. Indian shipbuilding industry has gained name in the recent past due to piling up of large number of new building orders be it for mercantile marine or Navy. The delivery schedule has not picked at the same pace as the new building contracts were signed. One of the major reasons for the delayed delivery has been the delay in the arrival of equipment and machinery from the foreign suppliers. Other major reason for the delayed delivery is that the shipyards took more orders than what they could easily execute with the existing infrastructure. which failed to match with orders bagged. Other factors which attributed to delays include clearance from government, local protests/ labour issues and poor planning.

9. **Price Disadvantage**. Shipbuilding in India attracts a complex set of levies and duties. The differential rate of duties and taxes between India and other nations leads to additional cost burden for Indian shipyards as described below:-

(a) A shipyard requires a working capital of around 25-35% of the cost of the ship during the entire construction period. The interest rates on working capital in India is average 10.5%. In contrast, the interest rates presently offered to shipbuilding yards overseas are significantly lower at around 5-6% in Korea and around 4-8% in China.

(b) In addition to the cost advantage that China and South Korea have, their respective governments provide discount/ subsidy at the time of sale of ships, which is around 5-10% in case of China and around 15-20% in case of South Korea. This further helps them to bid lower price in international competitions, resulting in a price advantage.

(c) The cost disadvantage due to the cost of input material, taxation and subsidies for both domestic sales and export sales by an Indian shipyard is estimated to be 41-44% for export sale with respect to China, which implies that the cost of building a ship in China is around 41% cheaper compared with that of an Indian shipyard for building a similar ship. Therefore, as a result of various economic inequalities, ships built in India are costlier than the ships built in China and South Korea. This is the core reason why many Indian ship-owners place orders with Chinese shipyards.

Naval Shipbuilding - Capability and Capacities

10. The Naval arsenal after independence consisted more of acquisitions than indigenous shipbuilding. Indian Navy imported large quantity of defence hardware from UK and other European countries. However, the bulk of the imports were from the Soviet Union. Over three decades of reliance on Soviet-produced military hardware starting from 1960s, India Armed Forces were in a position in 1991 in which 70% of Army armaments, 80% of Air Force armaments, and 85% of Navy armaments were of Soviet origin.

11. In the mid-1990s, the Indian Naval fleet numbered over 100 combat naval vessels, of which 15 were submarines, two were aircraft carriers, and another 23 were destroyers and frigates. Focused on developing a Blue water capability, the Indian Navy took several strides in warship building projects. With onset of 21st century, the Indian Navy was preparing for a long-overdue modernization program that was to include three Delhi & Kolkata class destroyers, two oil tankers, building up nuclear submarine & aircraft carrier and acquisition of four hydrography survey ships.

12. In 2003, Defence Acquisition Council approved the 10-year Plan for Navy to acquire 23 more warships including an indigenous air-defence warship. Since then, two modes of acquisitions have been adopted by the Indian Navy. Those ships designed in-house in Indian Naval design organisations built by Government shipyards and other category included those which are imported from foreign shipyards through acquisition contracts. The indigenous shipbuilding projects have seen rise from a mere 25% from 1990s to 55% in 2015 (Fig 2).

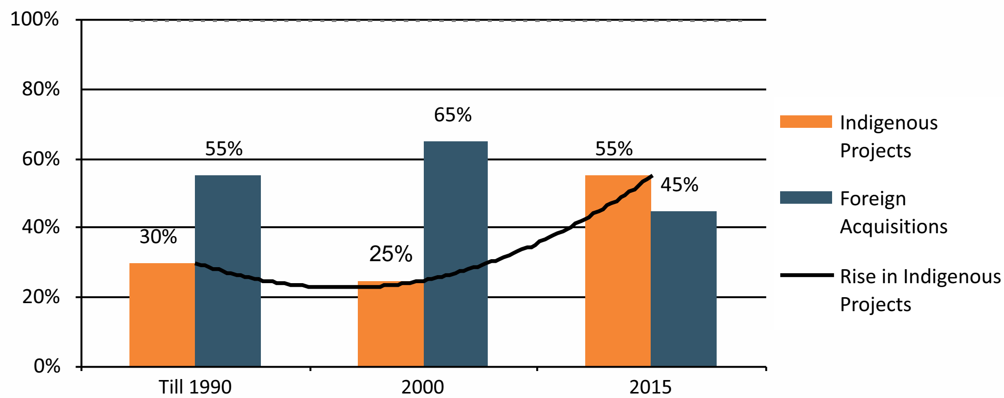


Fig 2. Indigenous Projects 1990-2015

13. While the shipbuilding industry has suffered decline from the days of rich heritage, the story of Naval shipbuilding is asymmetric to that of Indian shipbuilding. Indian Naval fleet has evolved over a decade through multiple shipbuilding and acquisition projects to achieve desired operational capability and reach. Concurrent acquisitions from various other countries were progressed to bridge the gap encountered with domestic shipbuilding base. However, India's defence industrial base remains limited, infrastructure is inadequate and in-house R&D facilities face internal challenges of herculean proportions.

Indigenous Equipment/ Ancillary Base

14. **Indigenisation of Defence Sector**. Whilst there has been increase in indigenous warship building projects, the domestic support for equipment/ weapon/ systems remains abysmal. There has been an attempt to diversify from import and boost indigenous production through increased R&D by Defence Research and Development Organisation (DRDO), a pseudo Make in India approach, the bulk of procurements to meet the Indian Navy's requirements continue to be met from the foreign sources as in-house R&D organisation is unable to keep pace with requirements and level of sophistication.

15. **Ancillary Base**. Indian shipyards import more than 80% ship systems and equipment from abroad. An important aspect to note here is that it took over 15 years for the Chinese shipbuilding industry to increase the use of domestic components in its shipyards. From sourcing 25% of components domestically during early-1990s, Chinese shipyards have now increased the level of ancillarisation to 60-65%. Similarly, the level of domestic component usage for Japanese shipyards was about 30-40% in mid-1950s, while it has touched almost 100% now. Korean shipbuilders, who sourced 20-25% domestic components in 1970s, now source about 88-90% components from in-house industry (Fig 3).

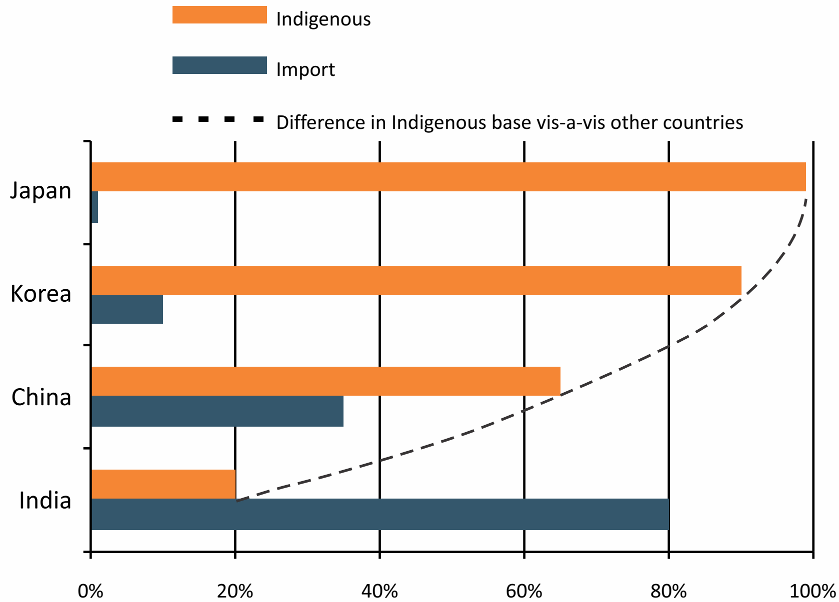


Fig 3. Comparison of Indigenous Capabilities

16. **Indigenisation Drive**. Indigenous development is the only way to ensure complete self reliance and Indian Navy has given focused attention to this endeavour by creating a new Directorate of Indigenisation at IHQ, MoD (Navy) with effect from 01 Sep 05 and evolved a 15-year indigenisation programme. Industry including the private sector can therefore play a vital role in meeting the needs of the Indian Navy through cost-effective utilisation of its know-how and existing infrastructure. However, the results of this indgenisation drive are yet to be accrued and real time application based products are yet to see absorption in warships on large scale.

17. **Contractual Issues**. Due to import lineage of the platforms and equipment, procurement and operational agencies of Navy had to inadvertently resort to import to overcome material deficits, technological upgrades and equipment maintenance. The procurement agencies have often complained about persistent problems with sourcing of spares for maintenance of imported equipment. Part of the blame can be apportioned onto the Indian contracts/ negotiators for not visualising and catering for life cycle support, offset clauses while negotiating contractual agreements, including greater wear and tear of the equipment due to varying climatic and operational conditions in Indian maritime domain. This is further compounded by the fact that some of the equipment imported became obsolete in few years after acquisition in absence of support through import/ domestic sector.

18. **Segments of Naval Shipbuilding**. As brought above, the Navy has unveiled a 15 year plan to achieve indigenous base in phases, from systems to weapons. The plan is aimed at enabling the development of equipment and systems through DRDO and Indian industry. It is prudent to look at current statistics of indigenisation to gauge the extent to which indigenisation is still pending. The role worthiness of warship can broadly be divided into three segments - to float, to move and to

fight. The Navy has achieved 90% indigenisation in the float category, while the move (propulsion) and fight (weapons) components stand at 60% and 30% respectively (Fig 4). The latter two remain the priority area and has sufficient scope for adoption of Make in India policy.

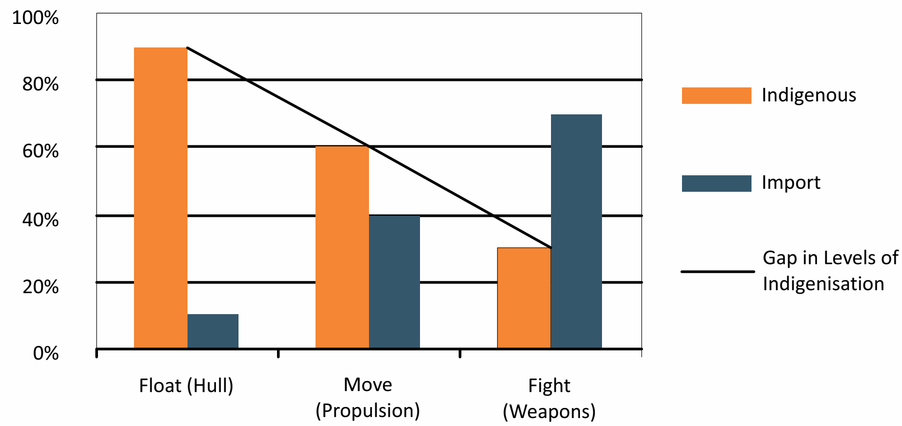


Fig 4. Indigenous vs Import

Systemic Issues and Gaps

19. *The Buzz phrase - Indigenisation of Defence Sector* - has largely remained a mirage as far as core defence industry is concerned especially in Move and Fight segments. In the crisis situation, dependence on other nations for weapons and equipment can put National Security in danger as we have high percentage of naval ancillaries of import nature. Unfortunately, till the end of last century, successive governments have treated defence as a holy cow whose activities were seldom discussed in the Parliament. The effect of such a stance has been that our dependence on imports of defence equipment continues nearly seven decades after independence and efforts at attaining self-reliance never took-off to desired levels. These gaps are attributable to certain systemic issues which were identified and discussed in succeeding paragraphs.

20. **Defence R&D**. DRDO, DPSUs and OFB were mandated to keep the military modern and fully stocked with state-of-the-art equipment. There was a conscious effort to keep the private sector out of the defence equipment manufacturing chain. Eventually, DRDO could not deliver on most technological fronts and DPSUs and OFB could not keep pace with requirements of Naval shipbuilding as far as weapon and ancillary base is concerned. The other concerns include following:-

(a) Technology intensive equipment, weapons and sensors for modernisation of naval platforms were per force imported despite in-house R&D in place.

(b) R&D projects crossed timelines and labs remained unaccountable due to inefficiency shown at various fronts. The reliability and strength from domestic R&D remains far-fetched.

The joint defence cooperation with Russia for development and production of advanced technologies and systems like joint development of the Fifth Generation Fighter Aircraft and the Multi Transport aircraft, as well as the licensed production in India of SU-30 aircraft are few examples of retarded pace of development.

21. **User Perspective**. A survey was undertaken to take the feedback of the end user (ships) on the indigenisation of defence sector based on the experience so far on use of indigenous prototypes of the imported equipments. The response indicates indigenous products scale high in terms of support and economy. However, the imported base is ahead in terms of availability and performance vis-a-vis indigenous products/ those developed through domestic R&D. The domestic R&D by far has not been able to instil significant confidence in end user (Fig 5).

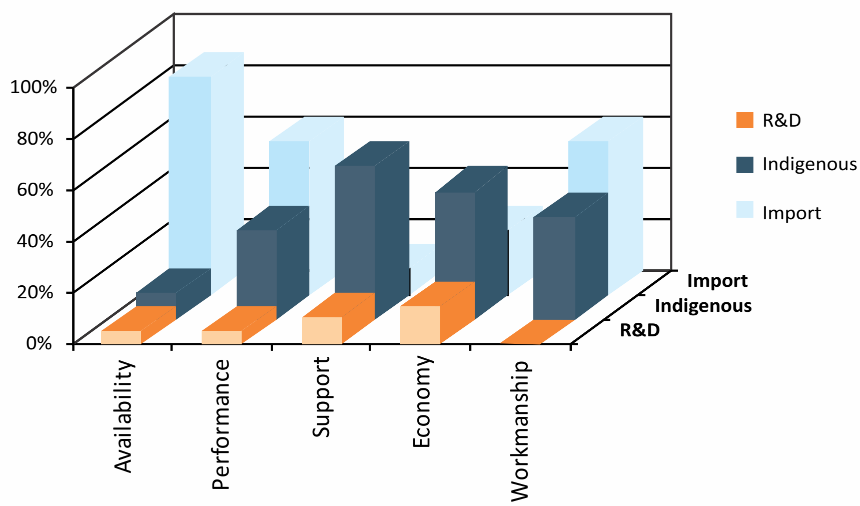


Fig 5. R&D vs Indigenous vs Import

22. **Procurement Process**. It is only in the last decade that the footprints of indigenous components have become prominent. While Navy has witnessed gradual increase in force levels, the component of ex-Soviet/Russian/ other countries continue to remain in significant proportions. There are delays and bottlenecks in getting timely supply of requisite quality spares in all segments. Interestingly, the blame cannot be put squarely on the procurement agencies. It is seen from the graph covering various disciplines (Fig 6) that the procurement guidelines on competitive bidding applies to vast range of Electrical, Weapon and Aviation fields infusing gaps in the following manner:-

(a) While the warship is role oriented and so the features of it in various domains, the norms of competitive bidding allows inferior vendors be it domestic/ foreign make enter into the range of prospective bidder inadvertently.

(b) End user is bound to keep widespread vendor base while sourcing item irrespective of its complexity and technology involved.

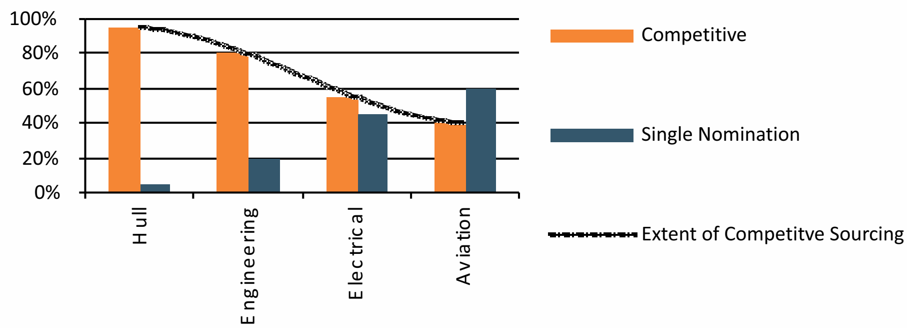


Fig 6. Competitive vs Single Nomination

(c) If the breakdown is analysed in the colloquial, Float, Move and Fight categories, wide range of critical equipment in various domains are affected as compliance of procurement norms is seldom difficult. Few such examples are highlighted in Table 2.

Table 2. Critical Equipment/ Technology

Category	**Type of Equipment**
Float	Fuelling rigs of tankers, Radar absorbent paints
Move	Gas turbines, Diesel engines, Gear boxes, Propellers, Control systems, IPMS
Fight	SAM, Surface surveillance radar, Air early warning radar, UAV, SRGMs
Diving	Night vision equipment with advanced optics, Micro UAVs
Submarines	Main motor generators, Propulsion motors, Integrated sonars

(d) Also in case of new shipbuilding and refit projects, the shipyards are selected on basis of L1 bidding. Whilst the price benchmarking is made so as to select the shipyards rationally, however, the L1 bidder even when quotes less than bencharmeked price is deemed qualified for obtaining the contracts. In such cases after the order is bagged by the shipyards, they mostly fail to maintain execution and delivery schedules. This is primarily due to the fact that the cost quoted to win the order turns out unsustainable to progress the work. Some examples in this regard are construction of Cadet Training Ship by M/s ABG Shipyard, Gujrat and reft of INS Jyoti by M/s L&T, Katupally. The procurement process lacks the provision to disqualify quotes when the price quoted is considered unreal taking into account contemporary conditions viz escalation, cost of raw material, equipment cost etc.

23. **Embargo on Warship Export**. Over 40 years, Indian shipyard have acquired invaluable experience of building warships and capabilities uniquely suitable for export warships to other countries. This was demonstrated by exporting an offshore patrol vessel to Mauritius. CGS Barracuda, built by DPSU M/s GRSE, was delivered to Mauritius, marking a day when India exported its first warship. Describing it as a 'Red-Letter Day' in the history of shipbuilding in India, Mr Rao Inderjit Singh, Raksha Rajya Mantri said it proves that the industry has come of age. However, the embargos of various proportions dissuades shipyard from exporting ships to foreign navies. This is a

big limiting factor for foreign equipment manufacturers to venture into Indian defence sector view limited absorption ground for offered technology and hence, technological gaps continue to exist. It will not be out of place to mention that India was declared the highest importer of arms and equipment in the world for the year 2013-14, a regrettable distinction.

24. **Reluctance of Private Sector**. Make in India policy has not come a day too soon. Despite there being giant industries within the country, these have refrained from participating in defence sector on grounds such as improbable return of investment, absence of support from State etc. One the confidence couldn't be imbibed in such companies and second, nil regulations were framed to impose participation of such companies in defence development programmes. Concerted efforts and policies are yet to evolve to bring private sector into Navy specific equipment manufacturing on a broader scale. If necessary, this can be made incentive based to make it lucrative for domestic industry, supplemented with Parliament Bills and Policies.

25. **Lagging Ancillary Base**. Ancillary industries usually lag the development of shipbuilding industry in any country. It requires the shipyards to achieve a Critical Mass before globally renowned ancillary companies such as Man, Wartsila, Caterpillar and Rolls Royce establish a sizeable presence. Defence projects worth Rs 80,000 Cr have been cleared recently by the government. Biggest of them being the decision to build six submarines in India at a cost of about Rs 50,000 Cr rather than sourcing it from outside. The decision is in line with Prime Minister Narendra Modi's 'Make in India' pitch. However, the swelling order-books of Indian shipyards have not been able to attract the foreign OEMs to the desired levels. This is the core reason why life cycle maintenance of platform/ equipment remains a challenging task for the ships in service.

Make In India Perspective

26. Indian Navy over the years has evolved into a vision centric advanced and technology intensive force. This is especially so as India's growing maritime prowess has not only created a better experience but also technology savy men and fleet. The navy now aspires for top-of-the-range equipment and is capable of handling complicated weaponry. The force of the 21st century looks at domestic industry seriously. Today, therefore, what Indian Navy only really requires from in-house defence sector are the high-end, cutting-edge systems. The flag ship initiative Make in India thus holds potential hope in this direction as no Navy wants to be held hostage of foreign dependency.

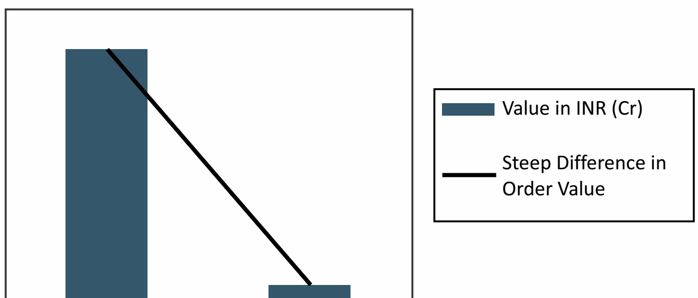
27. To cover the perspective holistically, Make in India approach in Naval shipbuilding has been divided into three broad levels viz shipyard, naval shipbuilding and technology. These along with recommendations on reforms in our procurement process, the mainstay of acquisitions, are discussed in succeeding paragraphs.

Shipyard Level

28. While the Naval shipbuilding share holds a very low share in overall Indian shipbuilding statistics, the indigenous warships construction has come a long way since the commissioning of INS Nilgiri on 03 Jun 1972. There are not many countries in the world having capability to produce

such a wide variety of warships ranging from Fast Attack Craft to Aircraft Carrier. This demonstrates that the steps taken in the past in indigenisation have yielded results upto some extent. Notwithstanding, Make in India campaign opens an array of avenues for Indian shipyards.

29. **Activate Private Shipyards**. The perspective plan is structured to continue at a pace such that Navy inducts ships and submarine at an average rate of five platforms per year. However, the demand and supply gap will continue as major chunk of orders lies with Government shipyards that are overburdened and loaded for atleast next five years and thus are unable to meet timelines as brought out earlier. A nominal share of Naval shipbuilding lies with emerging private shipyards (Fig 7). To overcome this gap, there is a requirement of involving the private shipyards at a larger scale in naval ship and submarine building projects.



	Govt Shipyard	Pvt Shipyard
Value in INR (Cr)	86660	6300

Fig 7. Defence Shipbuilding Orders

30. **Automation & Upgradation**. The first customer of Make in India campaign is Indian Shipyard. The driving factors are:-

(a) Most of the shipyards have not been able to deliver the desired output because the present design lacks customisation of systems and work processes. The expansion plans have been kept in back-burner and collaboration with international yard is the only way to bridge the gaps.

(b) Make in India initiative can be a medium for consultations related to modernisation of existing infrastructure. Most of the Indian shipyards believe that it would act to their disadvantage if they fully automate their shipyards to the level of Norwegian Shipyard or Japanese Shipyard or Korean Shipyard. This would take away their advantage of being a low cost destination in the labour intensive shipbuilding industry. Notwithstanding, the shipyards in India have to adopt an optimum share of labour and technology to achieve high productivity.

Naval Shipbuilding Level

31. **Evolve Perspective Plan.** Maritime Perspective Plan has identified gaps in force levels which are to be abridged in the period 2014-27 (Fig 8). For basing these projections on in-house industry, it is necessary to evolve a Make in India perspective plan in conjunction, which rolls out at similar pace. There is a requirement to set milestones and monitor growth of Indian defence sector.

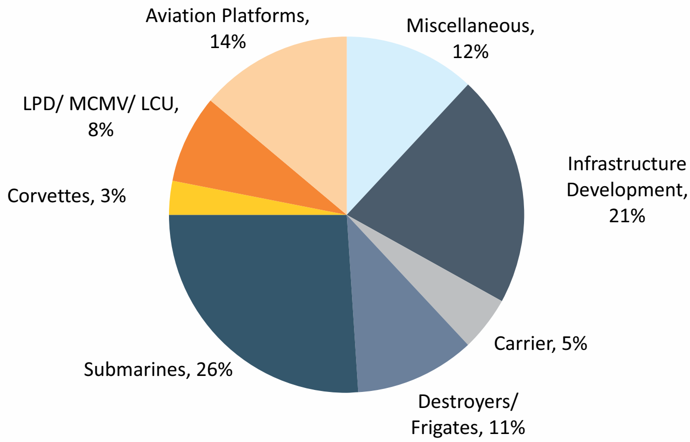


Fig 8. Maritime Projections 2014-27

32. **Initiative by Government**. The Ministry of Defence should take the initiative to become the facilitator for DRDO, public and private sectors to join hands and leverage foreign collaborators to transfer the technologies that can help make the joint venture an export hub for the region in line with 'Make in India' campaign. This phenomenon has already happened in the automobile sector - reputed companies like America's Ford, Japan's Toyota, Germany's Mercedes and France's Renault have set up production facilities in India.

33. **Building Capability of Domestic Industry**. 2013 edition of DPP has added a Buy & Make (Indian) category which seeks to enhance the indigenous participation and capability in acquisition of new products. An Indian company has to absorb 50% of the critical technologies, thereby enabling it to manufacture a high tech product indigenously. DPP also lays down the need for the vendor to provide offsets for all Buy (Global) transactions exceeding an amount of Rs 300 crores. These offsets should be wisely utilised for building up of in-house capability and promotion of indigenous base for critical spares and equipment. The future expansion/acquisitions plans of Indian Navy, as brought out above, offers attractive markets for any advanced defence industry, and ability to leverage this dominant position to its advantage rests with the higher echelons of Indian Navy.

34. **Strategic Ties**. Taking into account the defence cooperation forthcoming from US, France, Israel and growing awareness within domestic industrial base, Indian Navy has the flexibility to select the market of its choice with due diligence and wisdom gained from the lessons learnt from past acquisitions, and rightly by not placing all eggs in a single basket. Strategic alliance should be the

mainstay for progressing ToT, joint R&D and collaborations to evolve a model which is more reliable and long lasting. Among aviation assets, a major area of concern is helicopters. This is one sector where there is huge opportunity to gain from strategic ties under Make in India campaign.

Technology Level

35. **System Overhaul**. There is urgent need to overhaul our Politico-Bureaucratic-Research system for them to contribute effectively in technological augmentation of Navy. There is a evident need to revamp the DRDO, OFBs and lagging DPSUs shipyard to ensure they perform in a time bound and cost effective manner. So far, not much has been done by MoD in this direction. Experience has shown that there is a a long gestation period before results start showing in specialised fields like LCAs, ALH Marine Version, Towed Array Sonars, High strength steels etc. A realistic assessment of the time frame is required to fully implement 'Make in India' policy in all regimes of Naval shipbuilding.

36. **Thrust on Indigenisation**. The navy is in the forefront of indigenisation of its platforms, systems, sensors and weapons. In the past two decades, the defence imports from Russia have gone down from 80% share of market to 50%. However, vacuum of indigenous weapon, sensor, equipment continue to exist and persist. The navy needs to adopt a two pronged approach. Self-reliance being the cornerstone, firstly the potential of DRDO establishment and domestic industries should be harnessed. Secondly, wherever technology is readily available and collaboration is possible, Navy should consider the option of private public partnerships in the form of either Transfer of Technology or Joint Venture or Co-production between the appropriate players under Make in India initiative.

37. **Mode of Acquisition**. Naval acquisitions are often driven by the procurement guidelines which has some grey areas. Hence, it is important to define problem areas and identify areas that require change/ reforms. In order to ampligy problem explicitly, the acquisitions have been divided as per the procurement processes in vogue as give below.

(a) **Category 1**. Platform specific procurements (foreign supplier), notwithstanding QRs or DPP requirements (e.g. Teg class, Jalashwa etc).

(b) **Category 2**. Equipment specific procurements (either notwithstanding QRs or tweaked QRs to allow specific Equipment suppliers) either within scope of DPP or outside:-

(i) Foreign OEMs (127 mm Gun mount, Barak, Gas turbines, RAS/ FAS systems etc).

(ii) DPSUs/ DRDOs (Lynx from BEL, Mastic coatings, Steam turbines etc).

(iii) Collaboration between DPSU and Foreign OEMs (e.g. LR-SAM, IPMS, Auxillaries etc)

(c) **Category 3.** Technology specific procurements (e.g. software modules for CMS, Towed Array Sonars, Nuclear technology, stealth technologies etc).

(d) **Category 4.** Pure indigenisation projects on single supplier like Rukmani, NEWN, Humsa, EW systems, Anechoic rubber tiles etc).

(e) **Category 5**. Multivendor procurement with specific QRs (OTE or LTE) on the L1 methodology.

38. **Scope of Reforms in Procurement Process**. The above mentioned categories have inherent concerns and probable way ahead with a shade of Make in India may reform current procedures. Accordingly, category-specific issues and probable way ahead have been brought out in Table 3.

Table 3. Category-wise Recommendations

Category	Observations and Concerns	Way Ahead – Make in India
1. (Platform specific)	Procurement is based on bilateral relations and military cooperation terms, outside DPP guidelines leading to non-standard terms of procurement and equipment maintenance and spare support.	Future support and transfer of technology for country-specific systems to R&D organisations/ domestic industry to be embedded in such procurements.
2. (Equipment specific)	DPP prohibits equipment specific procurements. However, this is a necessary evil to remain abreast with military technology. There is no scope for indigenisation in this category and technological base remains unavailable within the country.	'Offsets' should be a must for all such acquisitions. ToT and indigenisation by volume/cost would require impetus. Capability to absorb technology through Offsets and ToT to be ensured by encouraging Public-Private partnership under Make in India initiative.
3. (Technology specific)	As of now outside DPP and has been advantageous without much drawbacks.	Include a chapter in DPP for such procurements with provisions of 'Buy & Make'.
4. (Indigenous projects)	Within DPP purview on piecemeal basis. However, the R&D part has been in conjunction with other PSUs.	Needs specific mention in DPP. A strong medium to implement Make in India initiative usefully if extended to Private Partnerships.
5. (L1 concept)	Pure DPP driven. L1 issues have been discussed at Para 22 above.	L1 methodology needs a close look as brought out earlier.

Conclusion

Make in India Framework.

39. It was never good, and so is not today, to be highly dependent on any foreign nation at least for operability of own defence forces. Diversification and collaboration are the options for obviating country-specific imports. According to the emerging opinion in the Indian maritime community, the country must be self-reliant in areas where technology denial regimes can be imposed like

nuclear, missile, aviation, weapons and metallurgy. Hence, while formulating the policy framework for Navy specific Make in India initiatives, the spectrum must include these two broad flanks:-

(a) **Broad-Basing of Equipment/ Technology Source**. Depending upon the category of acquisition, critical aspects related maintenance and spares support should be given due diligence so as to avoid dependency on one specific industrial base. It implies multiple Make in India initiatives are to progress in tandem. Ensuring a wider base preferably some within the country should be a key area of focus for redundancy.

(b) **Shaping the Indigenous Defence Industrial Base**. In order to dispel inimical effects of foreign imports, the need for shaping and developing indigenous defence industrial base holds priority as also the responsibility of Government to evolve domestic environment conducive for private sector. The key objective should be to leverage capital acquisitions through Offset Policy to develop the defence industry. In order to achieve this, it is imperative to encourage participation of domestic industries in manufacturing of defence equipments as enslaving to global market will not just only lead to prevailing pitfalls but also thwart the capability building of in-house industry. Therefore, sourcing of equipment/platform should be reinforced with policies binding Make in India components catering positive and reinforced development of indigenous defence industrial base.

40. Indian Navy's indigenisation programme is a right step towards standardisation of equipment such as pumps, control systems, valves and switchgear etc. The above goal is in line with the government's strategy to go for full indigenisation of all requirements. The latest decision to award major projects to Indian private companies has the potential to usher in a new beginning in Indian defence industry.

41. Navy's indigenisation programme offers 'Opportunities Galore' to industry and it is evident that supplies from indigenous sources is being encouraged even for ships acquired from abroad. Promoting local industrial base for warships would be a beginning of a partnership, which could last till the end of the service life of the warships. In the article 'Defence Indigenisation: Made in India, by India, for India', Mr Bikramdeep Singh has vary aptly articulated that as India inches to achieve its rightful strategic autonomy, it needs to do much more in planting the seeds for a commercially viable and technologically robust indigenous defence industrial base.

42. Strongly pitching for indigenisation of warships and submarines, Chief of Naval Staff Admiral RK Dhowan said that the future of Indian Navy is firmly anchored on indigenisation and the force has transformed from "Buyers Navy" to "Builder's Navy" after relentless efforts. To counter the problems of escalated import costs of equipment and spares, and embargoes/technology denial by foreign countries on a long term basis, the India Navy has to aim to achieve Self-Reliance in maintaining and supporting its vital assets through indigenous development route. Make in India is a welcome hand-shake between Naval shipbuilding and in-house defence sector and hopefully, it will shape both for good.

Biblography

E-Book

1. Brian K. Hedrick, India's Strategic Defense Transformation:Expanding Global Relationships, retrieved from http://www.strategicstudiesinstitute.army.mil/pdffiles/ PUB950.pdf.

Journals

2. Rod Thorton, India Russian Military Cooperation Which Way Forward, Journal of Defence Studies – 2012, IDSA, New Delhi.

Online Publications & Articles

3. Katherine Foshko Tsan, Re-Energizing the Indian-Russian Relationship: Opportunities and Challenges for the 21st Century, retrieved from www.jsia.edu.in/JJIA/PDF/Katherine-Re-Energizing.pdf.

4. 4 Main Centres of Shipbuilding Industry in India, retrieved from http://www.yourarticlelibrary.com/industries/4-main-centres-of-ship-building-industry-in-india/19662/.

5. India-Navy Modernisation, retrieved from http://www.globalsecurity.org/ military/ world/india/in-navy-development.htm.

6. Encourage Shipbuilding, 21 Oct 08, retrieved from http://www.steelguru.com/ indian_news/Encourage_shipbuilding_and_ancillaries_will_follow_Industry/67576.html.

7. L&T Plans to Build Ship Engines, 05 Feb 08, retrieved from http://www.livemint.com/Companies/cVFqiPaLM0I77uSJJgzvLI/LampT-plans-to-build-ship-engines-looking-for-mega-shipya.html.

8. INS Vikrant's first victory: Being built from Indian steel, 08 Aug 13, retrieved from http://www.business-standard.com/article/current-affairs/ins-vikrant-s-first-victory- being-built-from-indian-steel-113080701287_1.html.

9. We are strongly committed to the indigenisation process under the P75 programme, retrieved from http://www.spsnavalforces.com/story.asp?mid=28&id=8.

10.. New Directorate of Indigenisation set up at IHQ MoD (Navy), 09 Sep 05, retrieved from http://pib.nic.in/newsite/erelease.aspx?relid=11900.

11. Lighter, faster and an increasingly Indian submarine hunting corvette launched by GRSE under Navy's Project 28, 30 Mar 13, retrieved from https://thoughtso.wordpress.com/tag/ indigenisation/.

12. Vice Admiral (Retd.) GM Hiranandani, Warship Production-Life Cycle Management, 17 Sep 12, retrieved from http://www.indiandefencereview.com/ spotlights /warship-production-life-cycle-management/.

13. India-Navy Modernisation, retrieved from http://www.globalsecurity.org/ military/ world/india/in-navy-development.htm.

14. Bikramdeep Singh, Indigenisation: Made in India, by India, for India, retrieved from http://www.claws.in/images/journals_doc/16092657_BikramdeepSingh.pdf.

15. Towards Self Reliance-Transition to Eminence, The Indian Navy 1976-1990, retrieved from http://indiannavy.nic.in/te/self_reliance.htm.

16. Defence Projects get Rs 80,000 cr push from Government, 25 Oct 14, retrieved from http://indianexpress.com/article/india/india-others/centre-gives-nod-to-defence-projects-worth-rs-80000-cr/.

17. http://indiatoday.intoday.in/story/ins-kolkata-modi-commission-naval-warship/1/377343.html.

18. http://indiatoday.intoday.in/story/ins-kamorta-commissioning-arun-jaitley/1/ 378567.html.

19. First Indian Warship Exported to Mauritius, 20 Dec 14, retrieved from http://economictimes.indiatimes.com/slideshows/nation-world/cgs-barracuda-first-indian-warship-exported-to-mauritius/red-letter-day-in-the-history-of-ship-building/slideshow/45590324.cms.

20. Indian Shipyard imports 80% of Components, 18 Dec 12, retrieved from http://www.thehindubusinessline.com/industry-and-economy/logistics/indian-shipyards-import-80-of-components/article4214179.ece.

21. Encourage Shipbuilding and Ancillaries will Follow, 20 Oct 2008, retrieved from http://www.thehindubusinessline.com/todays-paper/tp-logistics/encourage-ship building-and-ancillaries-will-follow-industry/article1639385.ece.

22. Emphasis on indigenisation, says Navy Chief Admiral Dhowan, 04 Sep 14, retrieved from http://zeenews.india.com/news/nation/emphasis-on-indigenisation-says-navy-chief-admiral-dhowan_1464993.html.

Author's Biodata

Cdr Nitin Saxena

The officer is a Graduate in Naval Architecture and Ship Building, PGD in Warship Design from IIT, Delhi and did MSc in Defence Studies from Defence Services Staff College, Wellington. He was commissioned in 2001 in Corps of Naval Architecture of Indian Navy and has gained experience in docking and fabrication work/repairs of both IN ships and submarines. The officer has served at ND(Mbi), SBC (Vizag) and IHQ, MoD(N)/ DNA & DND(SDG). He is presently appointed at HQ FOCWF, Mumbai as Fleet Naval Architect Officer. The officer has also been commended by the Chief of Naval Staff and Commander-in-Chief.

article

2

CONVENTIONAL SUBMARINE BUILDING THROUGH "MAKE IN INDIA" PERSPECTIVE

(Cmde Pravin Rajpal & Lt Cdr Melin Aravind)

Background

1. With India's maritime neighborhood having navies with increasing submarine and anti-submarine capabilities, we unquestionably need a mix of both conventional and nuclear submarines. India has made significant progress in the field of nuclear submarines, but the plan for conventional submarines in the Navy has not manifested due to myriad reasons. Conventional submarines are superior to the nuclear ones where effectiveness in relatively shallow water is a critical requirement. They are optimized for stealth, weapons and sensors which provide effective operations close to the shores, both in offensive and defensive roles.

2. Our Navy has operated 22 conventional submarines since the inception of the submarine arm on 08 Dec 67 with the commissioning of INS Kalvari. The submarine arm will complete 50 years of its existence in the Indian Navy in 2017 and it is astounding that our nation has not been able to produce an indigenous conventional submarine in all these years. In this paper an attempt is being made to evaluate the past, current and prospective future of indigenous submarine construction in India.

3. The history of conventional submarine construction in India started with the production of SSK submarines at MDL in collaboration with the HDW in 1983. Two submarines were built within a span of 12 years. At this juncture, the technology transfer for construction of these conventional submarines was complete and indigenous construction, though not with an indigenous design, was a step away from becoming a reality. The Navy suffered due to the black listing of HDW which led to the production line at MDL being idle since 1994.

Indigenous Submarine Construction Program

4. A 30 year plan christened as Project 75 and Project 75(I) in collaboration with two separate foreign builders for indigenous submarine construction was approved by cabinet committee on security in 1999. This plan envisaged the development of two production lines to build six submarines apiece. The Indian Navy, apace with, would develop an indigenous submarine design which would produce 12 SSKs on these two production lines. By 2030, we would then have 24 modern SSKs.

5. Project 75 contract was signed in 2005 with MDL for the construction of six Scorpene submarines. First two submarines were to be constructed with assistance of French collaborator and the remaining 04 wholly by MDL. While the hull related works commenced in late 2006, the

actual construction process started only in 2011 owing to several logistics and material delays. However, no contracts have been issued under the Project 75 (I) till date.

Submarine Contruction Process

6. Unlike the construction of the SSKs in collaboration with the Germans, the Scorpene project was a completely new experience for MDL. The construction philosophy of the French had drastic variance from the expertise that MDL had developed earlier during the construction of conventional submarines with German collaboration. In order to appreciate the complexity and enormity of the project, it is important to understand the design and unique modular construction process of the submarine.

7. Scorpene submarine is constructed by joining five sections. The construction process starts with the fabrication of ring frames, followed by plate forming. Further, they are assembled into sub sections which in turn form the 5 major sections of the submarine. While the sections are being manufactured, a parallel activity of outfitting of cradles with equipment is progressed. Thereafter, the cradles are shipped inside the sections. Further, the sections are lowered onto the submarine launch pontoon in dry dock followed by the boot together which is the joining of the last two sections completing the submarine construction. A schematic representation of the same and photographs of cardinal activities are given below:-

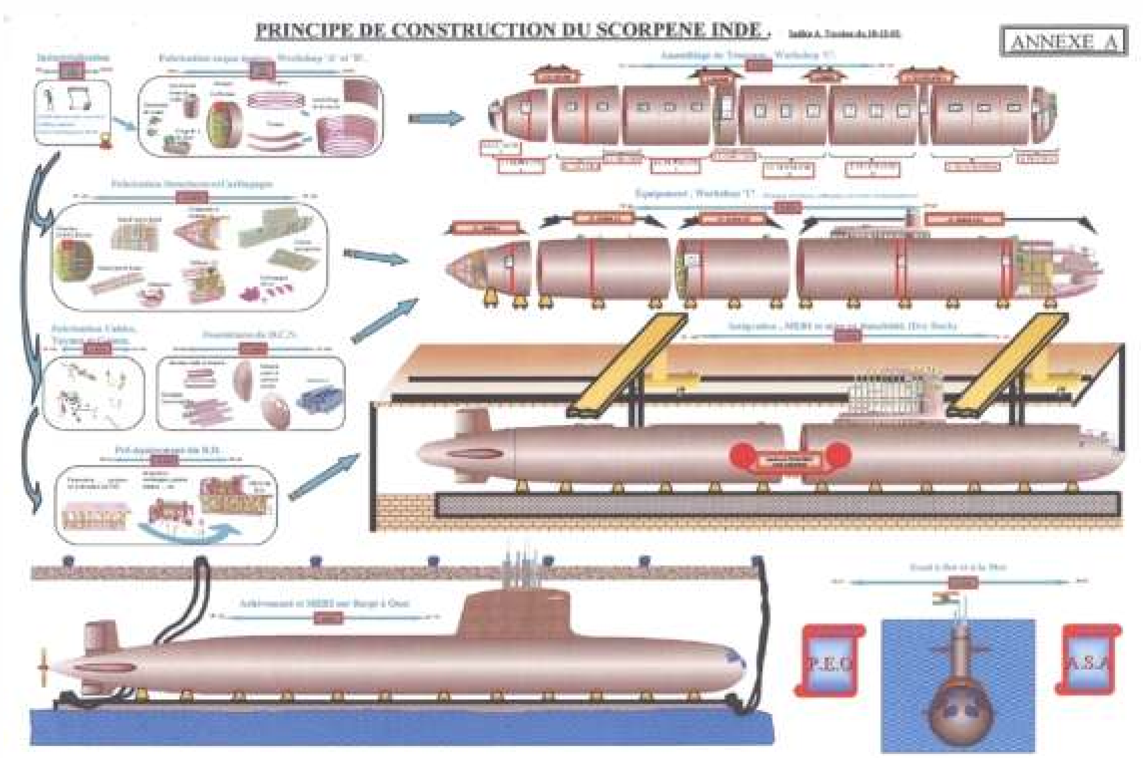


Fig. 1

Fabrication of sections

Lifting of joined sections

Machinery cradle embarkation

Installation of torpedo tubes

Lowering of sections on pontoon

Shaft line installation

Fig 2. Different Section

Propeller installation

Submarine on launch pontoon

Post undocking of the pontoon

Setting afloat

Fig 3. Process of Construction

8. There will always be variations in the sequence of activities followed by different countries in the construction of a conventional submarine, but broadly the process followed by the French encompasses all the present day concepts of modularity and Integrated Hull outfitting and painting. On completion of the above process of construction, the submarine is launched and undergoes STW inspections, harbour trials of various systems, followed by sea trials. On an average, it takes about 6 years (pie chart highlighting the duration placed below) for the whole process to complete which justifies the present status of the Project 75 where the first submarine is under preparation for sea trials. The second submarine is fully integrated and is undergoing preparation for launch. The remaining 4 submarines are at various stages of structural outfitting.

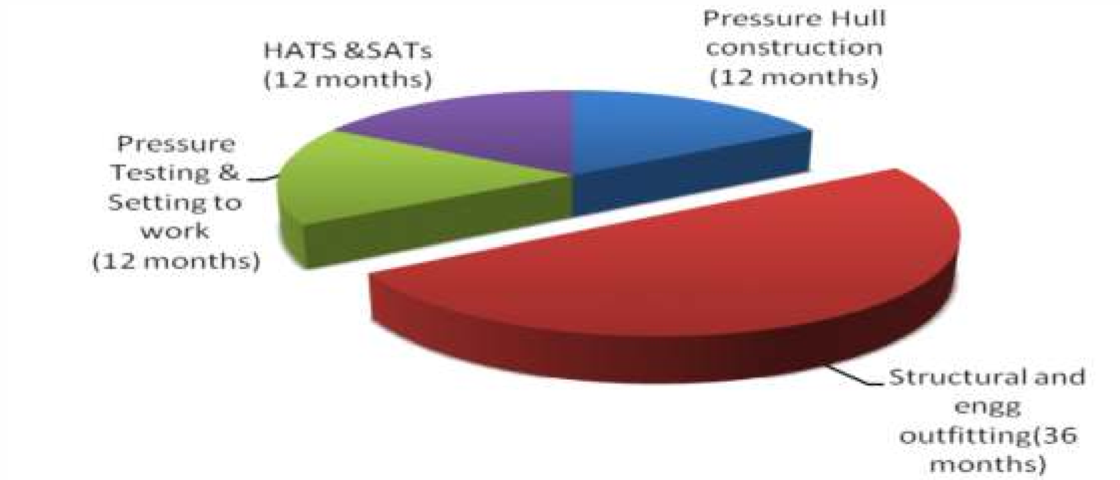


Fig 4. Time Lines

Are We Ready Now?

9. It is pertinent to mention that in 1995, post the construction of two type 209 class submarines at MDL, we were primed for launching our indigenous construction programme. However, due to various reasons we were not able to do so and after 20 years we are again at the threshold of envisaging the same programme. We surely are now better equipped to appreciate the processes and technologies being followed by two European countries that produce state of the art weapon platforms.

10. The best testimony of our countries capabilities to commence indigenous construction is marked in the celebrated success of actualizing several concurrent construction activities undertaken at various shipyards within our country. With the project 75 at this critical juncture, we need to ask ourselves whether we are ready for indigenous submarine building and if the answer is yes, how best we can accomplish the same in the coming years. Broadly, the capability for indigenization, not including the design, is determined by the following factors:-

(a) Technology and trained manpower

(b) Material

(c) Infrastructure

With the experience of the ongoing Project 75, let us try to explore these parameters to give clear perspective of our readiness level for indigenous conventional submarine construction.

Technology and Trained Manpower

11. Though the technology for the Scorpene submarines was bought in 2005, we would be operating these submarines only in 2017. It is true that the construction process which is being followed is in line with world navies, but it is time we need to critically evaluate the technology

which has been handed over to us. In the course of the last 12 years of the present project and the 12 years for construction of two type 209 submarines, our personnel have been trained by Germans and French in :-

(a) Construction process

(b) Documentation

(c) Quality assurance/ control

12. MDL and Naval personnel have gained tremendous knowledge and expertise in the various stringent standards applicable for welding processes, geometrical measurements, welding inspection including NDT (non destructive testing) procedures and acceptance/rejection criteria. Extensive welder qualification in Major Metal Arc Welding processes to build pressure hull structures was also undertaken during the course of the project which added to the technical skills of the MDL workforce. Another important aspect which facilitated training of personnel in the private sector industries was during the outsourcing of a variety of jobs related to submarine construction. We have better command now to critically use the technologies and develop superior construction philosophy to suit our shipyards and manpower.

Material

13. Availability of material is a major constraint in any construction program be it ships or submarine but more complicated in submarine building because of stringent quality requirements. Primarily there are two kind of material which have to be procured by the builder for the project:-

(a) Material to be imported

(b) Locally available material

In the current scenario certain main components like the combat suite including FCS, masts, gyro etc may need to be imported. However, various other major equipment can be indigenized provided public sector as well as the private sector is encouraged to do so. This is easier said than done but we have seen DMDE, Hyderabad over the last few decades has developed various vendors who have successfully managed production of ruggedised marine quality equipment. In the scorpene program the indigenization of critical material/ manufacturing equipment started with identification of Indian companies having infrastructure, tools and skilled workers for undertaking the process. This was followed up with regular monitoring of the local manufacturing process and timely technical assistance for ensuring quality of work. The same has tremendously increased the expertise and capabilities of Indian companies in their contribution to critical defense activities.

14. Some of the critical items where significant progress in indigenization has been made are the weld consumables, ventilation coamings, RO plant, cables, anechoic tiles, GRP casing panels, main batteries etc. Certain equipment like thrust block, hydraulic blocks, hydraulic plungers for hydroplanes etc the equipment was imported from OEMs in raw form but was machined in India

through identified companies. During the course of the indigenization process, it was also observed that some of the imported material which were procured from foreign firms could be sourced with ease from within India. In this phase of indigenization experience, we were able to analyze the entire plethora of material required for submarine construction and conclude that setting up production facilities for certain material may not be cost beneficial. For example, indigenization of steel. The quantum of infrastructure and research development required for producing a specific micro alloy steel like HLES 80 used for scorpenes is going to be phenomenal considering the fact that an entire facility needs to be set up for manufacture of a specific grade of steel which is going to be used only for a class of submarine and the same may not be considered cost beneficial by the industry. At present, we are having 4 different classes of submarines with 4 different types of steel. However, steel being the major item in submarine construction, we surely need to indigenize it either through public sector units or private manufacturers.

Infrastructure

15. Material movement and construction activities are majorly governed by the infrastructure, which predominantly affects the progress of a crucial project like submarine construction which in turn gives an edge to any shipyard. Infrastructure development undergone by MDL for the successful and speedy execution of the Project 75 is phenomenal. The private shipyards too are already well informed of the modern infrastructure requirements which will drastically reduce the build periods and attain world class benchmarks. Private sector has also realized the potential in submarine building and has made significant progress in development of infrastructure to gain confidence of the government to increase the possibility of competitive bidding for project 75 (I). The acquisition plans of some of the biggest industrial houses and the proposal to develop of 5000 acre defense infrastructure facility is an example of the capabilities of our private sector. The feasibility of utilization of private sector for development of the second production line of the ambitious submarine construction plan has also been evaluated by the Navy. The present government also has re-designed the military procurement programme and allowed 49% foreign direct investment in defence equipment manufacturing to promote local manufacturing and facilitate technology transfer. With the private and public sectors flourishing, the competitive advantage needs to be tapped to our advantage to create a revolution in conventional submarine construction.

Way Forward

16. Its time to exploit the technological expertise which has been developed over a period of 3 decades in the field of conventional submarine construction. The refinement of the constructional philosophy in comparison to the European methodologies followed for the two different class of submarines, which includes the sequence of production, system integration, effective utilization of the trained manpower etc. Although the expertise gathered over the years has been highlighted in the preceding paragraphs, it is paramount that the concept of "Make in India" has to start from the development of an indigenous design of a conventional submarine. The same needs to be followed

up with consistent research in various fields to upgrade the design from time to time taking into account the different technological advances across the world. At this point, It is relevant to mention that a multi-disciplinary design team was trained for almost two years in Germany to acquire knowledge of HDW submarine design with access to relevant software, design data, empirical formulae, linked values of design coefficients and were considered capable of ab initio design of a conventional submarine. This team formed the back bone of Submarine Design Group (SDG). SDG has had an institutionalized system in place to archive all such design know how imbibed by individuals or establishment. Though currently the original team may have disintegrated, we can hope that the knowledge pool accrued over the years is not lost and can be revived by forming a dedicated group for the desired conventional submarine design. Going by the world norms, a submarine design from conception to maturity takes about a decade. So while the designers work on producing a modern design, we can so as to not to keep our infrastructure facilities idling, go ahead and deliberate over the opportunities of buying out a proven design from the friendly countries, bearing in mind the time we may need to develop a 100 % indigenous design and production possibility within our country. Buying a design with license to build say 10 submarines would facilitate our manpower to retain their expertise and keep the machinery running before our indigenous design matures.

17. Identification of a second production line and setting up of state of the art infrastructure to handle sections of a modern conventional submarine on fast track is vital for the implementation of the long term submarine construction programme. Immediate implementation of Project 75 (I) would facilitate the setting up a strong second production line for the implementation of the second phase of the programme. Ideally the facility should be in addition to what is already available at MDL, as Project 75 (I) should progress concurrently during the final stages of Project 75 which will be completed in 2021. The dedicated conventional submarine design group should roll out the first indigenous design at the earliest to start the construction at MDL which is the first production line to mark the commencement of the second phase of the indigenous submarine construction plan.

18. Propulsion components, electrical machinery and most critical of all the weapon and combat systems are the game changers as far as indigenous construction is concerned. Development of these systems is highly specialized and requires deep understanding in the specific fields. Hence the same has been judiciously and very thoughtfully distributed across vertically specialized organizations in the Navy. However, over the years we have not achieved any major breakthrough in developing the technology for these critical systems. The major issue with technology is the speed of change. Accordingly, there is a need for speedy negotiation and absorption to avoid the product becoming obsolete prior to its introduction. Further, investing in modern defence equipment entails heavy initial expenditure with long gestation period before income starts flowing in. In the Indian environment, the government agencies have the capability of investing large amounts for developing a product and the private industry has the ability to speedily absorb and produce an item. Therefore a combination of the original equipment manufacturer, the government agencies and the private sector would possibly be the pragmatic path to be adopted for high degree of indigenization for such critical systems.

19. Despite the seemingly, massive requirement of defence systems, the orders are limited from the perspective of an industrial manufacturer. During the construction of Shishumar and Scorpene class submarine we have realized that unless we have a plan for construction of a series of boats more than 10, we will not be able to assure the industry for indigenization of critical equipment. The concept of mass production only can bring in the kind of impetus in the private sector undertakings. This also means that there is a need to promote export of defence products to generate economies of scale as applicable in mass production.

20. Simultaneously, we should also try to identify critical systems/ machinery which needs to be sourced from abroad and long term plans have to be made for availability and support of these systems/ machinery which would in turn integrate during the indigenous construction phase commences. We also need to assimilate the fact that sourcing these systems from other countries would mean that the total cost of the project would definitely shoot up. But at the least, it gives us the hope of operating platforms with state of the art technology in time.

Conclusion

21. Indigenization should not become a demonstrative effort and the idea is to execute the indigenous submarine construction plan effectively. Even if we are not able to achieve 100 percent indigenization in construction, we should resort to various means to build strategic partnerships with other countries and industries which will aid our industry to procure any item we want from anywhere in the world at any time. While we develop our own design, it may be prudent to buy a proven design and go for licensed production of 8-10 submarines of same class. Along with the existing infrastructure at MDL, we need to develop one more production line either in public sector yard or private sector in a competitive format.

22. The hard reality is that, indigenization, in the spirit that dependence on foreign sources is nil, is a complex network of operations and dependencies which will take a long time to achieve fully. The challenge is to ensure military preparedness while indigenous capability develops. On one hand, indigenous capability develops, the products initially will probably not be as good as others available in the market. On the other hand, a fledgling industry needs the support of steady and large quantity buyers until it overcomes its learning curve. However, the price of this indulgence could be time delays which we would need to endure. The most difficult part of this balance would be ensuring a successful interlocking set of relationships between the military, private sector, academia and the political leadership at least over the apprentice period. It is a demanding task and that is the very reason why it has taken a long time.

Author's Biodata

Cmde Pravin Rajpal was commissioned in Aug 1987 and joined the submarine arm in 1989. He is presently serving as Submarine Production Superintendent at SOT, Mumbai.

Lt Cdr Melin Aravind is an alumnus of the 14th Naval Architecture Course and was commissioned on 01 Jul 04. He has graduated from the Cochin University of Science and Technology in Naval Architecture and Ship Building followed by Post Graduate Diploma in Warship Design at IIT Delhi. He is presently carrying out the duties of Submarine Overseer (Naval Architecture) at Submarine Overseeing Team (Mbi).

article

3

INTELLIGENT NAVIGATOR
A SOLUTION TO THE AUTONOMOUS VEHICLE NAVIGATION

(Cdr MS Kapoor)

Introduction

1. Last century has seen a phenomenal change in technology which resulted in a paradigm drift from manual operations to automatic. Machines have replaced humans in every facet of life that varies from production units in industries to operation theatres in hospitals. Certain facts that have influenced this drift are, first, machines do not get tired and next they do not have mood swings that affect their efficiency. Not only it makes the life of operator or owner comfortable but obviates errors those are caused due to a person's inexperience, poor concentration, physical incapability, incompatible weather conditions, physical/ mental tiredness. Only factor that distinguished a lazy human from hardworking machine was that machines could not think and take decisions based on experience and worldly facts. However for the last six decades researchers and scientists worldwide are working towards imparting cognition to machines. For a machine to have cognitive behaviour that replicates human, it needs to first develop the 5 senses that human have. They should be able to see, touch, taste, hear and smell.

2. This approach paper is based on the ability of a machine, a computer in this case to see like human and interpret the visual data based on its database and experience. Field that deals with this aspect of human machine behaviour is called Computer Vision. This paper has conceptualised a Pilotless entering/leaving harbour of a ship using automatic plotting system called Intelligent Navigator. In this set up, a long range surveillance camera would be used for image acquisition and then Computer Vision techniques would be used to recognise and track objects like Taj dome or Prongs light to obtain bearing. These object bearings would be then used to plot position of ship on ECDIS. Any deviation from planned path would be then be corrected by passing an appropriate steering command to autopilot and speed command to propulsion system.

3. This method has many advantages when evaluated against human plotting methods and are elaborated in section 8. Next section describes basic working and illustrates sequence of events. Section 3 explains first step of the process which is acquiring image. Section 4 discusses various object detection algorithms with special emphases on Scale Invariant Feature Transform (SIFT) algorithm. Sections 5 and 6 bring out various ways that an object can be tracked and bearing obtained. Section 7 is dedicated to transferring, storing and using the data to plot position of ship and correcting its course based on inputs from various sensors. Section 8 brings out advantages of using this system. The Pilot Project undertaken as a 'proof of concept' is described in section 9 and finally the paper concludes in section 10.

Basic Working with Sequence of Events

4. For any water borne vessel it is important for her to know its exact position on chart while Entering/Leaving harbour primarily because of the constraint waters it is operating in. Position obtained from GPS has its limitation with respect to the accuracy and it is for this reason that onboard ships, bearing of known visual marks like conspicuous buildings, light houses and certain transit as shown in Fig 1. are taken manually at a frequency of 03 minutes and passed to the plotter who plots the position on the chart and indicates to the person on con whether the ship is on course or not and if not then by how much it is off course. Based on certain inputs course of ship is corrected and brought on track.

Fig 1. Conspicuous buildings

5. This method has been used for ages but has certain limitations, first, time for entire process of taking bearing, plotting position and carrying out correction to ship's course is limited to ability of a person's action and reactions. Therefore, average frequency of plots that can be obtained is one plot every three minutes. Now that the plots are obtained at low frequency of three minute, speed of ship is restricted to a safe limit wherein distance travelled by it in three minutes is less than one fourth the distances between two Limited Danger Lines (LDLs). This cap on speed increases the time it takes for a ship to enter or leave a harbour and might be detrimental in case of an emergency. Second issue attached with manual process of obtaining position and plotting is that of Human error, which may occur due to in experience, poor alertness, incorrect bearing read out, incorrect bearing written, wrong back bearing taken on chart and error in determining degree of off-course. Next, during in-conducive weather conditions, bearing lookouts have to fall back into bridge which has two disadvantages, first the bridge gets crowded and leads to chaos and second, view of buildings/light house is disrupted, which leads to limited no of visual marks being used to obtain bearing, which in turn affects the accuracy of the plot. Finally, entire process needs at least 5 hands, 2 for taking bearings, 1 for logging the bearings in log book, 1 for plotting the position of ship and 1 for steering ship to the correct course.

6. To overcome aforementioned limitations of present manual system, this paper proposes an automatic plotting system - Intelligent Navigator, which can be integrated to autopilot in the steering system to maintain ship on a pre defined track. Data flow is depicted in the Fig 2, first step is to capture an image and then carryout certain pre processing on this image to reduce noise. Next step is to detect and recognise the desired visual mark in processed image based on database of images fed in system.

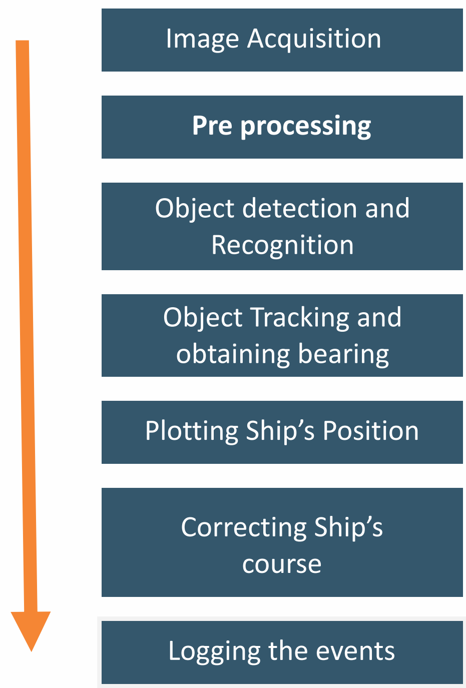


Fig 2. Various stages involved in the process

7. Once the visual marks are identified next step would be to obtain its bearing from ship. While instantaneous bearing of identified visual mark is sent to the plotter, the camera is locked on to the visual mark using a tracking window. For the period of the ship underway, changing bearings would be obtained at the rate of twenty readings per minute and passed on to plotter where the ship's position would be plotted at a frequency of twenty per minute.

8. Finally, average position obtained from ten instantaneous positions after a period of thirty seconds would be considered to be the true position. Further, based on deviation of this plot from the track on ECDIS and the inputs like speed, course steered, wind speed and direction, water current and radar input for vessels in vicinity, a corrective command would be generated for degree of wheel and revolutions of the engines. This entire process including the object bearings, plots and correction commands would be logged in a black box from where the data could be retrieved as and when necessary. Detailed technical working of the system is explained in the succeeding paragraphs.

Image acquisition

9. As mentioned earlier, vision is one of the most important of human senses and to make a machine develop this sense is a humongous challenge for the Computer Vision fraternity. But with recent advancement in technology and various image processing/Computer vision algorithms available, they have not only developed vision but have made machines see what a human eye cannot.

10. In this system, the first step is to acquire an image. The necessary requirements of the camera that would be used are under mentioned:-

(a) Long range of 10km.

(b) Frame rate of 20+ per minute [1]

(c) 120deg of lateral rotation.

(d) +/- 30 deg of vertical movement.

(e) Gyro stabilised

(f) IP67 standard

(g) DC input

(h) Day and night vision.

(j) Multi format picture output.

11. These requirements are met by the 8800 long range surveillance cameras shown in Fig 3. They presently marketed by Cohu [2]. Output of this camera is a video of frame rate higher than 20, rather than a still picture. Therefore in order to obtain the still images, frames would be required to be extracted at a rate of 20 frames per minute.

Fig 3 8800 series long range surveillance cameras marketed by Cohu [2]

Object Detection and Recognition

12. Images obtained from captured frames may include photographic grain, photodetector noise and a small amount of blur [3]. To negate these detrimental effects, every image captured is subject to pre processing where noise and blur is removed. Image processing tools like Average Filtering,

Median Filtering and Gaussian filtering are well known in their ability to remove salt & pepper and Gaussian noise, whereas methods like Multiplicative Multiresolution Decomposition [4] proposed by Serir et al and Hybrid Image Coding by Wang et al [5] are good techniques to remove the blur due to motion of camera.

13. Once we have clean images our next endeavour would be to identify object that are of importance to us. In this case we need to identify light houses, some prominent buildings or peculiar feature in the coastline from the image obtained. To do this we need a technique that would have the following attributes:-

(a) Invariant to scaling: size of object in database and in image may vary because of the variable capturing distance, therefore we need the algorithm should be invariant to the scale of object.

(b) Reliable: Algorithm should have a high recognition rate.

(c) Should be able to handle occlusion: The object at time may be occluded due to temporary factors like fog, a vessel or some movable object. It is pertinent that recognition algorithm is impervious to such partial occlusions.

(d) Fast: The time an algorithm takes to carry out feature detection, extraction and matching should be minimum for a real time application.

(e) Invariance to rotation: Due to pitching of the ship, there may be images obtained that have disoriented objects, algorithm should be able to handle small rotation in 2D plane.

14. A well know algorithm called Scale-Invariant Feature Transform (SIFT) was developed by Lowe in year 1999 [6] for detecting and then describing feature points in an image that are invariant to scale, linear translation and orientation as shown in Fig 4 . Since then this algorithm and its many variants have been extensively used for image processing and computer vision tasks involving object recognition. This algorithm meets all requirements mentioned above and in addition is unaffected by noise.

15. SIFT algorithm has three basic steps involved, (a) Detection of Key points, (b) Description of key points and (c) Matching of Key points.

(a) Detection. SIFT key points are detected as maxima or minima of Difference of Gaussian as shown in Fig 5 in image scale space. The DoG obtained after differentiating Gaussian blurs at each level in a particular scale is shown on the right hand side of the Fig 5. Now from these DoGs a pixel is selected as a key point if it is maxima or minima when compared to its 9 neighbours on a level up and down and 8 neighbours on the same level (26 neighbours) as shown in Fig 6.

Fig 4 Objects being detected even after partial occlusion [6]

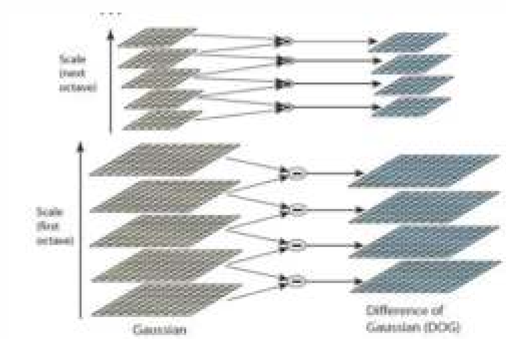


Fig 5 Difference of Gaussian at each octave

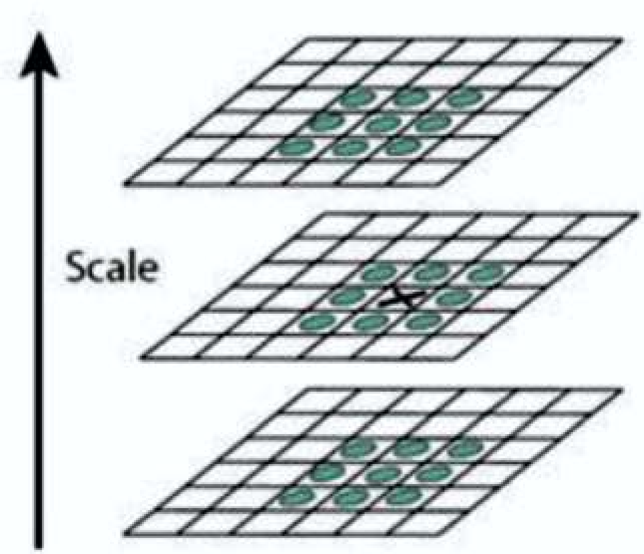


Fig 6 DoG at a particular scale.

Key points selected in this manner are then subject to a threshold filter that rejects key points that are below certain pre defined pixel intensity. A problem with this approach is that, image corners have high intensity variations and are likely to be selected as key point. To overcome this, another threshold is selected for the pixels that lie on the corner or edges. The parameters that govern selection of a pixel as key points are (1) No of Octaves, (2) Scale, (3) Peak Threshold and (4) Edge Threshold.

(b) Description. After a pixel is selected as a key point it is required to be represented in a uniform set of values called Frame and Descriptor. Frame is a vector with an orientation and a scale, and is of length 4 (2 for center co-ordinates, 1 for scale and 1 for orientation angle). The descriptor is a vector of length 128 and parameters that influence its value are (1) Magnification Factor and (2) Gaussian window size. Given a brief description of process how a key point is selected and later represented as Frame and Descriptor, an online version of SIFT algorithm developed by Andrea Vedaldi and Brian Fulkerson [7] is generally used to match images.

(c) Matching. Final step involved in recognition using SIFT, is matching descriptors that represents key point of input image with descriptors that represent key points in the image stored in database. Out of the many matching techniques, Vedaldi and Fulkerson use L2 norm as difference between two descriptors distances as a similarity function and descriptor that is closest is described as max match. Result of match is stored as array of key points that are most similar to a particular key point of input image and is called 'Match', therefore 'Match' is a 2 x 'no of closest match' which has 1st row as key points of query image and 2nd row as key points that are closest to key points of query image in 1st row. Length or no of columns of this matrix 'Match' gives us no of key points that have matched.

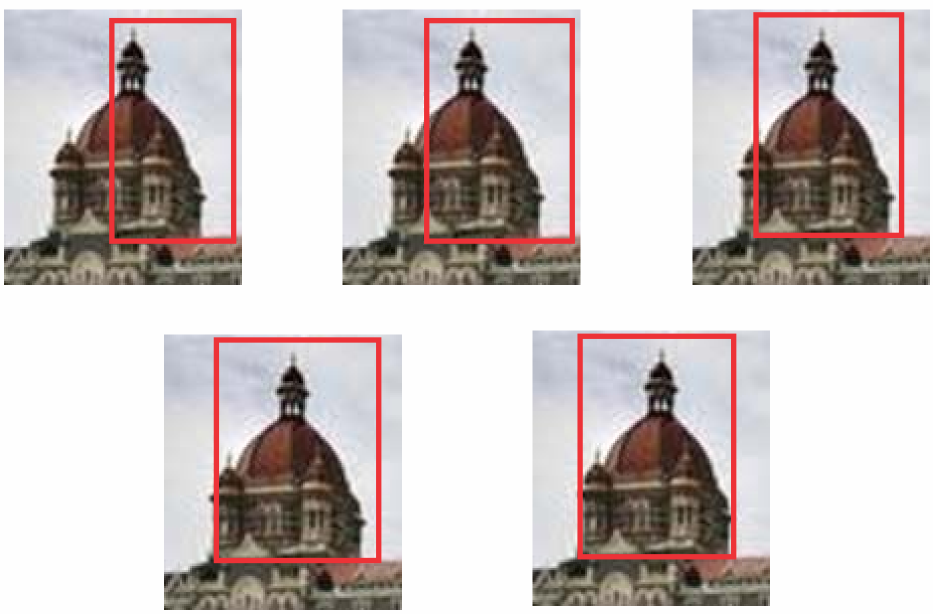
Object Tracking

16. After object recognition next step would be to obtain the bearing and then keep tracking the object for future bearings. Out of the various methods Condensation Algorithm (Conditional Density Propagation) is a famous method to detect and track objects in a cluttered environment and was developed by M Isard and A Blake in year 1998 [8]. Registration is another visual feature matching technique that accomplishes the task of tracking.

17. Another set very famous and extensively used technique to track an object is by using Filtering and Data Association. These techniques are applicable when we have the prior knowledge of an object in scene/image and its dynamics. Kalman Filtering is one amongst them which is extensively used in prediction models. Using Kalman filtering, this paper proposes a method in which the identified object is enclosed in a window as shown in Fig 7. This window would move with the object and a maximum feature match function defined by the part of object in the window of subsequent frames to the object in database will generate an error signal to the kalman filter and realign the window so as to get a maxima. This sequence is illustrated using the diagram in Fig 8.

Fig 7 Window enclosing the Object

Fig 8 Object Tracking using Kalman Filtering - realigning of tracking window to maximise feature match or the matching score.



Obtaining Bearing of Object

18. Now we have identified the object and have started tracking the Object using the method described above. Our requirement now is to obtain bearing. In Fig 9 below the identified object is placed in the centre of window with a marker at its centre.

19. This Virtual Marker that is shown above would correspond to a bearing on the virtual compass getting its feed from the gyro in a suitable format. This instantaneous bearing marked by Virtual Marker would be gathered for 3 seconds to generate a resultant bearing. In this time frame of events we would be able to generate 20 bearings of the object in a minute.

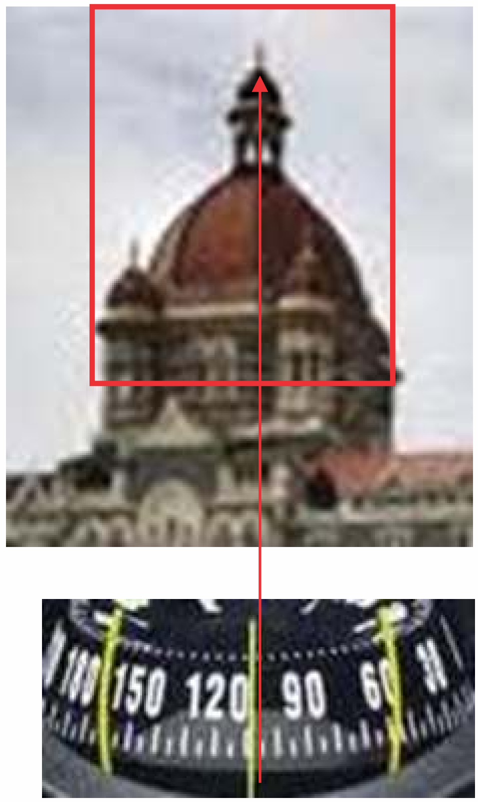


Fig 9 Window with a Virtual Marker.

Data Exchange and Storing

20. Bearing of objects identified by a set of 3 or more cameras would then be passed in a suitable format to ECDIS where ship's position would be marked on map and the degree of off-course would be calculated and fed back to the Intelligent Navigator from ECDIS.

21. Intelligent Navigator in addition to camera inputs would also receive inputs from various on board sensors as shown in Fig 10 below. Based on the inputs from these sensors about the water current (from tidal chart), ship's head (from gyro), wind speed (wind computer), speed (from Log), depth (from Imaging SONAR or Ecosounder) and degree of off track from ECDIS a decision on corrective wheel would be generated and fed to Autopilot. Entire set of bearings obtained, ship's position and the corrective wheel commands would be logged to an internal system from where the feedback for future processes would be taken and would also serve as a Black Box for providing evidence in case on any untoward incident.

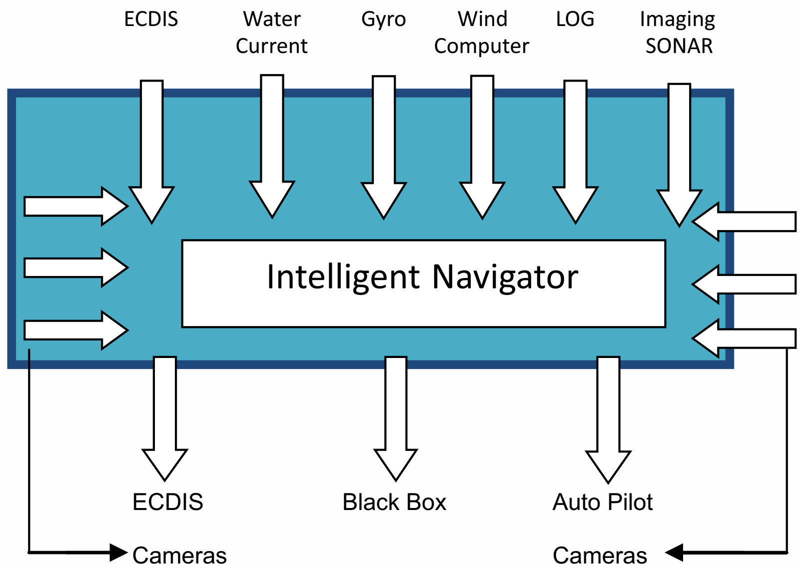


Fig 10 Input and Output of Intelligent Navigator

Advantages

22. As highlighted in section 2, manual pilotage has certain inherent limitations which translates into low frequency of ship's position being obtained and therefore limits the speed that a ship enters/leaves a harbour. Further, present system is prone to human error. Intelligent Navigator on other hand would obviate these human errors and would generate ship's position at a rate of 20 plots per minute which is 60 times higher than the rate of manual plotting. This high rate would eventually translate to precise plots and minor correction wheels that would lead to accurate navigation. Other advantages that are worth mentioning are enumerated below:

(a) Impervious to errors, even if there is one erroneous reading out of 5 bearings obtained, averaging of the bearings and high rate of plots would nullify the effect of it. i.e its would be able to handle as high as 20% error rate.

(b) The camera's are day/night, IR based and have a long range of 12 km. Being an IR camera the picture would not be affected by foggy conditions.

(c) During adverse weather conditions, presence of personnel taking bearings in enclosed bridge leads to additional chaos and confusion in bridge when it is of prime importance that silence in maintained for the command to evaluate the tactical and security condition the ship is under. Use of Intelligent Navigator would prevent this chaos and would provide a peaceful bridge for command.

(d) Image processing and Computer Vision techniques as described by Y rao et al in their survey paper [9] empowers the Intelligent Navigator to obtain clear pictures of objects in inclement weather conditions too.

(e) Algorithms for object recognition like SIFT is robust to both salt & pepper and Gaussian Noise which might be introduced by the camera sensors.

(f) SIFT algorithm can also detect objects when they are partially occluded.

(g) Most important factor is reduction in manpower. Presently there are at least 2 hands required for taking bearings, one for noting the bearings in the log book, one for plotting the bearing in the Chart and one for Steering. Intelligent Navigator solves this issue of manpower requirement.

(h) This system can also be employed during entering and leaving harbour in foreign waters too. What is required is, just the photographs of conspicuous objects to be fed in the system.

(j) Overcomes the situation when incorrect GPS feed is made available intentionally or unintentionally.

(k) Data can be logged in the Black Box and used for comparison and correction for future calculations by the system. The logged data can also be retrieved and served as evidence post any untoward incident.

(m) Set of cameras can also be used in surveillance mode for security in harbour. Using the object detection and tracking algorithms any movement of person, car or boat can be detected and a suitable alarm can be raised depending on the security Readiness State. This would be advantageous as number of sentries employed would reduce and an apt action can be achieved with minimum exposure of self forces to enemy.

Proof of Concept

23. This concept was developed in year 2012 by the author, while as an Instructor in Indian Naval Academy, Ezhimala. As a proof of concept, the Commandant and the Principal directed the staff to include this as the Student Project under the guidance of the author. A team of two students worked on the first three stages of the concept (refer Fig 2). Images of buildings in Kochi Harbour (Port Trust) in varying illumination, distance of image capture, object aspect and sea condition were obtained using a handheld Cannon camera. Using the SIFT algorithm, an accuracy of 80% was achieved.

(a) **(b)**

Fig 11. (a) and (b) are the images of the same object taken in varying lighting condition, aspect and distance.

Fig 12. Step 1 of SIFT algorithm- selection of Key-points.

Fig 13. Step 2 of SIFT algorithm- description of Key-points

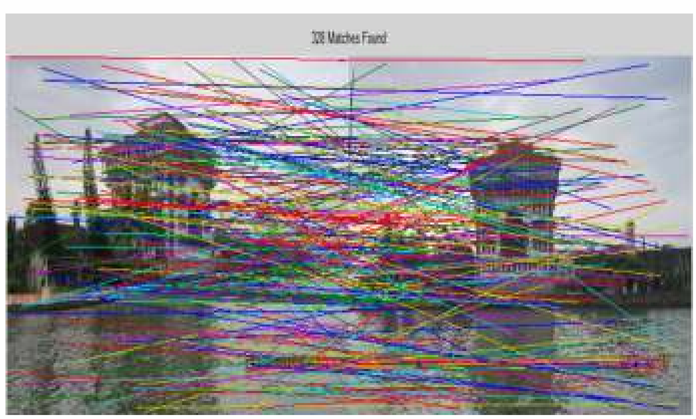


Fig 14. Step 3 of SIFT algorithm- Matching of Key-points

Conclusion

24. Advancement in Camera technology and availability of numerous robust 'Computer Vision' algorithms for object detection, recognition and tracking has changed the way computer perceives real-world objects. Thus, the ultimate aim of Artificial Intelligence, to infuse cognition in machines that a human possess, is not far from being attained. Today, several fields enjoy the advantages inherent in intelligent machines. This is true of the 'Intelligent Navigator' as well. It offers significant advantages over the traditional methods employed, especially while entering and leaving harbour. It is at least 60 times faster than the human in plotting the position of ship with a high degree of accuracy. Not only is the plotting much faster, 'Intelligent navigator' would be able to determine the degree to which the ship has deviated from a planned track and generate a command for wheel that would get the ship back on her intended track. This system would store data and use it in for future decision making as well. The promising results of the Pilot Project undertaken at INA, Ezhimala makes the ultimate aim of this project seem achievable. It is intended to take this approach further and to develop a prototype with collaboration of system integrators at WESSE and Indian industries, so as to be able to test it in the real world, so as to be able, in the future, to have ships that enter and leave harbour autonomously at higher speeds and zero error, even in relatively uncharted waters.

References

[1] A Handa, R A Newcombe, A Angeli and A Davison, "Real Time Camera Tracking - When is High Frame Rate Best", ECCV, 2012

[2] www.cohucameras.com/content/8800longrangeselectablecameralensip67

[3] A chapter on Image Processing available at www.simulatedvision.co.uk/CompVis_Chap8.pdf

[4] A Serir, A Hamadende and F Rerauth, "Blur reduction by Multiplicative Multiresolution Decomposition", 7th International Workshop on Systems, Signal Processing and their Applications, 2011

[5] J Wang, K Min and J Chang, "A hybrid Image Coding in overdriving for motion blur", Lecture notes in computer science, volume 4740,2007,pp 263-270.

[6] Basic information available at www.wikipedia.org/wiki/scale-invariant_feature_transform

[7] Online tutorial available at www.vlfeat.org/overview/sift.html

[8] Michael Isard and Andrew Blake, "Condensation - Conditional Density Propagation for visual tracking", International Journal of Computer Vision 29(1): 5- 28, 1998.

[9] Y Rao and L Chen, "A survey of Video Enhancement Techniques", Journal of Information Hiding and Multimedia Signal Processing, Volume 3, Number 1, 2012

Author's Biodata

Cdr MS Kapoor is an alumnus of National Defence Academy and Naval College of Engineering. He was commissioned in the year 2003 and has served onboard INS Talwar and INS Airavat. His ashore tenure includes, Deputy Director in ETMA, Staff officer to CSO(Tech) in Western Naval Command, Instructor in Indian Naval Academy and Deputy Director in DND(SSG). He is presently the Staff Officer to Controller of Warship Production and Acquisition. Cdr MS Kapoor has done his PG with Distinction in Artificial Intelligence from University of Southampton, UK . His research interest includes Computer Vision, Biometrics and Time-Series analysis.

article

4

Indigenous Shipbuilding at Private Shipyards

(Capt Nagesh, Lt Cdr J Karthik Kumar & Lt Cdr Conrad Michael)

Introduction

1. The growth of shipbuilding in general and warship building in particular, are vital for Indian Economy and National Security because of a consistent growth in sea trade and the need to safeguard strategic sea lanes of communication. While Shipping provides global interconnectivity between the producers, manufacturers and markets all across the globe, Warships are essential assets, to safeguard the security of the sea lanes and coastlines from a national security perspective. Use of foreign owned ships to meet India's enhanced energy and trade, runs the risk of self-imposed blockage during wartime. Shipbuilding infrastructure, capacity and capability in commercial and defence sectors are therefore critical for nation building. With a multiplier effect of 6.4 on investment, it is not only an important capacity and capability enabler, but also can significantly scale up the employment prospects for the burgeoning young population in our country.

2. There was a worldwide shipbuilding boom starting from 2003, when Indian shipyards received a disproportionately large number of export orders compared to the previous years. Riding the last boom in global shipbuilding and favourable Govt. policies, private sector shipyards have also upgraded their infrastructure in the recent past. However, onset of global recession of 2008andcompetiveness issues at Indian shipyards, manifested in failed/delayed deliveries, triggered large scale cancellation of orders. Further, Govt. subsidy was withdrawn in2007, which in combination with the prevailing recession, triggered a crash in the Indian commercial Shipbuilding world, leaving most of the private shipyards stranded with highly leveraged books. With cancellation of commercial orders, part of the capital which could fund augmentation of the infrastructure capacity is now severely constrained, thus straining the capacity of private shipyardsto expand. Most private shipyards today are beset with a dwindling order book, non-existent credit, falling incomes, liquidity crunch and adverse cash flows. Further, unable to service their debts, larger private shipyards with heavily leveraged balance sheets, had to resort to corporate debt restructuring (CDR) since 2012 and some eventually culminating in change of controlling stakes due to the failure of CDR.

3. In a globalized shipbuilding industry, Indian shipyards have several disadvantages which negate their natural competitiveness and adversely impact their chances of survival in the current scenario. With empty order books and limited future commercial ships on order, the survival option for the private shipyards is to diversify into building of small specialized vessels, naval vessels and repairs. Warship construction extended to private shipyards through competitive bidding since

2011, has also been adversely affected by the financial distress and competitiveness issues. However, considering the strategic significance, economic potential and spinoffs, there is a need to shore up the private shipbuilding industry and prevent erosion of a strategic industrial capability painstakingly acquired through considerable investments. Shipbuilding industry in India needs holistic attention to weather the current crisis and build the desired capability and capacity, so that the prowess in commercial shipbuilding benefits warship construction in realizing quality warships in minimal timeframes.

Economic and Strategic Significance of a Vibrant Shipbuilding Industry

4. Growth Potential. The Shipbuilding industry is critical to India's strategic and economic interests and is characterized by high growth potential due to its multiplier effect on the economy. Shipbuilding has spin offs to other industries, including steel, engineering equipment, port infrastructure, trade and shipping services. Further, shipbuilding is a labour intensive industry with tremendous indirect potential in employment generation and contribution to GDP through high contribution from other industries. India has about 8,000 km long coastline, around 30 shipyards, 12 major ports and 200 ports under states' jurisdiction. For a country that is predominantly peninsular with a massive coastline and about 1200 islands, India's shipbuilding capabilities have not kept pace with its economic development, market demand and human resource potential. This presents a huge scope for development of shipbuilding sector considering that country's opportunities in the sector have not been utilized fully.

5. Maritime Security Concerns. Security considerations at the strategic level also drive the need for amend defence cooperation in the entire Persian Gulf and the countries of ASEAN. The scenario of India, as an epicentre for low cost solution of retrofitting foreign warships can be an apt diplomatic expression to accomplish a constructive engagement. Indian shipyards along with Indian Navy have sufficient potential to assist the smaller Navies in the IOR for warship retro fitment which can favourably shape the maritime environment in the region. Further, excessive dependence on foreign owned ships to meet India's enhanced energy and trade, runs the risk of self-imposed blockage during wartime.

6. Outgoing Freight Bill. Of the $30 billion Indian export and import freight market, only 8 % is carried by Indian flagged or controlled vessels. This is also a compelling reason to justify the necessity to expand the Indian controlled tonnage. Moreover, for a world economic power in making, it is imperative for India to work on enhancing its presence in the country's freight market and also in that of the international market. With the nation already facing a huge trade deficit thereby putting pressure on the Indian Rupee and the economy, this huge outgoing freight bill is an additional drain.

7. Spin-off Potential to Indigenous Industries. Shipbuilding is an unusual industry since 65% of value addition during construction of ships comes from other industries. Further, the growth of the domestic shipbuilding sector, which today imports about 45% of its input requirements, can

provide a major trigger for large-scale indigenization of heavy engineering products and ancillaries. Heavy engineering industry is integrated with various core sectors for its demand. Shipbuilding industry can play the role of mother industry to heavy engineering, similar to the critical role essayed by auto manufacturing in case of light engineering. The growth projections for manufacturing in India would be higher with a vibrant shipbuilding industry.

Global Trends and Shipbuilding Industry in India.

8. Global leadership in shipbuilding has shifted hands signifying emergence of new economic power in the world. Due to high labour cost and lack of competitive edge there has been a gradual shift of shipbuilding from Europe to Asia. Until the middle of the last century, European shipbuilding dominated the world. Fast growth of the Japanese economy and successful coordination of supporting program for shipbuilding as a strategic industry, helped Japan to the leadership position. For some time, Japan and Europe controlled 90% of the market, but gradually Japan became the dominant player in shipbuilding. South Korea entered shipbuilding market in the late 1970's following previous experience of its neighbour Japan. It announced shipbuilding as strategic industry and in combination with low labour costs created the biggest shipbuilding industry in the world in just 20 years. China followed suite in the late 1980's and created a vibrant shipbuilding industry in a shorter time frame. China, caught the industrial expansion strategy and surpassed Japan in 2006 and South Korea in 2009 (measured by order book volumes). A snapshot of 35 year cycle in world shipbuilding is depicted at Fig 1. New shipbuilding entrants such as Vietnam, India, Turkey, the Philippines, Brazil, and Russia grew up and together reached the quantity of orders to equal European total. Europe has gradually been losing its positions in shipbuilding despite of its strategic specialization as a niche player.

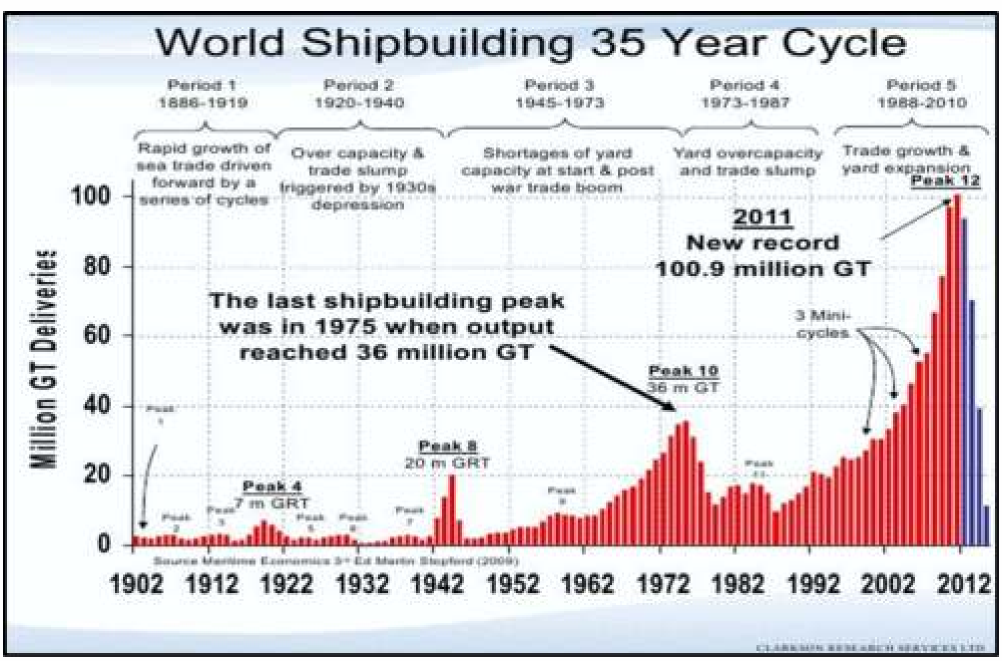


Fig 1: Global shipbuilding cycles (source [11])

9. Shipbuilding Life Cycle. Prominent Ship building nations have generally been observed to drive their shipbuilding output to the first place in the world during their industry growth period or mature period. In context of the progress of major shipbuilding powers, the shipbuilding industry life cycle has been shown in Fig 2.Chinese shipbuilding industry is on the cusp to take a new road to industrialization, in order to improve and transform traditional shipbuilding industry policy. The advantage of lower labour costs will continue to maintain over a longer period of time. With reference to the development cycle of Japan and South Korea, it has been projected that China shipbuilding industry growth is sustainable until the middle of twenty-first Century.

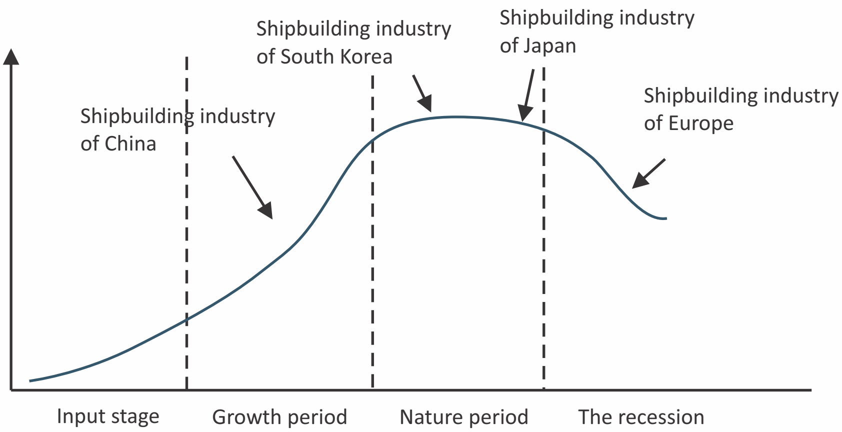


Fig 2: Shipbuilding lifecycles with position of prominent shipbuilding nations (source [8])

10. Impact of Economic Downturn and Commodities Market Crash of 2014. Globally Shipping grew rapidly with enhanced industrialization and liberalization of national economies, with impetus on free trade in a new global interlined world, till the well-known recession in 2008, which resulted in a major economic downturn. The fall in demand for global goods because of the recession, slowed down growth in shipping, with consequent impact on demand for building of new commercial ships. The shipbuilding demand to replace ships close to their end of life, aided by maritime regulations like MARPOL, also fell, as large number of newly constructed commercial ships had entered service in the same period. In September 2008, the new shipbuilding boom that ran since 2003 ended sharply. This in combination with the commodity crash of 2014-15 has left even the established leaders in shipbuilding struggling to win new orders. The plunge in oil prices caused new orders for ships worldwide to fall 34.7% in 2014.The number of orders won by South Korean shipbuilders fell 36%and its market share came down to less than 30%. While the Chinese share in the market reached 41.5%, the Japanese shipbuilders expanded their share in the global ship market to about 20% in 2014 (up from 17.4% in 2013). The weakening of the Japanese yen and the Japanese government's support for the shipbuilding industry contributed to the rise.

11. Indian Shipbuilding Industry. The Indian shipbuilding industry has since long being dogged by low capacity, poor productivity and lack of modernization. Indian government has tried various promotional and subsidy measures since the 1970's. Such measures have managed to keep the

industry alive at a time when the global industry was passing through a deep recession after the boom of the 1970's which, the country missed due to lack of industrial growth. Indian shipbuilding industry witnessed healthy growth in the recent past, driven primarily by the boom in global shipbuilding and Govt. subsidies. The annual turnover of the industry increased by more than 250%from 2002-07 as shown in Fig 3. Spurred by this recent growth several companies set up shipbuilding capacity and existing shipyards aggressively expanded their capacity.

12. Indian shipbuilding today comprises of about 30shipyards of various sizes, which includes 8 public sector rest private sector shipyards. The shipyards have about 20 dry docks and 40 shipways between them, with an estimated total capacity of over 280,000 DWT. Four shipyards operating under Ministry of Defence cater primarily to the needs of the Indian Navy. The other PSU shipyards are under Ministry of Shipping. Most notable among them being Cochin Shipyard Limited (CSL) with a capacity of 110000 DWT which is currently involved in the construction of the first indigenous Aircraft Carrier. The DPSU shipyards are primarily engaged in building high value, weapon intensive warships and submarines of highly complex design. In the private sector, the largest shipyard is at Pipavav,Gujarat, with shipbuilding capacity of 75000 DWT. The other prominent private sector shipyards are owned by ABG shipyard at Dahejand Surat (Gujrat), L&T shipyards at Hazira (Gujarat) and Kuttupally in Tamil Nadu and Bharti Shipyard at Dhabol in Ratnagiri district of Maharashtra. In terms of number of ship built or even Dead Weight Tonnage (DWT), the Indian private sector shipyards remain ahead of public sector shipyards. However, most private sector shipyards are engaged in building of medium to small vessels such as Offshore Supply Vessels (OSV) and Anchor Handling Tugs (AHT). Private players such as Pipavav, ABG and L&T have made huge investments for construction of large vessels. Pipavav and ABG shipyard have also been involved in the construction of Bulk Carriers and Offshore rigs/ platforms, albeit with limited success.

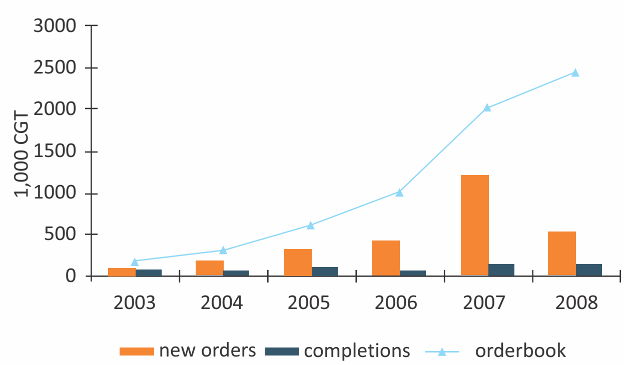


Fig 3:Indian Shipyards activity between year 2003 – 2008 (source [3])

13. Role of Subsidy. In the year 2002, the Government of India introduced a 30% subsidy scheme for both public and private sector shipyards. Many shipyards in India prospered due to large commercial shipbuilding orders in the boom period, helped by competitive labour rates, subsidy stimulus and global orders spilling over from foreign shipyards on account of their packed capacities. The Indian shipyards in private sector were overflowing with commercial orders in 2008

and there were grand plans for expansion through acquisition and modernization of their facilities through large debt funding. With global shipbuilding on an upswing, the Indian shipbuilding industry was able to take advantage of Government subsidy to establish its presence in the world. Fig3 summarizes the growth experienced by Indian shipbuilders in the period 2003-08. However, the Govt. subsidy was removed in Aug 2007.

14. Economic Downturn and Ensuing Shipbuilding Crash. Indian shipyards till 2008 did reasonably well and had come up from 0.2% of world shipbuilding tonnage to more than one per cent (about 1.3%). There was disproportionately large number of export orders to Indian Yards compared to previous years during the worldwide shipbuilding boom from 2003-08which coincided with the 30% subsidy (year 2002-07) to shipbuilding by the GOI. However, most shipyards failed to deliver the ships in time and this in combination with, the global recession (see Fig. 4) triggered large scale cancellation of orders, rendering shipyards unable to benefit from the subsidies. Further exacerbated by the withdrawal of Government subsidies in Aug 2007, India's share in world shipbuilding by 2013 plummeted to almost a negligible figure of 0.01%. The Indian commercial Shipbuilding world has come crashing down since 2009 with a dented reputation on account of time overruns and failed deliveries.

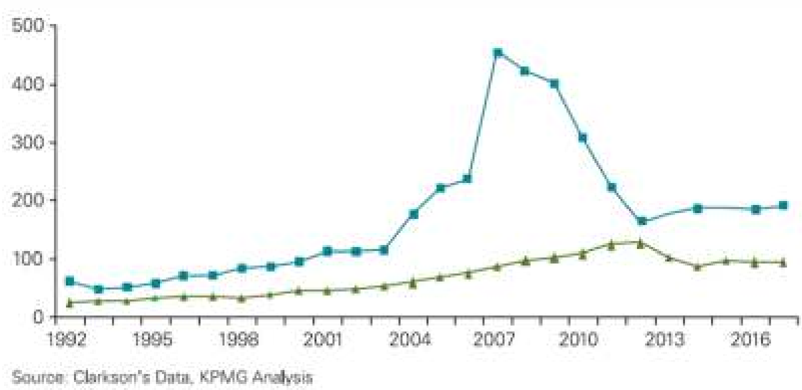


Fig 4: Global shipbuilding order book and deliveries (in mn DWT) (source [17])

Critical Gaps in Shipbuilding Industry.

15. The Indian Shipbuilding Industry had aspirations to acquire a 7.5% share in global shipbuilding by 2017. India, could have also emulated the Chinese model during the booming phase of large growth in commercial shipbuilding orders. However, for various reasons India seems to have missed the bus to benefit from the last boom in world shipbuilding and the current negligible share in world shipbuilding tonnage.

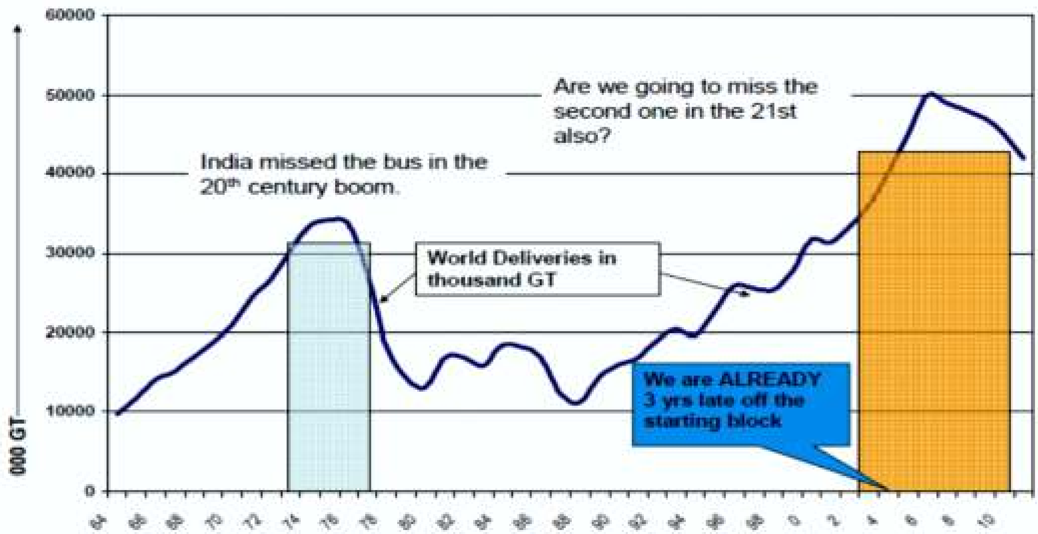


Fig 5: Global shipbuilding forecast (source [13])

16. Indian yards face systemic disadvantages in several areas which negate their natural competitiveness and adversely impact their chances of succeeding in a globalized shipbuilding industry. Indian shipyards lack global competitiveness and inability to build in short timelines. The productivity concerns induce the Indian owned shipping companies to order on foreign shipyards for cost and time savingsin spite of the current indigenous commercial shipbuilding capacity being more than 25 % of the domestic requirement for shipping. Some of the key gaps and issues afflicting competitiveness and capabilities of Indigenous shipbuilding in private sectors have been elaborated in succeeding paragraphs:

(a) Ship Design and Shipbuilding Processes. The Indian Shipbuilding Industry could not develop build strategy adopting modern shipbuilding practices or acquire such know how despite building new infrastructure. There has been a mismatch between the existing infrastructure and processes, compounded with a lack of application of modern technologies. Further, the industry was deficient in recognizing the need to encourage and promote Ship design capability within the country. Ship design is the foundation on which a ship is built and the single most important factor that determines quality, timely delivery and profitability. The industry did not significantly invest in process integration with infrastructure and enhancing the skills of shipbuilding personnel. Areas of improvement are technology intensive modern tools for 3D digital design, vendor base maturity to enable multicenter design, PDM/PLM implementation, commensurate human resource development, innovative build strategy and integrated shipbuilding and production for enhanced productivity.

(b) Supportive Government Policies and Cost Efficiency. The governments in all major shipbuilding countries have laid a thrust on development of the sector through formulation of supportive policies and measures such as subsidies, financial aid, easy finance, tax benefits, preferential orders etc. Japanese and South Korean shipbuilding industries received substantial government support during the 1970s and 80s, which helped them to emerge as top players in the world. In Korea, shipyard financing has matured and the evolved mechanisms to drive the cost lower. Over the last decade, the Chinese government has also taken several measures to foster the growth of its industry like direct aid, loss reimbursements, tax subsidies, etc. Further, the Chinese government provides sovereign refund guarantees for certain class of vessels, thus removing any related burden on the shipyard. The excise and duties that have been levied to the Indian shipbuilding sector further affect their cost efficiency. Indian Govt. supportive policies to the commercial shipbuilding industry would be fundamental in creating a level playing field against the established competing countries.

(c) Working Capital. Typically, a shipyard requires a working capital of around 25-35% of the cost of the ship during the entire construction period. The interest rates on working capital in India average 10-11%. In contrast, the interest rates presently offered to shipbuilding yards overseas are significantly lower at around 5-6% in Korea and around 4-8% lower in China. There are high interest rates on working capital in India with difference as high as 5-6% as compared to competing countries.

(d) Foreign investments. The South Korean government has taken active measures to stimulate FDI in the sector such as cutting corporate taxes, providing tax incentive packages along with low cost plant sites and rent free land lease in Foreign Exclusive Industrial Complexes. The foreign investment in ship building and shipping machinery sector has helped the Korean ship building industry in receiving world class technology, which puts it at almost par with the Japanese counterparts. In India, present system to obtain multiple clearances covering land acquisition, environmental clearance, power and water etc., from various departments acts as a deterrent to the investors.

(e) Ancillary Industries. Development of ancillary industries is critical for increasing cost competitiveness of shipbuilding and repairs. Japan, South Korea and China have formulated suitable fiscal as well as industrial policy for the shipbuilding and ship repair ancillary industry enabling them to develop scale as well as a cluster of ancillaries. The manufacturers in India suffer from the disadvantages accruing from small scale of operations. These advantages of scale are not available to Indian shipbuilding industry, which imports most of its input materials and is therefore unable to leverage advantages offered by bulk purchases and Just in Time supplies.

(f) Process Time. Process time refers to the total time taken by a firm in manufacturing and ensuring that the product reaches the target market which is an important measure of competitiveness of the sector. Countries which are able to achieve faster turnaround time and have quicker time to market enjoy competitive advantage in the market. Indian shipbuilding industry has poor infrastructure support in terms of transport and logistics facilities. There is relatively low hinterland connectivity for most of the ports and cargo handled in the country within the ports. This delays the entire production and distribution cycle for Indian industry.

Inadequate port facilities in India have become a bottleneck to the development of shipbuilding sector. This has often resulted in higher turnaround time at ports and high cost of administrative delays. According to an analysis by KPMG, the turnaround time at ports for India has been 84 hours when compared to 7 hours in countries such as Hong Kong and Singapore.

(g) Focus on skill development and R&D. The major shipbuilding countries have taken special efforts towards skill development and R&D of the shipbuilding industry. However, in India there is limited investment in R&D in ship designing and innovation. Indian shipbuilding industry is at an early stage but has to compete against established yards in Korea and China to grab a share of the market. Its lower scale leads to several disadvantages in design and manpower costs. Indian players have a lot of catching up in hand to meet the international players in ship automation and technology.

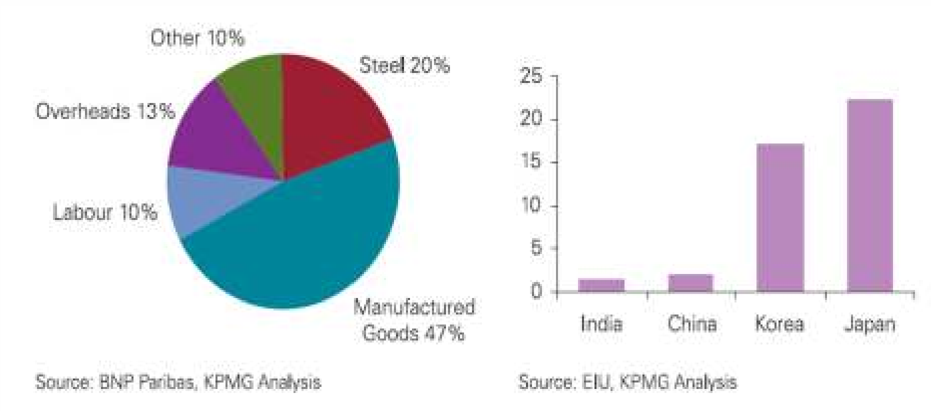


Fig 6(a): % Share of various inputs in Guangzhou shipyard, China
Fig 6(b): Cost of Labour in year 2008 (USD/day) (source [17])

(h) Labour Cost and Availability of Critical Material. India has the lowest labour costs amongst the countries like China, Japan & Korea as shown in Fig 6. However, this advantage is not translated into cost effectiveness because of factors like reliance on imports of critical raw-materials and higher financing costs.

(j) Labour Productivity. India has a huge disadvantage against the competing countries with labour productivity. Japan emerges as a leader with slight advantage over Korea in labour productivity in shipbuilding segment as evident from Fig 7. There is a shortage of basic skills in the industry with lack of manpower with techno-economic specialization in shipbuilding. The scale of operations is also small and in many cases workers working as platers, welders, fitters, etc. are less educated. The shipbuilding sector in China and South Korea has received government fiscal and policy support, enabling them to develop scale as well as a cluster of ancillaries. These advantages of scale are not available to Indian shipbuilding industry, and hence dent the overall labour productivity.

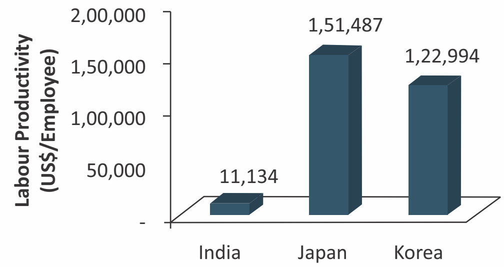


Fig 7:Comparison of Shipbuilding labour productivity across countries (source [15])

Indigenous Warship Design and Construction

17. The indigenisation drive of warship design and construction first launched by the Indian Navy in the 1960s has, over time, matured into a success story worthy of both adulation and emulation. Indian warship building industry over the past few decades has significantly grown into a well-established industrial base and has attained a prolific track record in indigenous design and production of warships and auxiliary vessels. The Directorate of Naval Design (DND) which recently celebrated its golden jubilee in 2014, is the bedrock of all warship design activities in the country and has to its credit 19 different design types ranging from small crafts, stealth frigates, missile corvettes, guided missile destroyers and most notably an aircraft carrier, to which more than 85warships have been built till date. Naval ship building in contrast to commercial ship building has shown an increasing trend with large number of orders being placed for warships, patrol vessels and auxiliary crafts on Defence Public Sector Units (DPSUs), public and privately owned yards in the country. Weapon intensive destroyers and frigates have been constructed and delivered from PSU shipyards, while Auxiliary vessels such as Yard Crafts have been delivered form private shipyards in India. Currently, Indian shipyards have as many as 46 indigenously designed warships in various stages of construction. Smaller equipment and systems have also been indigenised to the extent that, in the recently built Corvettes, nearly 90% indigenisation is said to have been realised.

18. Warship Construction at DPSUs. In an otherwise bleak scenario of commercial shipbuilding, the DPSUs have been fairly well-off, owing to an expanding Indian Navy with its warship building programs at DPSUs through nomination. For the MoD owned shipyards, their biggest advantage lies in long exposure to shipbuilding, enabling them to acquire warship construction skills, design capability and technology. These aspects are crucial for naval shipbuilding, which unlike the commercial shipbuilding is a difficult task given the complex nature of marrying a vast amount of weapons and sensors in an environment of high density fit in warships. However, there are higher expectations in respect of handling complexity of modern naval platforms required to support modern blue water Navy and also stem the time and cost overruns encountered in warship acquisition projects. Govt. with a focus on realizing improved build periods at DPSU shipyards has funded their infrastructure upgrades, as part of the Naval Shipbuilding Projects. These infrastructure augmentations have been commissioned in the recent past and many expected to be completed in the coming years. While these upgrades are significant in shoring up the

infrastructure, they are still much smaller in comparison to the infrastructure available in Korean, Japanese or Chinese shipyards.

19. Disadvantages with DPSUs. The DPSUs have prospered with government protection and assured loading of the yards through nomination. Accordingly there have been cases of delayed deliveries and cost over runs. The biggest disadvantage the PSU shipyards face is the decision-making constraint due to their limited operational and financial autonomy. It depends on the Govt. for approval of key decisions, which are often taken at a slower pace. In contrast the private sector has complete autonomy in decision making, which facilitates them to meet necessary infrastructural needs at a faster pace. Some other areas requiring further attention at DPSUs include process engineering changes, augmentation of design and manufacturing tools, multicentre design, integrated construction for shorter build periods, effectiveness of supply chain management, e-documentation, scaling up of design HR skills, modular construction etc.

20. Competitive Bidding and Inclusion of Pvt Shipyards in Warship Construction. Naval ship requirements and accordingly acquisitions have increased over the years and it was seen that DPSUs were unable to keep up with the required shipbuilding rates. A dedicated section on competitive bidding was introduced in DPP2011. Competitive tendering in warship construction was introduced to realize growing naval demand and rate of ship acquisition, wider choice of shipyards, real price discovery, cost advantage, timely delivery and improved quality of ships. However Private shipyards are exposed to the commercial shipbuilding downturns /cycles and associated turmoil. The idea mooted as a panacea to the difficulties of naval ship acquisition through PSU, has run into challenges off late, resulting in time over runs, management and quality issues in warship construction projects at private shipyards.

Performance of Private Shipyards in Naval Shipbuilding Projects

21. The private shipyards have been severely impacted by downturn in the economy and adverse cycles in commercial shipbuilding, which in turn have adversely impacted the naval shipbuilding embarked upon by them. Major private shipyards are currently undergoing acute financial stress with adverse cash flows and inability to service debts which stands escalated to an excess of $ 4 billion. With highly leveraged positions and falling incomes, the major private shipyards are currently undergoing Corporate Debt /Asset Restructuring. The severely stretched finances and adverse cash flow situation at the major private yards have also affected the timelines of Navalvessel construction projects undertaken by them. With lack of experience and expertise in building warships, the private sector lags behind in technological and design assistance in comparison to the DPSUs. Further, the private shipyards have been afflicted with aggressive costing to win contracts, which manifested in unfavourable cash flows with cascading effects on project time lines. Some of the pertinent gaps and issues of naval shipbuilding at private shipyards are as follows:

(a) Working Capital. Private shipyards which have been primarily engaged in merchant ship construction are susceptible to shocks and reverses in Commercial Shipbuilding which are now spilling over to Naval Ship building. Cancellations of commercial orders and highly leveraged balance sheets have adversely affected Cash flows and Working Capital for the construction of the Naval Ships in hand.

(b) Bank Guarantee (BG) and Cash Flows. In some cases performance BG is released post 90 days of delivery and supply of B&D spares inspite of a separate BG for B & D spares delivery. At times BG ends up blocking cash due non availability of the naval vessel or a drydock slot. Advance Bank Guarantee and Performance Bond have been issued by the bank to shipyards against Margin Money of 10%. However, in testing times some banks have raised the Margin Money to 100%. It is a paradox that a shipyard undergoing severe cash crunch is required to deposit 100% Margin Money.

(c) Aggressive Bidding and Poor Cost Estimation. There is inadequate legacy data for cost estimation of Naval Ships particularly first in class. Further, there are no Benchmarking Norms / Standards for estimation of Shipbuilding effort which may be applied to the evaluation of bid price/cost by private players. Owing to their inadequate exposure to the stringent requirements of naval shipbuilding, cost estimating by private shipyards may be flawed in focusing only on class requirements. Moreover, long gestation periods in RFP to signing of contract, design approvals, equipment delivery and ship construction result in cost escalation and cascading effects. The lure of being in race for high value warship construction contracts have led to aggressive costing by private players to win contracts, resulting in award of cash deficient naval vessel contracts.

(d) Foreign Exchange Rate Variation (FERV). FERV is not permitted in competitive Naval shipbuilding Contracts involving private shipyards. However, the same is accorded to DPSUs who build warships on nomination basis. Further Industry depends on import for a large content of material/components in shipbuilding due inadequate ancillaries. Such equipment import and procurement is vulnerable to severe currency fluctuations which have been volatile in the recent past

(e) Imposition of LD. Levying LD penalty for the complete contract as soon as the contractual delivery date has elapsed and deducting the amount from the ensuing stage payments disrupts the financial cash flow in the project. Currently there exists no scope of incentives for delivery before time.

(f) Adaptation to Concurrent Design and Approvals by IN agencies. There are major deficiencies in design capability of Private Shipyards. In-house design expertise is essential to address nature and complexities of Warship Construction. There are shortfalls inadapting to concurrent design and construction with ability to factor in essential change requests by IN towards enhanced equipment specifications and operational effectiveness. There have been delays in approval of contractual drawings / Key Plans by IN and difficulties in monitoring of receipt /dispatch which calls for effective technical and project management. IN tendency to deviate from Build Specifications and seeking modifications or new specifications midway through construction needs to be on unavoidable basis and brought within the scope of fixed price Contracts.

(g) Planning and Project Management. There is an absence of modern tools and techniques for Project Management and Monitoring. Shipbuilding plans/schedules are in comprehensive and unrealistic with disconnect between planning, production and procurement organization of the shipyard.

(h) Approvals and Delegation of Authority. Approval of Modifications and Delivery Period extension etc., are required to be taken up through CFA and deliberations on such cases are protracted and have large time penalties. Pending approvals lock vital working capital and delayed decision making have adverse cascading effects on time / cost schedule of Warship construction.

Conclusions

22. Shipbuilding capacity and capability in commercial and defence sectors have potential to significantly scale up the employment prospects for the burgeoning young population along with a massive multiplier effect on economy. Further, a shipbuilding industrial base, catering to the naval vessel acquisition and freight carriage through domestically owned merchant ships is strategically significant for national security.

23. The shipbuilding industry in India has not succeeded in building competitiveness primarily due to inadequate policy support, lack of private participation and shipyard inefficiencies. Moreover, currently amidst an economic downturn and adverse shipbuilding cycle, most private shipyards are plagued with dwindling order books, excessive debt, non-existent credit, falling incomes and severe cash flow constraints. The financial stress at the private shipyards have also affected the warship construction projects recently embarked upon by the industry. In light of its strategic significance, economic potential and spinoffs, need of the hour is to shore up the private shipbuilding industry and prevent erosion of the national shipbuilding industrial base (NSIB). From the east Asian growth story, it is apparent that Government patronisation of shipbuilding industry and ancillaries through supportive policies, is fundamental to drive competitiveness in delivering quality ships on time. The incumbent central Govt. has initiated some key measures in support of the ailing shipbuilding industry and some more are desired.

24. While the government has a major role to play, Shipbuilding industry needs to rise up to the occasion and graball avenues open to them to improve their competiveness, productivity and profitability. It is incumbent on all stake holders during this lean period to focus on enhancing competitiveness of indigenous shipbuilding through resolution of gaps and issues afflicting the industry on all fronts viz. regulatory/ fiscal policy, modern technology, design prowess, build strategy, HR skills, productivity and R & D. Simplification of bankruptcy norms and hastening of

procedures towards competent ownership of shipyards would be strongly desirable, towards improved competitiveness, debt reduction and de-leveraging of the industry.

25. Naval shipbuilding at the private shipyard is in its infancies and facing considerable challenges. It is imperative that proactive measures are adopted to plug the existing loop holes in warship contracts and enhance the effectiveness of warship acquisition through competitive bidding. The shipbuilding industrial base upon survival and maturity, along with economic benefits shall also bring quality and efficiency in construction and repair of warships. The expansion of the Navy and the Coastguard, the growth in the manufacturing sector in synergy with the "Make in India" campaign can offer unprecedented opportunities to all the stake holders. The private shipbuilding industry needs to rise to the occasion with enhanced competiveness and graduate towards a reliable and resilient pillar in nation building.

References

1. Manu Pubby & Deepshikha Hooda; Interview with the CNS : Private sector getting into warship building projects; ET Bureau; 3 Feb, 2016

2 Ronald O'Rourke; "Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress"; Congressional Research Service; Jan 16.

3. Capt S Ramanan, Capt Nagesh and Col D Kaushal et.al; Formulation of Effective Contracts for Naval Shipbuilding and Acquisition; CDM Project Report; 2015

4 Antony Prince; "Time to Wake Up and Make in India"; Maritime Gateway; Nov 14.

5. P Kirolikar; "Domestic Shipbuilding in Stagnant Water"; Project Vendor; Mar 14.

6. V Adm H Malhi; "Indian Shipyards"; Defence and Security of India; Feb 14.

7. Cdr SK Rao; "Acquisition of Ships Through Indian Yards - A Perspective"; Future Trends & Opportunities in Warship Design and Construction; Directorate of Naval Design, Golden Jubilee Seminar, 2014

8. HE Yujing, Qian Xinhua; "Analysis of the Life Cycle of China Shipbuilding Industry"; Canadian Research & Development Center of Sciences and Culture; Vol. 8, No. 2, 2014.

9. R Adm AK Saxena, Cmde GK Harish, Lt Cdr AP Singh; "Indian Shipbuilding Infrastructure - Much more with much less"; 2013

10. NAVSEA Public Affairs; "US Naval Shipyards: Supporting the Fleet Today and Planning for the Future"; Undersea Warfare; 2013

11. Global Shipping Review 2013;http://blog.ciltsl.com/archives/2014/03/global-shipping-review-2013

12. Laxman K Behera: "India's Naval Shipbuilding Industry: Key Gaps and Policy Options"; Defence Studies, Volume 12, No. 03; Sep 12.

13. Ministry of Shipping, Road Transport and Highways; "Report of Working Group for Shipbuilding and Ship Repair Industry for the Eleventh Five Year Plan (2007 - 2012)".

14. Cdr S Navneetha Krishnan; "Analysis of Chinese Shipbuilding Industry: Strategic Lessons for India"; Maritime Affairs: Journal of the National Maritime Foundation of India, Volume 7, Issue 2; 2011

15. D&B report on Indian Shipbuilding hosted on DSIR website; "Shipbuilding: Productivity & Efficiency Benchmarking"; "Shipbuilding: Executive Summary";http://www.dsir.gov.in/reports/isr1/Shipping/9_0.pdf

16. Excerpts from Seminar on Indian shipbuilding potential, Need for Impetus; Exim News Service: Mumbai, Sep 2010

17. KPGM White Paper; "Indian Shipbuilding Industry: Poised for Take Off?"; KPMG and FICCI Global Conference and Exposition on Shipbuilding; 2007

Author's Biodata

Captain Nagesh

Captain Nagesh Joined the Navy in 1989 as a 10+2 Technical Cadet and was commissioned as a Naval Architect Officer in Nov 1993. He is an alumnus of prestigious institutes such as IIT Delhi, IIT Kharagpur, Rhiniche Westfalia Techniche Hochshule Aachen (Germany), FSUE Sevmash (Russia), College of Defence Management and Osmania University, Hyderabad. Captain Nagesh is currently the Warship Production Superintendent at Warship Overseeing Team Dahej, which is overseeing the construction of Naval Vessels at private shipyards in Bharuch and Dahej, Gujrat. The officer has been deeply involved in design of ASW Corvettes and Indigenous Aircraft Carrier at Directorate of Naval Design. He has also served Senior Naval Constructor Overseer, WOT (Italy), during construction, trials and commissioning of the Fleet Tankers from Fincantieri, Italy. In his earlier appointments, the Officer has served onboard INS Dunagiri and at Naval Dockyard on the West coast of India, involved in refits/repairs of many ships. The officer also has a PhD (Applied Mechanics) from IIT Delhi. The Officer has keen interest in the field of composite structures, impact mechanics, nonlinear structural response and failure mechanisms, Finite Element Analysis, Warship Design and Ship Construction Technologies with numerous publications to his credit.

Lt Cdr
J Karthik Kumar

Lt Cdr J Karthik Kumar (42624-Y) is a Naval Architect Officer, commissioned in the year 2005. He graduated with B.Tech (Naval Architecture & Shipbuilding) from Cochin University of Science & Technology (2006) and Post Graduate Diploma in Naval Construction from IIT Delhi (2007). The officer has served in the Drydocks and Outfitting Departments at Naval Dockyard (Vizag), DDND(SDG), IHQ MoD(N)/ DDSP and is presently serving as the Naval Construction Overseer, Warship Overseeing Team(Dahej).

Lt Cdr
Conrad Michael

Indigenous Shipbuilding at Private Shipyards, Capt Nagesh et al., WOT Dahej

Lt Cdr Conrad Michael (52388-N) is a Naval Electrical Officer, commissioned in the year 2008. He graduated with B.E. (Electrical & Electronics) from Lakshmi Narian College of Technology, Indore (2008) and Electrical Specialisation Course from INS Valsura (2010). The officer has served as ALO(ASW) onboard INS Ranvir, Electrical Officer (LO) onboard INS Abhay, Instructor at INS Valsura and is presently serving as the Naval Electrical Overseer, Warship Overseeing Team(Dahej).

article

5

NAVAL SHIPBUILDING THROUGH 'MAKE IN INDIA' PERSPECTIVE

(By Col S K Jaini)

"No nation could aspire to be a great power unless it effectively uses the sea for both commercial and military purposes."

Admiral Alfred Thayer Mahan

1. India is projected to become the second-largest economy in the world by 2050 (in PPP terms)overtaking a large number of countries including USA[1]. By 2037, our GDP is expected to be around $ 17 trillion and by 2050 around $ 45 trillion. This will be mainly driven by merchandise trade[2], which accounts for about a 38% of our GDP ($ 757 Billion for FY 2015)[3]. However, despite the large size of our economy, our share is world merchandise tradeis barely 1.7% of world trade against China's 12.4%, thereby indicating a huge scope for future growth[4]. According to the Ministry of Shipping, around 95 % of India's trading by volume and 70 per cent by value is done through maritime transport[5]. However, only 10% approx. of this trade is carried by Indian flagged ships providing a huge scope for adding Indian Made & Flagged ships to the fleets. It should therefore be one of our core national interests to have a secure maritime environment so that economic growth and developmental activities can take place unhindered.

2. As per the India Maritime Security Strategy document, Navy is to ensure and enable maritime security in the sea areas of interest to India, to establish an environment conducive for the unhindered conduct of shipping, fishing and offshore exploration and other maritime interests that contribute vitally to economic growth and national development[6]. Maritime power, which is an instrument for providing maritime security, hinges on possession of powerful and complex platforms in all four dimensions i.e., sub surface, surface, air and space. Ships and submarines with longer reach, endurance and high potency, capable of operating as part of a multi-national fleet, fighting a range of battles from all out wars to asymmetric, economic and environmental threats will be plying the seas in the years to come. Such vessels, endowed with futuristic features and capabilities will have to be built to stringent economies of cost and time. This requires a developed military industrial base which can provide necessary military platforms in accordance with the aspirations as envisioned in the maritime capability development strategy.

[1]Global economic power projected to shift to Asia and emerging economies by 2050, http://monitor.icef.com/2015/03/global-economic-power-projected-shift-asia-emerging-economies-2050/, accessed on 14 Feb 16.

[2]Merchandise trade as a share of GDP is the sum of merchandise exports and imports divided by the value of GDP.

[3]Merchandise trade (% of GDP), http://data.worldbank.org/indicator/TG.VAL.TOTL.GD.ZS, accessed on 14 Feb 16.

[4]Catalyzing India's Trade and Investment, 01 Jul 2015 at http://www.eximbankindia.in/sites/default/files/indias-international-trade-and-investment.pdf accessed on 14 Feb 2016.

[5]Ports in India, 28 Dec 2015, http://www.ibef.org/industry/ports-india-shipping.aspx#sthash.Q5wiclu9.dpuf, accessed on 14 Feb 2016.

[6]Indian Maritime Security Strategy, 25 Jan 2016, http://ndiannavy.nic.in/sites/default/files/Indian_Maritime_Security_Strategy_Document_25Jan16.pdf.

3. Through Make in India, Government of India wants to encourage multi-national, as well as domestic companies to manufacture their products in India. India would emerge, after initiation of the programme, as the top destination globally for foreign direct investment, surpassing China as well as the United States. The whole Scheme is targeted at attracting investments in manufacturing so as to provide jobs to millions.

Importance of Shipbuilding

4. Labour market scenario India enjoys demographic advantage wherein almost 63 per cent of the population is in the economically active age group which if productively used can have a multiplier impact on growth and employment. The workforce participation rate i.e. the workforce as a proportion of the population stands at around 39 per cent in 2011-12. The education profile of the workforce is however dismal with nearly 55 per cent having education below primary of which nearly 30 per cent are illiterate. About 28 per cent have education up to secondary and the workforce with higher secondary and above qualification is only 17 per cent.

5. India needs to create 10 million additional jobs every year to meet the job demand coming in from the youth joining the labour force . If they are not quickly transferred to the work force, they are likely to turn the so called demographic dividend to a curse by creating large scale instability. This kind of employment can only be generated by growth in manufacturing, which will wean away labour from agriculture and provide higher remunerative jobs. The same is depicted in the Table 1 opposite . It is for this reason that new government has been focusing on shipbuilding very keenly. Shipbuilding in general and warship building in particular are accepted the world over as strategic assets as they are known to create large scale employment opportunities. Since the commercial ship building is not at its robust stage, given the global slowdown and commodity crash, leading to surplus capacity all over the globe, Naval Ship building is the only ray of hope for reviving this key industry.

Table 1: GDP: Sectoral Contribution & Employment

GDP : SECTORAL CONTRIBUTION & EMPLOYMENT		
Sector	Contribution of Sector: 2014-15	Employment : 2014-15
Agriculture	17%	49%
Industry/ Manufacturing	26%	20%
Services	57%	31%

[7] 'Make in India & the Potential for Job Creation'(CII Report) at http://www.ies.gov.in/pdfs/make-in-india-oct15.pdf

[8] 'India needs a big jobs miracle' by Russell Green&Gavin Martin at http://www.livemint.com/Opinion/z6bdNkAKJ0bWgUDa946geM/India-needs-a-big-jobs-miracle.html, accessed on 13 Feb 16.

[9] 'Economy of India', https://en.wikipedia.org/wiki/Economy_of_India, accessed on 13 Feb 16.

6. Shipbuilding acts as a catalyst for overall industrial growth due to spin offs to other industries, including steel, engineering equipment, port infrastructure, trade and shipping services. The indirect potential of shipbuilding industry in employment generation and contribution to GDP is therefore tremendous. The dynamics of India's economic growth will continue to create demand for new ships, and ship-building capacity within the country needs to be augmented to cater to this demand. If the domestic ship-building capacity is augmented, the benefits to the economy would be manifold, with spillover effects on other associated/ ancillary sectors, and generation of employment[10].

7. Although India occupies a small percentage of the global shipbuilding market, the Indian shipbuilding industry is well positioned for growth. According to a study by the Indian Shipbuilders Association[11], the industry can grow at a rate of approx. 30%, and this rate of growth could be achieved through supportive measures by the Government, including incentives for shipyards. As growth in international trade results in increased global and domestic demand for new vessels, Indian shipyards have certain advantages over shipyards in developed nations. India possesses a large pool of technical workers, and its cost of workforce is relatively low, compared to most other shipbuilding countries.

8. Government has made fresh attempts in 2015 at making shipbuilding industry competitive by granting financial assistance to shipbuilders-both state-owned and private-on each ship they build, irrespective of the size and type[12]. The Government has also decided to provide further indirect tax incentives for domestic shipbuilding industry[13] by providing exemption from customs and central excise duties on all raw material and parts for use in the manufacture of ships/vessels/tugs and pusher crafts etc.

Table 2 : Likely Future Requirements of Indian Navy in Two decades

Future Naval Requirements			
Type of Ship	**Nos.**	**Type of Ship**	**Nos.**
Indigenous AC	2	SSBN	6
L Heptr Dock	4	Scorpene Class Subs	6
Guided Msl Destroyers	7	Attack Subs- P 75I	6
Multi Role Frigates	11	Akula Class Sub- Lease	1
ASW Corvette	12	Refuelling Ships	5
ASW Crafts- Light	16	Mine Sweepers-Future	12

[10] 'Indian Shipping Industry: A Catalyst for Growth',http://www.eximbankindia.in/sites/default/files/Full%20OP/op142.pdf,accessed on 14 Feb 16.

[11] Ibid.

[12] 'India's Shipbuilding Ambitions get a fresh Lease of Life', http://www.livemint.com/Opinion/CtejdOpCXW0iGTUYHU401N/Indias-shipbuilding-ambitions-get-a-fresh-lease-of-life.html

[13] Central Government Notification Nos. 44/2015-Central Excise, 45/2015-Central Excise, 54/2015-Customs and 55/2015-Customs all dated 24.11.2015

Naval Requirements for Ships

9. Considering that in 1947, India had only 33 ships to secure a coastline of more than 7,500 km, the country has come a long way forward to the present fleet strength of 136 ships. In addition, there are 42 ships on order with another 30 in pipeline. Major warship building programme (does not include Auxiliaries, minor war vessels and aircrafts) for the next two decades is listed at the Table 2[14].

10. Indian Navy plans to build a force level of 160 warships by 2022 including 90 frontline ships consisting of aircraft carriers, destroyers, frigates and corvettes. Going by the age of the existing ships and their possible decommissioning, the requirement (reference) for the Navy is to induct 8 ships per year. This is not achievable going by the existing record of the DPSU shipyards as the present capacity of the four DPSU shipyards (MDL, GRSE, HSL and GSL) is roughly four ships per year. So the challenge for the Navy is to get at least four more ships per year from other shipyards some of which are preferably required to be able to construct frontline warships.

Naval Shipbuilding

11. India's overall shipbuilding industry comprises of 27 shipyards, of which six are under central government, two under state governments and 19 in the private sector domain. India's four Defence public sector shipyards are building a total of 48 ships and submarines[15]. The four shipyards are Mumbai-based Mazagaon Docks Limited (MDL), Kolkata-based Garden Reach Shipbuilders and Engineers (GRSE), Goa-based Goa Shipyard Limited (GSL) and Visakhapatnam-based Hindustan Shipyard Limited (HSL), which is the latest entrant in warship building in the country.

Of the four, three defence shipyards are rich with orders that assure business for a decade to come. MDL has an order book of Rs 60,000 crore; GRSE has Rs 30,000 crore; even the tiny GSL has Rs 30,000 crore in orders however HSL, in comparison, has just Rs 1,885 crore in orders[16]. Few other shipyards, notably the government owned Cochin Shipyard Ltd (CSL), is presently building India's first ever indigenous aircraft carrier and private-owned PDOECL has recently been awarded construction of five naval off shore patrol vessels, ABG shipyard is presently building 3 Cadet Training Ships while L&T shipyard is involved in the construction of submarine pressure hulls apart from a few Coast Guard Vessels. Among all the shipyards, the MDL is by far the leading warship

[14] http://www.forceindia.net/newsyoucanuse_indian_navy_procurement_plan.aspx&https://en.wikipedia.org/wiki/Future_of_the_Indian_Navy#Nuclear-powered, accessed on 15 Feb 16.

[15] '48 ships and subs under construction in Indian shipyards',http://www.deccanherald.com/content/480090/48-ships-subs-construction-indian.html , accessed on 15 Feb 16.

[16] 'Nurturing shipyards: the case of HSL', http://www.business-standard.com/article/opinion/ajai-shukla-nurturing-shipyards-the-case-of-hsl-115052501367_1.html accessed on 15 Feb 16.

builder in India, having constructed all major types of naval ships excluding the aircraft carrier and having full order book for almost a decade.

12. Despite the preferential treatment so far, the performance of DPSU/ PSU shipyards is fairly ordinary in terms of deliveries. MDL during the last three years has delivered three major warships and has 'INS Chennai' left for delivery from the past orders of the P-15A series. Deliveries of ships under Projects P-15B, P-17A and Scorpene-class submarines are scheduled with effect from September 2016, and will continue till 2025[17]. GRSE, on the other hand, has been the best performer. INS Kadmatt, an Anti-Submarine Warfare (ASW) Corvette indigenously built by GRSE was commissioned into Indian Navy at Visakhapatnam recently on 07 Jan 2016. Previously, INS Kamorta, the First of Class ASW Corvette built by GRSE was commissioned in Aug 2014. GSL has delivered 12 ships of which two were Extra Fast Attack Craft, a Sail Training Ship, two Advanced Offshore Patrol Vessels, five Fast Patrol Vessels, and two 90-metre Offshore Patrol Vessels.

13. The problem is not only with the DPSU/ PSU Shipyards, the performance of private shipyards, who were awarded contracts in last decade on competitive basis, has been disastrous resulting in significant delays. The Six Survey Ships order with AAGL, Gujrat is languishing since 2006 with no end in sight. The Cadets Training Ships have been delayed by almost five years by ABG Shipyard. A study by CDM[18] in 2015 had analyzed the reasons for sub-optimal performance of the private shipyards and found the following causes for cost and time overruns in competitive shipbuilding are as follows:-

(a) Downturn & reverses in global shipbuilding industry led to massive crunch on working capital and restricted cash flows, further leading to delays in projects and even stalling of projects.

(b) Aggressive price bidding by the shipyards to win contracts and subsequent realization of the non-feasibility of the costs resulting into delays/ compromise in quality to retain margins.

(c) Limited expertise/capability in design of warships.

(d) Diversion of stage payment funds by the promoters and management for sustaining other orders at the cost of naval projects.

Need to involve Private Sector

14. Warship building requires both capacity and capability. While DPSU Shipyards are capable of building the required warships for the navy, they are constrained by capacity as orders books of some of these yards such as MDL, GRSE and CSL are full and have very limited spare capacity to take on further workload. Some like GSL have capability but are constrained by their infrastructure to build big warships, while HSL and other private sector shipyards often have capacity but lack capability to build complex warships. The private shipyards like ABG, Bharti or POEDCL have huge capacities but do not have the capability to construct complex warships due to lack of experience. It therefore emerges that for naval shipbuilding to provide impetus to shipbuilding industry, a

[17] We see a bright future for defence ship construction',http://www.financialexpress.com/article/industry/companies/we-see-a-bright-future-for-defence-ship-construction/186748/ accessed on 15 Feb 16.

[18] CDM Project Study on 'Formulation of Effective Naval Contracts', 2015.

collaborative strategy involving both public & private shipyards would be the need of the moment. Accordingly, a Public Private Partnership model, which includes a co-operative and collaborative effort of both the private and the DPSU shipyards, was mooted by Ministry of Defence (DDP) with the new Defence Production Policy in Jan 2011"[19].

15. There are clear differences between warship and commercial shipbuilding. The cost of a warship is typically 70% systems, 30% hull construction and outfitting and by contrast, for a commercial ship the figures are typically 20% systems and 80% hull construction. The underlying skill sets and processes for warship work are not available in private shipyards so far. In general terms, the more war-like the vessel, the more complex the ship: this does not necessarily apply to hull fabrication, but does apply to many aspects of design, outfitting, sensors and weapon systems integration, trials and commissioning. Naval shipbuilding is specialist work and demands significant assurance regimes, engineering and professional support, whose underlying skills take time to build and effort to sustain. Private Shipyards have expertise in less complex auxiliary and support vessels, where commercial design and production techniques offer considerable efficiencies over warship construction practices.

16. The productivity of the Indian DPSU shipyards is much below the levels achieved by international standards.Table3 opposite aptly highlights the issue in comparing our performance with the best in the world.

Table 3: Comparison of Man Hours for Warship Building

Country	Ship Type	Lightship Weight (Tonnes)	Man Hours (Lakhs)	Man Hours per Thousand Tonne (Lakhs)
US	DD-51	7600	50	6.6
US	FFG-7	3000	25	8.3
Japan	DD173	7900	20	2.6
Japan	DD158	4000	10	2.5
Canada	FFH300	4800	21	4.4
Canada	DD6280	4600	23	5
India	Godavari Class	2800	104	37.2
India	Delhi Class	5900	210	35.5
India	P-17	5400	144	26.7
India	P-15A	5900	207	31.2
India	P16A	2800	110	39.3
India	P-28	2500	88	35.2

[19] DProdP 2011 Para 6 of this Policy manual states that "In order to synergize and enhance the national competence in producing state of the art defence equipment/weapon systems/platforms within the price lines and timelines that are globally competitive; all viable approaches such as formation of consortia, joint ventures and public private partnerships etc., within the Government approved framework will be undertaken".

Table 4: Trends in Average Build Period per Thousand Ton

Country	Avg BPPTT (months)
US	4.7
Japan	5
Italy	7.8
Germany	8.5
Canada	9.7
UK	10.8
India (MDL)	18
India (GRSE)	39.7

17. Similarly in terms of the **build-period trends**, it is almost four times more than the international standards.[20]. Also there are substantial time and cost overruns between the contractual milestones. The same has also been highlighted by CAGas, "As against the international timelines (for construction of a 1st ship of a class) ranging from 66-84 months, the indigenous construction of P-15 by MDL and P-16A by GRSE took 116 and 120 months respectively." The same is presented in Table 4below. Further, a part of the reason for inefficiency in the DPSU shipyards is due to the way the shipyards are allowed to function[21]. Being the government-owned enterprises, the DPSU shipyards have limited operational and financial decision making powers. In addition, they are also required to follow the strict government procurement rules which sometimes delay their modernization programme. Whereas, the private shipyards though lack design capabilities, experienced manpower etc., they enjoy rapid decision making with respect to commercial aspects, which is crucial for ensuring faster procurements of equipment, resources and hence results in faster production schedules. It is hoped that the experience on naval ship building with private shipyards would be better in terms of both cost & time. Let us now evaluate the concept of PPP.

How to Integrate Private Sector

18. There is a need to do some hand-holding for the private yards. The commercial scene is not at its best and if India has to see some growth in ship-building it has to come from naval shipbuilding. We need to explore ways and means of involving the private sector in this crucial endeavor. These methodologies could be of various kinds, such as outsourcing, subcontracting, formation of consortia, project - specific special purpose vehicles (SPVs), formation of JVs etc. With these guidelines, the first JV between a DPSU shipyard, i.e. MDL and PDOECL has been approved by the government in Jul 13. This 50:50 JV was a first joint venture project between public and private sector shipbuilders in the defence sector and was aimed at easing the workload of Mazagon Dock, the largest defence shipyard in the country. While a large number of formats exist for PPP, this paper

[20] SN Mishra, Shipbuilding and India's Offset policy, India STRATEGIC, Sep 2011 edition

[21] As per CAG report of 2015, "Garden Reach Shipbuilders and Engineers Limited created facilities without ensuring orders commensurate with the facilities created resulting in underutilization of facilities created. The facilities created in Goa Shipyard Limited remained underutilized due to non-finalization of collaborator for Mine Counter Measure Vessels project and non-receipt of orders for Offshore Patrol Vessels"accessed from http://www.cag.gov.in/sites/default/files/audit_report_files/Union_Compliance_Defence_Navy_Report_37_2015_chap_5.pdf.

attempts to highlight the model of a JV for constructing ships and adopting a shared build strategy. Generally accepted reasons for shared-build strategy include the benefits of providing work to more than one geographic region, maintaining a shipbuilding industrial base, accessing skills available only at different shipyards, overcoming capacity constraints and reducing costs.

19. In a PPP project, returns to the private partner are linked to the performance of their functions, i.e. the provision of outputs specified by the government, whereas in a conventional procurement approach, private partner is remunerated for the completion of a specific function. The main objective of a PPP mechanism is to achieve value for money. The gains associated with the inclusion of the private partner are based on the assumption that the private partner has more to offer than the public entity could realize by itself - it is assumed that the private partner will bring more innovative and cost efficient solutions in addition to a better management. Nevertheless, caution should be taken here that the mere inclusion of the private partner will not be sufficient to generate value for money required.

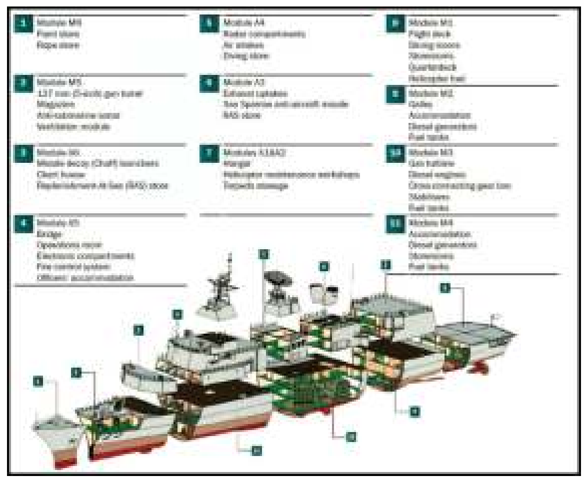
20. In general, it is observed that the PPP is being employed for creation of public infrastructure like roads, ports and bridges etc. and have not been extensively employed for warship construction. This was primarily due to the fact that in infrastructure development, the private sector can pump in funds for construction of these public facilities and operate them for generation of revenue. However, in the case of warships, the private sector cannot operate the ships for generation of revenue. Therefore, the PPP arrangement for warship building can be implemented by forming a JV between the DPSUs and Pvt Shipyards or the DPSUs outsourcing certain portions of warship construction to the Pvt Shipyards.

Shared-Build Strategy for Warship Building

21. Many commercial and military ships have been assembled at one shipyard from modules built at multiple shipyards in many countries. Currently, for example, large sections of Virginia-class submarines are built by Electric Boat (EB) and Northrop Grumman Shipbuilding-Newport News (NGSBNN), with the two shipyards alternating final assembly and test in USA. The Type 45 program in the UK builds some modules in Portsmouth that are shipped to BAE Systems' Govan shipyard on the Clyde, where other modules are built, for final assembly. The UK's new aircraft carrier, the Queen Elizabeth class (QEC, also known as the future carrier, or CVF), will be built at multiple shipyards, with final assembly at Rosyth. France used modular building on its Mistral-class landing-platform helicopter/landing-platform dock (LHD) amphibious ships; the first two ships of the class were built in two halves at different shipyards and brought together in Brest. The motivation for sharing build among multiple shipyards varies from program to program. These countries have used this strategy to offset constrained defense budgets and share production of a single ship to sustain multiple shipyards, to avoid monopoly to a single shipyard as also in the hope of reducing costs or in order to overcome capacity constraints[22].

[22] How a Shared Build Can Support Future Shipbuilding by Laurence Smallman ● Hanlin Tang ● John F. Schank ● Stephanie Pezard at http://www.rand.org/content/dam/rand/pubs/technical_reports/2011/RAND_TR852.pdf

22. These reasons will find great applicability in our scenario. While MDL is overburdened with orders worth more than 60000Crores, the output is meagre leading to avoidable delays and some of our private shipyards own huge capacities with very limited orders. We can easily exploit the strengths of both entities by using shared build strategy. The DPSUs and the private shipyards can take up the challenges of building warships in modules at multiple yards with final assembly at a single shipyard: the shared-build approach. This strategy could be adopted under a PPP in the form of a JV between the DPSU and private shipyards or the DPSUs outsourcing certain portion of the warship building to the private shipyards. This strategy of shared-build warship programs has been used effectively in the United States, France, Italy and the United Kingdom (UK). A few cases across the globe, where shared build strategy has been used, were analyzed to examine how cost, benefits, risks, and other issues affect a decision to follow a shared-build strategy and check the feasibility in Indian Scenario.



23. In programs with more number of platforms, it is possible to split the numbers of whole ships so that two or more shipyards can maintain efficient and effective build schedules, or drumbeats[23], and deliver the ships or submarines on time and to budget. Under this alternating strategy, yards will typically have similar drumbeats with a slight offset for start and completion of the hulls. The DDG-51 destroyer program split between BIW and NGSB-GC is an example of such a program. Such strategies, however, are becoming less common. In Europe, there have not been such long-run programs for more than 20 years. Splitting whole ships or submarines across multiple yards when the drumbeat and numbers have also proven to be very inefficient. Such considerations faced the UK MOD as it explored how to manage its Type 45 program. The decision was to choose a shared-build strategy for its Type 45 program[24]. By making this choice, MOD provided work to two regions, one near the Portsmouth naval base and the other near Glasgow and its long-established shipbuilding yards on the Clyde. It also met a requirement as to how to maintain the possibility of future competition for surface-warship production: Two separate companies, VT Group (formerly known as Vosper Thorneycroft) and BAE Systems Surface Ships (formerly BAE Systems Marine), were kept in business[25]. In sum, the shared-build decision for the Type 45 showed how to spread work and maintained the industrial base.

[23] Drumbeat is the build-schedule periodicity and is usually measured by the start of construction of each hull.

[24] Birkler, JJ et all. The Royal Navy's New- Generation Type 45 Destroyer: Acquisition Options and Implications, Santa Monica, Calif.: RAND Corporation, MR-1486-MOD, 2002.

[25] *The Ministry of Defence's (MOD), UK 2005 Defence Industrial Strategy encouraged BAE and VT Group to form a naval shipbuilding joint venture with the aim of maintaining the UK's naval shipbuilding capability in the long-term. In return, during 2008, the MOD signed a Terms of Business Agreement which pledged that the vast majority of its future naval orders will be placed with the new company for 15 years.*

24. Construction of the Mistral class shows a combination of reasons for choosing shared build for the first two ships. The French government determined the delivery schedule, and Direction des Constructions Navales (DCN) decided, for capacity reasons, it would be necessary to share the build between the DCN Brest shipyard and the commercial Chantiers de l'Atlantique Saint-Nazaire yard. DCN was the prime contractor but also chose to share some construction with the Polish Stocznia Remontowa shipyard to reduce construction costs. The French government allocated the final ship of the class to the Saint-Nazaire yard as part of a financial stimulus package while retaining DCN as co-contractor with STX France.

25. After a decision has been made to pursue a shared build strategy, the allocation of workload among the shipyards must be designed to meet the overall goals of the program. The key drivers for deciding on a workload distribution include capacity constraints, cost avoidance, and desire to maintain specific skills. Each shipyard has unique capabilities, facilities, worker skills, and resources. In the Virginia class program, the desire to maintain two yards capable of building nuclear submarines drove the workload allocation. Throughput limitations can affect the workload distribution of a shared-build program, as demonstrated in the LPD-17 and UK QEC programs. The British QEC program splits construction among multiple shipyards because no one shipyard can undertake such a large project. The primary objective in the QEC program was cost control, so the workload distribution was designed to minimize cost. Similarly, for the first two ships in the Mistral program, workload distribution was designed to balance the workload capacities of Chantiers de l'Atlantique and DCN and to reduce cost[26]. Chantiers and DCN already had ongoing projects occupying space in the yard. Sharing the build of the hulls between the two shipyards allowed construction to begin immediately without waiting for ongoing projects to finish. The modules were distributed to leverage each shipyard's unique specializations. Therefore, the workload allocation of a shared-build strategy depends critically on program goals and unique capabilities of each shipyard.

26. We could start with the program goal of expediting the construction of crucial platforms by employing shared build techniques. The surplus capacities in Gujrat with ABG or Pipavavon West Coast can be exploited by MDL or GSL or even CSL while capacities with Larsen & Toubro could be on East Coast shared by HSL or GRSE. We could construct hulls/ suitable module/ part thereof at these private yards and integrate weapons and systems at DPSU yards.

27. The potential benefits to the cost of a program that follows a shared-build strategy include the following:-

(a) **Maximizing the Learning Curve**. A shared-build strategy, in which the same modules are fabricated at the same yard for a relatively small number of hulls, can offer more opportunities to derive learning-curve efficiencies than an alternating, whole-hull schedule would offer.

(b) **Cross-Yard Learning**. In some circumstances, such as the Virginia-class program, the sharing of lessons learned and the collective innovation of more efficient processes can reduce

[26] To reduce costs, DCN, in turn outsourced some of the steel work to the Polish yard Stocznia Remontowa.

cost. In the case of the Virginia class, the motivation for cross-yard learning was underpinned by the agreement for equal share of profit. Since, warship building has been a DPSU domain so far, a shared build format could provide much needed experience to private sector to build capacity for future.

(c) **Outsourcing Benefits**. Assigning modules to shipyards with a specific specialization or lower manpower costs can lower the costs of an overall program. For example, the French Mistral class achieved cost reduction by outsourcing some steel work to a less costly Polish yard and by assigning the habitability modules to Chantiers. Assigning specific modules to specialized shipyards to reduce cost needs to be carefully balanced against other build strategy goals, such as the desire to maintain specialized skills at both shipyards. As seen in the Mistral class, outsourcing can also relieve existing or emerging capacity problems in the primary yards and keep a project on schedule, thereby avoiding any penalties for late delivery.

(d) **Spreading the Industrial Activity to more Geographies**. Yards in Gujarat benefit from a dense ecosystem of the MSME to support the shipbuilding activities. By adopting a shared build format we will encourage formation of similar clusters in different regions and spread the benefits of industrialization.

Conclusion

28. Indian Navy has embarked upon an acquisition programme to enhance its capacities substantially for both surface and sub-surface combatants to preserve long term maritime interest of the nation. The long term perspective programme is to acquire indigenous capability in design, development and construction of ships and submarines.

29. Infrastructure available in the DPSU shipyards is limited to cater the futuristic warships and adhere to timelines of force level requirements. The defence shipyards viz. GSL, MDL and GRSE have, therefore, embarked upon a comprehensive modernization programme. Further, after the transfer of HSL from the Ministry of Shipping to the Ministry of Defence, plans have been initiated for revival of the shipyard for utilizing the existing resources with requisite modernization for building the conventional warships as well as vessels for the Navy. Considerable facilities have also been created in the private sector to bridge the gap.

30. The growing capability of the industry is evident from its ability to construct major warships, including aircraft carrier, destroyers, frigates and submarines. This positive feature of the industry notwithstanding, there is certain weaknesses in the naval shipbuilding industry, which prohibit it from meeting the vast requirement of the maritime forces in the required timeframe and cost efficiently. Among others, the industry as a whole does not operate in a competitive environment, lacks the crucial capability in warship design and lacks civil-military integration for naval construction. Overcoming these challenges will be critical for creating a strong and vibrant naval shipbuilding industry in India. Among others, there is a need to completely open India's warship building to private shipyards and providing them a level-playing filed vis-à-vis PSU shipyards to bid

for all types of naval contracts, delegate key responsibility including warship design to the shipyards to ensure accountability in naval construction, build a strong ancillary industry for shipbuilding and promote close civil-military integration in warship building.

31. Adm Sureesh Mehta (Retd), *in his keynote address at a Seminar on Shipbuilding in India had stated "In our quest for self-reliance, the Navy is fully committed to participate in, and promote any government initiative to enhance indigenous warship construction capacity. We need to harness the resources of all the stake holders in this endeavor, both government and private in a coordinated and synergistic effort. In the process, as customers, the Navy would also need to introspect and find ways to overcome any internal procedural impediments that may have a negative effect on the productivity of our defence shipyards".*

32. Public Private Partnerships cannot be miraculous solutions for improving the warship building in India. The public sector can through joint efforts with private sector in the form of such partnership and using innovative strategies such as shared-build strategy in shipbuilding can enhance the warship building capacities. A strong and healthy partnership between the public and private sector shipyards would be critical in delivering the quality ships without cost and time overruns. Attaining strategic capabilities in warship design and production through self-reliance using Public Private Partnership will give India a much required shot in the arm and help India assume significant strategic role in world's geo-political affairs.

33. While we have discussed the aspect of construction of ships, which is more or less being done indigenously between DND and the Shipyards, albeit slow, the major portion of the cost is spent on weapons/ systems, which are mostly imported. We need to look at the local design & manufacturing of these crucial components in future to convert the navy to builders' Navy. A success in enhancing the naval ship construction would be a major shot in the arm of Make in India program.

Author's Biodata

Col SK Jaini is alumnus of National Defence Academy, Defence Services Staff College (DSSC-59) and College of Defence Management (HDMC-08). He was commissioned in Regiment of Artillery and did three tenures with Army Aviation. He was one of the few pilots to be selected for a tenure with Indian Navy (INS Dega) where he carried out extensive flying onboard various ships of the Fleet. He also served as Brigade GSO-1 of an Infantry Brigade in J&K where he was intimately involved in conduct & planning of Counter Insurgency Operations. He was also posted as Col GS (Doctrine) at HQ ARTRAC.

He commanded an Artillery Regiment in high altitude area of North East. After attending HDMC-08 at CDM, he is presently posted as faculty at CDM as Head of Department for Financial Management & Supply Chain Management. He was intimately involved as a Lead DS for a consultancy project study regarding 'Effective Contract Formulation for Indian Naval Shipbuilding' in 2015.

article

6

NATIONAL COMPETENCE IN MARINE PROPULSION – THE ROAD AHEAD (THE NAVAL PERSPECTIVE)

(By Capt Gaurav Doogar)

Introduction

1. The first of the marine propulsion systems, perhaps consisted of the paddles and ores, used primarily to propel small boats and crafts. Later, these were replaced by sails, which remained the source of propulsion for a long time until about end of 19th century, when coal-fired steam engines created a revolution in the field of propulsion systems, followed closely by induction of reciprocating diesel engines[1]. Since then, the last century has seen a quantum leap in the propulsion technology, including gas turbines, nuclear propulsion, electric propulsion and high speed water jet propulsions.

2. Today, maritime transport is the backbone of international trade and the global economy. Around 80 per cent of global trade by volume and over 70 per cent of global trade by value are carried by sea and are handled by ports worldwide[2]. This has not only resulted in boost in the commercial marine industry, but also the 'felt need' amongst the leading Nations to flaunt their dominance over the seas, through strong, visible and deterrent Blue Water Navies. Thus, there is a tremendous potential for growth in the marine industry, both in commercial and defence sectors in the future years to come, which would once again prove the theory propounded by Alfred Mahan, “Whoever rules the waves, rules the world”.

3. This paper is, therefore, an attempt to analyse the road map of growth in marine propulsion technology for warships vis-à-vis the potential of marine industry in India and the opportunities for participation by global players in pursuance of Government of India's vision of 'Make in India'.

Selection of Propulsion Systems

4. It is pertinent to mention that the main dimensions (length, breadth and draught) of any vessel and 'Form coefficients' of any hull are dependent on ships hydrodynamic performance, which in turn is dependent on the propulsion system[3]. Thus, the choice of propulsion system is very critical to meet the desired performance and speed requirements for a given displacement of a ship. In warship design, one of the most critical factors for selection of propulsion system is the speed of the vessel, coupled with large number of other factors[4], as listed below:-

---

[1] “Marine Propulsion” [online]. Available: https://en.wikipedia.org/wiki/Marine_propulsion.

[2] Jan Hoffmann, “Review of Maritime Transport 2015”, UNCTAD Publications, (2015),

[3] A. Papanikolaou, Ship Design, (Springer Science+Business Media Dordrecht (2014), 69-73

[4] Indian Naval Indigenization Plan (INIP) 2015-2030, IHQ MoD(N) / DoI [online]. Available : http://indiannavy.nic.in/..../INIP_2015-2030.pdf

(a) Capability of maximum speed, as well as low speeds for loitering and patrolling.

(b) Good endurance and fuel efficient over a wide operating range.

(c) High availability and maintainability (High MTBF).

(d) High power to weight ratio.

(e) Compact and modular construction.

(f) Low Noise – Airborne (ABN) & Structural borne (SBN).

(g) Low IR Signature.

(h) Low overall Life Cycle cost.

5. Having selected the criteria, the selection of propulsion system for a vessel largely depends on the displacement, purpose and role of the warship viz. Aircraft Carrier, Destroyer, Frigate, Corvette, Missile boat or Auxiliary vessels (Tankers, Off-shore Patrol vessels, etc). Although, the selection of propulsion system is a very complex process and requires a detailed evaluation of each selection criteriavis-à-vis the role of the vessel, today a large number of analytical techniques such as Force Decision Matrix (FDM) and Analytical Hierarchical Process (AHP)[5], are being used to quantify decision making and select the most suitable propulsion package for the given role (***Figure 1***).

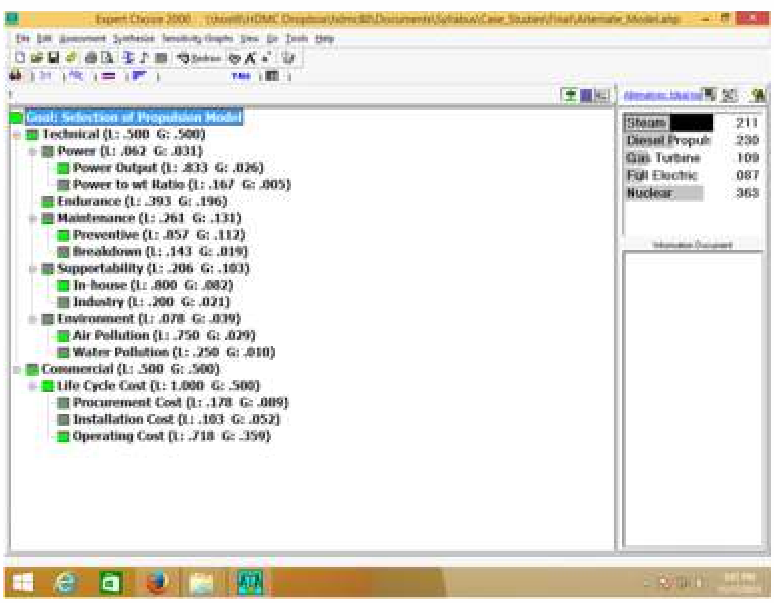


Figure 1: Use of AHP for Selection of Propulsion System using Expert Choice Software

[5]M S Shamasundara, "Analytic Hierarchy Process Approach for Selection of Ship Propulsion System – Case Study", IOSR Journal of Business and Management (IOSR-JBM), Volume 16, Issue 9.Ver. II (Sep. 2014), 14-19

6. Having chosen a suitable type of propulsion package, it is important that the propulsion package of a warship meets the following stringent requirements, critical for operation in marine, as well as the threat environment[6]:-

(a) Assured performance in the presence of six degrees of ship motion, significant of which are roll and pitch.

(b) Ability to withstand shock loads and attenuation of ABN / SBN levels.

(c) Appropriate material and metallurgical composition to withstand corrosion and erosion for assured performance when submerged / partially submerged.

(d) Wide temperature variation in machinery spaces.

(e) Minimum EMI / EMC interference.

(f) Adherence to IMO / Environmental standards.

7. The above requirements, especially capability to withstand shock, attenuation of ABN / SBN levels, compliance to EMI / EMC as per MIL / NES grades, makes the propulsion package for the Naval warships very different from the commercial propulsion systems. Thus, the propulsion systems are required to be customized to meet the Naval warships requirements and are required to undergo stringent type testing and trials prior to installation on board. The task of identifying correct technology and suitable OEMs, would thus be the most challenging and crucial factor, in defining the future growth of marine propulsion systems in the Indian Navy.

Indigenous Capability in Propulsion Systems for Warships

8. A propulsion system for any warship can be divided into four distinct components, from the point of view of role of vessel, design and performance. These major components are main engine, gear box, shafting and propeller. Another very critical aspect in a propulsion system is the control system, which not only provides the human-machine interface for operating the system, but most importantly integrates all the above components, so that the propulsion system can perform its intended task at the desired level of performance.

9. The recently commissioned IN ships and new construction projects in pipeline along with their propulsion systems is tabulated below[7] (Table 1):-

[6]INIP- 2015-2030
[7]Available: http://www.bharat-rakshak.com/NAVY/weapons/specs.html

Table 1: Class of Ships in Indian Navy with Propulsion Systems

S. No	Class of Ship / Project	Type / Model of Propulsion	OEMs
(a)	P-71 Indigenous Air Craft Carrier (Vikrant Class)	COGAG : 4 x LM2500+ Gas Turbines (20,000 KW each)	General Electric / HAL
(b)	INS Vikramaditya (Kiev Class)	08 x Turbo-Pressurised boilers, 4 shafts, 4 Geared Steam Turbines (134,226 kW)	KirovskiiZavod / Sevmash Shipyard
(c)	P-15 (Delhi class) / P-15A (Kolkata class) / P-15B (Visakhapatnam class) Destroyers	COGAG : 4 x DT 59 Reversible GTs (M36E Prop package - 48,000 KW)	Zorya-Mashproekt
(d)	P-17 (Shivalik) / P-17A Multi Mission Frigates	CODOG : 2 x LM 2500 GTs (18,000 KW each) and 2 x SEMT Pielstick 16 PA6 STC (5700 KW each) Diesel Engines	General Electric, Pielstick / KOEL
(e)	P-1135.6 (Talwar / Follow-on Talwar)	COGAG : 2 x DT 59 Boost GTs (16,543 KW) and 2 x DS-71 Cruise GTs (7350 KW)	Zorya-Mashproekt
(f)	Fleet Tankers (Deepak / Shakti)	2 x MAN Diesel Engines (9600 KW each)	MAN Diesels
(g)	P-28 / ASW Corvettes (Kamorta Class)	CODAD : 4 x 12 PA6 STC Diesel engines (3800 KW each)	Pielstick / KOEL
(h)	Landing Platform Dock (LPD) / Multi-Role Support Vessel - 04 in no.s	Electric Propulsion (with shafts)	–

10. The propulsion systems installed on IN ships, have been primarily sourced under various combinations of Work Share Agreement / MoUs and Transfer of Technology (ToT) between the Indian and Foreign OEMs, with respect to design, material, production, assembly, testing, trials, maintenance and spares support. Thus, each propulsion system has a unique configuration and mix of Indian and Foreign technology, based on the indigenous capability, type of technology and stringent requirements of the propulsion system. The broad mix of technological and indigenous capability available under each type of main propulsion system is enumerated in succeeding paragraphs.

11. **Steam Engines.** Sufficient developments have been made in respect to steam propulsion plants. Indigenously manufactured steam turbines from M/s BHEL and boilers from M/s Thermax and Naval Dockyard, Mumbai, are already in use onboard ships. A large number of steam auxiliaries have also been indigenized by local firms with collaboration with foreign OEMs. Although, steam propulsion has lost its supremacy, with induction of INS Vikramaditya, the steam propulsion system would continue to survive for a while longer. This would give ample opportunity for global and local firms for indigenization of main propulsion components / spares viz. Turbo-Driven Auxiliaries, Motor Driven Pumps, Boiler and Turbine Control systems, bearings, boiler tubes and refractory items, shafting components, lub oil coolers, condensers and evaporators.

12. **Diesel Engines.** The primary requirement for the diesel engines is to have low noise levels and high availability/ reliability. Although a great degree of self-reliance in lower power ranges has been achieved by firms like Kirloskar Oil Engines Limited (KOEL), Cummins, MAN Diesel & Turbo, MTU, Wartsilla, Caterpillar, etc, the high power diesel engines meeting Naval specifications are largely imported or assembled in India. The capability of indigenous design, metallurgy, control systems and manufacturing of critical components like fuel ignition pumps, governors, turbo-chargers, rotating components, non-magnetic engines, etc, arestill in nascent stages and need substantial boost. Another critical field is adherence to stringent environmental regulations, which requires technological advancements for reduction of emissions, as well as improving combustion efficiency in diesel engines. There is, thus, a strong need for enthusiastic participation of global firms, to meet the sefuture requirements of Indian Navy.

13. **Gas Turbines.** Presently all gas turbines, fitted in Naval shipsare of foreign origin, primarily dominated by Ukrainian gas turbines, which have been excellent workhorse, although hindered by high specific fuel consumption. Indigenisation initiatives taken in this filed include inductionof General Electric's LM 2500 gas turbine on the basis of its licensed manufacture in India by HAL, with progressive increase in indigenization. Development of a fully indigenous Kaveri marine gas turbine (marinederivative ofLight Combat Aircraft (LCA)gas turbine) is also beingpursued at GTRE, Bangalore. There has also been considerable indigenous effort in GT control systems and its ancillaries by local firms such as BEL, Precision Power, etc. However, there is a need to develop indigenous gas turbines in the range of 11-15 MW and 20-25 MW for fitment on future ships as main propulsion units, which have better fuel efficiency, reduced IR signature and more compact & enhanced aero-thermo-dynamics design[8]. This may involve improved designs of compressors for

attaining higher pressure ratios as well as better combustion chamber designs for achieving higher turbine entry temperatures, there by achieving higher power output. Developments in the field of advanced materials for combustion chamber and turbine blades would also be required to achieve enhanced power outputs. The leading global manufacturers in the field of gas turbine propulsion are General Electric, Zorya-Mashproekt and Rolls Royce.

14. **Electrical Propulsion.** Electrical propulsion technology is maturing at a fast pace for marine applications. This technology provides considerable advantages in terms of higher efficiency, increased flexibility in installation, improved survivability, reduced emissions, lower noise signatures, reduced maintenance and manning requirements and considerable savings in through life ownership costs[9]. Due to these inherent advantages, commercial shipping has already adopted this technology extensively, and the technology is being increasingly adopted for warship applications. Advanced navies like the US Navy, Royal Navy and French Navy already have in place major programmes for adoption of this technology, and in the not too distant future, this isexpected to become the standard technology for naval propulsion packages. Indian Navy has also selected electric propulsion for its new LPD programme. Although, the technology has taken a good leap forward, there are large number of challenges in electric propulsion, such as size / weight / material of the Propulsion Motor, choice / design of converters (Cyclo / Synchro), switch gears / breakers, High Voltage cabling, transformers and design of thrusters / pods[10] (Figure 2). Moreover, compliance to stringent Naval standards of shock, EMI / EMC, noise signature, Ingress Protection and design & safety aspects of high voltage electronics, make choice of electric propulsion for future projects more challenging. The Indian industry would need to gear up to this new technology by entering into suitable collaborations with leading global firms in electric propulsion, such as ABB, Rolls Royce, Siemens-Schottel, General Electric and Converteam, USA.

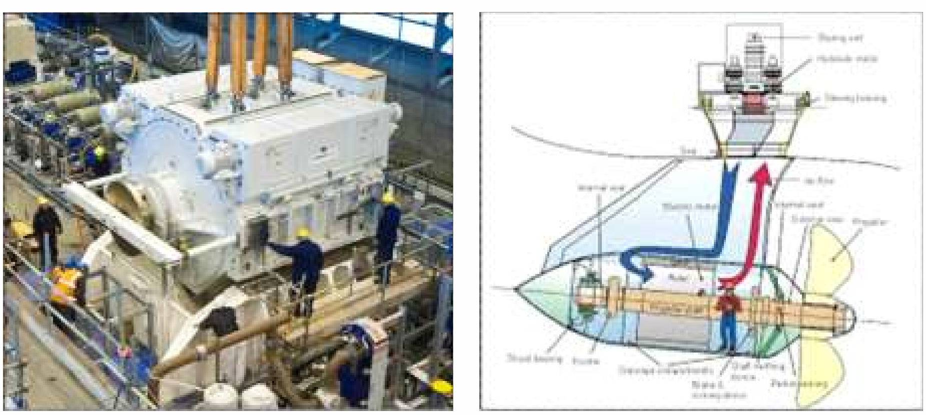


Figure 2: Advance Induction Motor (AIM) and POD Propulsor

[8]INIP- 2015-2030

[9]Ibid.

[10]JM Prousalidis, "On Studying Ship Electric Propulsion Motor Driving Schemes" (Feb 2016).

15. **Nuclear Propulsion.** Nuclear power presents the ultimate AIP solution affording high speed, mobility, autonomy and submerged endurance limited only by stores capacity and crew fatigue for submarines. After INS Arihant, the Indian Navy is favourably considering Nuclear Propulsion for the second aircraft carrier (IAC-2), along with the new generation aircraft launch system, EMALS (Electromagnetic Aircraft Launch and Recovery System), from the US General Atomics[11]. These two new generation system will open a new path for collaborations / joint ventures between the Indian industry and the foreign OEMs who have the expertise and technology know-how in Nuclear propulsion and EMALS.

Propulsion System Components / Integration

16. Apart from the Propulsion systems discussed above, there is a huge scope of ToT / collaboration with global manufactures, in design, production and integration of the following major components of the propulsion system:-

(a) Reduction Gear. For efficient power transmission to the propeller, marine gearboxes should possess hardened / heat treated rotating parts (pinions / gear)with high efficiency, good reliability and low noise levels. Gearbox generated noise is a major factor in the overall under water noise signature of ship. Presently some gearboxes of ships are being manufactured in Indiaby M/s Elecon, under joint ventures with foreign firms such as M/s MAAG, Switzerland & M/s Renk, Germany[12]. However, majority of critical parts, rotating gears / pinions, bull gear, couplings, clutches, etc, are all imported from abroad and, thereafter, only assembled in India (Figure 3). Further, there is a critical requirement of gearboxes in the range of 01-50 MW for the new construction ships. A large number of OEMs have delivered / have been short-listed for gear boxes for IN projects viz. Walchandnagar- DCNS (France), KPCL, Wartsila (France), ZF Marine (Germany), Reintjes (Germany), Twin Disc (Singapore). Thus, there is a need to gainfully engage these global leaders to enhance own expertise, infrastructure and production facilities to be self-reliant and self-confident in the field of marine gear box manufacturing.

Figure 3: Marine Gear Box

[11] Gulshan Luthra, "After Arihant, Indian Navy considering Nuclear propulsion for Aircraft Carriers", India Strategic, (Dec 2015).
[12] INIP- 2015-2030

(b) **Machinery Control Systems.** As brought out above, control system ensures integration of all sub-components of propulsion package. To ensure substantial indigenization, the design of all machinery control systems have been evolved around open architecture standards. This has enabled indigenous availability of core hardware, as well as software of machinery controls on all new construction ships. A large number of Indian vendors (along with collaboration with foreign firms) have been participating in the IN projects, viz. L3 Communications, L&T, BHEL, KOEL-DCNS, Tata Power SED and Marine Electricals. Majority of the software coding is being done in India, in fact Indian firms are undertaking coding for even foreign projects, due to enormous talent pool of software engineers in India. However, majority of hardware components are imported, including processor cards, I/O devices, LCD / LED panels, OFC cables, sensors, actuators, etc. The Indian industry needs to use technology transfer and attract the global manufacturers to develop indigenous content, since the same would have considerable benefits to entire electronics / IT sector.\

(c) **Shafting/ Controllable Pitch Propellers (CPP).** Some headway has been made in indigenous development of fixed pitch propeller shafting systems with foreign collaboration. However, other critical components such as propeller, stern tube bushes, 'A' bracket bushes, plummer block bearings and gland sealing are still being imported. The import content in case of CPP shafting systems is much higher (**Figure 4**). The leading OEMs in this category are GSL, L&T, Wartsila and Fincantieri, Italy. There is need to indigenously design and develop CPP shafting systems with a greater indigenous content for the future indigenous ship construction projects.

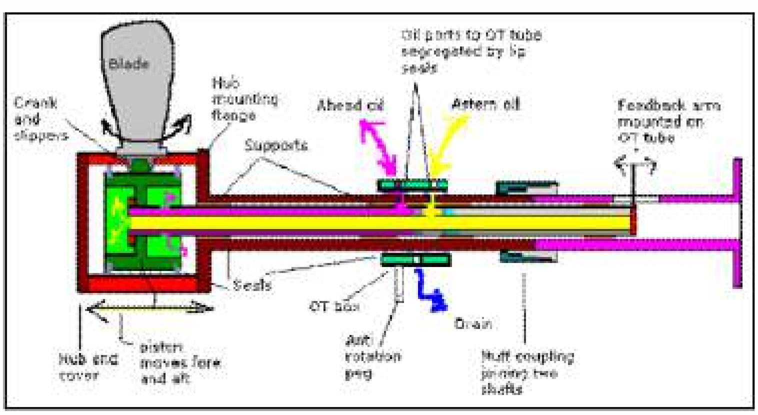


Figure 4: Controllable Pitch Propeller

(d) Propulsion System Integration. One of the most critical aspects in any propulsion system is seamless integration of all its components viz. main engine, gear box, shafting and propeller. The job requires development of a mathematical model to validate the design, control algorithm, propeller-engine matching and to ensure that the desired performance / max. speed is achieved during the sea trials. This job is done by a Propulsion System Integrator (PSI). At present, adequate expertise for the integration of propulsion system is not available within the country and is presently sought from foreign vendors' viz. DCNS, Wartsila, Fincantieri, Converteam and Alion Science & Technology. With a large number of ships being inducted under the indigenous ships building programme, there is an urgent need for Indian industry to acquire adequate expertise andin-house competence in Propulsion system machinery selection, design and integration.

'Make in Indian' Initiative by the Government

17. It is pertinent to mention that in today's competitive scenario, the investment opportunities have to be equally favourable to all partners. It is, therefore, important that if at one hand, the Indian defence sector expects foreign collaborations and transfer of cutting edge technologies from global partners, the global firms also expect their interest of expansion of business opportunities, demand stability, ease of business and increasing profit margins to be met from the Indian industry.

18. Make in India' is one such initiative taken by the GoI to turn Indian into manufacturing powerhouse. The policy is as much an invitation to investors to set up plants in India, as an attempt to improve the country's rank in World Bank's Ease of Doing Business Index. The major impetus of this has been in the Defence sector. In the next seven to eight years, India would be investing more than US$ 130 billion in modernization of the armed forces[13]. The opening of the strategic defence sector for private sector participation will help foreign original equipment manufacturers to enter into strategic partnerships with Indian companies and leverage the domestic markets and also aim at global business. Let us now highlight few initiatives taken by the Government along with factors which can make India into future defence manufacturing hub:-

(a) The Defence Procurement Procedure (DPP) 2016, to be notified shortly has been incorporated with amendments to boost investment in India. The offset policy has been amended to the effect that foreign vendors will not be required to invest 30% of the value of investment in the indigenous defence sector for contracts less than Rs. 2,000 Cr, up from the existing ceiling of Rs. 300 Cr.

(b) In defence production, the Government has allowed companies to raise foreign ownership up to 49%, without prior Government approval.

(c) The Government liberalized the licensing policy and now most of the components, parts, raw materials, testing equipment, production machinery, castings, forgings etc. have been taken out from the purview of licensing. The companies desirous of manufacturing such items no longer require industrial license[14].

(d) Short-listing of top five Indian Shipyards viz. Mazagaon Dock, Hindustan Shipyard, Cochin Shipyard, Pipavav and L&T Shipyard to compete for Rs. 64,000 Cr project to build high-tech

[13]Rahul Singh, "Defence-War on Imports", Hindustan Times, (13 Feb 2016), 02.

[14]"Need to enlarge role of private sector in production of defence equipment", Dailyhunt, (01 Feb 16).

submarines in partnership with foreign firms, such as Thyssen Krupp Marine systems (Germany), Rubin Design Bureau (Russia), DCNS (France), Navantia (Spain) and Saab Kockum (Sweden).

(e) Order to build 12 modern Mine Counter-Measure Vessels (MCMVs) at a cost of more than Rs. 32,000 Cr on Goa Shipyard Ltd, in collaboration with foreign firms (likely Kangnam Corporation, South Korea or Intermarine, Italy).

19. As stated by Hon'ble Prime Minister that"India today offers the 3 'Ds' for business to thrive, which are democracy, demography and demand". Add to that a tech-savvy and educated population, skilled labour, robust legal and IPR regime, and a strong commitment to calibrated liberalization. India's manufacturing sector has evolved through several phases - from the initial industrialisation and the license raj to liberalisation and the current phase of global competitiveness[15]. Today, Indian manufacturing companies in several sectors are targeting global markets and are becoming formidable global competitors. Many are already amongst the most competitive in their sectors. A few other important factors which offer lucrative opportunities for foreign firms to invest in India are as follows:-

(a) India is on the threshold of major reforms and is poised to become the third-largest economy of the world by 2030.

(b) India has the third largest pool of scientists and technicians in the world. Skilled manpower is available in abundance in Semiconductor Design and Embedded Software. India also has strong design and R&D capabilities in auto electronics and industrial electronics.

(c) The cost of manpower is relatively low as compared to other countries.

(d) Low cost of manufacturing.

(e) India has also developed SEZs that are specifically delineated enclaves for the purpose of industrial, service and trade operations, with relaxation in customs duties and a more liberal regime in respect of foreign investment.

Recommendations and Conclusion

20. The warship shipbuilding is a sector with cyclic demand. The design costs in marine propulsion are extremely high and the cutting-edge technology changes at rapid pace. It is, therefore, difficult to remain competitive and at the same time deliver state-of-art propulsion systems which are efficient over entire range, low noise, reliable and meet demands of high speed & manoeuvrability. Although, the competence of the Indian Industry in the marine propulsion has shown tremendous growth in the last decade, there exists a large void in the field of design, production, manufacturing and technology know-how, to meet the requirements of future new construction projects. Thus,

[15]The Next Manufacturing Destination" [online], Available: http://www.makeinindia.com/article/-/v/direct-foreign-investment-towards-india-s-growth.

there is requirement of transfer of technology and sharing of resource pool between the Indian industry and global players to utilize, what each is best capable of.

21. A model adopted by Boeing, USA[16], in this respect gives a clue, to what can be adopted by the Indian industry for cooperation with the global players in the field of marine propulsion. Based on the said model, a proposed way-ahead is as follows:-

(a) **Conglomeration.** Cooperation based on technology synergies and process design, is better represented as conglomerate. As highlighted above, India is an ideal place of manufacturing due to its vast talent pool, cheap labour, liberal business norms and low cost of manufacturing. The conglomeration can be formed between companies based on expertise in design, technology and manufacturing. Irrespective, whether the global order is from which Navy of the world, the conglomerate can work as a single entity, to deliver complex / state-of-art propulsion systems, by entering into a work share agreement, under which technology / design is provided by one firm and the manufacturing is undertaken by other in India. This will have tremendous advantages both in delivering the latest in technology and reducing the cost of development & production. The model would ensure that both the collaborators gain from the expertise / technical know-how of each other, through sharing of technology, procedures and work force. The conglomerate can further be diversified by adding firms which have core competence in Propulsion System Integration (PSI) and machinery controls, to provide unique solutions to complete propulsion package for new projects, under one roof.

(b) **Economic of Scope.** Economy of scope is a relatively new idea in economics that simply relates how one firm can produce two separate goods in two different markets at a lower cost than two separate firms. Diversification in different areas benefits a company by not only reducing the effects of a shock on a specific industry, but also by lowering the overall costs when there may be high fixed costs associated with research, design and development. The above concept of conglomeration can be further extended to diversifying into different sectors of marine propulsion viz. commercial vessels and defence warships, wherein the conglomerate can service both the sectors. Expertise and infrastructure within the conglomerate can be shared to make the components of propulsion system for commercial vessels, whereas the same components can be ruggedized (in terms of shock, EMI / EMC, Low noise, etc) to meet the demands of the defence markets. This would result in economy of scale, lower development cost, less manufacturing startup cost, cross subsidization, diversification, risk reduction, and brand recognition.

22. **Conclusion.** The specific roles of Navies across the world would continue to extend across the entire spectrum of security of the nation; from protection of SLOCs topeace keeping, through the low intensity segment to high-intensity conventional hostilities up to and including nuclear conflict. In the last two decades, the capabilities of Navies (and so also the adversaries) have grown considerably and are forecasted to only improve with time. Thus, warships would

[16] "Boeing Competitive Advantage based on Economics", Civil Aviation [online]. Available: http://www.airliners.net/aviation-forums/general_aviation/read.main/3421849.

continue to acquire niche technology to make them more lethal platforms and requirestate-of-art marine propulsion systems, whether it is gas turbines, nuclear, electric or hybrid propulsion systems. To take advantage of this growth and in pursuance of the GoI vision of 'Make in India', it is important that the Indian industry and the global partners recognize this tremendous potential and join hands to form conglomerates, which will not only deliver the best technology in the world but also ensure overall economy growth of Nations.

Bibliography

1. A Papanikolaou, Ship Design, (Springer Science+Business Media Dordrecht (2014).

2. Gulshan Luthra, "After Arihant, Indian Navy considering Nuclear propulsion for Aircraft Carriers", India Strategic, (Dec 2015).

3. Indian Naval Indigenization Plan (INIP) 2015-2030, IHQ MoD(N) / DoI [online]. Available : http://indiannavy.nic.in/..../INIP_2015-2030.pdf.

4. Jan Hoffmann, "Review of Maritime Transport 2015", UNCTAD Publications, (2015).

5. JM Prousalidis, "On Studying Ship Electric Propulsion Motor Driving Schemes" (Feb 2016).

6. MS Shamasundara, "Analytic Hierarchy Process Approach for Selection of Ship Propulsion System – Case Study", IOSR Journal of Business and Management (IOSR-JBM), Volume 16, Issue 9.Ver. II (Sep. 2014).

7. "Marine Propulsion" [online]. Available: https://en.wikipedia.org/wiki/Marine_propulsion.

8. "Need to enlarge role of private sector in production of defence equipment", Dailyhunt, (01 Feb 16).

9. Online site : http://www.bharat-rakshak.com/NAVY/weapons/specs.html

10. Rahul Singh, "Defence-War on Imports", Hindustan Times, (13 Feb 2016).

11. "Boeing Competitive Advantage based on Economics", Civil Aviation [online]. Available: http://www.airliners.net/aviation-forums/general_aviation/read.main/3421849.

12. "The Next Manufacturing Destination" [online], Available: http://www.makeinindia.com/article/-/v/direct-foreign-investment-towards-india-s-growth.

Author's Biodata

Captain Gaurav Doogar, was commissioned on Nov 94. He did his Mechanical Engineering from INS Shivaji, Lonavla. The officer has undergone M. Tech in Industrial Engineering Management from IIT, Kharagpur, Staff College (64thbatch) from DSSC, Wellington, and presently doing HDMC-11 at College of Defence Management at Secunderabad. The officer's afloat appointments include Asst. Engineer Officer on Rajput and Mysore (Commissioning Crew), Senior Engineer on Delhi and Engineer Officer onboard Mumbai. The Officer's Staff appointments include Senior Instructor at EPCT School, Shivaji, Joint Director at IHQ MoD(N) / DME and Additional Command Refit Officer at HQWNC, Mumbai. The officer has distinction of being awarded 'CNS Silver Medal' during B.Tech and MESC Trophy at Shivaji, MPCTC Trophy at DIAT, Pune, and IIT Silver Medal at IIT, Kgp, for standing first in order of merit in respective courses. The officer has contributed several papers for journals and seminars on varied topics.

article

7

MAKE IN INDIA AND TIMELY DELIVERY OF SHIPS

(By Capt (IN) SujitBaxi)

Background

1. “Make in India” program was announced by the H'ble Prime Minister during his very first Independence Day address from the Red Fort in 2014. One of the objectives of the program was to encash the demographic dividend that our country enjoys, i.e. between now and 2025 the working age population is likely to grow by about 100 million (Report by Macquarie Research & Global Demographics). This makes India the largest contributor to the global working population, compared with a decline of 29 million in China, an increase of 53 million in North Africa and Middle East, 44 million in Africa and 39 million in developing Asia.

India's Age Structures in 2011

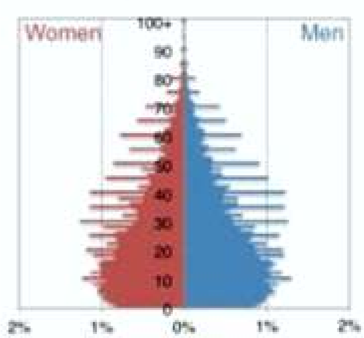


Fig 1. Percent of Population

India

India is poised to become the world's youngest country by 2020, with an average age of 29 years, and account for around 28% of the world's workforce.

2. This not only makes India a market with great consumption potential, making it an attractive market for investors but also puts added pressure on the Government of the day to create suitable job opportunities for its citizen. When seen from an overall perspective, India is sitting on the cusp of future glory. This golden opportunity needs to be exploited so that the next decade or more belong to “Indian growth story”, which has also been agreed by many thinkers and specialists. So this makes “Make in India” an extremely important national program which needs to be pursued with all sincerity and honesty. India needs to create 1 million jobs every month to be able to provide employment for the population entering working age group and for those moving out of agriculture.

3. Another important aspect indirectly related to the program is the Human Development Index (HDI), which is linked with the quality of life of the citizens. India ranks 135 on the global Human Development Index rankings. The ranking is based on a collective index of life expectancy,

education and income standards of population.India ranks lowest among the BRICS countries and even lower than few of its neighbours like Sri Lanka.

4. Although such a comparison is not appropriate, but what is important is that only 10% of India's working population is working in the organised sector, as against 60-70% in developed countries. Also this population with informal employment is insecure, poorly paid and has no social security. There's also a difference between wages of regular workers and informal or contract workers. Added to this is the fact that of the 11 million students graduating from colleges each year, only 20 percent get jobs relevant to their skill sets. These issues therefore need to be addressed in order to improve HDI ranking of the country.

Make in India – Shipbuilding

5. Though “Make in India” is being approached by all sectors of the industry; and it has multiple facets such as “Digital India”, “Startup India”, “zero defect, zero effect”, etc; the prime focus of this paper remains Shipbuilding. Considerable initiatives have already been taken by the Government of India. In its bid to give a push to ship building and ship breaking under the 'Make in India' scheme, government has granted 'infrastructure' status to the industry. This will enable the shipyards and domestic manufacturers to get long term loans for 20-25 years and access overseas loans too.The industry's demand for infrastructure tag had been pending for over a decade. This is a path breaking decision and would go a long way to boost ship building and the cost disadvantage for Indian players will be neutralized. In addition, this decision would help create more jobs and boost ancillary industry.

6. The government had also declared financial assistance to domestic shipyards for any vessel built by them irrespective of size for domestic sale or export purpose. A subsidy of Rs 4,000 crore spread over 10 years has been approved to spur ship building industry. A so-called right of first refusal on all government purchases both for shipbuilding and ship repair has also been given for Indian shipyards.

7. The Ministry of Surface Transport is aiming to raise cargo and passenger movement through waterways from the current five per cent to 30 per cent in the next 15 years. This means that there will be demand for more coastal ships, barges and passenger vessels, which would offer more opportunities to local shipyards. The government plans to introduce seaplane services, water buses, hovercrafts and floating hotels and restaurants to connect coastal towns. India's waterways could contribute at least 2 per cent to the country's GDP.

8. India's defence budget is the ninth-largest in the world and the country is the largest importer of defence equipment. The government spends close to $40 billion annually on the defence budget and now wants to lower the percentage of defence equipment imported from 60percentto 30 percent. The government is expected to pump in a whopping $250 billion into the sector in the next decade to transform India into an industrial power house. In a bid to reform the country's defence procurement policies and procedures, the government has already increased the FDI limit for

military production from 26 to 49 percent and there is a clear preference for equipment manufactured in India. The government has also abolished the need for licenses for a number of defence products.

Indian Shipbuilding Today

9. Almost all yards were flooded with orders with foreign firms waiting in queue with joint venture offers including the government support with 30 per cent subsidy. However, the bubble burst following 2008 global recession, leading many shipyards in the country to bankruptcy. The fact today is that less than 10 per cent of our cargo is carried by Indian flagships and below three per cent of our foreign going merchant ships are built in India. Majority of Indian ships proceed to foreign dry docks for periodical repairs thereby reducing the stake of Indian shipyards in the global shipbuilding to an abysmal 0.3 per cent.

10. Of the many orders executed for Indian Navy by Private/ DPSU/ PSU shipyards in the past many years, only a handful of them have been delivered in time (time is an important indicator of efficiency). In case of Private shipyards, one of the important reasons for this delay has been availability of finances. Although these shipyards are highly capable technically, they are not strong financially. Irrespective of the size they rely heavily on rolling of funds. Even though Indian Navy has been a good pay master, and paying in stages, these shipyards have not been able to meet the requirements of delivery due to losses occurring on account of depletion of other business (both domestic/ international).

11. Further, Indian shipyards have a limitation on draught of vessels that they can handle due to water depth available. Even the technology that they can handle puts a limitation on the types of vessels that can be constructed. Non-availability of inhouse design department is also a severe restriction. So, on the whole Indian shipbuilding, on its own, can only look at small size, low technology vessels. Though the Private shipyards have been employing foreign consultants/ designers of repute to assist in construction of slightly higher end Naval ships, the ability to pay the price for a continued service is marred by financial problems.

12. The DPSU/ PSU shipyards on the other hand are on a more comfortable wicket. There is an almost assured business which is available, and also funds are made available for modernisation. They have sufficient experience of handling high end technology and have sufficient backing of inhouse design department to support them through the production. Although they also have depth restrictions at the water front, they can build all types of vessels required by the Navy. However they have a restriction on the sizes that they can build for Merchant Marine, and also the high technology vessels such as the LNG carriers, Dredgers, etc.

13. Although the Indian Navy is putting considerable focus on Make in India for shipbuilding, the pie of “small” “low technology” vessels that can be handled by Private shipyards is small. In order to stay alive, these shipyards have been resorting to aggressive bidding which has also not helped the cause. Aggressive bidding has only reduced the margins available to shipyards to handle

uncertainties. Cost cutting has been applied on employment of designer throughout the project, but without this “brain” the available “brawn” has not been able to deliver.

The Brighter Tomorrow

14. The DPSU/ PSU shipyards are on a reasonably comfortable wicket and would definitely sail through the troubled waters. However the Private shipyards need to brace for the difficult times and come out with some innovative methods to come out a winner during the coming decade. The first thing to do would be financial consolidation, i.e. restructuring of loans and pumping in of fresh funds. It is already being done, and some of the cash rich Indian companies are buying large private shipyards. But will this alone be sufficient to handle high end ship/ submarine orders being floated in the coming days; and deliver them in time?

15. The shipyards may therefore need to create their own “brain”, i.e. create their in house design expertise, or hire it. This facility cannot be a temporary marriage of convenience which is dependent on availability of funds, but it would have to be a permanent relationship which should withstand the rigours of the business environment and stay stable through thick and thin. One low cost option could be to take Governmental support to create this organisation centrally (such as NIRDESH) to give design assistance to all Private/ DPSU/ PSU shipyards for projects for which design is not provided by the owner (Directorate of Naval Design in case of Indian Navy). A few years ago, an organisation called National Ship Design & Research Centre (NSDRC) at Vizag provided such services under the aegis of Ministry of Shipping & Surface Transport.

16. Once the finances and the technology support is ensured, business opportunity needs to be created to support the venture. A plethora of organisations within the country could be tapped to ensure business for ship building as well as ship repair, i.e. Indian Navy, Coast Guard, Dredging Corporation of India (DCI), Shipping Corporation of India (SCI), Gas Authority of India Limited (GAIL), Oil & Natural Gas Commission (ONGC), Inland Water Authority (IWA), Para Military Forces, and many more. In a number of cases “build and operate” model could be adopted to ensure availability of sustained business.

17. Business opportunities could also be expanded by exploiting strengths resident in the shipyard, such as trained manpower (welding, cutting, fabrication& assembly), space and construction capacity/ infrastructure, to take subcontracting orders from the DPSU/ PSU shipyards. Efforts to create Joint Ventures between Private/ DPSU shipyards were initiated some time back, but failed. However sub-contracting through competitive bidding may pass the rigours of the test. This strength could also be employed to target business of offshore structures such as oil rigs, floating quays/ jetties (for islands), etc.

18. Since the Private shipyards are being taken over by companies that have interest and expertise in products required by Army and Air Force also, a model could be considered where the strengths of purchased shipyards are used to deliver the new line of products, such as trucks, jeeps, armoured vehicles, aircraft components, mines, missile container, Underwater Autonomous Vehicle and

torpedo components, etc. The facilities could also be exploited for business related to any other industry, such as green energy, ancillary industry, etc. Export (especially to third world countries) could also be looked at in a big way.

Conclusion

19. There is no doubt that Indian shipbuilding has been through a very rough patch and is presently in need of a strong booster injection for its revival and recovery. The Government of the day has also understood the felt need, and has come out with a plethora of measures to ensure its speedy and sturdy recovery. Organisations such as Indian Navy and Coast Guard have always been supporting the Make in India effort, and have been the pioneers. At present there is considerable optimism in the air that Indian shipbuilding will come out of these troubled times with flying colours.

20. Although the above efforts may be just sufficient to ensure that Indian shipbuilding does not die off during the next decade, something more needs to be done to ensure greater glory is achieved by the efforts of all the parties concerned. One, the other organisations within the country have to give more business opportunities to our shipyards. And last but not the least, the shipyards themselves, in conjunction with the new owners have to come out with innovative business models to create markets for their product/ exploit the available facilities. They may also collaborate amongst themselves/ with Government shipyards to create business opportunities or create facility for design support.

21. The nation is on the move, and nothing can stop the combined will of 1.25 billion people who have decided to bring in a golden future for themselves. With concerted efforts put in the right direction by all stake holders we would certainly see QUALITY ships being delivered in TIME.

Author's Biodata

Captain Sujit Baxi was commissioned in the Indian Navy on 27 Nov 1993 in the Naval Architecture cadre of the Engineering Branch. The officer completed his B.Tech in Naval Architecture & Shipbuilding from Cochin University of Science & Technology in 1995. He has thereafter completed Post Graduate Diploma in Naval Construction and M.Tech in Corrosion Sciences from IIT Delhi and Powai respectively. Presently he is undergoing Higher Defence Management Course from College of Defence Management, Secunderabad. At sea, he has served as Naval Architect Officer on INS Ranvijay and as Fleet Naval Architect/ Information Technology Officer in the Western Fleet. In staff, he has served at IHQ(N) in Directorate of Naval Architecture in various capacities and been a part of most indigenous ship/ submarine construction projects and closely interacted with shipyards. He has participated in indigenisation efforts of the Directorate and been closely associated with IN ship building/ procurement projects executed abroad. The officer has wide experience of ship repair by virtue of two tenures in Naval Dockyard, Mumbai as Assistant/ Senior Manager in Dry Docks & Hull Preservation department and Integrated Repairs Complex respectively. The officer has served as Senior Naval Construction Overseer at the Warship Overseeing Team (Mumbai) overseeing construction of two classes of frontline ships, viz. Stealth Frigate (Project 17) and Stealth Destroyer (Project 15A).During this time he has also carried out capacity assessment of Private shipyards on the West Coast.

article

8

NAVAL SHIP BUILDING THROUGH MAKE IN INDIA PERSPECTIVE

(By Lt Cdr Naveen Mavi)

History of Ship Building in India

1. In the present era, the shipbuilding industry is being dominated by players from the US, Europe, and Eastern Asia. But there was a time in the ancient past, when shipbuilding in India was a major and thriving industry. Some of the most important aspects of the can be recounted as follows: -

(a) **Ancient India.**

(i) The maritime history of Indian shipbuilding begins right from the time of civilization in Harappa and Mohenjo-Daro. The Rig-Veda, one of the four Vedas (Hindu holy writings) talks about various parts of a vessel in Sanskrit language. Various details about the ancient marine industry is documented in the Arthashastra (written by Kautilya) and various other writings of the ancient Indian folk-lore.

(ii) The shipbuilding industry in India was mainly carried on in the coastal territories like Bombay, Cochin, Tuticorin, Mandvi and Cuddalore. The ships and the shipyards that existed in Ancient India were u sed to carry out and further the existing international trade with the then existing European empires. In addition to the European empires, trading through the oceanic routes also existed between India and some of the other South Asian territories.

(b) **Colonisation Period.** With the advent of the European voyagers like in the 13th century, shipbuilding in India suffered as these voyagers laid the foundation stone of colonization in the country. However, due to the political alliance formed between the Indian rulers in the Western coast of the country to counter the shipbuilding and naval efforts of the Western powers, shipbuilding in India saw a resurgence of sorts towards the 17th century (specially through efforts by Chatrapati Shivaji).

(c) **The Wadia's Era.**

(i) During the 18th century and first half of the 19th century, the shipbuilding activity in India was dominated by the Parsi community. Shipbuilding activity at Surat thrived during the Moghul period. It was during the declining years of the Moghul period, that the Parsis had started absorbing skill in the art of shipbuilding. In addition to building ships on order, the Parsis also dealt with construction of boats for sale. After Surat, the shipbuilding moved to Daman, Dhabul, Bassein and Bombay. On an average one or two ships per year were being built at Bombay. During 1736 to 1743, a total of twelve ships of different types were built i.e Schooners, Grabs, Sloops, Ketches and Brigantines.

(ii) The Indian Shipbuilding suffered as there was no competent rulers who could hold the fort of Indian Maritime Industry. This lack of competence from the Indian perspective also ensured a further oppression for the Indians from the British rulers. But while on one hand the Indian suffered a backlash, construction of several British ships were awarded to the Indian ship yards which kept alive the hopes and promises of the Indian ship construction industry in the chaotic times.

Naval Ship Building in Post Independence Years

2. In the post Independence years, the Indian Navy consisted of a few mostly second hand ships. Over a period of time, as the requirements of the IN grew, the acquisition of increasingly more sophisticated ships started from the late fifties and the same led to technological modernisation. The humiliating military reverses during the Sino-Indian conflict of 1962 led to a comprehensive review of national security based on the premise of continuing hostility from both Pakistan and China. ***However IN still did not receive the required attention of the Political Leadership and no major overhauling was undertaken/ planned.*** The priority accorded to Army and Air Force requirements to counter threats across land borders, limited the Navy to a ship replacement program. Further, the scarcity of foreign exchange for importing the latest technologies compelled the Navy to innovate and indigenize.

3. Post 1947, IN ship design made a modest beginning in 1962 with the establishment of a design cell in the Directorate of Naval Construction (DNC). In 1965, this cell had expanded to become the DNC's Central Design Organisation (CDO). By 1968, CDO had successfully designed and handed over to the Navy numerous auxiliary vessels. In 1966, CDO had also played an assistant role in the construction of new fleet Tanker Deepak in Germany. The directorate was subsequently renamed as Directorate of Naval design in 1970 (as it is known today)

4. The first serious attempts towards indigenization in Naval ship building (here after referred as NSB) began with conceptualisation of Leander Class frigates by the GOI and was subsequently followed with Project 16 and Project 25. The details of the same are as follows: -

(a) **Leander Class.** The ships under this project was constructed at MDL, Mumbai. However technical expertise for the same was sourced from UK. The MOU Agreement for the Leander frigate Project was signed on 22 Dec 64, between the GOI and Vickers Yarrow, UK. It was agreed that Yarrow would provide technical aid including the provision of basic technical drawings and the placing of 60 British technical and other personnel from senior managers down to foremen level to assist MDL in the project. Supplies of major items were to be from Vickers/Yarrows only. A Total of Six ships were constructed under the project with the last one, INS Vindyagiri getting commissioned on 08 Jul 81. The major take away of the project was that IN got an hands on experience with the designing of ships especially during the last two ships of the class.

(b) **Godavari Class.** A total of three frigates were constructed under this projected at MDL, Mumbai. The last of the ship, INS Godavari was commissioned in 1988. ***The major learning***

experience was the installation and integration of Russian systems. Also the ships were fitted with indigenous Sonar systems.

(c) **Project 25/ Khukri Class.** In 1975, design work commenced on ships of the P 25 Corvette Project, which eventually culminated in commissioning of the Khukri class. Orders for the first two corvettes were placed on MDL. As the lead yard, MDL provided drawings and shipbuilding material inputs to Garden Reach for building the next two corvettes. The last of the project, INS Khanjar, was delivered in 1991. Except for the Russian weapon systems, all four corvettes were fitted with indigenous equipment to the maximum extent.

Naval Ship Building (NSB) - The Present Scenario

5. Looking back at the long colonial past and the humble beginnings of Naval Ship Building, it can be easily stated that we have come a long way and giant leaps have been taken in a short span of 50 to 60 years. Naval ship building primarily picked up pace in the late eighties and early nineties. Details of the Naval ships constructed in India during last 30 years and those under construction are as follows: -

Table 1. Details of the Naval Ships Constructed in India during last 30 Years

Sl.	Project/ Class of Ship	Ship Yard Involved	Remarks
(a)	Sukanya Class	HSL, Visakhapatnam	A total of seven ships were constructed. 04 out of 07 ships were built at HSL, Visakhapatnam
(b)	LST/ Magar Class	HSL, Visakhapatnam GRSE, Kolkata	02 ships were constructed at HSL, Visakhapatnam and were outfitted at GRSE, Kolkata
(c)	Project 25A	GRSE, Kolkata	A total of 04 ships were constructed at GRSE, Kolkata and were outfitted at MDL, Mumbai
(d)	Project 16/ Delhi Class	MDL, Mumbai	Guided-Missile Destroyer, last of the three ships, INS Mumbai commissioned in 2001
(e)	Naval OPV	GSL, Goa Pipavav Pvt. Ltd, Gujarat	04 ships commissioned by GSL. 05 out of 09 ships under construction at Pipava Shipyard
(f)	Project 17/ Shivalik	MDL, Mumbai	Guided-Missile Frigate. All three ships completed in 2012

Sl.	Project/ Class of Ship	Ship Yard Involved	Remarks
(g)	Project 16A/ Kolkota	MDL, Mumbai	Guided-Missile Frigate. 02 out of 03 ships commissioned
(h)	Project 28/ ASW corvettes	GRSE, Kolkata	02 out of 04 of the class commissioned. Balance under construction
(I)	Visakhapatnam Class	MDL, Mumbai	01 out of 03 ships launched
(j)	Project 17A	MDL, Mumbai GRSE, Kolkata	A total of 07 ships planned as follow on of Shivalik Class. 03 out of 07 ships to be constructed at MDL, Mumbai. Balance 04 at GRSE, Kolkata
(k)	Indigenous Aircraft Carrier	Cochin Shipyard, Cochin	Ship was launched in 2014. Likely to be commissioned in 2018

6. Present Capability wrt Indigenisation. Naval ship building primarily comprises of three components:-

(a) **Float Segment - The Silver Lining.** The country has been able to achieve 90 per cent indigenisation in the float category where in the steel required for the hull of ships is being developed/ manufactured in-house, with the assistance of PSU like SAIL and private industry players like TATA Pvt. Ltd. It is pertinent to note that the metallurgical knowhow required for the same, which was missing for a considerable time has been acquired and has made the float section highly cost effective.

(b) **Move Section.** Indigenisation upto levels of 60% has been achieved in the move section. However a lot is required to be done. It is pertinent to note that the country has still not developed its first GT engine and the same is being imported from friendly nations like Ukraine. Further the indigenous capabilities in fields like Shafting, Propellers and Gear Boxes are also not very promising. Countries like Srilanka are found to more capable on the said front where in the yards are found to be better than us in activities like shafting etc.

(c) **Fight Section – The Problem Area.** The indigenous content in this segment is limited to 30% only. Although great success has been achieved in some segments. However the same has been largely limited few systems. Further details are as follows: -

Table 2. Indigenisation Status

Sl.	Type of System	Product	Remarks
(i)	Guns	Ootomelara Main gun	Being manufactured at BHEL, Haridwar under License from Otomelara. Successful system. ***However Technical Knowhow not being handed over by the foreign OEM.***
(ii)		AK 630 Gun	Being Manufactured at OF, Cossepur Successful system. ***However poor TOT***
(iii)		CRN 91	Being Manufactured at OF, Cossepur ***Indigenous but poor in performance***
(iv)	Surveillance Radars	Revathi	
		AMDR	Manufactured by Israel/ imported with Nil indigenous content
		FREGAT	Manufactured by Russia/ imported with Nil indigenous content
(v)	EW systems	Ellora	Manufactured Indigenously by BEL, Hyderabad
		Sanket	
		Varuna	
(vi)	Missiles	Barak/ SAM	Manufactured by Israel/ ***imported with Nil indigenous content***
(vii)		LR SAM/ SAM	Jointly developed by Indian and Israel. ***However the Know how for core technologies like Missile seeker, INU not available with India***
(viii)		SHTIL/ SAM	Manufactured by Russia/ ***imported with Nil indigenous content***
(ix)		Brahmos/ SSM	Jointly developed by Indian and Russia. ***However the Know how for some of the core technologies not available with India***

Sl.	Type of System	Product	Remarks
(x)	Missiles	KLUB/ SSM	Manufactured by Russia/ ***imported with Nil indigenous content***
(xi)		Dhanush/ SSM	Indigenously Developed. A success story
(xii)		K4/ SSM	Indigenously Developed. Under trails. Likely to be a success story
(xiii)	Fire Control systems	LYNX	Developed by BEL with a high Indigenous content. A successful system being installed on low tonnage platforms
(xiv)		EON 51	Manufactured by Israel Company. ***Being Imported with Nil indigenous content***
(xv)	Navigational Radars	Bridgemaster	COTS item. ***Being imported.***
(xvi)	UW systems	HUMSA/ USHUSH	Developed by BEL. Found to be promising and being installed onboard under construction ships
(xvii)	TTL	Indigenous Torpedo Tube Launcher	Indigenous system being manufactured by M/s L&T Pvt. Ltd. Being installed onboard al under construction platforms
(xviii)	Communication Systems	PAE 3060/ TR 2400/ ST 1075	Most of the systems being manufactured by DPSUs under TOT. TOT and performance satisfactory
(xix)	CAIO	Combat Management System	A complete indigenous effort overseen by WESEE.

Note. It is quite evident from the table shown above that Fight Section is lagging behind in indigenous content and requires a special push at the policy level (GOI/ MOD). It is pertinent to note that major component of the ship building cost is attributed to the weapons and sensors fitted onboard the ship. Further the same also consumes the major chunk of the revenue budget during the refits and maintenance cycle thereby making it necessary to increase the indigenous content in this section.

7. **Quality of Naval Ship Building.** Quality aspect in the present set up seems to be satisfactory. However the same is not the best in the world, especially with respect to the habitability aspect onboard ships. The living spaces are still cramped. Further degutting/ installation of many of the systems require removal of other system thereby bringing out the lacunae in the planning and designing capabilities.

8. **Cost Effectiveness of Naval Ship Building.** Most of the Naval ship building projects are affected with cost overruns, sometimes to the extent of two to three times the original contract cost. These cost over runs are primarily attributable to the poor planning and lack of integration among the various agencies like IHQ, MOD and the shipyards. The delays are primarily due to bureaucratic procedures involved in procurement of systems required for fitment onboard ships under construction. On many occasions, it has been observed that delay in procurement of system costing few crores (from foreign vendors) results in cost over runs by a few hundred crores.

9. **Time Periods Involved in Naval Ship Building.** A large percentage of the projects completed in recent past and those under construction are running late sometimes to the tune of four to five years. Again this delay is attributable to procedures mentioned above and the same can be certainly cut down.

10. **Core Technologies.** Most of the core technologies used in the weapons/ sensors were developed during the World War II (view necessity being mother of all inventions) and the Cold war era. This was also the period when India was under the colonial rule followed by a financially weak economy and hence the nation missed to tap this period of Defense Industrial Revolution. This was also the period that led to monopoly of few arms manufacturing nations like USA, Russia, UK, France and Israel over the rest of the world. There is a pressing need to develop or acquire the core technologies used in the weapons and sensors like RLG, Missile Seekers etc. through dedicated R&D or G to G (Government to Government) liaisons/ collaborations.

The Way Ahead – Make in India

11. Make in India was launched by the present government in end 2014 with an aim to cut down the import cost in general and to generate employment by creation of jobs in the manufacturing sector. The defense budget of India stands at a whooping four billion dollar, with a great portion of that being allocated for the IN modernization (under MAPP). IN is aspiring to become a 200 ship navy (by 2025) with more than 40 plus ships, worth rupees one lakh crore on order in various Indian shipyards. It is an easy conclusion that Naval ship building can contribute a lot to the Make In India campaign and at the same time it can gain a lot from it. Some of the proposals that can be undertaken in the naval ship building category though Make In India are as follows: -

(a) **Promoting DPSUs - With Accountability.** Presently there are a total of 39 OFs (Ordinance Factories), 09 DPSUs and Fifty odd R&D labs under the DRDO in India. The OFs are completely state owned and primarily cater to the needs of Indian Army with a small chunk of production (less than 2%) going to IN in the form of TOT item like AK 630 and CRN 91 guns. Further DPSUs function on the corporate model with majority ownership being with the GOI. Although the DPSUs and the DRDO labs have contributed to the indigenous content of NSB. However the same is found to be lacking on the core technology front. the following is recommended for the same: -

(i) The Control of MOD/ DPP over the DPSU should be relaxed and the same should be made more accountable to the buyer i.e IN. Provision for monitoring of projects by IN may be incorporated in the DPP with the DPSU being accountable for delays (through LD).

(ii) **Practical QRs.** on various occasions, It has been observed that QRs floated by the directorates/ NHQ are impractical/ not available in the country. Further, sometimes the QRs lead to single vendor situation under the Buy (global) category leading to withdrawal of RFP (under extant DPP rules). Dedicated effort should be made to keep the QRs generic so that products available indigenously may also get a chance to participate in the contract. It is suggested that QR formulation committees with members from the DPSU/ Industry/ MoD be incorporated to ensure drafting of practical QRs.

(iii) **Superior Foreign Product v/s Inferior Indigenous One.** In order to match the most latest technologies available around the world, there is a tendency to go for a superior foreign origin equipment despite a little inferior indigenous alternate being available. It is a known fact that any equipment/ system procured for IN will be exploited for a minimum duration of 08-10 years. It is also known that all ship fitted equipment require intensive maintenance (view being exploited in marine environment) and spare support. The past experiences have shown that equipment sold by the foreign vendors are used by the same as long term/ high return investments, wherein exorbitant amounts are charged for the spares required for upkeep of the systems. Therefore it is a understood fact that little inferior indigenous equipment is always better than the Superior Foreigner one.

(iv) More financial powers should be allocated to CMDs of DPSUs and shipyards in order to ensure faster procurement by the same. This will further result in time bound development of products/ completion of projects.

(v) **Export Permits.** More leverage may be provided to the DPSUs to export successful systems to friendly countries, thereby leading to better balance sheets for the same.

(b) **Large Inventory but Less Classification.** Study of the inventory of major Blue water navies like UK, France, US, Japan and South Korea clearly indicate that the variety in same type (frigate/ destroyer etc) of ships is limited i.e the above mentioned navies maintain more number of ships but less number of classes. However an analysis of the inventory of IN indicates the opposite. It is pertinent to note that foreign origin weapons system inducted into IN, require an extensive maintenance infrastructure to be developed at the yards. Generally this infrastructure is primarily imported from the respective system OEM only. Further, whenever the system is phased out of service, this infrastructure also become obsolete, thereby putting strain on the exchequer. Lower variety in the system/ ship inventory will ensure that the maintenance infrastructure at yards is not required to be changed frequently.

Further large inventory of ships with same equipment fit also allows the buyer to place bigger orders on the indigenous supplier thereby making it more cost effective for the same to manufacture. It is therefore necessary that equipment produced indigenously and having a satisfactory performance be fitted on all possible platforms, instead of going for too much of variety. The past orders of IN especially the follow on class (P-28A, P-17A, P-16B, NOPV) clearly indicates the policy shift towards the above mentioned concept.

(c) **Indigenous 1 V/s Lowest 1.** The present procurement procedures (DPP) entails that every defense contract has to be awarded through tendering procedure with, L1 being the winner. It is imperative that in order to promote make in India there is requirement to tweak the procedures and make them more indigenous (I1) friendly (equipment with higher indigenous content) over the L1 specifically when the L1 is a foreign vendor. Further provisions can be incorporated in the DPP to promote I1 over the L1, even in the Buy (Indian) category on case to case basis. It is recommended that Indigenous equipment with I content more than 70-80% should be granted contracts over the L1 options (with a much lower I content).

(d) **Integration of Defence Agencies.** There is a general dis-integration among the various agencies involved in NSB where in the MOD/ DPP performs the function of auditor over all other agencies. There is a requirement to integrate all agencies involved in ship building like Ship yards/ Design Agency/ MOD(DDP)/ DPSU.

(e) **Core Technologies.** A major cost component of Naval ship building in spent towards procurement of the Weapons and Sensors. Further the Indigenous capabilities in this section are limited to 25-30 % only. It is important to note that some of the technologies used in the W&S systems are available with a few countries only and hence are supplied at exorbitant rates by the foreign vendors. There is a serious requirement of making breakthrough in these technologies and the same are required to be produced indigenously. In order to achieve the above mentioned objective following is recommended: -

(i) **Research and Development.** The present expenditure on R&D in defense is very minimal, if compared with the arms manufacturing countries of the west. It is therefore necessary that more funds be pumped in for development of core and strategic technologies. In addition better laws/ environment should be created for the IP Rights which will further promote R&D among the private industry also. eg. France, Israel USA etc pump money to the tune of 2-4% of the GDP into R&D in defense products

(ii) **Higher Education System.** Highly trained manpower is a essential prerequisite for any defense industry to thrive in a country. However there is a general absence of ready to absorb manpower viz-a-viz for R&D in defense industry. Also there is a requirement to promote research through the existing academia like IITs. Dedicated projects at IITs may be funded for development of core technologies. Reference can be taken from contries like Israel.

(iii) **Joint Ventures.** Joint Ventures may be established as was done in the case of development of system like Brahmos and LR SAM with technologically advanced countries to ensure availability of core technologies indigenously.

(f) **Promoting Private Industries.** The presence of private Ship builders and Arms manufacturer in NSB is very minimal and the same is required to be increased by incorporating necessary amendment at policy level. The following may assist in the expansion of the NSB industry:–

(i) The long term plannings of IHQ / GoI with respect to capital procurements should be shared with the civil industry at the planning stage only to provide sufficient opportunity to the later to plan necessary infrastructure expansions, joint ventures etc.

(ii) Presently there are no provisions of Trial Platform (ships) being made available to the Indian OEM for testing of products during the development stage, which acts as a big impediment for the manufacturer. Provision of dedicated platforms/ ships for trails will go a long way in pushing the indigenous manufacturing in NSB industry.

(iii) **Laboratories for trials.** A large no of systems inducted/ procured into the navy are required to undergo extensive lab trails (as per international standard). However the non-availability of dedicated lab facilities for the said trials have hindered the progress of DPSUs and private firms. Hence dedicated high end laboratories should be established by the GOI/ MOD to facilitate the testing of systems under development.

(iv) **Export License.** Presently Indian Manufacturers are not allowed to export their products without license. A more conducive policy frame work is required to be devised which should reduce the government control over export rights (keeping minimum to strategic products only). This step will allow the manufacturers to sweep more profits, thereby allowing the indigenous industry to flourish.

(v) **Single Window Info System.** There is a general disconnect between the MOD/ buyer and the indigenous private industry about the procedures, requirement and regulations of procurement in NSB items, thereby creating confusion. Dedicated information dispersal mechanism, at all level (MOD/ NHQ/ Cmd HQ) can be created for better integration between the buyer and the manufacturers.

(vi) **FDI Limits.** The FDI in defense is presently limited to 49 % only. However the same is required to be increased on case to case basis. It is recommended that FDI limit for strategic projects may be enhanced further to 50-60%. This might lure foreign suppliers to set up manufacturing plants in India and might lead to TOT WRT the core technologies/ golden parts.

(g) Offset Policy.The present policy requires the vendor to have a specific amount of Indigenous content in the supplied items (30-50%) where in the supplier is required to source the components from Indian sources only. The offset policy is required to be tweaked to ensure the following: -

(i) The foreign vendor under Buy (global) category should manufacture core technologies in India only.

(ii) The contract value for Buy (Indian) category should be enhanced to Rs 2000 crore (from present Rs 300 crore) to promote Indian MSMEs.

(iii) The offset content for Make category should be enhanced to minimum 50 per cent.

(h) Human Resource. As mentioned above, the defence industry requires highly skilled labour. However, the Indian higher education system is presently not in sync with the above mentioned labour requirement. A large no trained technical manpower retires from the services every year. There is a requirement to prepare policy framework to ensure that this readily available manpower is absorbed into the budding defense industry of India.

Conclusion

12. Make in India is an ambitious project, but it is one that India desperately needs to kick-start and sustain its growth momentum. With relentless policies towards this end, it is possible to make India the powerhouse of manufacturing sector in the world. As per the official estimate of the MoD, India is likely to spend around $130 billion on defence modernisation in the coming seven-to-eight years. While this makes India one of the largest defence markets in the world, the opportunity it offers should be fully exploited for the benefit of local industry. This will not only improve India's self-reliance in defence production but will have a multiplier effect on the wider economy. The government must ensure that the local industry is geared and incentivised enough to rise up to the expectations and make the government's 'Make in India' initiative a success story.

Author's Biodata

Lt Cdr Naveen Mavi

Lt Cdr Naveen Mavi is an alumnus of 19th Naval Engineering Course. He is a graduate in Electrical and Electronics Engineering from the Naval College of Engineering, INS Shivaji, Lonavala and has undergone the O-150 Electrical Specialization Course at INS Valsura. He was commissioned in the Indian Navy in Jan 2007. The Officer has held appointments such as Asst. Electrical Officer (Navigation Direction and Weapons) onboard INS Jalashwa followed by Deputy Manager Weapons at Naval Dockyard, Visakhapatam. The officer has done his M.Tech in VLSI and Embedded systems from Delhi Technological University, New Delhi. He is presently appointed as Training Co-ordination Officer at INS Valsura.

article

9

NATIONAL COMPETENCE IN MARINE PROPULSION – THE ROAD AHEAD

(By Lt Cdr Nishchint Mahajan)

Introduction

1. Ship's propulsion system can be either mechanical or electrical. Mechanical propulsion system implies the use of the diesel engine to drive the ship's propelling shaft. The electrical propulsion, on the other hand, is a system consisting of a prime mover (a steam turbine, diesel engine, etc.) and a generator, electric motor and the appertaining equipment (measuring instruments, converters). To develop future ship propulsion systems within reasonable timescales, research and funding are needed in a number of areas viz. fuel cells capable of sustainable powers for ship propulsion, modular nuclear reactors, electric propulsion techniques, ship operational methodologies and perhaps high capability batteries and hydrogen generation.

2. This paper discusses in brief regarding the conventional propulsion methods like diesel engines and gas turbines. In the case of other propulsion options, the subject of nuclear propulsion, air independent propulsion, fuel cells, electric propulsion and hybrid propulsion are discussed. The paper identifies a range of propulsion options, from short and long term perspective, which could be undertaken in a sequential way and research on these options are underway worldwide. However, dedicated research in the field of advanced propulsion techniques needs to be further undertaken to pave the way for future platforms.

History of Various Marine Propulsion Technologies

Diesel Electric Propulsion

3. Diesel-electric propulsion is a century old concept. When the early diesel engines were reliable enough to be used for ship propulsion in 1903-04, they were still non-reversible. Thus at that time, electric power transmission was the only method to overcome this basic technical problem. The first marine diesel-electric application worldwide was the Russian river tanker Vandal commissioned in 1903.

Electric Propulsion

4. The first-generation electric propulsion was brought into use in the 1920s. The high propulsion power demand, during those times, could only be achieved by turbo-electric machinery. Typically, steam turbine generators provided electric power that was used to drive synchronous electrical motors on each shaft, whose speed was decided by the electrical frequency of the generators. With

the introduction of efficient and economical diesel engines in the middle of the 20th century, steam turbine technology and electric propulsion more or less disappeared until the 1980s.

Nuclear Propulsion

5. The United States Navy beat the Soviet Union in the development of nuclear powered ship. The development of a nuclear propulsion plant was authorised by Congress in Jul 51. Captain Hyman G. Rickover of US Navy, who would go on to be known as the father of the nuclear submarine, led the Naval Reactors Branch of the Atomic Energy Commission and by 1955, the navy had placed a nuclear propulsion reactor in the USS Nautilius. The advantage of a nuclear engine for a submarine is that it can travel long distances underwater at high speed undetected, avoiding the surface wave resistance, without refuelling. Unlike diesel engine driven submarines, the nuclear engine does not need oxygen to produce its energy.

Short Term – Conventional Propulsion Technology

Diesel Engines

6. In the present scenario, diesel propelled machinery is the principal means of marine propulsion. Engines are broadly classified into slow speed two stroke; medium speed four stroke; and high speed four stroke engines. Since the 1960s and 70s the development of slow and medium speed diesel engines has been driven by the need for better fuel economy. The result has been increased stroke/bore ratio, peak pressures and mean piston speeds in slow speed to achieve significant reductions in specific fuel oil consumption. Similar improvements in turbo charging efficiency, fuel injection technology, brake mean effective pressure and firing pressures have brought down specific fuel oil consumption in medium speed four stroke engines.

7. Today, the steam turbine has very largely given way to the diesel engine. This transition happened relatively quickly and coincided with the breakthrough of turbo charging and heavy fuel burning in slow speed diesel engines which gave these engines both the power and the fuel economy to become more efficient than steam turbine propulsion.

8. The diesel engine is currently the most widespread of marine prime movers. It is a well-understood technology and a reliable form of marine propulsion/ auxiliary power generation, with engine manufacturers having well-established repair/ spare part networks around the world. In addition, there is a supply of trained engineers and the education requirements for future engineers are well-understood, with appropriate training facilities available.

Gas Turbines

9. Gas turbines have been successfully used in marine environment and represent a proven high power density propulsion technology. Gas turbines were first introduced into warship propulsion in

the 1950s to facilitate high speed sprint modes of operation since their power density was high. A further operational advantage was the relative ease with which gas turbines could be started and stopped which gave rapid access to high levels of power. Gas turbines can be used either in purely mechanical propulsion drive configurations or alternatively to generate electricity, which is then used by electric drives to propel the ship. This gave rise to a variety of hybrid powering arrangements involving combinations of gas turbines with steam turbines (COSAG); with diesel engines (CODAG) and with diesel generators (CODLAG).

10. Gas turbines have the advantage of low weight when compared to their diesel engine equivalents. This weight advantage, therefore, allows designers considerable flexibility in locating gas turbines in a ship when a turbo-electric drive is specified. A further variation of gas turbine technology is the combination of a gas turbine with a heat recovery steam turbine running on the flue gases, enabling a rather greater overall thermal efficiency for electricity generation.

Long Term - Advanced Propulsion Technology

Air Independent Propulsion

11. Air Independent Propulsion (AIP) is a marine propulsion technology that allows a non-nuclear submarine to operate without access to atmospheric oxygen (which is otherwise accessed by surfacing or using a snorkel). AIP can augment or replace the diesel-electric propulsion system of non-nuclear vessels.

12. Modern non-nuclear submarines are potentially stealthier than nuclear submarines; a nuclear ship's reactor must constantly pump coolant, generating some amount of detectable noise. Non-nuclear submarines running on battery power or AIP, on the other hand, can be virtually silent. While nuclear-powered designs still dominate in submergence and deep-ocean performance, small, high-tech non-nuclear attack submarines are highly effective in coastal operations and pose a significant threat to less-stealthy and less-manoeuvrable nuclear submarines.

13. AIP is usually implemented as an auxiliary source, with the traditional diesel engine handling surface propulsion. Most such systems generate electricity which in turn drives an electric motor for propulsion or recharges the boat's batteries. The submarine's electrical system is also used for providing "hotel services" viz. ventilation, lighting, heating etc, although this consumes a small amount of power compared to that required for propulsion.

14. Indian Defence Research and Development Organisation has developed an AIP system based on Phosphoric Acid Fuel Cell (PAFC) to power the last two Kalvari-class submarines which are based on the Scorpene-class submarine design.

Fuel Cells

15. Fuel cells, like a battery, produce energy from an electro-chemical process rather than combustion. Fuel cells have no moving parts but do require additional support machineries such as

pumps, fans and humidifiers. Two reactants, typically hydrogen and oxygen, combine within the fuel cell to produce water, releasing both electrical energy and some thermal energy in the process. Unlike a conventional battery in which the reactants consumed in the energy conversion process are stored internally and eventually depleted, the reactants consumed by the fuel cell are stored externally and are supplied to the fuel cell in an analogous way to a conventional diesel engine. Hence a fuel cell has the potential to produce power as long as it has a supply of reactants.

16. In the ongoing research on fuel cells, various values for the fuel cell efficiency are quoted but all should be treated with caution and considered in relevant context. The fuel types, storage conditions, inclusion of a reformer and type of output power must all be considered. Comparison of fuel cell performance with that of diesel engines should not be based on merely considering the engines themselves. Rather, the whole propulsion chain should be taken into account as diesel engines produce rotary output and fuel cells produce DC electrical output.

17. Fuel cells offer potential for ship propulsion especially in auxiliary and low-power propulsion machinery. For marine propulsion, the high-temperature solid oxide and molten carbonate fuel cells show most promise, while for lower powers the low temperature proton exchange membrane fuel cells are more suitable. While hydrogen is the easiest fuel to use in fuel cells, this would require a worldwide infrastructure to be developed for supply to ships.

18. Fuel cell technology if successfully developed for Navy shipboard application, could reduce ship's fuel use substantially by generating electricity much more efficiently than is possible through combustion and greatly reduce the carbon footprint

19. There is strong interest worldwide in developing shipboard fuel cell technology for both powering shipboard equipment and for ship propulsion. In Europe, fuel cell technology has been incorporated into non-nuclear-powered submarines, such as the German Type 212 submarine, and is starting to be applied to civilian surface ships. ONR and the Naval Sea Systems Command (NAVSEA) have a shipboard fuel cell program for developing fuel cell power systems for Naval ships with an acquisition cost, weight, and volume comparable to other market options.

Integrated Electric-Drive Propulsion

20. Compared to a traditional mechanical-drive propulsion system with two separate sets of turbines (one for propulsion, the other for generating electricity for shipboard use), an integrated electric-drive propulsion system can reduce a ship's fuel use by permitting the ship's single combined set of turbines to be run more often at their most fuel-efficient speeds. Depending on the kind of ship in question and its operating profile (the amount of time that the ship spends travelling at various speeds), a naval ship with an integrated electric-drive system may consume 10 percent to 25 percent less fuel than a similar ship with a mechanical-drive system.

21. Integrated electric propulsion (IEP) or integrated full electric propulsion (IFEP) is an arrangement of marine propulsion systems such that gas turbines or diesel generators or both generate three phase electricity which is then used to power electric motors turning either

propellers or water jet impellers. It is a modification of the combined diesel-electric and gas propulsion system for ships which eliminates the need for clutches and reduces/ eliminates the need for gearboxes by using electrical transmission rather than mechanical transmission of energy.

22. Studies have revealed that despite higher capital costs of electric propulsion machinery, considerable cost savings can be achieved view lower life cycle costs. Further, propulsion is not the only requirement for power. The weapon systems, navigation equipment and domestic consumers also consume electrical ship service load. Appropriate combination of loads would therefore ensure optimum running of power generation equipment at highest possible efficiency.

23. The use of a common power system for both propulsion and ship services is termed Integrated Full Electric Propulsion (IFEP). The term 'All-Electric Ship' (AES) now generally refers to a ship with an IFEP system. Efficient operation is obtained through the use of the minimum number of prime movers that are necessary to meet the required load, all running near their optimum efficiency. A typical frigate with mechanical transmission has four prime movers to generate electricity and two to four to propel the ship. With electrical propulsion, the same prime movers (say 04) can be used for both requirements viz propulsion and other ship services.

24. The advanced world navies of countries such as USA & UK have been engaged in research activities since the 1980s, towards design / development of warships based on IFEP packages.

25. **Advantages.** The main advantages of electric propulsion are as follows:-

(a) Improved life cycle cost by reduced fuel consumption and maintenance, especially where there is a large variation in load demand.

(b) Reduced vulnerability to single failure in the system and possibility to optimise loading of prime movers (diesel engine or gas turbine).

(c) Less space-consuming and more flexible utilisation of the on-board space increases the payload of the vessel.

(d) Flexibility in location of thrusters, since thrusters are supplied with electric power through cables, and can be located independent of prime mover location.

(e) Improved maneuverability by utilising azimuthing thrusters or podded propulsion.

(f) Less propulsion noise and vibrations due to shorter rotating shaft lines and fixed speed prime movers.

26. **Electric Propulsion in India.** Plans are presently underway to build a new scientific research platform vessel, the Class XII merchant vessel by Bharati Shipyard, based in Mumbai. Bharati has chosen GE Power Conversion, with its extensive experience and understanding of the global marine industry, to supply the power and propulsion system for the ship. This will be the first diesel-electric ship built in India to incorporate medium-voltage equipment. The medium-voltage propulsion system is rated at 3.3 kV, with two propulsion motors of 5 MW. Each motor is fitted with one of GE's

MV7000 drives, which stand out from the pack with their high efficiency and control flexibility. Indian Navy presently has warships with mechanical propulsion only. INS Amba (now decommissioned) was the first initiative taken by IN towards electric propulsion. However, Amba was also not a truly IFEP platform. The ship had two independent and mutually isolated electrical power systems, viz a DC-based system for propulsion / submarine battery charging and an AC-based system to cater to ship's loads including weapons and navaids. With the Indian Navy becoming a blue water navy and her future planned growth, it is essential that Indian Navy takes a considered view on migration to IFEP based warships.

Nuclear Propulsion

27. Existing onboard energy storage and power generation systems predominantly develop power by combustion. In contrast, nuclear power generation is the fission of large, heavy nuclei into smaller fission products under controlled chain reactions. This releases large amount of heat energy which is transferred to a coolant to generate useable power via an appropriate thermodynamic cycle. Nuclear propulsion, therefore, represents a potentially radical solution by being an unending reaction process.

28. The ship or submarine will be fitted with one nuclear power plant. The plant uses water to transfer heat generated by the power plant to the steam generators. This heat is around 250 to 300 degrees Celsius. Water will turn to steam at 100 degrees C so the system is pressurised to prevent this from happening. The steam is provided by water commonly referred to as feed water. The feed water is then fed to the steam generators and maintained at a constant level.

29. The Russian, US and British navies rely on steam turbine propulsion, while the French and Chinese ships use the turbine to generate electricity for propulsion (turbo-electric transmission).

30. **Advantages.** The main advantages of electric propulsion are as follows:-

(a) Nuclear submarines can remain submerged and deployed for far greater periods than diesel electric submarines, and it has improved implication for their operational performance as well.

(b) Greater power output provided by nuclear reactors allows nuclear submarines to travel significantly faster than their diesel counterparts.

(c) Nuclear ship propulsion during operation emits no CO2, NOX, SOX, and volatile organic and particulate emissions.

(d) Nuclear propulsion offers further flexibility for ship design and operational planning with respect to ship speeds.

31. **Nuclear Propulsion in India.**

(a) INS Arihant is presently the only nuclear powered submarine, which has been made in Indian yard. This recent success attained post development of INS Arihant has greatly added to our advanced marine propulsion technology. INS Aridhaman is being prepared for launch and two more submarines are under construction. The Indian Navy already has clearance to build six SSN (nuclear propelled) submarines, and indications are that two to three more SSBN Arihant class vessels are also under different stages of planning and construction, and that they will be larger, and with more powerful nuclear reactors than that of Arihant. Progression to build nuclear reactors for aircraft carriers is logical, particularly as fossil fuel powered vessels are dependent on continuous supply of oil irrespective of the growing cost factors as well as the emerging threats in the Indian Ocean.

(b) The technology regarding nuclear propulsion needs to be further enhanced and implemented onboard ships especially aircraft carriers. The Naval Design Bureau (NDB) is working towards designing a 60,000 to 65,000 tonnes aircraft carrier which is likely to have nuclear propulsion.

(c) Development and complex installation of nuclear propulsion will have to be done onboard the ship for the first time. The NDB and scientists from DRDO (Defence Research and Development Organisation) and BARC (Bhabha Atomic Research Centre) are systematically coordinating in this regard. The success in installing nuclear propulsion in Arihant using low enriched uranium (LEU) offers the incentive and inspiration for such a skilled task. INS Vishal which is presently under construction in Cochin yard is likely to be nuclear propelled.

Hybrid Propulsion System

32. Mechanic and electric power works together in the propulsion train, optimising the propulsion efficiency for ships with a flexible power demand. The combination of mechanical power delivered by diesel engines and electrical power provided by electrical motors, delivers propulsion power which assures the ship a broad operational capability, providing the right amount of power and torque to the propeller in each mode of operation. A diesel-mechanic propulsion system is often designed according to its maximum power demand, which, for example, is fitted for a tanker or cargo vessel according to the most hours of the operation profile. A propulsion plant is efficient if it is better prepared for changes in operation during the vessel's trip or even during the vessel's lifetime. The hybrid propulsion is being developed keeping this factor in mind.

33. Hybrid propulsion is an option where one or more modes of powering the ship can be utilised to optimise performance for economic, environmental or operational reasons. Most commonly today the different powering modes feed a common electrical bus bar from which power can be drawn for various purposes. The Royal Navy's Type 45 destroyers are a typical example where an integrated electric propulsion system comprising two WR21 gas turbine alternators and two diesel electric generators supply propulsion electric induction motors at 4.16 kV.

34. It is estimated that hybrid diesel-electric propulsion system will use at least 20% less fuel for the ship than an equivalent diesel mechanical propulsion system operating at design speed with the vessel fully loaded.

Advanced Propulsion in Indian Navy – Recommendations

35. As brought out in preceding paragraphs, the main technologies which have a tremendous potential in marine propulsion are predominantly electric and nuclear propulsion. AIP has already been developed for Kalvari class submarines using fuel cells and it is an extremely promising technology for submarines. The Royal Navy has already inducted Type 45 Frigates employing IFEP, and the future carriers (CVF) with electric propulsion are likely to be inducted soon. The US Navy too has embarked on an ambitious Next Generation Integrated Power System (NGIPS) programme. The US presently has 11 nuclear powered aircraft carriers and 71 nuclear powered submarines.

36. With better fuel economy, reduced operating cost, redundancy, lower noise & vibration signatures and operating flexibility, IFEP has the potential to revolutionalise propulsion systems in future warships. Further, although the present IFEP warships employ MVAC, future generation warships may employ HFAC or MVDC. A large amount of research activity is being carried out in this direction and IEEE has already promulgated IEEE Std 1709 for 'Recommended Practice for 1 kV to 3.5 kV MVDC Power Systems on Ships'. It is therefore imperative that the IN quickly evaluates the feasibility of induction of IFEP warships and develop domain expertise in the field.

37. Nuclear ship propulsion has considerable advantage during operation as compared to diesel which is presently being used to a large extent. Nuclear propulsion has clear greenhouse gas advantages and has been examined to be a practical proposition for naval ships and submarines. Significant research needs to be undertaken in the design and safe operation of shipboard nuclear propulsion plants. The conventional methods of design, planning, building and operation of ships would, however, need a complete overhaul since the process would be driven by safety and systems engineering approach. Issues would also need to be addressed in terms of, training and retention of crews, setting up and maintenance of an infrastructure support system, insurance and nuclear emergency response plans for ports.

Recommendations

38. A dedicated facility needs to be setup in the country for further research in the field of marine propulsion, with alliance from private enterprises, shipping industry, premier educational institutes and Indian Navy. The recommendation are divided into two parts based on the type of advanced propulsion to be implemented in the IN:-

(a) **Electric Propulsion.** The following are recommended:-

(i) **Identification of Industry Partner for IFEP.** Industry majors such as Converteam (now GE), Rolls Royce and ABB have considerable R&D and production experience in the field of IFEP. A suitable Industry partner may be identified to recommend IFEP solutions including architecture & technologies, for the IN.

(ii) **Establishment of Land Based Test Site.** Once the technologies and IFEP architecture for IN are identified, it would be necessary to undertake shore trials of system components, prior to onboard installation. A 'Land based Test Site' may therefore be established for trials/ evaluation of identified IFEP components. The facility will need to cover entire range of testing not achievable through available industry resources.

(iii) **Identification of Class of Ship for IFEP Implementation.** A suitable Class of Ship may be identified for implementation of IFEP.

(iv) **Participation in the IEEE Electric Ship Technologies Symposium (ESTS).** This biennial international symposium, held under the aegis of the IEEE Power and Energy Society, provides a forum for academia, military navies and industry to meet and discuss progress and future of electric ship technologies. Areas include research, design and future advances in electric ship technologies, integrated electric power systems, open architecture, systems, component specifications, electric propulsion, dynamic loads, electric power conversion and storage, distribution systems, reconfiguration, testing, standards, etc. IN participation may be considered in the next ESTS.

(b) **Nuclear Propulsion.** A dedicated Nuclear Propulsion Program (NPP) needs to be set up to provide effective design, development and operational support for nuclear propulsion plants onboard ships and ensure its safety and reliability. The Program should be responsible for all related facilities, environmental and personnel safety, radiological controls, as well as training of personnel. This would require dedicated research laboratories, nuclear-capable shipyard and training facilities. NPP would comprise of military and civilian personnel who would design, build, operate, maintain, and manage the nuclear-powered ships and the associated facilities. The following would be part of NPP:-

(i) **Stringent Design and Regulatory Process for Nuclear Propulsion.** To design and build nuclear-powered merchant ships, significant changes to the normal design procedures are required. The process would be driven by a safety factor in which the building, operation, maintenance and decommissioning of the ship are the principal features. The safety aspects would embrace the nuclear, mechanical, electro-technical and naval architectural aspects of ship design with safety and integrity of the nuclear plant taking precedence.

(ii) **Research and Development Laboratories.** A team of engineers, scientists, technicians, and support personnel along with dedicated labs are required to develop advanced naval nuclear propulsion technology and to provide technical support for the continued safe, reliable operation of all existing naval reactors.

(iii) **Shipyards.** A dedicated shipyard to provide the nation's capability to overhaul, repair and refuel nuclear-powered ships. These complicated tasks require an experienced and skilled workforce specifically trained to do naval nuclear propulsion work.

(iv) **Establishment of Shore Facilities.** In addition to the requirements imposed on a nuclear-propelled ship, nuclear regulatory arrangements would be applied to the shore facilities used to support the shipboard reactor plants. These arrangements would need to be identified in the appropriate safety factors and levels of security similar to those currently applied to civil nuclear power plants are likely to act as a basis for the consideration.

(v) **Nuclear Power Training School.** It is essential that a training school be established with collaboration of DRDO and BARC in order to train our officers, sailors and civilians for shipboard nuclear power plant operation and its maintenance. The NPP's unique training requirements would be met by special-purpose training facilities staffed by highly qualified instructors.

References

(I) Royal Academy of Engineering (2013), "Future Ship Powering Options –Exploring alternative methods of ship propulsion".

(ii) GAO-06-789R Navy Propulsion Systems," Report on Propulsion Systems for Navy Ships and Submarines", 2006

(iii) http://www.indiastrategic.in/topstories4382_After_Arihant_Indian_Navy_considering_n_propulsion_for_aircraft_carriers

(iv) "Hybrid Propulsion Concept on Ships" – Thorsten Volker, University of applied sciences Bremerhaven, Germany

(v) http://csis.org/blog/nuclear-vs-diesel submarines

(vi) http://nnsa.energy.gov/aboutus/ourprograms/powernavy2/aboutnr

(vii) "Hybrid Propulsion systems- efficiency analysis and design methodology of hybrid propulsion systems" – Bas Kwasieckyj

(viii) "Navy Ship Propulsion Technologies: Options for Reducing Oil Use – Background for Congress" – Ronald O' Rourke

(ix) http://thediplomat.com/2015/07/revealed-details-of-indias-second-indegenous-aircraft-carrier/

(x) http://www.defencenow.com/news/397/drdo-developing-air-independent-propulsion-for-indian-submarines.html

(xi) http://www.fuellcelltoday.com/media/1879152/13-07-03_fuel_cells_and_submarines.pdf

(xii) http://moes.gov.in/content/ocean-research-vessels

Author's Biodata

Lt Cdr Nischint Mahajan

Lt Cdr Nischint Mahajan was commissioned in the Indian Navy in Jan 2007. The officer is an alumnus of Naval Engineering College and belongs to O-150 Electrical specialization course of INS Valsura. The officer did his M.Tech in Radio Frequency Design and Technology from IIT Delhi. His appointments include ALO (Volna), INS Ranjit and Electrical Officer, INS Prabal. He is presently appointed as Senior Instructor Faculty of Training Projects in Electrical Technology School at INS Valsura.

article

10

NAVAL SHIPBUILDING THROUGH 'MAKE IN INDIA' – WAY AHEAD?

(By Capt Manoj Jha)

"Just as it is impossible to stand on the shore and pinpoint the spot from which a wave originates, so too, it is difficult to establish when the story of India's maritime heritage began. The seas are timeless, and men sailed them long before history was recorded."

KM Panikkar
Noted Maritime Historian

Introduction

1. A flourishing shipbuilding sector and efficient indigenous warship construction programme are linked to economic growth. India's economic development since 1991 has resulted in a liberalised economy which is today better integrated with the rest of the world. If present growth trends hold, India is projected to be the third largest economy in the next decade. Consistent with that growth, there would remain enormous increases in capacity for India's transportation network, especially in the maritime sector. About 90% by volume and 70% by value of the country's international trade is flows through the sea route involving the maritime sector[1]. Notwithstanding the huge requirement of transportation for own requirements, the share of Indian ships in the carriage of India's overseas cargo has remained low. Further, the fleet of Indian ships are ageing and there would arise a need to replace own ageing ships with new ones. This also brings to focus the importance of Indian shipbuilding industry to contribute towards 'make in India' initiative of the Govt of India.

2. While 90 % of the nation's international trade volume is carried by sea, during 2014, only 8.5% of the cargo was carried by Indian flagged vessels; compared to 40% share by Indian flagged vessels in 1980s[2]. This clearly indicates the shipbuilding industry did not keep pace with growing international trade. Further, large portion of the Indian shipping fleet is over 15-20 years old[3] and would require replacement. Thus, there is enough market for the shipbuilding industry to cater for own requirement. Going by the projected growth in merchant traffic, Indian shipyards therefore needs to gear up to tap the potential of growing demand for ships. The present shipbuilding capacity of India is highly inadequate as per the global shipbuilding standards. The productivity level of all the Indian shipyards are also low. Further, in order to realise higher growth potential it is of utmost importance that the shipbuilding industry is nurtured to grow. **In addition to**

[1]Integrated Headquarters, Ministry of Defence(Navy), "Ensuring Secure Seas : Indian Maritime Security Strategy", October 2015, p.25.
[2]Ibid. p.26.
[3]Ministry of Road Transport and Highways, Transport Research Wing, 'Indian Shipping Statistics 2014', March 2015

contribution to the manufacturing sector of GDP, domestic shipbuilding would also contribute towards the Services and Infrastructure sector. Needless to say, these would generate additional employment for our human resource and would boost the government's 'make in India' initiative.

3. The success story of shipbuilding industry in Japan, Republic of Korea and China merits attention. Post domination of European countries in shipbuilding till Mid 20th Century, Japan demonstrated to be a global trend setter in shipbuilding commencing 1950s. Korea focussed on shipbuilding industry commencing 1970s only to witness unprecedented boost to its economy and to become global leader in shipbuilding till last decade. On account of economic reforms and strategic vision, the shipbuilding industry in China started to grow gradually commencing late 1980s only to become a global leader commencing 2010. The shipbuilding industry in these countries contribute significantly to their economy.

4. Notwithstanding, India having a rich history of flourishing shipping and shipbuilding industry since Bronze Age and its favourable geographic location on the Indian Ocean; the shipbuilding industry in India has lagged far behind its potential. This could be attributed to the far reaching consequences of the legacy of colonialism with skewed development of infrastructure, which made it virtually impossible for India to have a self-reliant shipbuilding industry. As a result, India lost its rich maritime heritage and traditional shipbuilding skills during the prolonged British rule.

5. As emerging navies acquire capabilities commensurate with their perceived role, the Indian navy pursued indigenous warship construction by aligning itself with defence shipyards, to assure self-reliance in the long term. Warship construction since has been almost completely undertaken by the Defence Public Sector Undertaking (DPSU) Shipyards, with foreign acquisitions having been resorted from time to time to tide over capacity constraints or maintain force levels. Besides ensuring self- reliance, indigenous shipbuilding also helps to provide a tremendous boost to a host of ancillary industries as it aids economic growth. Continuing the impetus to indigenisation efforts is therefore a cornerstone of Indian maritime strategy which has been highlighted by the Indian Naval Indigenisation Plan (INIP) 2015.

6. **Opportunities Galore.** Despite huge opportunities, the DPSU shipyards have been unable to leverage this aspect and demonstrate levels of capacity and productivity, comparable to modern shipbuilding yards in other countries. As on date (Feb 16),45 ships and submarines for the Indian Navy are on order at various DPSU, PSU and private shipyards across the nation[4]. As the Indian Navy aspires to grow to 200 ship navy[5] from existing 138 platforms, there is huge opportunity for the shipyards. If we consider average life of ship to be 25-35 years (for minor / major combatants), approximately 30-35 ships are likely to be de-commissioned by 2027, at an average of about three ships per year. If the Indian Navy is required to grow to 200-ship Navy, approximately 90-95 ships

[4]Based on speech by Adm RK Dhowan, CNS "Currently, we have 48 ships and submarines under construction" during "Indigenisation and Innovation" seminar on 16 July 15 accessed on 13 Dec 15 from www.youtube.com uploaded by PRO Navy, New Delhi.

[5]VAdm P Murgesan, VCNS during an interview to PTI, as reported by 'The Economic Times' on 14 July 2015, "Indian Navy aiming at 200-ship fleet by 2027", accessed from www.economictimes.indiatimes.com on 12 Dec 2015.

are required to be inducted by 2027. **This would necessitate an average induction of about 8-9 ships per year from existing 3-5 ships per year.**

7. It is needless to say that self-reliance in this sector is of strategic significance. It is needless to state that India requires a vibrant and strong shipbuilding industry for economic as well as strategic considerations. The current pace of producing a destroyer / frigate by Indian shipyards in 7-8 years is considered much longer vis-s-vis global benchmark. Thus, there exists a need to study the potential of Indian shipyards in general and DPSUs in particular so as to identify thrust areas that would enable warship construction in India to realise its economic and strategic potential.

8. In the changing global environment, where economic activity is paramount, the maritime sector has gained substantial importance. As highlighted earlier, trade, the most essential aspect of a nation's economy, is mostly through the maritime route. The need to safeguard the sea lines of communication (SLOCs) necessitates strengthening of both capacity and capability the Navy. Further, Indian Ocean region is marred with many traditional and non-traditional security challenges. Accordingly, keeping in tandem with India's maritime interests, the nation should have the wherewithal to design and build quality ships, both for the Indian Navy and the Merchant Fleet. This paper would dwell upon aspects related to warship construction only.

Aim

9. This paper aims to study the various aspects of warship construction in India. It highlights the current challenges which have thus far impeded its growth and suggests measures to fast-track warship construction in DPSU shipyards in order to meet growing requirements of the Indian Navy in tandem with government's 'Make in India' initiative.

10. This paper would focus on DPSU shipyard aspects while recommending options and strategies that could be adopted to synergise warship building through indigenous efforts.

Warship Construction in India

11. As mentioned earlier, the long era of colonialism had literally left India with no capability to pursue defence shipbuilding programme. Thus, post independence, based on recommendations of several committees, the most notable amongst those being the Sir CP RamaswamyIyer Committee of 1947, need for shipyards was felt and consequently in 1960s Mazagon Docks and Garden Reach Workshop were acquired by the Government. These became the first two DPSU shipyards. Later, GSL and HSL were acquired. Indigenous shipbuilding started at GRSE in 1961 with construction of three SDBs (Ajay, Abhay and Akshay). This was followed by survey ship Darshak having been delivered by HSL. With the licensed production of the Leander class frigates at MDL in the late sixties, warship building in modern India got a shot in the arm. Almost all types of warships - Destroyers, Frigates, Corvettes, Patrol Vessels, Amphibious Ships, Tankers, Survey ships and Submarines have since been built by our Defence Shipyards. Today, the shipbuilding industry in India revolves around 27 shipyards[6]. These include four DPSUs (MDL, GRSE, GSL& HSL) and four PSUs (two each under control of Central Govt and State Govt) and 19 private shipyards. A warship

construction programme has a number of elements which interact with each other, including feasibility studies, design issues, system integration, construction, tests and trials. It also involves technology transfer, development of new equipment, identification and purchase of large number of items including weapons and sensors, from numerous indigenous and foreign suppliers. Prior analysing the problem areas, it would be important to briefly look at the four DPSU shipyards.

12. **Mazagaon Shipbuilders Dock Limited (MDL).** The yard is the leading defence shipyard with capability presently constructing of constructing warships of 6500 dead weight ton (DWT) and merchant ships up to 27000 DWT[7]. The shipyard's infrastructure consists of three dry docks, four slipways, and three wet basins. Its shipbuilding capacity is expected to increase in the coming years, with the completion of the on-going modernisation plan. Currently, MDL has been constructing missile destroyers (3rd ship of the Project 15A and four ships for the Project 15B, Visakhapatnam Class) and Project 75 Scorpenesubmarines. MDL has also been shortlisted to build three ships of Project 17A; which are follow on of Shivalik Class ships. While the shipyard has been making profit consistently, there has been huge time and cost overruns in various warship construction projects so far[8].

13. **Garden Reach Shipbuilders & Engineers (GRSE).** GRSE was acquired by the MoD with primary objective of developing a shipyard for second line of frigate construction. However, these were limited to three ships of Project 16A Brahmaputra class, which were delivered between 2000 and 2005. The other ships built by GRSE include P25/P25A missile corvettes, fleet tankers, fast attack craft and patrol ships, among others. Currently, last two ships of the Project 28 ASW Corvettes, eight LCUs and four WJFACs are at different stages of construction at the shipyard. GRSE is also expected to build three ships of the Project 17A (follow on of Shivalik Class) in consultation with MDL as the lead shipyard. GRSE too has undertaken modernisation of shipyard.

14. **Goa Shipyard Limited (GSL).** GSL is the smallest DPSU shipyardand has expertise in building ships up to 105 metres length, 3000 ton DWT, and 4.5 metres draught. Following the liberation of Goa, GSL was leased to MDL which controlled the shipyard till 1967. Till date, GSL has built Fast Patrol Vessels (FPVs), survey ships, Sail Training Ships, missile boats, and offshore patrol vessels. Like other defence shipyards, GSL is also on a modernisation drive, with the objective of enhancing its shipbuilding capability by 200 per cent. While the Value of Production (VoP) of the shipyard has consistently been on the rise, the shipyard had incurred loss during FY 2013-14[9]. This DPSU has track record of minimal delays in delivery of vessels. Currently, the shipyard does not have any major order for construction of naval ships.

15. **Hindustan Shipyard Limited (HSL).** HSL, one of the oldest and largest shipyards of the public sector, was transferred to the MoD from the ministry of shipping in 2010. The shipyard has built 173 vessels so far and repaired nearly 11925 ships of various types. However, the shipyard has been

---

[6]"Report of Working Group for Shipbuilding and Ship Repair Industry for 2007-12", Ministry of Shipping, Road Transport & Highways, http://www.planningcommission.nic.in

[7]Ministry of Defence, Government of India, Annual Report 2010-11, p.69.

[8]"PAC Slams Over Delays in Warship Building", Times of India, 24 December 2015

[9]Goa Shipyard, Annual Report 2014-15,p.2.

making losses off late. MoD in consultation with Indian Navy is in process of forwarding fresh ship construction orders to the Yard to improve it's performance. The recent issue of Letter of Offer for construction of 05 Fleet Support ships is a case in point.

16. After having looked at the DPSUs briefly, let's look at what ails these shipyards.

DPSU Shipyards – What Ails these ?

17. **Inadequate Planning / Project Monitoring.** Slippage in warship building is often recognised very late in the programme, making it difficult to overcome. While Earned Value Management (EVM) metrics is the most commonly used yardstick to track progress schedule, DPSU shipyards use 'milestones', which does not adequately qualify progress and identify factors contributing to the slippage. Percentage progress of work is not calculated holistically but invariably linked to factors contributing value of production (VoP). For example, if a main engine is simply lowered onboard or main gun or associated FCS are placed onboard; it contributes towards VoP and approximately 80% progress in that field/activity is calculated towards Programme Evaluation and Review Technic (PERT)/milestone calculation. While this procedure may be acceptable for Hull related activities, problems related to machineries and equipment where II, Setting-to-Work (STW) and trials are involved. This problem is further aggravated in case of weapon equipment and sensors where significant time is required for STW, trial and commissioning. Thus, while initial progress of upto 70% is reached as per projections, timelines start to fail at the STW/trials phase. Reliance on project management tools is further inadequate and unrealistic. Further, production units are unable to synergise yard effort due to poor understanding of the overall build plans. This is further compounded due to delayed decision on finalisation of system/ equipment and at times, freezing of SQRs.

18. **Delayed Decisions / Non Freezing of NSQRs.** Design of any warship starts with the Naval Staff Qualitative Requirements (NSQRs) of the ship or class of ships which spell out the role of the ship including the equipment, weapons and systems fit of the platform. While SQRs are expected to be frozen prior conclusion of contract, in some cases, especially with respect to weapon platforms these get delayed and does not match with requisite schedule. At times, selection of equipment too gets delayed leading to adverse effect on the overall project. Delayed decision and non-freezing of Staff Requirements are one of the reasons for lack of accountability for delays; which is seldom addressed. While the decision may be delayed or SQRs may be amended, non-availability of proper industrial support base further compounds the problem.

19. **Poor Industrial Base Support.** There is a grim situation so far as technology intensive weapons, systems, equipment or sensors are concerned. In the recently published Indian Navy Indigenisation Plan (INIP 2015-30), it has been admitted that while upto 90% indigenisation has been achieved in the 'float' category only 60% and 30% indigenisation exists in the 'move' and 'fight' categories respectively. This is primarily due to lack of industrial base. So far as other non-technology intensive items for the shipyards are concerned, a large number of the ancillary suppliers to DPSU shipyards are professional businessmen / traders with little technical background. With profits taking

precedence over development, little effort is devoted to improving a product, incorporating technological advancements or even providing technical / R&D inputs. Since fit and finish, aesthetic appeal and professional pride cannot are difficult to be included in specifications, they are often the first casualty of this process and remain unchanged. This leads to the issue of vendor rating.

20. **Vendor Rating.** Of all the suppliers who provide a variety of equipment and fittings, only a few can be trusted to deliver in time while ensuring quality. It is therefore essential that we confine ourselves to a reliable vendors, as the gains from establishing a guaranteed supply chain, would more than offset gains from opting for the cheapest vendor. Further, as most vendors typically supply material for several projects across shipyards, a comprehensive vendor rating system shared between shipyards would aid performance monitoring, and facilitate accurate assessment of vendor capacity. Not only would this improve material sourcing, but would enable effective negotiations with the vendor during price negotiations and delinquent meetings. These could be aligned to the commercial practices followed by these DPSU shipyards.

21. **Commercial practices.** Defence PSU shipyards are governed by rigid procurement procedures. These procedures while aiming to structure the process towards full transparency and equal opportunity, are increasingly denying the navy and the shipyards the much needed freedom to exercise discretion based on sound professional judgment and painful past experience. The L-I syndrome, and the commercial activity associated with ordering even low value items on a fast track, hampers progress at every stage of shipbuilding. Thus, there is a strong need to simplify and rationalise the commercial procedures, reduce the number of intermediate checkpoints and fix time limits for each activity. Regular monitoring of the status of order using appropriate management information software is absolutely essential, for timely initiation of corrective measures and identifying alternatives. Items need to arrive just-in-time for production or fitment on board. Long storage periods in store houses and re-preservation of equipment at repeated intervals are neither cost effective nor desirable.

22. **HR Issues.** The productivity of any industry is related to the skill level of its workforce. Key reasons for low productivity in our DPSU shipyards has been low contact time, low motivation, poor supervision and training, a large no of trades, and inefficient use of facilities. Labour legislations and union related issues have created significant barriers for making the shipyards more efficient. It is almost impossible to shed jobs and to rationalise work standards and processes. The result is an employee count that does not justify the output. Shipyards have also not always managed to recruit professionally competent senior level managers with high leadership qualities to adequately motivate the workforce. As a part of the HR initiatives, more efforts is required to bring about an attitudinal/cultural change to synchronise personal/department goals with that of the shipyard.

Options & Strategies

23. **Identifying Shipyards with Niche Expertise.** The current practice of placing order for a particular class of ships on nomination basis or competitive bidding basis may not be the most desirable option. While competitive bidding leads to cost effectiveness, the same may not be

desirable in a long-term perspective with strategic vision. For example, the GRSE has been undertaking construction of ships ranging from WJFACs to LCUS to ASW Corvettes to Project 17A frigates. While this may be conforming to current policies and regulations, the same may not be the most efficient practice in the larger strategic interest. Thus, based on expertise, infrastructure and capabilities available, the shipyards could be identified to produce a type of platform such as destroyers, frigates, conventional submarines, SSNs, LPDs etc and could be nurtured accordingly so as to drive the strategic benefits. However, this strategy would be productive or beneficial only when shipyards have their desired efficiency with respect to delivery timeline and quality assurances. Counter-argument with respect to competitive pricing may be offered against this proposal. It is opined that in order to build niche strategic capabilities, competitiveness may not be the best answer. In this regard, the navy could develop an internal set of norms based on prior performance, to gauge if its plans and the shipbuilders proposals are realistic.

24. **Series Build.** Construction of warships is more efficient when a series of ships of identical design is constructed. The 'learning' achieved over a series of vessels results from a combination of shipyard learning and ship learning. Shipyard learning is due to improvements in processes and practices which is transferable to other projects and has a direct bearing on the yards productivity. A larger number of ships ordered in a series yields all round improvement in efficiency and economy, by eliminating the 'learning curve'. The effects of the learning curve on the productivity of shipyards and therefore on the cost to the navy must be realised. Ships should be built through independent series production lines, for delivery at regular intervals. Thus far, there has been precedence of building only 3-4 ships of a class for majority of recent projects related to weapon platforms (except Project 17A). This could be owing to funding constraints and long build period. Due to such long build periods, a weapon system so finalized while seeking govt sanction may not remain the most desirable option when the ship is inducted into the service. Thus, a three-pronged approach may be applied in order to achieve series build :-

(a) Prioritisation of projects, should there be a funding constraints.

(b) Indian shipyards need to adopt best practices and enhance efficiency in order to enhance productivity and reduce build period.

(c) De-link developmental system from build period adopting modular approach.

25. **New Weapons Projects.** Feasibility studies, and development of a new weapon system should precede concept design with a considerable head start. This is not only true for primary weapons and sensors but also for a host of other equipment, whose non-availability of timely binding data affects ship design and delays progress of build. Shipyards use such delays not only to cover up their own slippages, but also add to the costs by billing the project for an idle workforce and infrastructure. As with warships, a separate perspective plan for development of weapon and CMS systems would need to be drawn up, delinking it from current ship projects with separate funding. All such equipment that are under development should be clearly indicated with cut-off dates while pursuing contract, specifying alternate in-service equipment that would be reverted to, should the

development slip. One of the mitigation plan for such developmental aspect could be the needs to have an inherent capability in design so that platforms are amenable to technological upgrades during their lifetime. The modular approach to shipbuilding is in fact born out of this reality wherein ships built with modular technology are easier to be modernized / upgraded. However, it must be remembered that even this approach can never replace the original designed role.

26. **New Approach to Modular Construction.** Adopting modular construction reduces build-period and also the overall cost of the project. Currently, the practice of modular construction for surface platforms remain limited to fabrication of hull portion with very limited outfitting work. The progress of outfitting work at shop floor is faster than onboard ship and the cost of labour for undertaking such task onboard ship would always remain costlier than shop floor. The modular construction philosophy could truly succeed only when due diligence has been given to the aspect of 'detailed designing' by shipyards. Thus, a robust design department would remain a pre-requisite for the success story of modular construction. Shortcomings in 'detailed design' would lead to excessive re-work. Once the same 'detailed design' has been implemented on all ships of the class, this would also enhance overall ease of maintenance onboard ships.

27. It is also recommended that should the same class of ships be built at two multiple shipyards (for example four ships of Project 17A at MDL and three ships at GRSE), modular construction of parts / sections could be divided between shipyards to enhance overall efficiency. For example, Block A for all seven ships of P-17A are produced by MDL and Block B for all ships by GRSE and this could be transported to respective shipyards. While this would require significant co-ordination between shipyards in addition to internal financial transaction. Inefficiency at one shipyard could adversely affect productivity of other. While there could be skepticism to this approach, if implemented, this could significantly enhance productivity, efficiency and reduce build period.

28. **Authority & Accountability.** There have consistently been time and cost overruns in almost all projects which has also been recently been highlighted by the parliamentary panel on PAC. However, it is not always the Defence Shipyards which have been on the wrong end of the stick, quite often the delays have been due to various factors such as change in NSQRs midway through the construction phase, effects of sanctions, technology control regimes, delay in availability of materials, labour and Trade union issues etc. In the corporate sector, while CEOs and top management have their final say, there is lack of independence or the lack of it in decision making by the DPSU shipyard management. Perhaps, it is due to lack of empowerment of the shipyard CMDs in financial and implementation aspects. More often than not, the shipyard management has to depend upon NHQ to get large number of decisions, even on mundane and routine issues.

29. If the shipyards are entrusted with the implementation of such high value projects / programmes, then there is no reason why the management cannot be empowered financially and administratively to implement the project in schedule and in budget. Many times, a fixed cost project is delayed due to lack of cutting-edge technology in time or due to cost escalation view unforeseen issues necessitating quick decision making. The current mechanism of large number of decisions remaining pending till convening of CPRM (which is a quarterly event) is considered an

inefficient mechanism. While absolute empowerment of shipyard CMD may not be acceptable due various reasons, a standing Board under chairmanship of CMD/Concerned Director of shipyard may be constituted with representatives from DDP (where applicable), steering directorate (and professional directorate) of NHQ, WOT (including trial agencies, where applicable) so as to arrive at a corporate decision making structure. This may go a long way in cutting delays.

30. **Collaboration & Partnership.** Warship construction requires committing huge resources in the form of technology, skills, expertise and infrastructure. World over, warship building is ceasing to be an activity confined to just one shipbuilding yard. Changing market conditions have compelled consolidation and globalisation at the level of prime integrators and specialist high level sub system suppliers in several fields. Thus, collaboration is an important means of creating indigenous technology and developing intellectual assets in the country. Joint ventures with foreign shipyards and design bureaus could aid in imbibing modern technology in 'Integrated' and 'Modular' construction, facilitating better quality and better build periods. The trend today is towards collaborative efforts between shipyards and the same could be progressed by our DPSU shipyards.

31. In order to optimise shipyard loading, collaborative construction between DPSU/Private shipyards may be progressed; this is beyond sub-contracting. The aim of the collaborative approach is to use the capabilities and resources of private shipyards to overcome the limitations of the DPSU shipyards in enhancing the overall indigenous warship building capacity. While DPSU shipyards have the expertise and experience in warship building, private shipyards can provide additional infrastructure and facilities induction/hiring of skilled manpower on more attractive terms and bring in new technology through tie-ups with advanced ship yards. The strength of both private and DPSU shipyard could be synergised through a mutually beneficial partnership.

32. **Adoption of Latest Techniques.** The DPSU shipyards are to be willing and geared to adopt and adapt to the latest techniques and technologies which would enhance efficiency in long-term. Integrated construction is one such step in ship construction, and could optimise the general performance of the shipyard significantly as such. This methodology has changed traditional ship construction processes world over, demanding a complete re-engineering process focused on the build strategy. A key element to be infused into our warship build programmes in totality, it would contribute to shorter delivery times. Success to this is once again hinged on detailed and meticulous planning and timely availability of equipment.

33. **Govt Policies.** The government should take urgent policy decisions to promote the shipbuilding industry as a sector. **A significant portion of the cost of the ship pertains to minor equipment and fittings manufactured by ancillary industries. Once the shipbuilding industry attains critical mass, these ancillary industries would become viable, jump starting the economy.** The Indian private sector is often found to be unwilling to partner the risks involved in defence projects and are reluctant to work without assured orders. Long term returns can accrue from a committed defence industry partnership with the exciting possibility of garnering export orders, and its obvious benefit of national interest. The Govt policy pertaining to subsidy in shipbuilding sector which was stopped in 2007 could be resumed.

Conclusion

34. Colossal resources in terms of skill, expertise, and infrastructure need to be mustered to produce a modern warship. The 'self-sufficiency' that we seek should be in certain well defined core areas; and in our quest for self-sufficiency, we should not waste time and resources towards re-inventing the wheel. Whenever it's required for better efficiency, and wherever it will save time, we should enlist expertise from India or abroad.

35. To improve the scheduled performance of its shipbuilding programmes, the navy should develop an internal set of norms based on prior performance, to gauge if its plans and the shipbuilders proposals are realistic. The cost assessment at the initial stage is to be based on actual pricing and estimated rates of inflation. Prior to production, the emerging cost should be verified by an independent financial review before separately negotiating the build contract and committing to the main investment.

36. The Indian Warship building industry has taken giant steps over the past four decades with a high degree of self reliance. However, there is a vast scope for improvement and we need to draw from some of the modern and innovative design and ship building practices, to synergise our warship acquisition process.

37. A paradox that exists in India is that certain specific sectors especially information technology has become world-class in their competitive structure, while others have languished. As this paradox has generally been ignored, a focused effort has to be made to revive lagging sectors like shipbuilding, because of its critical importance to the nation's long-term, overall prosperity. India's development as an emergent economic entity and her growing international stature is increasingly linked to her ability to shape the maritime environment and thus the indigenous shipbuilding industry assumes an unprecedented strategic significance.

Author's Biodata

Capt Manoj Jha a Gunnery Specialist, was commissioned on 01 Jan 95. Some of his appointments include specialist onboard Mysore and Rana, instructor at Dronacharya and JD at IHQ MoD(Navy) / DNT and DACP. He also served as EXO onboard Viraat and commissioning CO of Kamorta. The officer is currently undergoing NHCC at the Naval War College Goa.

article

11

NATIONAL COMPETENCE IN MARINE PROPULSION - THE ROAD AHEAD

(By Captain Sameer Singh Chaudhry & Captain Gagandeep Singh Sidhu)

Introduction

1. India is on the path to build a strong Navy of nearly 60 warships and 110 auxiliary/ support platforms. Presently, nearly 47 platforms are at various stages of construction in Indian Shipyards[1]. This would take India into select group of countries with true blue water naval capabilities and strengthen India's vision of becoming the net security provider in the Indian Ocean Region (IOR)[2]. Therefore, it is of paramount importance for the Indian Navy to have a strong in-house ship design and building capability supported by a robust manufacturing base to become a self-reliant regional force with minimal foreign dependencies. The Indian Navy has been committed to this strategic vision and a clear reflection of this is evident in its enduring support to indigenous warship building programmes. Towards this, the Indian Navy has released a vision document at its Indigenisation Seminar in July 2015 titled "Indian Naval Indigenisation Plan (INIP) 2015-2030", to enunciate the need for indigenous development of various advanced systems for its platforms that the Public and Private sector industry may focus on to meet the Indian Navy requirements in future. Further, Prime Minister Narendra Modi's push to 'Make in India' is likely to give impetus to the Indian Navy's effort to become self-reliant.

2. The Indian Navy in particular has actively pursued its goal of self-reliance since early 1960's with most major warship construction programmes being progressed within the country. Presently, the Indian Navy has successfully matured its design organisation, which has been the corner stone of India's indigenous warship building programme, starting with a modest beginning by designing auxiliary craftsand growing to successful design of all major classes of warships including frigates, destroyers and an aircraft carrier.

3. The Indian Navy considers the industry as an important stakeholder not only as provider of the needed technical know-how and vast manufacturing experience, but also to bring its concepts and proposed capability to fructification in the form of world class defence hardware that would serve its needs. Towards this, the role of Public and Private sector has been significant in realisation of the Indian Navy's in-house warship designs. The indigenous industry, in supporting the Indian Navy vision of self-reliance, has reached a stage wherein equipment content of upto90 percent in 'Float' category, 60 percent in 'Move' category and about 30 percent in 'Fight' categoryis being

---

[1]Kulshrestha, S (Jan 2014) India's Warship Building Capability : SP Naval Forces (Issue Jan 2014) Pg 11, 13

[2]The term 'Net Security Provider' was used by former Prime Minister of India, DrManmohan Singh while laying the foundation stone of National Defence University on 23 May 2013

manufactured within the country[3]. Further, a number of projects are underway for indigenous development of marine systems including main propulsion controls through various agencies such as DRDO, DPSUs like BEL and Private Sector firms like L&T, Mahindra Defence Systems and Tata Power SED [4].

4. In the 'Move' category, though 60 percent indigenisation has been attained, but this continues to be restricted to low end auxiliaries of Main Propulsion Plants. This paper evaluates the present national competence in marine propulsion with a clear focus on the warship sector. Emphasis has been laid on the challenges which have restricted the progress. More importantly, the paper proposes a road map for the Indian Navy, working in synergy with Industry partners to achieve a much desired increased indigenous content from the present 60 percent to 80-90 percent in the 'Move' category, focusing primarily on Marine Propulsion systems. The paper deliberates that in pursuance of the country's 'Make in India' vision, the time is presently ripe for both the Indian Navy and its Industry partners to take their buyer-seller relationship to the next level to achieve its goal of self-reliance in the Marine Propulsion equipment.

The Slow March - Present Indian Industry

5. Many large and prominent Indian firms like Tata, Mahindra, Reliance, Kirloskar and Larsen &Tuobro, have set up special verticals to support the country's vision of 'Make in India', and thereby the Indian Navy's goal of self-reliance. Notable achievements have been made in indigenisation of equipment in 'Float' category. However, the limited success in 'Move' category equipment has resulted in import of equipment from diverse sources. Some of the reasons for low levels of indigenous capability in the 'Move' category are as follows: - (a) High developmental costs with long lead time.

(b) Higher equipment performance standards to meet naval requirements.

(c) Economy of scale view requirements of limited numbers.

(d) Poor results of Research and Development project in field of marine Gas Turbines.

(e) Rapid development in technology to meet more stringent emission norms, becoming a roadblock in induction of contemporary indigenous technology.

6. In the Marine Propulsion sector, indigenous development has been limited to low capacity diesels, auxiliaries, hydraulic systems, pumps, compressors and propulsion/ auxiliary control systems. This paves the way for further collaboration in the self-reliance efforts in main propulsion engines, gearboxes and shafting systems. Some of the systems where complete self-reliance has been achieved in the 'Move' category are as follows: -

---

[3] *Indian Naval Indigenization Plan 2015-30*
[4] *Kulshrestha, S, op. cit.*

Table 1: Complete Self-Reliance achieved[5]

Ser	Equipment	Firm
(a)	SteamTurbine	M/sBHEL
(b)	Boilers	NavalDockyard,Mumbai, M/sThermax
(c)	ROPlants	M/sRochem, M/sTechnoprocess
(d)	Pumps	M/s Best &Crompton, M/s Alekton, M/s BEPumps
(e)	HP Air and ACCompressors	M/sELGICompressors, M/sACCEL
(f)	AC and Ref Plants	M/s Voltas, M/s KPCL, M/sACCEL
(g)	Steering Gear &StabiliserSystem	M/s VeljanHydrair, M/sL&T, M/s GeetaEngg
(h)	Gas	TurbineGenerator (GTG) ControlSystemM/s BEL
(j)	Machinery Control Systems	M/s KOEL, M/s Symtronics, M/s L&T

Scope for Capability Development

7. The major marine equipment in the 'Move' category where there is a shortfall in indigenous manufacturing capability is warship Main Propulsion systems (other than steam propulsion). The present status of warship Main Propulsion in service with the Indian Navy and its scope for development in future is as follows: -

(a) **Gas Turbines.** The Indian Navy presently has in service Soviet origin Main Propulsion Plants on board its Rajput, Delhi, Talwar and 1241 RE class ships. The in-house designed P-17 and under construction aircraft carrier, Vikrant have the General Electric engine LM2500. All Soviet origin Main Propulsion Plants are being fitted as complete propulsion packages, which include Engines and Gearboxes supplied by Zorya, Ukraine and Shafting and Propellers supplied by Russian manufacturers. This is also the case for in-house designed ships with Soviet origin Main Propulsion Plants i.e P-15A and P-15B projects. For the indigenously designed P-17 and Vikrant, the General Electric LM2500 engines have been supplied by Hindustan Aeronautical Limited (HAL), Bangalore, which undertakes licenced production of the General Electric engine from OEM knock down kits. HAL also has necessary infrastructure to support the engines in service. It may be noted that no component of LM2500 engines is locally procured/ manufactured and only assembly of complete knock down kits is being undertaken. On the development front, Gas Turbine Research Establishment (GTRE), Bangalore has been the only agency involved in development of a marine Gas Turbine under its Kaveri Marine Gas Turbine (KMGT) programme. This programme involves development of a marine derivative engine from the indigenous aero engine for Light Combat Aircraft. Post initial setbacks, renewed focus by the Indian Navy has put the engine development programme back on track by designating Bharat Heavy Electrical Limited (BHEL) as the production agency with GTRE being the lead technical agency. With indigenous Destroyers being designed with COGAG plants of engine rating of 12 MW, there exists a scope for indigenous capability building for a marine Gas Turbine engine in this power range.

[5] *Indian Naval Indigenization Plan 2015-30, op. cit.*

(b) **Diesel Engines**. Kirloskar Oil Engines Limited (KOEL), MAN, GRSE/ DEP-MTU and Cummins India have all been involved in licenced production of marine Diesel Engines in India. Within this category, KOEL with its licenced production of SEMT Pielstick engines has been a major supplier of Main Propulsion diesels for P-25, P-25A, P-28 corvettes and P-17 frigates. However, in the recent past, the takeover of SEMT Pielstick, France by MAN, Germany, has led to discontinuing of licenced production of these engines. Therefore, Indian Navy's resolve to have indigenous manufacturing capability in Main Propulsion Diesel Engines in the range of 1 to 6 MW power range assumes prime importance.

(c) **Gearboxes**. The majority of main propulsion gearboxes installed onboard frontline warships are imported, either from Zorya, Ukraine for Soviet origin Main Propulsion Plants or from Renk, ZF and Reinjtes for indigenously integrated Main Propulsion Plants with engines of Western origin. The Indian firms involved in supply of Main Propulsion Gearboxes for Naval platforms are Walchandnagar Industries, KPCL and Elecon, mainly through collaborative agreements with foreign OEMs and minimal indigenous content. Efforts to undertake indigenous development and manufacturing was progressed by KPCL with recently inducted Water Jet Fast Attack Crafts. However, premature failures on these units led to replacement of the gearboxes with imported ZF make units during the operational period of the ships. Therefore, there exists a strong case for renewed/ focussed efforts towards indigenous manufacturing and capability building with regard to main propulsion gearboxes in the range of 1-50 MW, especially for the new construction ships.

(d) **Shafting/ Controllable Pitch Propellers (CPP)**. As in the case of Gearboxes, Soviet origin Main Propulsion Plants also have integrated Russian origin shafting and propellers. Presently, limited competence exists in country for indigenous manufacture of shafting as whole equipment. Though minimal manufacturing capability in terms of bearing components exists,it is considered grossly inadequate. In case of Propellers, Fouress has displayed credible capability for indigenous supply of fixed pitch propellers. However, for Controllable Pitch Propellers, the indigenous capability is limited only to certain hydraulic components with majority of the system being imported. Thus, there exists a need to indigenously develop shafting systems, including CPP, with a greater indigenous content to attain self-reliance in this field.

(e) **Induction of Future Technology - Electricand Nuclear Propulsion.** The Indian Navy envisages the construction of four Multi-Role Support Vessels (MRSV) ships with Electric Propulsion and the next Indigenous Aircraft Carrier (IAC-2) with Nuclear Propulsion in the near future. In case of MRSV project, collaborative tie up of three Indian Private sector shipyards with global leaders with experience of building these ships forms the basis of ship construction. It may be inferred that the electric propulsion plant for MRSV ships would be integral to the design of the foreign shipbuilders.

8. It can therefore besummarised that Gas Turbines, Marine Diesel Engines, Gear Boxes, Shafting and Propellers for warships which are presently imported hold much scope for indigenous manufacturing by the Indian Industry to help the Indian Navy to achieve self-reliance in 'Move' category. These can be broadly classified into the following:-

Table 2: Marine Propulsion Equipment for Indigenous Manufacture

Ser	Equipment
(a)	Gas Turbines (12 MW)
(b)	Main Propulsion Diesel Engines (1-6 MW)
(c)	Complex Marine Gearboxes (1-50MW)
(d)	Shafting
(e)	Propellers - Both Fixed & Controllable Pitch

Models for Indigenous Capability Building

9. Bringing forth a holistic view of the indigenisation paradigm, the Kelkar Committee[6] had correctly brought out that concept of indigenisation needs to involve capability enhancement and development, increasing the know-why, design and system integration[7]. The Ministry of Shipping Report on Maritime Agenda 2010-2020 submitted in 2011 recommended development of Indian Ship Building Industry to enhance domestic ship building capabilities and adopt a mission mode approach for the same[8]. It also recommended a mechanism to synergise the efforts of Indian Navy/ Ministry of Defence and Ministry of Shipping for meeting the long term requirements of the country in both warship and commercial shipbuilding.

10. As has been highlighted earlier, the present indigenous capability in the field of Marine Propulsion is limited to auxiliaries and is virtually absent in case of main engines, gearboxes and shafting. Development of indigenous capability in this field would involve one or a combination of approaches, including Research & Development, Joint Ventures, Transfer of Technology, Public and Private Sector Partnership[9] models. Some of the key dynamics of these models are as follows: -

(a) **Research & Development**. Where the know-how and know-why of niche technology would not be shared by the foreign OEMs at any cost, development through Defence Research and Development Organisation (DRDO) route is essential for self-reliance. This model is also suitable for development of equipment wherein the required infrastructure and investments are prohibitive for Private sector to venture. Such projects are normally taken up as a national mission for capability enhancement. The Indian Navy has accordingly committed to support the Research and Development efforts of DRDO, DPSUs and educational institutions towards enabling the creation of home grown technologies to meet the challenges of the future. In the field of Main Propulsion technology, Gas Turbine is the niche technology equipment where indigenous development is necessary. Development of a marine Gas Turbine engine of an

[6]Vijay Kelkar committee was set up in 2005 by Government of India/ Ministry of Defence to review Defence PSUs, DRDO, Ordinance Factories and Private sector partnerships to promote Indigenisation and co-production of Defence equipment in India
[7]Kulshrestha, S, op. cit.
[8]Ministry of Shipping, Government of India,Maritime Agenda 2010-2020, Chap 18 (Pg 385)
[9]*Singh, Randeep (2009), Indigenization for Warship Building ; Ship Building in India: Challenges and Strategies (Pg 141-48)*

approximate 12 MW power rating is being progressed under this route by GTRE. No other Marine Propulsion equipment is envisaged to be developed under this route.

(b) **Joint Ventures**. Development of equipment through joint ventures is appropriate for units which are expensive with low volumes of requirement and may not justify the high investment costs. This route, even in a conflict scenario, would adequately support the equipment in service and could also enhance capacity building to a certain extent. Licenced production of equipment also falls under this model. Joint ventures of Defence Public Sector Undertaking, Garden Reach Shipbuilders and Engineers -Diesel Engine Plant (GRSE-DEP) with MAN and MTU along with KOEL with SEMT Pielstick have manufactured engines for multiple projects in the past. This route makes it a recommended option for 'Make in India' manufacturing of Diesel Engines, Gearboxes and Shafting either through licenced production under Joint-Venture companies

(c) **Transfer of Technology (ToT)**. ToT is an important route for achieving certain degree of self-reliance. However, high volume of production is a must to be cost effective in such a model. The downside of this route is that the much needed transfer of know-how and know-why invariably is not provided. Foreign OEMs tend to hold back critical design parameters for ensuring continued reliance on them. This route is therefore not considered applicable for manufacturing of Marine Propulsion equipment in the country.

(d) **Public Sector Units (PSU)**. Though India has a strong PSU base for manufacturing of certain high end technology equipment, it is observed that no PSU specialises in Marine Propulsion technology and the shipyards invariably fill this void, in the form of either a joint venture with foreign OEMs or undertaking limited in-house production of small components. This model was used by GRSE-DEP for limited licenced production of MAN engines for survey class (Sandhayak and Investigator) and LCU Mk II ships and MTU engines for Seaward Defence Boats (SDB) at its Diesel Engine Production Plant. The tie-up with MTU for production of SDB engines was at the insistence on the Indian Navy. Another notable achievement in this model has been the development of steam turbines by BHEL and steam auxiliaries by HAL. However, this model is associated with thepre-liberalised era and is less relevant in the present day scenario where most of the global leading manufacturers have their presence in India through respective subsidiaries.

(e) **Private Sector**. Private sector participation is off late becoming the most preferred route to gain in-house manufacturing capabilities due to its competitive outlook including work culture with reward system and ability to retain competent, capable and productive manpower which reduces the technology absorption period and manufacturing time. However, the major drawbacks of this route are the inability to show repeat orders on the same firm due to procurement procedures involving multiple vendor situation and low order quantities making it commercially unviable. This can be overcome by developing new models of engines that are aimed at commercial segment and adapting these to naval applications. A case in example is DV series engines (albeit power rating < 1 MW) developed by KOEL and being fitted on NOPV and CTS shipbuilding programmes. Unwillingness to undertake large projects with high R & D costs by the private sector is another major shortcoming in most cases. It is pertinent to note that most leading international manufacturers of Marine Propulsion equipment have already opened their subsidiaries in India for product support of in-service units. Confidence building measures with suitable policy incentives need to be put in place to influence these OEMs to bring their manufacturing capabilities to Indian soil. Private sector route through OEM setting up manufacturing plants directly in India is considered most relevant in enhancing the capability for manufacturing of Marine propulsion equipment in India.

11. It is there foreinferred that a combination of these models would have to be adopted to have a roadmap for developing indigenous manufacturing capability in Marine Propulsion equipment. For the indigenous marine Gas Turbine, Research and Development by GTRE and subsequent manufacturing capability through PSU route i.e. BHEL is an ideal approach. For the Diesel engines, Main Propulsion Gearboxes, Shafting and CPP systems - Joint Ventures, OEM subsidiaries (Private sector) with manufacturing capabilities and Research & Development by Indian Private sector Company (eg. KOEL) is the recommended approach.

Proposed Road map to Self Reliance

12. The process of gaining competence in the field of Marine Propulsion Technology and corresponding capability development using key enablers of Joint Ventures and Private sector partnership can be broadly classified into three phases of Short, Medium and Long term. The broad timelines proposed for these phases are only guiding factors and would have to be adapted to the number of ships being built under a particular class, corresponding requirement of main propulsion plants, associated shipyard, propulsion system integration agency and above all the Defence Procurement Procedure guidelines in vogue. These phases and their envisaged timelines with an example of how these stages would progress over the induction of a class of ships are: -

(a) **Short Term (2 to 4 years) -Setting up of Indian Subsidiaries**. The foreign OEMs would be mandatorily required to set up their Indian subsidiary for maintenance and life cycle support of equipment when being considered for supply of equipment for new construction warships through special clause in the Request for Proposal. Policy of enhancing the present FDI limit from 49% to the industry sought 100% in the near future for a niche core technology could be a key enabler in this process. This would ensure participation of local personnel into these technological fore runners. Towards this, most of the main suppliers of marine propulsion equipment such as MTU, Wartsilla, Cummins, MAN have already set up their Indian arms and are currently providing satisfactory product support for their equipment in service. This stage in Marine Propulsion Technology other than in case of Gas Turbines (GE LM2500) and Russian origin complete Propulsion Plant packages can be considered complete. However, since the sale of Russian origin equipment is normally controlled through their state agency, setting up of an OEM subsidiary may not be feasible. During this phase, the delivery of first ship set of marine propulsion equipment is envisaged through import. Additional advantages also include the following: -

(i) **Indigenous Product Support**. Presence of Indian subsidiary would ensure enhanced and prompt product support of the equipment coupled with greater OEM accountability both at the ship building stages as well as post induction into service.

(ii) **Technical Expertise**.As the Indian subsidiary provides product support to the installed equipment, the local engineers would gradually gain technical acumen and competence towards highest levels of maintenance. This would result in removal of the first barrier between technology and the local technical manpower.

(b) **Medium Term (3 to 5 years) - Assembly of New Units in India**. With absorption of technical know-how of the equipment by the Indian subsidiary, the environment would be conducive to undertake assembly of new units from imported knock-down kits in India by the OEM Indian subsidiary. Availability of trained manpower would encourage the OEM to set up further facilities to take advantage of low labour costs that India offers. Supply of second ship set of marine propulsion equipment could therefore be assembled from knock down kits for engines and gearboxes. Indigenous production or sourcing of technologically low end components such as casings for gearboxes, integrated heat exchangers and instrumentation for diesel engines could also be undertaken at this stage. Simultaneously, setting up of plants and increasing local vendor base by the OEM subsidiary would be progressed concurrently.

(c) **Long term (5-8 years)- Local Manufacturing of Equipment**. By this stage the OEM is expected to complete the setting up of his facility to undertake complete production of 'Make in India' product. Towards this, the OEM would have developed his local sub-vendor base in the form of Micro Small and Medium Enterprises (MSMEs) to localise sub-assemblies towards reduction of the production cost. Advantages for both the OEM and Indian Navy at this stage would include the following: -

(i) **Product Support**. With 100% manufacturing being undertaken in India, the highest levels of product support would be available. Further, the supply chain for procurement of maintenance spares would also be short and prompt.

(ii) **Research and Development**. The strong technical base available in the form of institutions like IITs, IISc, would allow the OEMs to automatically collaborate in the field of Research and Development of their new products resulting in infusion of Marine Propulsion Technology into India.

13. Additional Incentives/ Initiatives to boost Marine Propulsion Technology infusion. To attain technical prowess and capability in the field of Marine Propulsion Technology for warships, certain additional incentives would be required to lure the global market leaders to set up local manufacturing units in India. These incentives could be in the form of the following: -

(a) **Enhancement of FDI to 100 percent**. This could be a game changer since it would allow the foreign OEMs to directly set up units in India to manufacture Marine Propulsion equipment.

(b) **Setting up of Special Economic Zone**. Tax breaks/ setting up of exclusive defence SEZs etc would also boost the confidence of OEMs to set up infrastructure in India. An example which could be emulated is Israel, a country which boasts of an advanced defence industry, and continues to incentivise local enterprises through a 15 per cent price preference.

(c) **Soft Loans**. The Indian defence industry operates in a hostile financial framework that tends to render it less competitive vis-à-vis foreign manufactures with double-digit interest regime compared to the nearly zero interest rate system prevalent in Europe, US and many other countries increasing the cost of working capital for the Indian industry, making them uncompetitive vis-à-vis the products offered by foreign manufactures. Therefore, offering loans on low interest rates for the defence Manufacturing sector could be considered as an incentive to boost 'Make in India'.

(d) **Exchange Rate Variation (ERV) Protection**. The Indian industry also suffers on account of the variation in exchange rates wherein as per the Defence Procurement Procedures (DPP), Indian Companies are required to bear all the risks associated with ERV. To overcome this, the Indian manufacturer could declare the effect of ERV on his product and a protection offered to ensure a level playing field wherever indigenous manufacturers are competing with foreign OEMs.

(e) **Taxes and Duties**. Under the prevailing taxes and duties structure, virtually no incentive is offered for any local company to undertake indigenous defence production. In fact, India follows an 'inverted structure' by which direct import is allowed free of duties whereas manufacturing the same product at home attracts several taxes and duties, though of late, weightage towards formulating the comparative tender statement has done away with this disparity.

(f) **'Infrastructure Status' to Defence Manufacturing Sector**. Creation of conducive financial framework for the local industry is essential to promote local manufacturing. Accord of 'infrastructure status' to defence manufacturing industry would address the industry's concerns about taxes and duties. The same would also become an incentive for new investments and would promote manufacturing of Marine Propulsion equipment in India. Grant of a 'deemed export status' to certain sales of the local industry whenever such sales are likely to substitute direct import would further promote defence manufacturing capacity in India.

(g) **Nomination of Equipment for Shipbuilding Projects**. Assured volumes through nomination of key indigenous elements of Main Propulsion Plant components like Diesel engines, Gearboxes and Shafting systems will encourage companies to invest in development of indigenous products. An example of this is on-going development of a 280 mm bore medium speed engine by KOEL to fill the void left by SEMT Peilstick demise. Development of equipment would get a certain boost if assurance is provided to the OEM for fitment on nomination basis, though present procedures preclude the same. But if mechanisms on indexed yearly price escalations are put in place to safeguard against monopolistic trade, such nominations can be achieved.

(h) **Defence Procurement Procedure (DPP) - 2016**. DPP-2016, which is in final stages of approval[10] is likely to introduce the following incentives towards indigenous manufacturing capability building: -

(i) **'Indigenously Designed, Developed and Manufactured' (IDDM) equipment**. The category of IDDM as top priority and the first to be chosen for tenders is likely to be introduced. It is understood that this will have two sub-categories - one where it will be mandatory to have 40 per cent local content in case the design is also indigenous and second where in case the design is not Indian, 60 per cent local content will be mandatory. Further, the definition to be counted as an 'Indian company' would be a company that is controlled and operated by Indian nationals so that the Intellectual Property Rights would remain within the country. This would reassure the Indian Companies to progress indigenous development of defence equipment.

(ii) **Private Sector Research and Development**. DPP-2016 is also likely to introduce the policy of funding Indian private entities (Medium and Small-Scale industries) in Research and Development to encourage more local development. Towards this, Department of Defence Production will fund up to 90 per cent of the Research and Development, of which 20 per cent will be given in advance and in 24 months the entity will be given tender. If the tender is not given, the private company will get a refund of its expenses. For the medium-scale industry, funding would be upto Rs 10 crore for Research and Development.

14. **Envisaged Roadblocks in Proposed Roadmap**. The Indian defence industry was opened up to the private sector in 2001. However, limited success has been achieved since then. The biggest hindrance in the private sector's participation so far has been mistrust. When it comes to big contracts, procedural hurdles come in the way, making it virtually impossible for the private sector to get into complex defence manufacturing. Moreover, single source procurement from the private sector is still considered a taboo, whereas import without competition is accepted. There is a need to change the mind-set and treat the private sector as an equal partner. This can only be demonstrated by awarding big contracts, preferably through the 'Make' and 'Buy and Make (Indian)' procurement categories, which hold the key to the success of the private sector's participation in defence production. The key envisaged roadblocks in the proposed model are as follows: -

(a) **Sharing of Know-How and Know-Why**. The unwillingness to part with its technology by the OEMs is an envisaged roadblock in the frame work. To be able to do this, the OEM should have the complete Intellectual Property Rights of its product and not be dependent on other sources and suppliers. The OEM's balanced approach in becoming a willing stakeholder in supporting indigenous co-production and co-development through an institutionalised mechanism would be a key to success of this model.

---

[1] *News article in DNA dated12 Jan 2016; www.dnaindia.com*

(b) **Economy of Scale**. A key concern for the OEM could be the economy of scale for setting up of infrastructure in India. However, this could be easily offset by the cheaper production costs and potential of exporting the equipment to emerging Navies of IOR, India being the net security provider to the region. An example is importing of Main Propulsion Gearbox for Offshore Patrol Vessel built at Indian Shipbuilding Yard for Sri Lanka. India's shipbuilding industry, with orders for construction of Offshore Patrol vessels and Fast Interceptor Crafts for friendly foreign navies in IOR is gradually maturing into regional warship building hub. Standardization of Marine Propulsion equipment across platforms would be an ideal solution to rake up the economy of scale.

(c) **Upgradation of Indian Sub-Vendors**. Small and Medium Enterprises (SMEs) would need to upgrade manufacturing capabilities and production technology in order to meet the standards of OEMs of Marine Propulsion equipment to become their sustainable sub-vendors. This could be overcome by giving soft loans through government schemes to these sub-vendors on recommendation of the main equipment OEM

(d) **Naval Technical Specifications**. The role of Indian Navy remains pivotal in laying down its specifications for equipment. Without comprising on the quality, the Indian Navy could have a re-work the specifications in terms of what the platform demands and what the Indian manufacturer can deliver, rather than running for the best in the world. Competition amongst Indian manufacturers is essential to create quality products with upgradation of technology.

Conclusion

15. The Indian Navyhas been a pioneer in indigenous capability building and its blue print for future is firmly anchored in indigenisation and self-reliance as has been put out in the INIP. A key area of focus for the Indian Navy has been to maximise the indigenous content in 'Move' category, where major Marine Propulsion components such as Main Engines, Reduction Gearboxes, Shafting and Propellers for warships are being imported. To achieve this, the paper concludes that a two pronged approach of attaining niche Gas Turbine technology through Research &Development by DRDO/ Public sector and building a strong manufacturing base for other equipment such as Diesel Engines, Gearboxes and Shafting systems through Private Sector is essential. If achieved, this would heralda new era of technology enrichment in the field of Marine Propulsion for the country.It may therefore sufficeto say that to achieve this competence, a national mission mode and holistic approach would need to be adopted where both DRDO/ PSUs and Private Industry would be required to achieve their respective goals in a time bound manner.

Author's Biodata

Captain SS Chaudhry is an alumnus of 6th Naval Engineering Course and completed B Tech in Mechanical Engineering from Naval College of Engineering, INS Shivaji, Lonavla. He has done M Tech in Corrosion Science and Engineering from IIT Powai. He has done tenures in OPV, SNM and LST (L) class ships in addition to two tenures at ND(V). He was also Oi/c Diesel Testing and Tuning Team, Visakhapatnam. The officer is presently undergoing Naval Higher Command Course at Naval War College, INS Mandovi.

Captain GS Sidhu is an alumnus of Rashtriya Indian Military College, Dehradun and National Defence Academy, Khadakwasla. He completed his B Tech in Mechanical Engineering from Naval College of Engineering, Lonavla and his M Tech in Systems and Controls Engineering from Indian Institute of Technology, Mumbai. He had tenanted multiple tenures onboard Delhi class destroyers and shore appointments in Naval Dockyard, Mumbai and Directorate of Marine Engineering at IHQ MoD(Navy). The officer is presently attending Naval Higher Command Course at Naval War College, Goa.

article

12

INDIA'S SHIPBUILDING INDUSTRY - FUTUREMARKET LEADER WITH 'MAKE IN INDIA' PARADIGM ?

(By Captain Jasvir Singh)

Introduction

1. **History of Shipbuilding in India**. During the period of the Indus valley Civilisation, single / double masted ships from India are reported to have ventured for trade as far West as Euphrates (modern Iraq) and up to Malaysia on the Eastern sea board. From the fifth century BC to the sixth century AD, India continued to dominate the sea in the region. The art of ship building and sea and coastal navigation further flourished under the Maurayans. Emperor Ashoka is also reported to have encouraged recruitment of foreign experts for ship building and navigation. The war office of Chandragupta Mauraya had a full fledged 'Admiralty' under a Novadhayaksha which controlled a fleet of small ships to protect the harbours from pirates. The Andhra dynasty which followed the Maurayas, were the first to develop a blue water navy of the times and colonized Java and Sumatra. Main ship building centres were Calicut, Cochin, Kaveripattinam and Masaulipatnam. The shipping and ship building flourished during the Mughal era in various parts of India. In 1600s the British set up factories near Surat to manufacture Ghurabs (about 300 tons) and Galivats (about 70 tons) from strategic point of view. In 1735, in order to build ships at a site closer to the scene of action, the British transferred their Naval Dockyard from Surat to Bombay. Shivaji, the great Maratha leader, laid foundation of the Maratha navy in 1659. Naval activities were initiated which led a modest ship building programme near Konkan coast. It is evident that India has rich history in shipbuilding spread across the coastal regions.

2. **Peculiarities of Shipbuilding**. The shipbuilding industry has its own distinctive features as compared to other industries. It is unique in a way that:-

(a) It has to sell first and construct later, unlike the auto industry or other industries, where one manufactures first and sells later.

(b) The shipyards get orders only if they are credible (deliver ships on time) and it can be credible only after successfully executing consistently under international competition.

(c) Further, it has to be globally competitive against the best yards in the world. Unfortunately, the shipyards are faced with very stiff taxes, tariff, duties and other charges.

(d) The deliverables of the sector involves long gestation periods and requires high cost finances over a long period.

3. **Relation of Ship Construction vs Marine Equipment**. The shipbuilding industry is centred around two sub-sectors, namely, Ship construction (shipyards) and Marine equipment (shipyard

supply industry). The role of marine equipment manufacturers has become more important over time. Originally most of the shipbuilding work was carried out at the shipyards themselves. With technological advance, the role of marine equipment industry - as the supply industry to the shipyards - has increased dramatically. While in the 1970s most of the shipbuilding work was carried out at the shipyards themselves, nowadays the share of marine equipment is assessed at 50%-70% of the product value, and can be 70-80% in the more specialised segments. Close ties between equipment suppliers and shipyards therefore exist. The yard's focus is being driven by an increasing cost-efficiency combined with a focus on project management. Consequently, the scope for "adding value" is moving more into the domain of the component / equipment supplier. As a result, the marine equipment sector, which is defined as 'the supply industry to the shipyards', is becoming increasingly important.

4. In 2005 the total worldwide marine equipment market (turnover) was estimated at US $ 64 billion. Of this US $ 64 billion, around US $ 40 billion concerns the naval marine equipment and after sales. Around US $ 24 billion is related to the marine equipment in the commercial shipbuilding sector. When also the supplies to the oil and gas sector are taken into account (as is being done in certain definitions of the marine equipment industry), and additional turnover value of US $ 58 billion in 2005 can be added, bringing the total to some US $ 122 billion. Figure 1 shows the geographic structure of the marine equipment market in 2005 and includes all equipment used in commercial and naval ships and the after-sales services. Asia and Western-Europe are the regions with the largest market shares. The global market share of the marine equipment sector in Europe is clearly higher than the share of ship construction, reflecting the strong export position of this sector. Within Asia, the shipbuilding nations Japan and Korea had the strongest position. In 2004 the production output of South-Korea was estimated at US $ 4.4 billion and of Japan at US $ 7.3 billion.

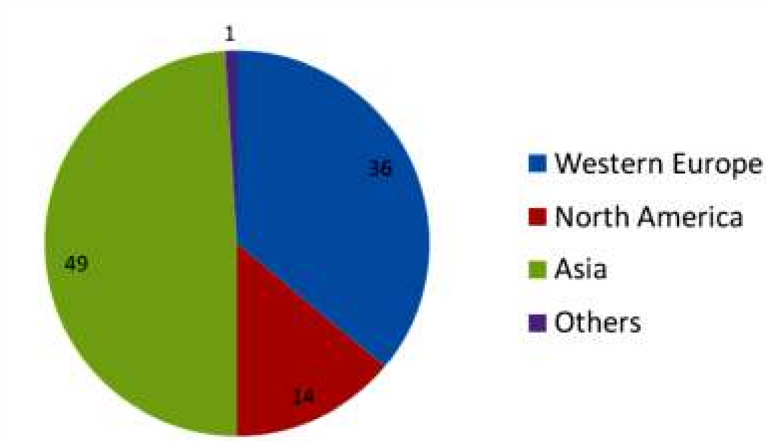


Fig 1. Marine Equipment - Regional Market Shares in 2005 (Turnover Value)

Global Shipbuilding Scenario

5. For three decades in the post World War II era, shipping and shipbuilding industries were dominated by European nations and United States. However, high labor costs in the yards of Europe and USA, one of the major determinants in this cost competitive industry, has led to a gradual shift of the centre of shipbuilding to the Asian countries over last two decades. Today shipbuilding has become an attractive industry for developing nations. Japan used shipbuilding in the 1950s and 1960s to rebuild its industrial structure. South Korea made shipbuilding a strategic industry in the 1970s and now China is in the process to repeat these models with large state supported investments in this industry. Global shipbuilding industry is estimated to be US $ 167 billion and is presently dominated by South Korea, Japan and China, which together account for around 85 percent of the world output. The market share of major shipbuilding nations is shown in Figure 2. Europe is active in many segments, and - notwithstanding the overall dominance of Korea, Japan and increasingly China - European companies are still dominant in a few specialised market segments such as cruise vessels (99% market share), offshore vessels (43%) and luxury yachts (65%).

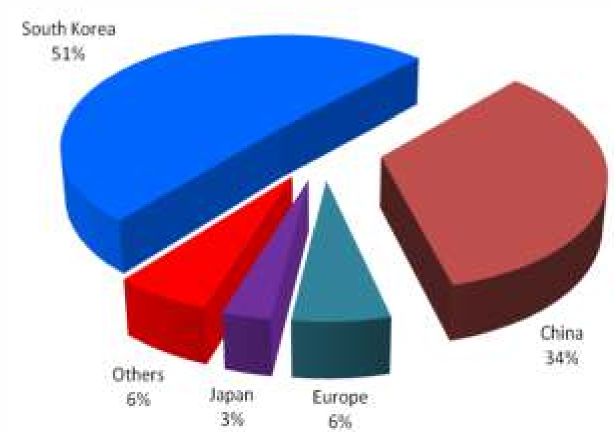


Fig 2. Market Share of Major Shipbuilding Nations

6. **Naval Shipbuilding**. Naval shipbuilding sector receives only limited attention since the market of naval ships cannot be seen as a fully open competitive market and is influenced strongly by non-economic factors. It is much stronger dominated by "soft" political and strategic factors than regular commercial shipbuilding. The naval shipbuilding market is a relatively stable market. In terms of US dollar value there has been a significant increase in the average cost of a naval ship. Partly this is due to exchange rate developments, but also an explanation can be found in economic-driven factors (material, labour and equipment) and customer driven factors (complexity, requirements and procurement rate), which each account for about half of the growth.

7. North America and Europe prevail in the naval shipbuilding market with a combined market share of nearly 85% (Figure 3). There are some reasons for this dominant position. Firstly, the naval shipbuilding industry requires a highly-skilled workforce which can be found in these regions. Next to that, most countries desire domestic shipyards to build their naval ships, for the ships and the newest technologies are object of classified material. The largest navy in the world is the US Navy, at a large distance followed by Japan, Germany, Taiwan, China, Britain, Korea and Russia. It this respect it should be noted that, although yet at its infancy stage, also naval shipbuilding in South Korea is growing rapidly, becoming a major supplier of patrol and supply boats for navies. This is further stimulated by the ambitious naval shipbuilding program that has been initiated by the Republic of Korea Navy.

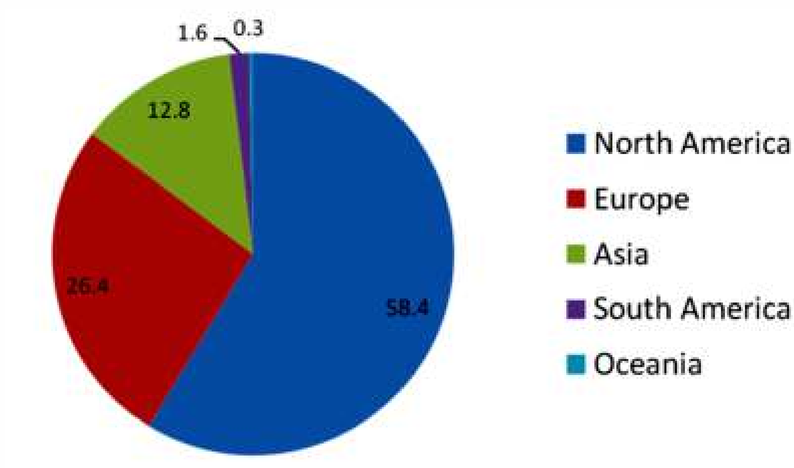


Fig 3. Market Share in Naval Shipbuilding by Region (in USD; 2006)

8. The major shipbuilding nations of the world are as follows:-

(a) **Japanese Shipbuilding Industry**. The Japanese shipbuilding industry is divided among six major shipbuilders and 18 medium-sized shipbuilders. The majors are components of large, diversified heavy industry conglomerates, and most have two facilities. Also, only the majors build naval warships. The major shipbuilders are substantially vertically integrated, even to the point of producing large components such as main propulsion, low speed diesel engines etc. At most, they totally outsource certain parts of the accommodation outfit. They use peak outsourcing to level the demands within their shipyards and to manage their workforce. However, because of their high throughput, flexible workforce, and shop management ability, Japanese shipbuilders experience relatively few in-yard labour demand fluctuations when compared with their overseas counterparts. During peak demand periods, a major Japanese shipbuilder will spread work over its facilities or may outsource blocks to smaller shipyards or specialized companies. In the general course of shipbuilding operations, major shipbuilders rely heavily on in-yard subcontract labour, mostly in production, to provide management with the flexibility that the traditional Japanese labour employment system does not accommodate. Medium sized Japanese shipbuilders are less vertically integrated than the six majors. They evolved this structure primarily to minimize fixed costs. These medium sized shipbuilders outsource to a much higher level than their major counterparts, especially in design and research and development functions. At least one of these builders, Shin Kurushima, has established a subsidiary company to handle all pipe work for its multiple shipyards. Japan's medium sized builders do use subcontractors to a high degree to manage peak workloads. Typically, 30 to 50 percent of the workforce for this size of shipbuilder will be made up of subcontractors.

(b) **South Korean Industry**. The South Korean shipbuilders are vertically integrated, maintaining more functional capabilities in-house than other leading shipbuilders. They rely little on total outsourcing in their shipbuilding processes. This is partly a result of their very large scale operations. It is heartening to see that the World's three largest shipyards are in South Korea, namely, Hyundai Heavy Industries, Daewoo Shipbuilding & Marine Engineering and Samsung Heavy Industries.

(c) **Chinese Shipbuilding Industry**. China has emerged as a major destination for shipbuilding and ship repair, and has a goal to become the No. 1 shipbuilding nation. Over the last two decades, China has developed 58 shipyards and is in the process of building the World's largest shipyard near Shanghai. The country's economic boom together with the strategic choice to develop heavy industry activities has led to a strong increase in global market share.

The Indian Scenario

9. The Indian shipbuilding industry, consisting of Mazagaon Dock Ltd, Mumbai, Cochin Shipyard Ltd., Kochi, Hindustan Shipyard, Vishakhapatnam and Garden Reach Shipyard Enterprises, have been turned into Defense shipyards, undertaking construction of mainly warships. ABG shipyard was the first to build and export a newsprint carrier for a Norwegian client in 2000 and established India's competitiveness in building and delivering ships of the international standards. India's Pipavav Shipyard, biggest pvt shipyard in India and rated as the World's sixth largest shipping facilities, is equipped with four docks capable of handling up to 500,000 deadweight tonnes (DWT). With a capacity of 74,500 tons they are manufacturing the largest ships being built in India, which are being delivered from 2010 onwards. The shipyard has an outstanding order book worth US $ 1.1 billion for 26 new 74,500 DWT Panamax Bulk Carriers. Pipavav, Bharati Shipyard, Hindustan Shipyard, ABG Shipyard, Larsen & Toubro and Shipping Corporation of India could raise the US $ 4.5 billion investment to US $ 10 billion in five years and to US $ 50 billion in 10 years. Adani shipyard is the lastest entrant and has been attracting attention for its aggressive marketing.

10. In India, shipbuilding had not been recognised as an infrastructure industry in our way to become a shipbuilding nation. It is not therefore surprising to see that shipbuilding do not find a mention in the emerging areas of education by AICTE. It was being contemplated that with the opening of the Indian Maritime University (IMU), this serious issue of availability of a competent

human resource to strengthen Indian Shipbuilding would be addressed. However, this has not happened and no major course on shipbuilding has commenced at any of the four existing colleges under the ambit of IMU. The Indian Shipbuilding industry is low on automation and labour intensive in comparison to the Western, Korean and Chinese yards, resulting in a cost advantage in terms of labour.

11. As far as the Indian scenario is concerned, the government has developed a National Maritime Development programme with a vision to make India a leading player by the year 2025. A draft policy for the maritime sector has been formulated to give boost to all maritime sectors, including shipbuilding and ship repair. Implementation of tonnage tax regime in shipping has created demand for new ships and marine vessels. Due to recent government policies, private shipyards, especially small and medium-sized shipyards, have been able to procure substantial orders, both domestic and export. There has been considerable interest in the private sector to invest in shipyards, which has emerged as a good investment opportunity.

12. **Public Sector Yards**. Shipbuilding industry has been through a lean phase through the 1990s which has affected not only Indian Shipyards, but globally leading to closure of many shipyards in USA and Europe. The slump in the 1990s and the government orders on reduction of manpower in public sector has led to two paralytic effects on these yards, namely, the loss of skilled manpower and inadequate upgradation of facilities. The public sector yards including Defense-Public Sector Undertakings (DPSU) are facing acute problems from a long time and there seems to be no solution. The reduction in manpower during the lean phase and the sudden boom in the demand has made it impossible to meet targets, only using in-house manpower. The problems being faced by the PSUs are as follows:-

(a) Required to go through elaborate tendering process for each vessel.

(b) Difficult to standardise since each time, a different supplier may secure the order.

(c) Cannot establish long-term relations and obtain attractive discount and credit terms with a group of suppliers because of the tendering process.

(d) The decision making is often slow and payments could be delayed.

(e) Old shipyards with outdated machines.

(f) Frequent design changes by the buyer, which may also lead to equipment becoming obsolete.

13. **Private Sector Yards**. The private sector yards have certain advantages as compared to the public sector yards:-

(a) Quick decisions are taken based on price, credit terms and project delivery schedules.

(b) Standardisation and efficient supply chain management is possible

14. **Lack of Technical Education wrt Shipbuilding**. While technical education aims to equip one with knowledge and skill sets necessary for the professional task expected out of the individual, the requirements have seldom been spelt out. Hence, we do not have many institutes in the country imparting technical knowledge oriented towards shipbuilding. Further, interdisciplinary training is generally absent in the conventional technical education and it would be incorrect to expect a graduate from such a system to be capable of meeting the engineering needs of a shipyard. Higher engineering institutions of our country, mainly aim at producing personnel basically trained for analysis, research, design and at times for teaching. Hence, the gap remains and we lack an educational institute in the country dedicated to the nuances and aspects of shipbuilding. Other maritime institutes either offer diploma level courses in marine engineering or aim at making seafarers rather than shipbuilders or ship designers. Only few courses by IITs at Kharagpur / Chennai / Delhi or Andhra University provide graduates / post graduates who are directly employable at shipyards based on these courses. Majority of the students never join the Indian shipbuilders in view of better prospects and huge demand for them abroad. Hence, very few graduates are available today to meet the existing demand of nearly 12,000 personnel required for Indian Shipyards.

15. **Ship Designing**. In India, ship designing for the commercial vessels is being undertaken in a very limited manner, as ship design has been considered as a complex project. Design of any ship evolves through a design spiral where there are several overlapping, repeated and complex activities. Design spiral becomes more complicated with the increase in the complexity of the ship, mainly warships. Though ship design evolves through a time consuming design spiral, European, Korean and Japanese design organisations have mastered this art and are capable of undertaking and delivering ships design in a short time span.

16. **Outsourcing**. Outsourcing has become a necessity in the shipbuilding industry in India. The reasons for this are the slump in shipbuilding during the 1990s and the sudden spurt in the industry in 21st century. Shipyards to overcome the problem of non-availability of qualified and effective human resource have resorted to outsourcing. While outsourcing may be the mantra to profitability today, performance and customer satisfaction of any good shipyard can be judged through the value addition index. Lesser the outsourcing content of the shipyard, higher would be the value added by the shipyard indicative of better technical expertise, higher area of core competencies and higher customer satisfaction. However, in absence of an assured supply of manpower trained to do shipbuilding, there is an increasing trend in ratio of indirect to directly employed workforce in shipyards indicative of high outsourcing.

17. **Technology**. There has been increasing awareness among the managements of shipyards that we can no longer derive comfort from low labor cost which can easily be offset by low productivity. There is a trend to bring in new technology such as energy saving devices in shipyards to increase productivity and thereby reduce construction cost. Improved technology is also being used in the shipyards to reduce time for design of different types of vessels and thus improve deliveries. Looking at the prospects of Indian shipbuilding industry, it has been observed that cost

competitiveness remains the significant advantage of domestic shipbuilding industry considering the two major parameters of shipbuilding viz., steel fabrication and labor. China is emerging as a major shipbuilding nation leveraging on these advantages and posing serious threat to South Korea and Japan. Considering this, it can be said that a proper strategy taken in the right direction could leverage the competitive benefit and lead the Indian shipbuilding industry towards better prospects. Major challenge is the lack of support infrastructure. Steel, main engine and major equipment together account for over 60 percent of the cost of a vessel and for ships built for India, almost all of these have to be imported. However, countries such as Japan, Korea and China have an established shipbuilding and steel plate manufacturing set up.

SWOT Analysis - Indian Shipbuilding

18. To identify the current situation of the Indian shipbuilding industry, a SWOT analysis was carried out. Primary data has been collected by interacting with the experts in the industry and executives employed in both PSUs and private shipbuilding industry. Analysis of this data has helped in identifying the key factors of Strengths, Weaknesses, Opportunities and Threats. The details are as follows:-

19. **Strengths**. The strengths are:-

(a) India is a nation which has the maximum number of naval architects and marine engineers through our educational system.

(b) Indian skill set has proven capability of advanced software development and applications.

(c) Presence of reputed academic institutes such as IITs and research organizations such as NSDRC, NSTL, DMRL, etc.

(d) Success of Indian project managers in completion of several complex projects on schedule.

20. Weaknesses. The weaknesses are:-

(a) Indian Shipbuilding industry did not mature in line with the global standards.

(b) Number of Indian ship owners is very less for its size and coastline, when compared with other small European nations.

(c) Indian industry has not supported growth of shipbuilding activity.

(d) Inadequate policy support in the past.

21. **Opportunities**. The opportunities are:-

(a) 'Make in India' policy of the governmnet to give boost to the Indian Indutry.

(b) Growth in Indian economy. Indian global trade is improving warranting more ships.

(c) Labour cost is very cheap in India, which can be a major factor to initiate large scale shipbuilding in India. This will provide large scale employment.

(d) Increase in offshore energy resources, such as oil and gas, warranting more ships to support this activity.

(e) Vast coastline can be better exploited for maritime activities such as tourism, coastal transport, fishing etc, warranting more ships.

22. **Threats**. The threats are:-

(a) Availability of ship along with design at a cheaper cost from Asian countries.

(b) Large scale brain drain of naval architects and difficulties to retain human resources talent within the country.

Strategies for Shipbuilding Under 'Make in India' Paradigm

23. Before proceeding to strategise the Shipbuilding Industry under 'Make in India' perspective, it is important to have a Vision. The vision could be '**India will be the market leader in shipbuilding industry including Naval shipbiuilding by 2025 by manufacturing high technology ships, at lowest cost and minimum time**'. To regain the traditional glory that India had for shipbuilding and fulfill the vision, the strategies to be adopted by India to emerge market leader by 2025 is enumerated in succeeding paragraphs.

24. **Formation of Consortium**. The different technologies that go into building of a ship are hydrodynamics, propulsion system, material technology, construction technology, etc. A single organisation may not be having all the expertise available with them. Therefore, shipbuilders should have tie-up and effective synergy with different R & D organisations such as NSTL, DMRL, etc and academic institutes such as IITs, so that they are capable of designing and constructing ships using the latest technology.

25. **Favorable Government Policies**. Indian Government will also have to initiate favourable policies to promote shipping and shipbuilding industry. Government of Japan, Korea and Vietnam has been giving support to this industry, as they have realized that shipbuilding industry has the capability to propel the complete economy of the manufacturing sector. The government needs to provide following incentives to the shipbuilders:-

(a) Automatic approval for investments.

(b) Release of foreign exchange.

(c) Retention of sales proceeds in foreign exchange.

(d) Subsidy from the government coffers.

(e) Foreign direct investment.

(f) Tonnage tax benefits.

(g) Freedom to government owned shipping companies.

(h) Update National Maritime Development Policy to provide further thrust.

(j) Incentives for setting industry within 100 km of the shipyards

26. **Boost to Ship Designing**. The shipbuilding sector has to take ship design along with it. Both shipbuilding and designing will have to complement each other. The countries that are leading in shipbuilding such as European countries, Japan, Korea are doing very well in ship design. Shipyards have to play a major role in ship design. Today, all the Indian shipyards are only associated with production design of ships. There is a need for the shipyard's design office to work on ship design starting from concept design to production design. It is essential to have a few national level ship designing organisations in both government and private sector. At present, we have only NIRDESH for ship designing. This organisation needs to be strengthened and patronized by the Indian shipbuilders. We need to exploit the strength in the Indian software industry. The designing should be used for better project management and faster production. The ship designing can also be used for inventory management. As the design is progressing, it should be possible to get estimate of bill of material required for construction of the ship. This would help the shipyard to get a fair idea of the type, amount and schedule of material that will be required for the construction of the ship, even when the ship design is not complete. This would help in JIT inventory management and supply chain management.

27. **Consolidation of Talented Human Resources**. Majority of the human talent available in the country are used only for low end shipbuilding. It is essential to retain talented naval architects and marine engineers within the country. Some of the Indian project managers are acknowledged for their capabilities globally. Examples of world class projects executed by Indians are Konkan Railways, Delhi Metro, Nano car project etc. Similar talented project managers, if positioned for shipbuilding by PSUs or private sector players may take the shipbuilding industry to a new level.

28. **Shipbuilding Colleges**. Since the shipbuilding industry is an amalgamation of products and processes of numerous industries, it is appropriate that the human resource for shipyard is educated and trained in a college that meets such specific demands / requirements. Offering an additional discipline at an existing institute or running a separate curriculum akin to marine engineering and making shipbuilding professionals may not be the best alternative. With the ever-rising demand for shipbuilding professionals it is befitting to open dedicated shipbuilding colleges. On observing the history of Marine Engineering in India, we find that we have made inroads from the conventional fields of engineering to marine engineering in the past few years. However, as we produce good mariners somewhere down the line we may have ignored the needs of shipbuilders. World over, thrust has been to treat shipbuilding as a specialized subject and dwell upon it distinctly from conventional marine engineering. Shipbuilding institutes have sprung up across various maritime nations. China for example boasts of the 'Wuhan Institute of Shipbuilding Technology' and the 'Harbin Engineering University'. Japan too has had a shipbuilding college since 1942, which began as 'Kawanami High School of Shipbuilding' and is presently known as 'Nagasaki Institute of Applied Science'. It is a leading educational institution with highly specialised courses for shipbuilding.

29. **Exposure to Students**. To improve exposure of the shipbuilding industry, shipbuilding engineers / marine engineers / naval architects from engineering colleges and technicians from ITIs can to be deputed for competencies and attachments at the shipbuilding yards.

30. **Womb to Tomb Support**. The shipbuilders must use PDM and PLM packages, so that they can offer life long support to the ship owners for maintenance and operation of the ship, similar to the automobile industry.

31. **Boost to R & D**. R&D is extremely important for shipbuilding which focuses on relatively complex, high value ships. Expenditure on R&D in Europe and Korea shows that all countries have a R&D ratio below 1% (of production value), with Korea showing the highest figure.

32. **Boost to Technology**. Technology is the key for shipbuilding industry especially for naval shipbuilding. The next generation of emerging shipbuilding technology, based on data-centric and rule-driven software solutions, fully supports and facilitates the revision of working processes. It streamlines shipbuilding design, preserves existing data and makes it re-usable for future projects vital for shipbuilders needing to improve their productivity and cost competitiveness within current constraints. The technology has the capability to support flexible ship design, production and life cycle management within a single integrated environment. It offers shipbuilders better decision support for global design and production ultimately making their yards more competitive. The new technology wave bursts through the barrier imposed by traditional design technology. Rather than being about simply delivering design (as with CAD), it focuses on delivering the best design; more productively and within shorter project schedules.

(a) Modular Design and Construction. Designing of ships from concept design stage, keeping the final 'Modular Build Technology' into consideration. Many design organizations are adopting this concept of modular design to facilitate building ship by modular construction, so as to improve the shipbuilding efficiency.

(b) Virtual Design. Undertake ship designing using 3-D modeling with virtual reality from concept design stage itself rather than working on 2-D drawings and then converting them to 3-D model later during production. This idea was first implemented in 1998 for designing of a passenger ship by M/s Delta Marine of Finland. Today majority of the ship owners also want a 3-D model of the ship for their future requirements. Some design organisations are today undertaking 4-D virtual design of ships, where the 4th dimension is project / process time. This concept helps in identifying the progress of shipbuilding at different time scale, during design stage itself. The overall saving in design time by adopting this technique is 2 to 6 months for a typical passenger vessel.

(c) Project Management Softwares. The efficiency of the project should be measured for continuous improvement. There are project management software that are capable of measuring the efficiency of design. Data envelope analysis (DEA) is one of them.

(d) Robotics for large variety of uses

(e) Ergonomic Assembly Lines

(f) Welding Automation

(g) NC Cutting Machines

33. **Use Indigenous Steel**. In addition to the cost of labour the price of steel is an important factor in determining the cost price of a vessel. In this respect steel prices in Europe are clearly higher than Asia, although the current economic situation the worls over and the resulting drop in steel prices has reduced the price gap. If any shipyard wants to compete successfully in the international market, ship steel needs to be manufactured in the country. This would make the input costs of these materials for building ships competitive.

34. **Use Indigenous Marine Machinery**. Manufacture of all major marine machinery indigenously and attract major machinery manufacturers to start manufacturing equipment under 'Make in India' concept and transfer of technology. The Indian maritime community needs to attract major engine and equipment makers to set up manufacturing units in the country, which would make the input costs of these materials for building ships competitive.

35. **Public-Private Partnership**. The PSUs may be operated on Public-Private Partnership (PPP) basis in order to improve efficiency and bring in accountability. The private players can pump in money to generate profits so that all the stakeholders are benefited. The Indian maritime community could be on a great opportunity as growing partnership between the public and the private sectors, the shipping industry can scale new heights and India can emerge a major maritime service nation.

36. **Improvements in PSU Shipyards**. Following steps may be implemented in the PSU shipyards to ensure better output and ensure quality ships in less time:-

(a) Upgradation of infrastructure coupled with modern machines. All old machines to be phased out and new state of the art technology machines brought in.

(b) Undertake modular construction. Install Goliath cranes for better material handling.

(c) Provide incentives to the management and the work force.

(d) Overcome bureaucratic hurdles.

(e) Institute flexible procurement procedures.

37. **Quality**. If India has to be recognised as a shipbuilding nation, then we have to construct ships of International quality meeting all International norms, including meeting emissions standards.

38. **Multiple Ships of Same Class**. India should construct more ships of same class / design for indigenous use. This will enable the shipyards to work on principle of assembly line and provide optimisation of all resources. If the model is succeeful, we may produce warships at the lowest prices and aim for exporting ships to third world countries by ensuring competitive pricing.

Conclusion

39. It is a complicated issue to forecast who will be the leader in the shipbuilding industry after the 2020s. It seems that South Korea would probably be more dominant than the competitors. During this period, world shipping industry seems to be driven by the two countries; China is expected, without doubt, to dominate lower end vessels such as bulk carriers and tankers and South Korea may lead the more value-added ship market.

40. The key to determine a future leader seems to be the technology. It has been the technology that enables former and present leaders in the shipbuilding, such as Europe, Japan and South Korea to keep a dominant position. New entries in the shipbuilding industry always start with inexpensive and relatively simple vessels and later move on to complicated vessels in order to increase market share. China will inevitably face strong challenges from Vietnam, India and Brazil who have showed their ambition to enter into low end vessel market.

41. Only a concerted multi-pronged approach to adopt best practices in design, procurement and production, coupled with augmentation of key facilities and a will to exempt shipyards from additional liabilities, can provide a level playing field to the Indian shipyards to match their performance with that of Korean or Chinese yards. India must emerge as a big player and be ready to take the place yielded by the European and Japanese shipyards by the 2025. Quality of our products, men and material, are second to none. The market and the future beckon. We only need to have the will and our priorities right. With government providing full thrust to the industrial sector, time is ripe for India to take advantage of 'Make in India' perspective and emerge as a market leader by 2025.

Author's Biodata

Captain Jasvir Singh

Captain Jasvir Singh was commissioned in the Indian Navy in 1994. He graduated from the Naval College of Engineering, Lonavala in 1995 as part of 7th NEC and completed Post graduation in the field of Indusia! Tribology from IIT Chennai in 2003. He was awarded Gold Medal for Outstanding Academic Record and also Best Project in the field of Artificial Neural Networks during M.Tech Course. The author has served onboard Indian Naval Ships Shakti as AEO as well as EO and other front line ships namely, Godavari, Ajay and Brahmaputra. The officer has served at INS Shivaji as Senior Instructor EPCT School, as Deputy OIC at MTU, Mumbai and in Naval Dockyard as Deputy Manager Systems and DGM(IRC). The officer is presently posted as Deputy General Manager (Planning) at NSRY (Karwar). The officer is an alumni of 16th TMC from Naval War College. He has presented two papers at National Convention of Marine Engineers and National Convention of Maintenance Engineers. The officer has presented various papers in the Indian Naval symposia and seminars. The officer has been commended by the CNS on two occasions and by the CinC. The officer has experience of interacting with shipbuilding yards, namely, Fincantieri and Sevmash. The officer has also visited various marine equipment suppliers at Russia, namely, Proletarsky Zavod, Kaluga Turbine factory, Kirovsky Zavod and Rolls Royce Factory at Kristinehamn , Sweden.

article

13

MAKE IN INDIA - WAY AHEAD FOR THE INDIAN NAVY

(By Cdr A K Pandey & Cdr Sunil Korti)

Introduction

1. **What is Make in India**. 'Make in India' is an initiative of the Government of India, to encourage domestic as well as multinational companies to manufacture their products in India. The initiative was launched by Prime Minister Narendra Modi on 25 Sep 14[1]. The primary objective of the initiative is to focus on job creation and skill enhancement in twenty-five sectors of the economy[2]. These being automobile, automobile components, aviation, biotechnology, chemicals, construction, defence manufacturing, electrical machinery, electronic systems, food processing, IT and BPM, leather, media and entertainment, mining, oil and gas, pharmaceuticals, ports and shipping, railways, renewable energy, roads and highways, space, textile and garments, thermal power, tourism and hospitality and wellness[3]. The initiative hopes to attract capital and technological investment in India[4]. In all the above sectors 100% Foreign Direct Investment (FDI) has been permitted except for the sectors of space, defence and news media, where FDI has been restricted to 74%, 49% and 26% respectively[5].

2. **Why Defence Manufacturing**? India has the third largest armed forces in the world.It has the eighth largest defence budget in the world, accounting for 3 per cent of global defence expenditures. India has also emerged as the largest defence importer, accounting for nearly 10 per cent of global defence imports. About 60% of its defence requirements are presently being met through imports and it spends about 31.5% of its total defence budget on capital acquisitions[6]. Thus of a total allocation of INR 2467.27 billion (US$ 37.02 billion) in the financial year 2015-16, about INR 777.19 billion (US$ 11.6 billion) is being spent on importing defence equipment. This is a sizeable sum of money that is being spent every year in an effort to modernise our armed forces and this is likely to grow in the years to come. With growing obsolescence and a 10 per cent annual rise in the capital budget for equipment procurement, a conservative estimate indicates that India will spend nearly $100 billion over the next eight years to modernise and equip its armed forces. If India has to consolidate its position as a regional power, harbours ambitions for a permanent seat in the

---

[1] *"Look East, Link West, says PM Modi at Make in India launch". Hindustan Times.25 September 2014. (Accessed November 06, 2015)*
[2] *Make in India - Sectors" n.d.< http://www.makeinindia.com/sectors> (accessed November 10, 2015)*
[3] *Ibid.*
[4] *Ibid.*
[5] *"Make in India Intiative" n.d.<http://www.dnaindia.com/money/report-pm-modi-s-make-in-india-turns-one-all-you-need-to-know-about-the-initiative-2128448> (accessed November 12, 2015)*
[6] *"MakeinIndia - Sectors - Defence Manufacturing" n.d.< http://www.makeinindia.com/sector/defence-manufacturing> (accessed November 10, 2015)*

UN Security Council and in the future grow in to a global power, then it is of paramount importance that she gains self-sufficiency in this vital sector.

3. The ambit of defence technologies is wide spread for any armed force as it involves the research, development and manufacture of ships, submarines, aeroplanes, helicopters, tanks, artillery guns, missiles, torpedoes, UAVs, pistols, rifles, ammunition, food, drugs, NBC gear etc. Of all the armed forces, the Indian Navy is the one force that operates in all the three dimensions and thus requires platforms that operate below, on and above the water. This makes the Indian Navy's requirement the most vast and diverse. The 'Make in India' initiative will have an impact on all these aspects/technologies and thus will impact the Indian Navy the most. As it is not possible to cover each and every type of technology or process that the 'Make in India' initiative will have an impact on, the essay will focus on a subset of defence manufacturing viz. the warship building industry, which is the most important sector for the Indian Navy.

An Overview of the Indian Defence Industry

We are focusing on developing India's defence industry with a sense of mission. This is why it is at the heart of the "Make in India" programme.

(By Prime Minister Narendra Modi)

4. **Defence Industry in India**. The early government of independent India had a large nation to defend - in the west against her twin sister who shared a blood soaked partition and in the east against a nation with unreliable intentions of territorial advances. Apart from the fragile political stability of those times, the assets available with the defence forces of the country were also limited. A nascent and fragile domestic industrial base, sparse economic resources, and a fast growing population placed heavy loads on the country. Indigenous defence production was definitely critical, but the huge responsibility of providing for the population and facilitating a stable and reliable economy forced the early governments to give lower priority to defence production and self-sustenance. Necessary defence hardware was therefore imported from all possible sources, varying from the United Kingdom to Poland.

5. A beginning to resort to indigenous defence production was made through the decision to set up Defence Research and Development Organisation (DRDO) in 1958, from the erstwhile Technical Development Establishment (TDE) of the Indian Army and the Directorate of Technical Development and Production (DTDP) of the Defence Science Organisation (DSO).[7] A number of initiatives were taken to achieve self-sufficiency in defence matters, through various laboratories of the DRDO. The DRDO has been successful on many a front in recent years, notably the Integrated Missile Development Programme (IMDP), which saw the successful indigenous production of Intercontinental Ballistic Missiles (ICBMs) such as Agni series.

---

[7] *Govt of India. Ministry of Defence, n.d.<http://www.drdo.gov.in> (Accessed November 15, 2015)*

6. While the R & D aspects were looked after by the DRDO, the production aspects of such indigenous military hardware were undertaken by the Defence Public Sector Utilities (DPSUs) and Ordnance Factories, which were controlled by Department of Defence Production (DDP). Private sector was not involved in R & D or production of defence hardware since independence. In fact the production of defence hardware was restricted to public sector through the Industries (Development and Regulation) Act of 1951. A task force set up in 1998 assessed that the public sector alone could not deliver, the private sector was allowed to participate in the defence production and manufacture in 2001, which was controlled strictly through legislation.[8] Foreign private industrial collaboration was permitted upto 26% of Foreign Direct Investment (FDI) in 2012[9] and it was increased to 49% in 2014.[10] Presently, the defence industrial base includes 41 Ordnance Factories, nine defence public sector undertakings and about 6000 large, medium, small and micro undertakings from the private sector.[11]

Evolution of Indian Warship Building Industry

7. India is one of the very few nations in the world who design and build warships for itsNavy.[12] The country has a very old tradition of skilful warship building. The Wadias of Surat established the Bombay Dock (now the Naval Dockyard, Mumbai at Lion Gate) where the oldest warship still afloat as a museum in the UK, the HMS Foudroyant (renamed HMS Trincomalee) was built in the late 1760s.

8. These skills were however lost during the British rule and had to be rediscovered post-independence. The post-independence senior naval leadership realised the importance of warship building and thus in the 1960s, India launched the Leander class frigate building programme. In 1964, under a three-way agreement between the Indian Government, the British Ministry of Defence and Mazgaon Docks, the British agreed to supply India with the design of the Leander class which was being built for the Royal Navy in UK.[13] Accompanying this agreement was another order for the construction of two inshore minesweepers in India, in collaboration with another British shipyard, M/s J Samuel Wite and Company.[14] These were essentially the first major warships built in India since independence.

9. Three more ships, Himagiri, Udaygiri and Dunagiri were built after learning layout and minor structural modifications through a design contract with a Dutch firm NEVESBU, who had undertaken a similar exercise in their Van Speijk class of frigates. Along with ship design and building skills, capability to produce warship equipment and systems indigenously, was simultaneously developed. The construction of the 3600 tonne Godavari class followed in the late 1970s, a fully

---

[8] *Govt of India.Ministry of Defence.Department of Defence Production.<www.ddpmod.gov.in> (accessed November 06, 2015)*
[9] *Ibid.*
[10] *"FDI in Defence" n.d.< http://articles.economictimes.indiatimes.com/2014-08-26/news/53243869_1_defence-sector-fdi-cap-fdi-ceiling> (accessed November 12, 2015)*
[11] *"A Blue Print for the Defence Industry", n.d.<http://www.thehindu.com/opinion/lead/a-blueprint-for-the-defence-industry/article6193910.ece> (Accessed November 22, 2015)*
[12] *RajeshwerNath, ' Towards Modern Ship Design and Shipbuilding in India', Indian Defence Review, Vol 22(3) Oct-Dec 2007, p 91*
[13] *Rahul Roy-Chaudhary, 'India's Defence Shipyards', Defence, 1995.*
[14] *ibid*

indigenous design with a hybrid mix of weapons and sensors, both indigenous and imported.[15] Another laudable achievement was the construction of the two HDW 209 Type 1500 class submarines (Shishumar class) in the late 1980s.[16] In a span of 35 years since the construction of the first Leander class, a few corvettes, missile boats, offshore patrol vessels as well as a number of auxiliary and support vessels have been built in Indian shipyards.

Indian Warship Building Industry - Current Scenario

10. As is substantiated by the history of warship industry's evolution and more recent progresses, India has the capability to be a warship building power, with the advantages of cheap labour cost[17] and experience of building a total of about 95 warships so far. However, it remains far from being a self-sufficient industry and the reasons for the same require to be analysed. This would aid in giving us a clue so as to arrive at the focus areas that the government needs to concentrate on so as make the "Make in India" campaign a true success.

11. **Status of Indian Shipyards**. Present day warship building in India is mainly centred around 32 shipyards. Among these, there are eight public sector yards, of which six yards are under the Central Government and two under the State governments. Of these six shipyards, four are operated by the Ministry of Defence and are designated as defence shipyards. These are Mazagon Dock Ltd (MDL), Garden Reach Shipbuilders and Engineers Ltd (GRSE), Goa Shipyard Ltd (GSL) and Hindustan Shipyard Ltd (HSL) which are engaged in warship building. The remaining shipyards are in the private sector. These shipyards operate 20 dry docks and 40 slipways with an estimated capacity of 681,200 DWT. A major share of this capacity is held by the 8 public sector yards. Only Cochin Shipyard Limited (1,10,000DWT), Hindustan Shipyard Limited (80,000 DWT) and Pipavav Shipyard (400,000 DWT) have the required infrastructure to build large vessels.[18] Private shipyards baring Pipavav Shipyard though more in number are severely limited by capacity and size of ships they can build.[19] Indigenous Shipbuilding accounted for nearly Rs. 8511 Crores ($1.9 billion) during 2010-11 and constitutes nearly 60 per cent of the Navy's total acquisition budget.[20]

12. **Indian Warship Building Industry vs International Standards**. India currently shares only 1.3% of the global ship building.[21] However, this was achieved through an impressive 13 fold increase from 2002, when the share was a mere 0.1%.[22] The productivity achieved by Indian DPSU shipyards is much below the levels achieved by international standards.[23] Whereas the Indian first tier yard of Mazagaon Dockyard Limited (MDL) has a capacity to build 1.33 ships per year, the comparable international standard is 5.7 per year.[24] The build term trends are almost four times more than the international standards. For example, the 3500-ton Godavari Class guided frigate was built over 72

[15] *Rahul Roy-Chaudhary, 'India's Defence Shipyards', Defence, 1995.*
[16] *ibid*
[17] *RajeshwarNath. 'Towards Modern Ship Design and Shipbuilding in India', Security Research Review, Vol1(3), Apr 2005.*
[18] Indian Ship Building- Current Scenario", n.d.<http://www.mantrana.in/Indian- Shipbuilding.html> (Accessed November 25, 2015)
[19] ibid
[20] ibid
[21] "Indian Shipbuilding Set to Recover Lost Glory?" n.d.<http:// www.maritimeprofessional.com> (Accessed November 20, 2015)
[22] "Ship building and India's Offset Policy", n.d.<www.indiastrategic.in/topstories1157_Ship_Building_ and_India.html> (Accessed November 20, 2015)
[23] Ibid.

months and 1.8 million man hours, a warship of similar displacement is built in USA in 30 months and 2,50,000 man hours.[25] Time and cost overruns are also substantial, with cost overrun of approximately 300% and time overrun of 22-30% for the Delhi Class destroyer.[26] A primary challenge for our shipyards therefore has been to deliver quality ships on time and within the contracted cost. This inspite of the fact that the order books of our shipyards are full.

Indian Warship Building Industry - Road Blocks

"Our defence industry will succeed more if we can transform the manufacturing sector in India".

(By Prime Minister Narendra Modi)

13. The warshipbuilding industry has its own distinctive feature as compared to other industries in the country. It is unique in a way that it is an amalgamation of a large number of sub-processes. To build a warship a number of other industries need to be well developed so as to support the shipyard and this not only includes defence hardware but many others such as steel industry, auxiliary machinery manufacturers, main propulsion plant manufacturers and others.The overall cost of building a warship in India is relatively cheap as is evident from the example that the three Project 15-A Kolkata-class destroyers will each cost the navy Rs 3,800 crore (US $950 million) each , including the cost of long-term spare parts. Compare this with the three 6,250-ton destroyers, fitted with the Aegis radar and fire control system, that Australia has ordered which will cost them Rs 32,000 crore (US $8 billion). This makes the Australian destroyers cost at about Rs 11,000 crore per destroyer, almost three times the cost India is paying for its Kolkata-class destroyers.[27] However, productivity in Indian shipyards is one tenth of that in modern shipyards abroad.[28] Moreover, Indian shipyards take at least three times more time to build ships.[29] This is evident from the fact that the Kolkata class has been delayed by almost 4 years and has had a cost escalation of almost 225%.[30] It is thus obvious that inspite of the large strides that we have taken in warship building since independence, there are numerous problems that plague this sector.The most prominent ones are listed below.

(a) Capital Issues.

  (i) Lack of technologically advanced Infrastructure.

  (ii) Underperforming ancillary industry.

(b) Defence Hardware.

---

[24] *Ibid.*
[25] *Ibid.*
[26] *Ibid*
[27] *"Project 15-A Kolkata DDGHM - Program" n.d.<http://www.globalsecurity.org/military/world/india/d-project-15a-program.htm> (accessed Nov 23, 2015)*
[28] *RajeshwerNath, 'Towards Modern Ship Design and Ship Building in India', Indian Defence Review, Vol. 22(3), Oct-Dec 2007, p 91.*
[29] *Ibid.*
[30] *"Project 15-A Kolkata DDGHM - Program" n.d.<http://www.globalsecurity.org/military/world/india/d-project-15a-program.htm> (accessed Nov 23, 2015)*

(i) Reliance on Foreign Vendors for Weapon systems.

(ii) Limited private R&D.

(c) Procurement Policies

(d) Lack of Skilled Work Force

(e) Fiscal Policies.

(i) Excessive Taxation

(ii) Lack of government subsidy

(d) Design Technology.

14. Each of the above mentioned issues will be covered in detail in the succeeding paragraphs.

Capital Issues

15. **Lack of Technologically Advanced Infrastructure.** DPSU shipyards suffer from poor infrastructure and also have technologically older equipment. Thus they have inadequate infrastructure for undertaking warship construction.[31] Despite regular requests submitted by these yards for infrastructure upgradation, the Ministry of Defence has not taken effective steps to improve the situation.[32] There are also no dedicated upgradation programs but only piecemeal efforts as funding is primarily financed through the ship building projects in the form of assets financed by the Indian Navy. In the absence of alternatives like adequate reserves or low interest financing schemes for these shipyards, the Indian Navy has spent over Rs 600 crore from 2003 onwards for the modernisation of MDL and GRSE through different projects with the aim to arrest time and cost overruns. Thus, the projects from which funds have been sanctioned have not benefitted in full measure from the modernisation activities.[33] The lack of readiness of these shipyards has thus resulted in delays in warship construction.

16. A case in point refers to MDL, where a need for modernisation was felt as early as 1995 by the shipyard and accordingly, a modernisation programme was also submitted by MDL to Ministry of Defence. However, no action was taken on this plan. When the Letter of Intents were issued for P 17 and P 15A shipbuilding projects (1998-2001), MDL emphasized that these facilities needed to be available progressively between 2003 and 2006 to attain the required shipbuilding capacity. The Ministry of Defence however decided that the funding for modernisation of the shipyards would be through naval ship-building projects. The initial estimate for the modernisation program was Rs 281 crore. However, due to delays, the shipyard modernisation plan was only approved in March 2006 at a cost of Rs 423 crore. As of November 2010 only Rs 210 crore was expended for modernisation

[31] *Ibid, pp 32.*
[32] *Ibid*
[33] *Ibid.*

project of the shipyard.[34] It is thus evident that the modernization programme of MDL envisaged as early as in 2001 could not be completed in the last ten years and resultantly all warship construction projects have been significantly delayed. Thus in the case of the P15A ships, the delivery of the first ship is likely to be delayed by over 4 years and the delivery of the second and third ship may be delayed by more than two years each due to inadequate facilities at MDL.[35] The same is amplified in the table placed at **Appendix A**.

17. **Underperforming Ancillary Industry**. The industries that provide machinery equipment and other miscellaneous items needed for ship building is termed as the ancillary industry.[36] The ancillary or the support industry in Indian ship building sector is neither developed nor matured as compared to other shipbuilding markets in the world. This is primarily because of low volumes of the Indian shipbuilding industry.[37]Ancillary industry plays a very vital role in shipbuilding in general and warship building in particular. In DPSUs, presently, almost all the machinery and equipment required inside a ship are imported, because they are cheaper and of good quality. Such machinery and equipment, which are specific to warships, such as main engines, gear boxes, shafting, propellers, generators, switchboards, valves, pumps etc, are not manufactured in India because of low volumes. Therefore even though India has the industrial capability, there is no incentive to produce in the country.

18. It is not surprising therefore that India's defence PSU shipyards also spend a vast amount of their resources in importing key raw materials (such as warship quality steel), parts, and components from foreign sources. The import dependency, which is over Rs 4,300 crore from 2007 to 2012 for three key PSU shipyards (MDL, GRSE and GSL), has also a strategic underpinning and an impact on build period of warships.[38] An example is in the case of P17 ships. The ships were intended to be powered by the General Electric LM-2500 gas turbines. However, a stop work order by the Obama administration on gas turbine engines resulted in halting the construction of the P17 ships and consequent delay in the project by almost a year.[39]

Defence Hardware

19. **Reliance on Foreign Vendors for Weapons and Sensors Suite**. The DRDO has successfully designed certain high technology equipment, such as the BrahMos missile, Prithvi and Agni series of ballistic missiles, and HUMSA sonar. However, their number is limited and does not cater for the varied demands of the Indian Navy. Also, the Ordnance Factories manufacture a majority of low

---

[34]*Ibid.*
[35]*Ibid.*
[36]*Government of India, Ministry of Shipping, Road Transport and Highways,Report of Working Group for Shipbuilding and Ship Repair Industry for the XIth Five Year Plan (2007-2012), Mar 2007, p 23.*
[37]*Government of India, Planning Commission, The Manufacturing Plan - Strategies for Accelerating Growth of Manufacturing in India in the 12th Five Year Plan and Beyond, p 138.*
[38]*'Shipyards in Turmoil - Indian Shipyards: Distress Among Limited Gains', Defence and Security of India, 01 Dec 12, New Delhi.<www.defencesecurityindia.com/indian-shipyards-distress-among-limited-gains/> (Accessed November 20, 2015)*
[39]*Ibid.*

technology military equipment and only a limited number of high technology military hardware under license or Transfer of Technology (TOT) from DRDO or foreign vendors. Thus, much of the weapon and sensor suite onboard Indian Naval Warships is imported. Therefore, the primary raison-de-être for the warship viz. the weapon and sensor suites, whose delivery, testing and proving is in the hands of foreign suppliers. This invariably results in inordinate delays in warship construction programmes as many a time weapon or sensor suites that have been contracted for are not delivered in time or take long lead time to prove which adds to the delay in commissioning and in turn to the overall cost of the programme. The fitment of foreign weapon and sensor suites also increases the reliance on them for spares during the lifecycle of the sensor or technical support, which may at times effect the operational availability of these critical systems.

20. **Lack of Private R&D**. Presently, only DRDO conducts extensive R&D in weapon and sensor suites for the Indian Navy, with almost nil private participation. Thus there is no competition for the DRDO to better itself or work against a timeline to deliver quality products. The lack of private sector R&D into weapons and sensor systems designing severely limits the growth potential that would be provided by the private sector and thus is a definite hindrance in progress towards self reliance.

Procurement Policies

21. The Indian Navy needs to take a relook at its procurement policies and come up with a policy that encourages Indian public/private sector defence manufactures. It also needs to take a relook at the number of platforms of a particular type that are being ordered so as to make the shipyards more profitable whilst ensuring that Navies needs are also met.

Lack of Skilled Work Force

22. To have a competitive and self-sufficient warship building industry, the availability of skilled labour force is of paramount importance. This not only applies to shipyard workers who must be multi skilled but also to higher level management/ designers who must be highly qualified at their respective jobs. At the shipyard worker level, the lack of sufficiently trained/skilled labour force results in excessive man hours for building warships and thus leads to longer lead times to commission them vis-à-vis other leading ship building nations. An comparative assessment of the same is evident from the fact that the total man hours taken by the United States of America (USA) to build the DD-651 class of destroyers (8315 tonnes) was only 5,000,000 hours whilst the Delhi class (6500 tonnes) took 18,200,000 hours to build. This is more than three times the man hours required by the USA. The same was also reflected in the long time taken for delivery, i.e., for the FFG-7 it was 30 months whilst for the Delhi class it was 100 months.[40] A comparative table indicating the same for various leading warship builders in the world is placed at **Appendix B**.

[40] *RajeshwerNath, 'Towards Modern Ship Design and Shipbuilding in India', Indian Defence Review, Jan-Mar 2005, Vol. 20 (1), pp 30-34.*
[41] *Ibid.*

Fiscal Policies

23. **Excessive Taxation in Warship Building Industry.** There exist close to 19 various types of taxes which are levied on various activities in ship building. A summary of the taxes levied on shipbuilding industry is placed below along with the comparison with foreign yards at **Appendix C**. These range from taxes on procurement of raw material to finalisation of costing of the final project. Thus, there is a need to rationalise certain taxes and customs procedures to give this industry the competitive edge.[41] Such an effort should also aim at bringing the taxes and duty structure on par with other major warship building/ship building nations so that our ships yards are also competitive vis-à-vis foreign shipyards.

24. **Lack of Government Subsidy**. Indian shipyards have to pay service tax, customs and excise duties and VAT on all indigenous items as well as on complete ships.[42] Even though, the government has tried various promotional and subsidy measures since the 1970's however most have been ineffective due to lack of commensurate industrial growth in the country at that time.[43] Government subsidies would partially negate the effect of the taxes and duties, and therefore aid shipyards in pricing competitively in the international market. Thus government subsidies play an important part in ensuring that Indian private ship builders are able to compete in the global market.

Design Related Issues

25. **Insufficient Number of Design.** There are less than a dozen firms in India that have basic ship designing expertise and almost none of them have warship designing expertise.[44] All warship designing in India is carried out by the Naval Ship Design Bureau. Barring Goa Shipyard Limited (GSL) which has limited warship (and only small warships) design capability; all other DPSU shipyards have absolutely no warship design capabilities.[45] This is a serious lacuna in ensuring that our shipyards become globally competitive as they are unable to offer designs to international customers, as the designs on which they are presently building ships are owned by the Indian Navy.[46]

26. The cases of P15A and Project 28 (P28) ships are relevant here. In these projects, a sizeable share of detailed design was envisaged to be undertaken by MDL and GRSE respectively. However these shipyards have not been able to deliver on their part of the work share due to a variety of reasons such as lack of qualified design personnel. Consequently, much of the load is falling back on

---

[42] *Joshin John, Vijaya Dixit, Dr Rajiv K Srivastav;'Indian Shipbuilding in the Global Context: An Empirical Study on Current State of Industry and Exploring Scope for Improvement',IIMLacknow News Letter, Vol XXII, Feb 2012, pp 133-171.*
[43] *Government of India, Ministry of Shipping, Road Transport and Highways, Report of Working Group of for Shipbuilding and Ship Repair Industry for XIth Five Year Plan (2007-2012), 2007, New Delhi.*
[44] *Ibid.*
[45] *Defence and Security of India, 'Defence and 'Indian Shipyard Warship Design Capability'New Delhi,.<www.defencesecurityindia.com/indian-shipyards-inturmoil-among-limited-gains>(Accessed, November 25, 2015)*
[46] *Joshin John, loc. sit.*

the naval design bureau.[47] In addition, the Naval design organisation, which is the premier ship design bureau in India, though a fully computerised unit, still does not use the state of the art tools and technologies prevalent in modern shipyards such as those of Japan, China or South Korea.[48] The use of latest designing tools and technologies will improve collaboration/integration between design and manufacturing which will in turn result in considerable reduction in the time from design to execution stage. It will also ensure that delays due to faulty design are removed at an early stage rather than during ship construction which will ensure that there are no cascading delays.[49]

Indian Warship Building Industry - The Way Ahead

"A strong Indian defence industry will not only make India more secure. It will also make India more prosperous."

(By Prime Minister Narendra Modi)

27. Having analysed the various problems that plague the Indian Warship building industry, an attempt will be made to suggest a way ahead so that we can overcome these hurdles and ensure that the Indian Navy accrues maximum benefit from the "Make in India" initiative. Many of the issues brought out above cannot directly be addressed by the Indian Navy, however they can be projected as serious impediments for the success of the "Make in India" initiative. Also for the initiative to succeed the solutions to these problems also can be projected by the Indian Navy to the Government of India to take up and implement for a holistic approach.

Capital Improvement

28. **Improvement in Infrastructure**. The modernisation effort by the government, in respect of DPSU shipyards has been in fits and starts at best. To overcome this problem one method could be to identify certain DPSU shipyards in which disinvestment can be carried out and thus introduce private players. This would result in capital infusion into these yards and thus allow them to modernise at a rapid pace. However certain yards can be retained as DPSU yards to maintain some governmental direct control in this vital sector as MDL and GRSE. For these DPSU yards a comprehensive modernisation programme can be put in place. This modernisation programme must comprehensively encompass all the latest technology and infrastructure required for undertaking state of the art ship construction. Thus, technologies which support the ship building practices such as integrated construction and 'modular' ship building methodology must be incorporated. This would reduce build times considerably and would also improve quality of construction. The estimated saving in labour hours from using extended modularisation is placed at **Appendix D**. The construction of ships of the Project 17A (P17A) is due to begin shortly at MDL and GRSE. To ensure that the build period of these ships is lesser than previous ships of the P-17 class and comparable to global standards, these shipyards needs to adopt modular technology. The advantages with respect to build period with such advanced infrastructure/capability, in the case of

P17A, would be that the "first of class" ship is likely to be constructed in 66 months, and the follow on ships in 60 months, which would compare very favourably with world standards of "time to completion" for ships of similar size and displacement.

29. **Ancillary Industry**. One of key areas that needs to be strengthened under the 'Make in India' initiative is the ancillary industry. For manufacture of any defence hardware there is always a need for ancillary equipment such as the correct quality steel, wiring, paints, PCBs, pumps, valves, generators, switchboards and a host of other such material. This is more so applicable to the warship building industry. Thus this is one areas that shipyards and especially defence shipyards need to study as to what ancillary equipment can be outsourced while retaining essential technical manpower for critical defence related work. The 'Make in India' initiative should be the platform that could be used to clearly lay down the type of ancillary equipment required and invite private players to take up manufacture either by R&D or the JV route to strengthen the domestic industrial base.

30. Another option to boost the ancillary industry could be the formation of Special Economic Zones (SEZ),co-located with shipyards. This would act as an zone of attraction for private players to set up shop as SEZs are areas within which, items that are manufactured would be exempt from a number of taxes and thus makes these items globally competitive. Companies operating from these zones can import raw materials duty free, which makes them highly competitive in the global market and thus the business model more tenable. This step would provide a boost to domestic ship building and by in turn to warship building. Therefore, an integrated facility of a shipyard and SEZ would create backward and forward linkages of various ancillary and related components of the maritime sector. A marine ancillary industrial cluster in the region of an SEZ would also be able to cater to a number of other shipyards that can grow in the region. Thus, by declaring SEZs around and including the shipyard, the ancillary industry would get a definite boost and the ships built by using such equipment would be more competitive in the global market making shipyards export oriented. SEZs would ensure that the ancillary equipment produced in them would be competitively priced in the global market, thus opening up new markets overseas. This would ensure that the problem of low volumes, that the industry presently faces, is addressed as these equipment can then be exported to shipbuilders worldwide. Another possible solution, to address the problem of volumes, is to ensure that much of the ancillary equipment used in warship building is compatible with that of commercial ship building. This would result in requirement of larger volumes and thus be profitable for equipment manufacturers.

R&D and Manufacture of Defence Hardware

31. To ensure complete self-reliance in the warship building sector or in any other defence sector, it is of vital importance that India becomes a manufacturer of defence hardware. To ensure this it is vital that private sector is encouraged to set up R&D units for developing the latest defence hardware products. This can be facilitated by the government by setting up JVs between DRDO and private companies initially or encouraging JVs between private sector and foreign defence

manufacturers. The route of private companies acquiring foreign defence manufacturers can also be explored to quickly infuse state of the art technology into Indian private sector market. The government can also set up a new agency on lines of the US Defence Advanced Research Projects Agency (DARPA), which can partly fund research by private sector companies in niche defence technology both for the R&D phase and thereafter for setting up of the production line. This would result in the best and state of the art products being available to the Indian navy to choose from. The Indian Navy can boost this model by opting to fit a standard type of weapon on a large number of platforms so as to make its manufacture financially viable.

Reassess our Procurement Matrix

32. The Indian navy needs to reassess its procurement policies so as to ensure that it gives maximum opportunity to Indian public/private defence manufacturer's when procuring a weapon system or sensor suite rather than for foreign vendors. To make their business viable the navy also needs optimise the number of classes of ships that it maintains so that more number of same class of ships are ordered which makes the Shipyards procurement chain profitable and in turn makes the ancillary industry profitable.

Training of Skilled Work Force

33. The government needs to build institutions of learning which offer courses in specialised skills that are needed by the ship building industry. Shipyards also need to invest in training and upgrading their work force on a continuous basis. Presently, there are only three government recognised ship building institutes in India, other than the training programmes being run by shipyards. To evolve into a major shipbuilding hub, the government and private institutions need to set up more number of training institutes to train unskilled labour into skilled labour so as to build a larger base of skilled work force. Also, training in shipbuilding itself must be a continuous process where workers and managers regularly undergo training to update their skills. Successful foreign yards spend as much as 1 to 1.5% of revenues on training. This amounts to an average of 8 to 10 days per year as full time training of everyone. Indian shipyards need to implement such training schemes to not only ensure that its work force is in-date, but also up to date with the latest technology and innovative techniques. It is also important that the work force is multi-skilled. This would result in a reduction in the number of trades in the shipyard and also abolish the mate/helper concept. A multi-skilled work force would be able to do all jobs like plating, marking, welding, engine fitting, pipes fitting and others. This would go a long way in improving ship productivity substantially.

Fiscal Policies

34. **Moderation of Taxation.** As has been brought out, there are over 19 different types of taxes levied on various activities in ship building. These include taxes on procurement of raw material to finalisation of costing of the final project. The cost of building and selling warships in India is much higher than abroad. As warship building is a globalised industry and not protected by tariff barriers,

it needs incentives and suitable promotion. Thus taxes such as service tax on warship building is unwarranted. Indian shipyards must therefore be exempted from service tax as shipbuilding is a manufacturing activity. Similarly, waving off a number of other taxes on import of goods and export of finished product would result in improving the competitiveness of Indian warship building industry. Towards this, the creation of SEZs, co-located with shipyards, would also result in tax holidays on both import of raw materials, specialised shipbuilding equipment and export of finished products, which would make our warship building industry globally competitive. Also, the government must declare the warship building and ship building industry as infrastructure industries, as this would accrue the advantages of availability of funds at nominal rates of interest and tax benefits on all finished products.

35. **Providing Subsidy to Warship Building.** A study by Klijnveld Peat Marwick Goerdeler (KPMG), one of the largest professional auditor services company in the world, carried out in 2008 brings out that shipbuilding in India, though cheaper as compared to Western countries, is costlier by a factor of 40 to 50%, as against South Korea and China. Though these figures are for commercial shipbuilding, they may be taken as the same for warship building due to similar taxations involved. Subsidies have been historically used by shipbuilding leaders as an effective fiscal tool for the industry's growth as seen in the case of China and Korea. Thus, the government must provide subsidy for warship building so as to negate the effect of excessive taxation and ensure that our warship building is competitive in the global market. Towards this, a 30% subsidy was given on all finished products by the government from 2002 to 2007. The withdrawal of the scheme led to an immediate down turn in the commercial shipbuilding industry. The share of Indian Yards in Global Order Book for commercial ship building that was previously rising suddenly saw a marked downfall. The new orders that rose sharply from 0.01 million DWT in 2002 to about 3.19 million DWT in 2007 took a sharp drop. As the scheme was in effect for a very short duration, the warship building industry couldn't capitalise on this scheme. To enhance competitiveness of Indian shipyards, it is thus recommended that the subsidy scheme be brought back in force till the time the warship building industry catches up with its global counterparts. Subsidies will also promote indigenisation, as they can be linked to sourcing of at least 50% of materials and components in terms of cost from domestic suppliers to facilitate growth of the ancillary industries. According to the Shipyards Association of India, the revival of the subsidy scheme will wipe out the systemic disadvantages on financial and taxation faced by local builders and put Indian yards on par with global yards.

Design Technology

36. On 02 Nov 09, the former Chief of Naval Staff Admiral Nirmal Kumar Verma said "*We need to revisit the building strategies of the (Defence) shipyards. There is a need to do much more. Construction schedule is where our shipyards lag. The reason for delays is the basic method of construction (adopted by the shipyards)*". With respect to modular ship construction being

followed by foreign shipyards, he said, "This is found to be the most efficient means of ship construction by which time taken for delivery of the platform is minimised and the work at the dry dock is optimised." Currently the Defence Shipyards in India build ships by launching the hull in water after welding it and thereafter the shipyard's craftsmen install machinery and equipment in highly cramped spaces. This also contributes to inordinate delays in delivery of warships to the Navy as ships have taken nearly ten years to build. However the major shipyards in countries like China and South Korea have moved to modular ship building wherein large tonnage blocks are manufactured independently along with their equipment, electrical wiring, pipelines etc and then fitted to neighbouring blocks precisely, to finally form the warship. MDL's modular shipyard costing Rs 824 crores was commissioned only in Jun13. It is now expected that in the near future, MDL would build destroyers in 72 months and frigates in 60 months. This technology is considered the way ahead for warship building in India and all shipyards need to adopt this.

37. Other modern developments in the field of ship building have been in design technologies. Three dimensional computer aided modelling is one of the technologies that is being universally used by majority of leading ship building firms of the world. Such 3D modelling solutions provide comprehensive work sharing capabilities, design automation tools, and customisable design rules that can capture the company's know-how and create competitive advantages. It can be used to periodically review and identify necessary changes during the design phase itself, when modifications are easier to make and more economical to implement - from both cost and schedule perspectives. 3D modelling is used in design activities related to plates, profiles, piping, equipment, outfitting structures, Habitability Ventilation Air Conditioning (HVAC) ducting and hangars and supports among many others.Hyundai Heavy Industries (HHI) Shipbuilding Division, which builds warships for the South Korean Navy, has not only implemented a 3D Computer Aided Design (CAD) solution but also more comprehensive solutions such as the Product Lifecycle Management (PLM) technology. To make maximum use of these techniques and technologies, all DPSU and private shipyards should have integral design bureaus, which employ these technologies. This would ensure that the shipyards are efficient and do not lose time due to faulty designing. These bureaus should evolve into primary design agencies, which would ensure that they can field their designs in the commercial market and thus compete globally.

38. Another technology that can be introduced is the virtual ship building concept.This technology simulates and optimises the entire shipbuilding life cycle process in a virtual environment from initial development stage to launch. The LPD 17 USS San Antonio was the first warship to be designed in virtual reality developed between the US Navy Office of Naval Research and Samsung Heavy Industries Co Ltd, through digital manufacturing solutions provided by DELMIA Simulation tools such as IGRIP, CATIA, QUEST and ER60. The design for the San Antonio was 80% complete before any steel was cut. No steel was cut or welded until every step was proven through simulation, thus avoiding re-work and re-weld. The ship was assembled on screen, block by block to make sure that every assembly, sub assembly and component fit and would work together as planned. However, through processes which do not use digital designing as is adopted presently in

Indian Defence Shipyards, only 20-30% of the ship design is complete when production starts. The US Navy has reported that the virtual design technology resulted in a saving of $370 million in the LPD ship programme. It is therefore prudent for Indian shipyards and design organisations to incorporate digital shipbuilding with virtual reality in warship building.

Development of Commercial Ship Building

39. Another way ahead in improving design efficiency in warship building is to utilise the commercial ship building industry to aid naval shipbuilding. It is a path to getting warships much quicker and cheaper. For example, Hyundai Corporation decided in 1972 that it wanted to get into commercial shipbuilding. They bought some real estate in a tiny fishing village in the southern tip of Korea and by 1979 they became the largest shipbuilder in the world. The world's four largest shipyards are all in Korea today, of which HHI is the largest, accounting for 17% of the world's new shipping tonnage in 2007.This shipyard has an enormous amount of design capability and that is what the Republic of Korea Navy is capitalising upon. The HHI yard is several generations ahead of most other shipyards in design technology. When they do a preliminary design, they have the weights, lengths and so forth, for all the cabling, piping and everything else in the ship, in effect all that is required for a detailed design. The whole process is done without any human interference, except to do some checking. Therefore, when they were asked to undertake the design of a new 10000 tonne destroyer for the US Navy to carry the Aegis weapons systems, they were able to complete the ship from design to delivery in record time. The Republic of Korea (ROK) Navy for itself, fitted the Aegis system on its KDX III warship launched in May 07 with 128 vertical launch cells. The ship is larger than the Arleigh Burke DDG 51 of the USN and 10ft longer and 3 ft broader than the Japanese Aegis ship, the Kongo class. The ROK Navy has developed so much confidence in the commercial shipyard's design capabilities that they have eliminated the contract design process and have turned the whole warship building process over to the commercial yard. The ROK Navy believes it will get warships at a faster and lower cost by this procedure.

Change the Transfer of Technology Model

40. The present model of Transfer of Technology (TOT) is based on the principle of learning "How to?' from the manufacturer. This in turn means that the Original Equipment Manufacturer (OEM) only imparts that part of the technology so as to train our personnel on how to assemble or maintain the equipment. This continues to make us rely on him for any critical repairs as our personnel do not learn the "Why". It is more vital to learn the "Why" and towards this future contracts must cater for the involvement of design/R&D agencies in the TOT so that scientists from the DRDO or selected Indian partner company can be deputed to absorb the technology with an aim to carry out further research and development and produce the follow on series of that equipment. A case in point is the Israeli model, who have built their defence manufacturing on US technology but have now started innovating ahead on these platforms and export better versions such as the F-16I than those available with the US.

Convert the "Brain Drain" into "Brain Gain"

41. Another important angle that the government can target is the aspect of Indians expatriates or PIOs working in niche defence sectors abroad. These people who are the real brains behind many a success story in the West are the pool of talent that was lost by India due to the phenomenon of "Brain Drain" after the 1980s. The government needs now convert this loss into a "Brain Gain" by executing schemes to woo these people back to India by offering good pay and perks and using a nationalistic platform so that they can contribute the advanced technology of their respective fields to Indian Defence sector by either setting up start-ups in India or by joining Indian public/private sector companies.

42. The cream of the Indian brains mainly the IITs and NITs of the country which have primarily become the workforce generator for the MNCs of the world could contribute immensely in boosting the Make in India perspective of the Defence sector. In this regard two suggested models can be worked at.

Indegenisation Projects at IIT

43. Considerable amount of expertise has been developed by major shipbuilders like MDL, HSL, GRSE in manufacturing the hull structure however the major challenges in indigenisation are experienced at equipment and component levels primarily engines, generators, pumps, compressors, valves , weapon , sensors, PCBs, motors alternators . These components are being indigenised by indegenisation units however the progress and technological advancement are negligible. The first model aims at targeting this problem by utilising IITs and NITs to undertake Indigenisation projects in niche areas. As part of this plan every IIT can be tasked with a list of Projects for the defence industry under a set of renowned professors in collaboration with the private manufacturing sector. It is proposed that under the aegis of Directorate of Indegenisation (DOI) specific Indegenisation projects to be identified in consultation with the respective administrative authorities and professional directorates based on the present equipment level lacunaes and future envisaged technological advances. Post finalisation of list of projects, these project to be discussed with respective IITs to finalise the scope of work, based on SOTRs. Once the scope of the project is finalised private sectors players be invited to discuss the modalities of manufacturing and estimated cost /duration. Based on the cost and time duration the projects be handed over to these IITs with allocated budget. The overall project to be conducted by DOI alongwith respective Indegenisation Units with periodical review on a quarterly basis. The core sector expertise can be provided by the student officers undergoing the M Tech from these institutions. It is understood that similar model is being adopted at IIT Delhi for research projects in Underwater technology, however the modalities are not on an expandable scale and is lacking with other IITs.

Compulsory Service in R&D PSUs

44. The students from IIT , NITs and most of the government engineering colleges are provided with the best of infrastructure and educational support at a subsidised rate from exchequers money however very few of these offer any services to the R & D for core government sector PSUs. It is

known that all MBBS students have to undergo mandatory 2 to 5 years public service in rural areas post completion of MBBS. The second proposal being a more radical approach on similar lines wherein it is proposed that students from IITs ,NITs and all government funded institutions should undergo mandatory service of two year in government R&D sectors like DRDO, NPOL, NSTL BEL, SAIL,HAL etc under the Make in India programme. During the proposed duration the students be offered adequate pay package as per industry standards and the pay package should be performance based and should be given an option for permanent absorption post completion of 2 years of internship .This proposal would not only enable infusion of best of the talents but also eventually help in fructify most of the R & D projects in these sectors.

Conclusion

"Speak Softly, and Carry a Big Stick"

(By President Theodore Roosevelt)

45. India is one of the fastest growing markets in the World and with its large population is also one of the largest consumers in the World. Thus, both countries (international community) and companies cannot afford to ignore us. Therefore, without a doubt the "Make in India" initiative is certain to have a positive impact on the growth story of the nation and will result in a boost to indigenous manufacturing in the 25 sectors that have been targeted.

46. The essay has concentrated on one aspect and probably the most important aspect of defence manufacturing in so far as the Indian Navy is concerned viz. the Warship Building Industry. It has attempted to highlight the various problem areas that exist in this sector and some solutions that would harmonise our efforts to ensure that the "Make in India" initiative is an even more resounding success. Though the solutions seem at times specific to the Warship Building Industry, however they are not so. Many of them can be generically applied to any defence sector such as R&D and manufacture of defence hardware, development of the ancillary industry, reassessing of procurement matrix, fiscal policies, design technology or TOT model etc.

47. The sector of Defence Manufacturing is an important and vital part of this growth story. The larger the Indian economy becomes, the more vital it will become to have strong armed forces. Continued dependence on overseas suppliers for vital defence hardware may prove to be our Achilles heel.It may rise to become the biggest impediment in India taking its rightful place in the League of Nations and in the future an economic world power.

Recommendations

48. Having studied the various road blocks that are impeding our warship building industry from truly maturing in to a self-sustaining sector under the "Make in India" initiative and some solutions as to how to improve it. A few recommendations which can be generically template for any of the defence manufacturing industries are as follows:-

(a) Disinvest in selected DPSU shipyards such as CSL and GSL whilst retaining some yards such as MDL, HSL and GRSE as DPSU yards. Use this money to modernise these selected yards so as to make them at par with international yards.

(b) Create a specific list of ancillary industries that directly contribute to the warship building industry and provide incentives for manufacturing in these sectors.

(c) Create SEZ around shipyards so as to boost ancillary industry and provide them cheap raw material and tax free export to make them competitive at global level. Provide tax holidays and subsidies to make manufacturing more globally competitive. These measures would also boost the commercial shipbuilding sector and in turn the warship building sector.

(d) Facilitate JVs between DRDO and private sector or between foreign defence manufacturers and private sector to create Indian subsidiary's to manufacture quality high technology defence equipment in India.

(e) Boost R&D by allowing all defence manufactures both public and private to have their own R&D division so as to give greater competition to DRDO. Provide government R&D institutes with state of the art design technology and tools.

(f) Indgenisation and R & D in defence sector to be undertaken in collaboration with IITs by setting up a governmental agency similar to US DARPA so as to fund research into niche technologies by leading Indian Institute's or by private sector and thereafter to set up production line if contract awarded.

(g) Compulsory service in government R & D sector by students of leading government institutes like IITs and NITs.

(h) Indian armed forces to give preference to Indian defence manufacturers over foreign ones during procurement and larger number of similar platforms to be procured to improve scale of economy/business model.

(i) The government should build dedicated training institutes to provide sufficient trained and skilled manpower to defence industrial base.

(j) Change the TOT model to from procuring the 'How to' to procuring the 'Why'. This may mean procuring slightly older technology initially as foreign vendors or governments would not sell their state of the art technology but this would enable us to build a base to develop our R&D sector to catch up quickly.

Appendix A
(Refers to Para 17)

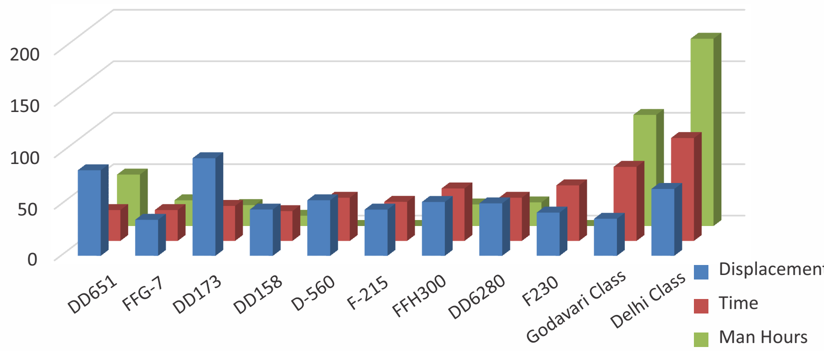
COMPARISON OF DELIVERY TIME OF VARIOUS INDIAN WARSHIPS

Project / Date of Original /Revised Sanction	Ship	Original date of delivery of Ships	Revised date of delivery [8]	Status as of September 2010 in percentage terms	Expected Date of Delivery
P 17 January 1998 March 2006	Ship 1	December 2005	September 2008	100	Delivered in March 2010
	Ship 2	December 2006	May 2009	95.53	January 2011
	Ship 3	December 2007	December 2009	89.18	May 2011
P 15A June 2001 February 2006	Ship 1	2008	May 2010	71.08	March 2012
	Ship 2	2009	May 2011	57.52	March 2013
	Ship 3	2010	May 2012	46.77	March 2014
P 28 March 2003	Ship 1	August 2008	June 2012	47.67*	June 2012
	Ship 2	August 2009	March 2013	27.86*	March 2013
	Ship 3	August 2010	March 2014	11.79*	March 2014
	Ship 4	August 2011	January 2015	5.36*	January 2015

Government of India, CAG Performance Audit Report No. 32 of 2010-11

Appendix B
(Refers to Para 23)

COMPARISON OF MAN-HOURS OF WARSHIP CONSTRUCTION



RajeshwarNath. 'Towards Modern Ship Design and Shipbuilding in India', Military Technology, MILTECH, Oct 2005

Appendix C
(Refers to Para 24)

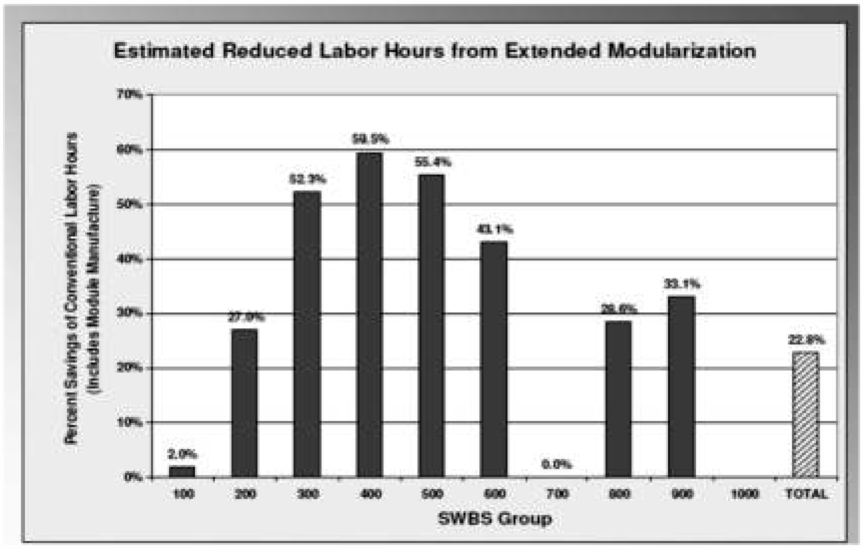
VARIOUS EXISTING TAXES LEVIED ON INDIAN SHIP BUILDING INDUSTRY

Details	Total Additional Per ship (%)	Cost disadvantage v/s Foreign yards (%)	Taxes/Duties paid back to govt. (%)	
			Domestic Order	Export Order
VAT and CST	4.00	4.00	4.00	0.00
Working Capital	4.00	2.00	-	-
Bank/Refund Guarantee	3.60	2.40	-	-
LC Cost	0.30	0.20	-	-
Insurance	1.60	0.60	-	-
CAPEX Finance	0.90	0.40	-	-
CAPEX Custom Duty	1.70	1.70	1.70	1.70
Custom Bond Cost	0.25	0.25	0.25	0.25
Clearing and Forwarding	0.60	0.30	-	-
Excise and VAT	4.18	4.18	4.18	4.18
Service Tax	1.40	1.40	1.40	1.40
Freight Differential	2.50	2.50	-	-
Price of Equip Differential	5.00	5.00	-	-
Octroi	2.50	2.50	2.50	2.50
Power	0.50	0.50	-	-
Corporate Tax	3.50	1.20	3.50	3.50
Tax on Foreign Income	0.27	0.27	0.27	0.27
Income Tax	0.00	0.00	2.05	2.05
Taxes by Ancillary Units and sub-contractors	0.00	0.00	1.00	1.00
Total	37.6	30.2	20.85	16.85

Government of India, Ministry of Shipping, Road Transport and Highways, Report of Working Group of for Shipbuilding and Ship Repair Industry for XIth Five Year Plan (2007-2012), 2007, New Delhi.

Appendix D
(Refers to Para 29)

ESTIMATED REDUCED LABOUR HOURS FROM MODULARISATION



Government of India, Ministry of Shipping, Road Transport and Highways, Report of Working Group of for Shipbuilding and Ship Repair Industry for XIth Five Year Plan (2007-2012), 2007, New Delhi.

Bibliography

Books

1. CmdeKNVaidyanathan and Cdr Jagmohan, 'Warship Design: Capability and Capacity', Shipbuilding in India : Challenges and Strategies, Ed. Ravi Vohra, TVS Ramana, KW Publishers Pvt Ltd, 2009.

Documents

2. Government of India, Ministry of Shipping, Road Transport and Highways, Report of Working Group for Shipbuilding and Ship Repair Industry for the XIth Five Year Plan (2007-2012), Mar 2007

3. Government of India, Planning Commission, The Manufacturing Plan - Strategies for Accelerating Growth of Manufacturing in India in the 12th Five Year Plan and Beyond

Periodicals

4. The Hindustan Times, "East, Link West, says PM Modi at Make in India launch", 25 September 2014.

5. 'Towards Modern Ship Design and Shipbuilding in India', RajeshwerNath, Indian Defence Review, Vol 22(3) Oct-Dec 2007

6. India's Defence Shipyards', Rahul Roy-Chaudhary, Defence, 1995

7. 'Indian Shipbuilding in the Global Context: An Empirical Study on Current State of Industry and Exploring Scope for Improvement', Joshin John, Vijaya Dixit, Dr Rajiv K Srivastav; IIMLacknow News Letter, Vol XXII, Feb 2012,

8. 'Problems and Prospects of Shipbuilding in India', RajeshwerNath, Agni, Jan-Apr 2004, Vol. VII (III).

Websites/ Internet Resources

9. http://www.makeinindia.com/sectors
10. http://www.dnaindia.com/
11. http://www.drdo.gov.in
12. http://articles.economictimes.indiatimes.com
13. http://www.thehindu.com
14. http://www.mantrana.in
15. http:// www.maritimeprofessional.com
16. ww.indiastrategic.in
17. http://www.globalsecurity.org
18. www.defencesecurityindia.com

Author's Biodata

Commander A K Pandey is an alumnus of 12th Naval Engineering Course. The officer is a post graduate from IIT Mumbai and has done tenures onboard Ranjit, Sindhukesari, Shalki, Shivaji and 10 SS. The officer is presently posted as Chief Engineer Officer at COMCOS (W)

Cdr Sunil Korti is an alumnus of the National Defence Academy, Pune and the Defence Services Staff College, Wellington. He is a Navigation and Direction specialist and has served as the Navigating Officer of submarines INS Shalki, INS Shankush and INS Shankul based at Mumbai. He has also been the Executive Officer of submarines INS Shankush and INS Shishumar and was an instructor at Submarine School, INS Satavahana, Vishakhapatnam. He is a prolific writer and has won First Prize in the prestigious Commodore Nott Essay Competition twice. He has recently completed his Commanding Officers Qualification Course and is presently the Staff Officer (P75) at COMCOS (W), Mumbai.

article 14

NAVAL SHIPBUILDING : THROUGH 'MAKE IN INDIA' PERSPECTIVE.

(Cdr MA Pradeep)

Introduction

1. The Indian navy's operational footprint in the Indian Ocean has also increased in the past decade. Indian's navy's capabilities and posture has increased many folds. Its fleet of 14 submarines, 27 principal surface combatants and nearly 100 patrol and coastal combatants, alongside two squadrons of maritime patrol aircraft, is to be expanded with the reported aim of becoming a 200-ship navy in the next decade. As a result, India has one of the most ambitious warship building programmes in the world.

Indigenisation Efforts

2. The Indian Navy has been a pioneer in the field of indigenisation. Warship building in Independent India was ushered-in, with the license production of the Leander class frigates in the early sixties at the Mazagon Dock Ltd. Six ships of the class were built and delivered between 1972 and 1981. The Navy's Central Design Office emerged as the Directorate of Naval Design(DND) in 1970 to form the nucleus of all warship design activities in the country. Since its inception DND has undertaken 17 different designs, ranging from small craft to destroyers, from which about 119 warships have been built.

3. Even though warship design capabilities have been developed within India primarily with effort of DND and Shipyards, the equipment fit were still largely imported. Indigenous equipment development was also primarily being done by PSUs like BEL and BHEL with active support from organisations like NPOL etc. Major contracts are still with 09 Defence PSUs, which account for approximately 20% of the market and around 70% is met through imports. Indian Navy had to acquire military technology through import from diverse sources. Requisite expertise also had to be created for their operation and maintenance. While much has been achieved by the Navy in pursuit of indigenisation over the past decades, Government of India's vision of 'MAKE IN INDIA' has give the required fillip for launching into a new phase of self-reliance by manufacturing technologically advanced equipment within India.

4. Recently Chief of Naval Staff had confirmed that apart from submarines being built under ATV project, over 47 warships including a 65,000-tonne aircraft carrier and six Scorpene submarines are on order. The Navy is proud of the fact that all 47 platforms under construction, ranging from an aircraft carrier to submarines are being built in Indian shipyards, both public and private. This has ensured that the Indian shipbuilding industry is been provided with impetus it needs.

5. The Navy has unveiled a 15-year plan to achieve full indigenisation in all phases of warship construction, from ship-building to systems to weapons, and aligned it with Prime Minister Narendra Modi's "MAKE IN INDIA." The Navy wants to involve private industry in a big way in this

initiative. The Indian Naval Indigenisation Plan 2015-2030 is aimed at enabling the development of equipment and systems through the Defence Research and Development Organisation (DRDO) and Indian industry over a 15-year period.

6. Indian Naval Indigenisation Plan (INIP) 2015-30 was released by the Honourable Raksha Mantri during a seminar on Innovation and Indigenisation, which was hosted by the Indian Navy along with the Confederation of Indian Industry (CII) in July 15. Warship building capacity may be disaggregated into three elements, which pertains to the ship's ability to 'Float', 'Move' and 'Fight'. The 'Float' element refers to the ship's (water-tight) structure. The 'Move' element refers to the appropriate propulsion system of the warship. The 'Fight' element relates to weapons and sensors pertaining to all dimensions of naval operations, viz. surface, sub-surface, air and the electromagnetic-cyber spectrum.

7. Currently, Indian Navy has achieved 80%-90% indigenisation in the 'Float' component, about 60% in the 'Move' component, and about 30% in the 'Fight' component. The 'MAKE IN INDIA' initiative will enable the Navy to further enhance indigenisation levels to achieve the goal of future warships being "100% Made in India". The INIP is a major enabler of 'MAKE IN INDIA' drive, which will further boost indigenous development of equipment for naval platforms, within our own country. Further, it is aware of the serious shortfalls in terms of both Indian R & D and Indian manufacturing, which reflects the Navy's clarity of perception in charting the course ahead. The five drivers of the INIP are

(a) Lack of credible R&D in military sciences and technologies.

(b) Inadequate amalgamation between R&D and the manufacturing sector

(c) Absence of an integrated approach amongst users, designers and manufacturers.

(d) Commercial un-viability due to a lack of economies of scale approach

(e) Effect of technology-denial regimes,

Warship Building Capability

8. The Indian shipbuilding is mainly centered around 27 shipyards comprising 8 public sector (six are under Central Government and two under State Governments) and 19 private sector shipyards. The shipyards have 20 dry-docks and 40 slipways between them, with an estimated total capacity of 281,200 DWT. However, all of the shipyards are not involved in naval shipbuilding. Out of the six shipyards under the Central government, only four are Defence Public Sector Undertaking (DPSU) shipyards. DPSU shipyards have contributed immensely towards indigenous warship development program with active support and participation of Indian Navy. Although DPSU shipyards are primarily responsible for naval shipbuilding, some others, both in the public and private sector are also involved in construction of naval ships.

9. Traditionally, the DPSU shipyards have been favoured by the Ministry of Defence (MoD) for construction of major warships owing to the perception that private shipyards may not be able to deliver the vital defence requirements. Many a time, orders have been placed on DPSU shipyard , beyond their capacities for the above reason. A major criticism of the warship construction

programme in India lies in its huge time and cost overruns giving the impression that DPSU shipyards are not in the same league as compared to their counterparts abroad. It is beset by delayed timelines and dependence on foreign suppliers. The lack of self-reliance leads to high production and life-cycle costs, the uncertainties with regard to assured supply of spare-parts, and also the stretching of timelines. The observations by the Comptroller and Auditor General (CAG) regarding cost growth for naval projects have been found to be 260 % for P 17, 226 % for P15A and 161% for P28.

10. It may be noted that, although India has attained a credible capability in warship-building over the years, the role of prime-movers for naval shipbuilding has been assigned to the four Defence PSU shipyards. While MDL and GRSE have the expertise and experience of building frontline frigates and destroyers, GSL and HSL have historically constructed smaller vessels or vessels with proven design. Therefore, even the DPSU shipyards differ widely in their role, areas of strength and outputs. Put together, the present ship building capacity of these Defence PSUs based on past averages is close to four ships per year - a number too low to meet the expectations of Navy. Apart from these shipyards CSL has been assigned the responsibility of building the first indigenous aircraft carrier Vikrant.

Defence Shipbuilding Orders

11. Current Indian warship building activity is not restricted to the DPSU shipyards, orders are also on other government and private shipyards like Cochin Shipyard Ltd, Alcock Ashdown Shipyard, ABG Shipyard, and Pipavav Shipyard. Some of the naval orders on the Indian shipyards are:

Shipyard	Orders
Mazagon Dock Ltd	Six Scorpene class Four Type-17A stealth frigates Three Type-15A destroyers Four Type-15B destroyers
Garden Reach Shipbuilders and Engineers Ltd, Kolkata	Three Type-17A stealth frigates Four Type-28 ASW Kamorta class corvettes
	Three follow-on Water Jet Fast Attack Craft namely Tarmugli, Tilanchang and Tihayu
Goa Shipyard Ltd:	Four offshore patrol vessels (OPVs) Six mine countermeasures vessels (MCMVs)
Hindustan Shipyard Ltd	Two Mistral class LPDs
Ship Building Centre (SBC):	Four (not confirmed) Arihant class nuclear submarines
Cochin Shipyard Ltd (CSL):	Indigenous aircraft carrier
ABG Shipyard	Two training ships
Alcock Ashdown Shipyard	Six Catamaran survey ships
Pipavav Defence and Offshore Engineering Co. Ltd:	Five OPVs to be ordered Four Project 11356 Class Frigates under Make in India route by Russia
Bharthi shipyard Ltd	Fast speed boats Technology demonstration vessel.

Pending Orders:

a) Two landing platform docks (LPDs) on private shipyards
b) Two submarine support ships
c) Two deep submergence rescue vehicle (DSRVs)
d) AON for SLEP of four 877 EKM submarines and two SSK submarines.
e) AON for construction of four survey ships by private shipyard.
f) DAC clearance for two midget submarines.
g) EOI for construction of IAC -II to shipyards.

12. In addition to the above, three Intermediate Support Vessels (ISVs) were commissioned into the Indian Navy as T-48, T-49 and T-50 on September 29, 2015 in consonance with the 'Make in India' initiative. 14 of the ISVs were built indigenously by M/s SHM Shipcare, Thane while four were built by M/s ADSB and five by M/s Rodman Polyships.

Shortfall in Capacity

13. As per Indian navy's long term plan over 75 ships and 24 submarines are due for acquisition by 2027. Indigenous construction of these ships requires and estimated annual capacity of 107 standard ship units(SSUs). The combined capacity available in the defence PSU shipyards is only about 39.25 SSUs. if the requirement of Coast Guard ships (approximately 158 ships) is also considered the gap in capacity widens further. The intended induction program envisages to induct ships and submarines at a rate of 5 platforms per year. In addition to the construction demand, the demand for repair and refitting of naval vessels are also increasing, considering the naval dockyards are already overloaded beyond their capacity to refit the platforms, due to an aging fleet and with the increase in force levels.

14. However considering the past performance of DPSU shipyards, even with the proposed capacity expansion and modernisation of DPSUs, there is a huge gap in demand and capacity. The requirement of making warship abroad has been primarily governed by capacity of Indian DPSU's to meet the timelines in replacing the aging fleet of Indian Navy and Coast Guard rather than capability. Therefore, it is imperative that our private shipyards raise to the occasion and increase the ship building capacity of the nation.

Private Sector Shipyards

15. Public and private sector shipyards enjoy a unique set of advantages and disadvantages. For the MoD owned shipyards, their biggest advantage lies in long exposure to shipbuilding, enabling them to acquire certain construction skills, design capability and technology. These aspects are crucial for naval shipbuilding, which unlike the commercial shipbuilding is a difficult task given the complex

nature of marrying a vast amount of weapons and sensors into warships, which are increasingly required to be stealthier and more durable. While, the Defence PSU have experience and design capability in warship manufacturing but are slow and inflexible in quick adaptation of modern technology. Private shipyards have modern technological system but relatively inexperienced personnel who can understand the nuances of warship design and integration of machineries.

16. In last decade, there has also been tremendous thrust on warship building by Indian private players namely L&T, Pipavav Offshore and Defence Engineering, ABG, Bharati shipyard Limited, to name a few, who have created world class infrastructure to cater to growing demands. Estimations show that the private shipyards have established capacity of about 27000 DWT . The recent acquisition of Pipavav Offshore and Defence Engineering by Reliance Infrastructure, together with sole management control substantiates the fact that private sector is geared up to tap this opportunity.

Opportunities and Areas for Indigenisation

17. Shipbuilders primarily need to have excellent design and integration capability. With increasing construction of warships within the country, leading equipment manufacturers have also given greater thrust in indigenous manufacturing of equipment installed onboard ships. Indian Navy has played a greater role in identifying these industries and including them in the list of nominated vendors for all warship construction program thereby giving adequate impetus to indigenization and sourcing of equipment within India. The last Anti Submarine Warfare Corvette (Kamorta Class) built by GRSE has a remarkable indigenous content of over 90%. New technological advancement in field of composite material is also being taken up by Shipyards like GRSE, with last of the two Kamorta Class ASW Corvette being built with super structure of composite material.

18. The INIP 2015-30 enumerates the major technology areas and capabilities that the Indian public and private sector industry may focus on, to meet the indigenisation needs of the Navy. Various equipment and systems proposed to be indigenised for the Navy over this 15 year period have also been listed in the INIP. These are tabulated below.

Category	Equipment /System
Float	Arrestor Wires on Aircraft Carriers Aircraft Lifts RAS System\ Composite Superstructure Long Life Paints for Underwater Hull, Flight Deck and Radar Absorption Composite Foldable Hangar Door Bow Sonar Dome Glass for Window on Ships Bridge
Move	Gas Turbines(11-15MW And 20-25 MW) Main Propulsion Diesel Engines Marine Gear Boxes Shafting Propeller(Fixed And Variable Pitch) CFC Free Fire Fighting Systems for Magazines and Machinery spaces Air Independent Propulsion Steam Generation Equipment Canned Motor Pumps
Fight	Surface To Air Missile Surveillance Radar Air Early Warning Radar SATCOM Aviation Control Suites Fire Control Systems Integrated Mast And Control System For Submarines Mine Hunting And Portable Diver Detection Sonars Light And Heavy Weight Torpedoes Towed Array Sonars UAVs / ROVs/ AUVs / GPS INS SRGMs
Aviation Equipment	Naval Utility Helicopters, Naval Multi Role Helicopters Deep Repair Facility for Older Generation Aircraft TU 142M, IL-38 Seaking, Kamov etc.
Diving and SOVs	Night Vision Equipment With Advanced Optics Diving Sets With Full Face Masks UAVs and Micro UAVs Underwater Diver Lamps
Submarines	High Density Valve Regulated Lead Acid Batteries Main Motor Generators Propulsion Motors Non Hull Penetrating Masts Optics For Submarine Masts Integrated Sonars

Challenges for Indian Naval Shipbuilding

19. Warship building in India also suffers from various weaknesses and a number of challenges. Some of the constraints of Indian shipbuilding industry are enumerated below:-

(a) Shipyard Infrastructure and Facilities: Infrastructure available in the Defence PSU shipyards is inadequate to cater the futuristic warships and adhere to timelines of force level requirements. The defence shipyards like GSL, MDL and GRSE have, therefore, embarked upon a comprehensive modernization programme. Further, after the transfer of HSL from the Ministry of Shipping to the Ministry of Defence, plans have been initiated for revival of the shipyard for utilizing the existing resources with requisite modernisation for building the conventional warships as well as vessels for the Navy. Considerable facilities have also been created in the private sector to bridge the gap.

(b) Requirement of Large Financial Resources: Ship building is a very high capital intensive industry due to requirement of large financial resources for establishment and modernisation of shipyards, and investments. Hence only governments or large established corporate have the capacity to setup green field / brown field projects.

(c) Lack of Compatible Indigenous Propulsion and Power Generation Systems: The GT/diesel propulsion and power generation packages continue to be procured from abroad for major ships. However, for some corvettes, Kirloskar Oils and Engines Limited (KOEL) have commenced supplying engines and with Walchandnagar Industries working in collaboration with DCNS France, more import substitution is likely to follow. However a lack of established options continues to be major constraint.

(d) Long Gestation Periods Between Design and Construction: Long gestation periods between design and construction leads to design and equipment changes during construction. Long construction times associated with telescopic method of construction have led to flexibility in carrying out changes in designs and major equipment by the Indian Navy, which in turn has resulted in increases in costs and delays

(e) Restricted Technologies: Restricted access to defence technology, particularly in areas of electronics & communication, missiles and smart ammunition; which is closely guarded by firms and nations. The lack of access to critical technologies, many of which are of dual use, delays the projects. Other critical technologies in stealth, smart materials, ab initio weapon system design, etc continue to elude the warship building effort in India

(f) Limited Research and Development (R&D): Indian industry's emphasis on R&D has been rather low with most companies spending only about 2% of their sales revenue on R&D. Prohibitive cost of R&D for development of cutting edge technologies which is further accentuated by the lack of synergy between the institutions working in this area.

(g) Supply of modern weapon systems by the industry Naval weapons are complex in design due to the corrosive sea environment in which they have to operate, severe space and weight restrictions, and problems of stabilisation as the ship rolls, pitches and yaws. The indigenous effort has still not matured to provide viable weapon system or even subsystem solution within the required time frames and the budgeted costs. Economic viability, arms export policy and non-availability of technological prowess, appear to be the main reasons for the same. However some of the success stories in this area are , production of BrahMos missile system; TAL torpedo by the Bharat Dynamics Limited (BDL); electronic warfare (EW) systems and Sonars by the Bharat Electronics Limited (BEL); AK630 and miscellaneous ammunition by Ordnance

Factory Board (OFB); super rapid gun mount by the Bharat Heavy Electricals Limited (BHEL); Russian rocket system (RBU) and transportable target launchers by Larsen and Toubro (L&T). A lot more indigenous effort would have been made and protracted delays in development of other weapon systems like surface-to-air missiles and heavy weight torpedoes needs to be curbed.

(h) Monopsonic Defence Market: The Defence industry being monopsonic in nature, companies find it difficult to commit adequate funds for R&D in the absence of guaranteed business at the end of the development cycle. Low volumes of high technology equipment are unattractive to qualified vendors. Absence of consortium approach between the designer, manufacturer and the vendor.

(j) Constraints of Public Sector Shipyards: The current level of performance of PSU Yards is due largely to the lack of competitive environment in which they operate. Like other production agencies under the MoD, PSU shipyards are treated as the captive production agencies to meet the requirements of the defence forces, ensuring orders to them, irrespective of their capacity, capability. This leads to often at the cost of timely delivery, developing alternative capacity and promoting competition within the large industry. Cost and time overruns are common. Lack of coordination between planning, design and production departments are some of the important causes for such delays and problems in implementation of the project plan.]

(k) Lack of Level Playing Field to Private Shipyards: One of the reasons why India's warship building is not at a pace with the induction requirement is because the private yards are out of ambit of the major shipbuilding projects. Historically the defence production, including naval shipbuilding has been retained in the exclusive domain of the public sector enterprises. This continues to be so even though the 2001 reform measures have allowed 100 per cent private participation in defence production. The biggest obstacle for private yards is MoD's shipbuilding procedures, which favour the public sector enterprises over the private yards.

(l) Lack of Design Capability in Shipyards: Today, capability and responsibility to design complex warships (with association of major equipment manufacturers and collaborating foreign shipyards), is available only with the Indian Navy. The control of overall design, selection of major equipment and weapon sensor packages currently remains with the Indian Navy. The shipyards have not developed this crucial expertise because of their dependency over the ages on the Indian Navy. This restricts them in their manufacturing and in undertaking value additions. The private shipyards resort to buying the designs from foreign collaborators and depend upon the Indian Navy for providing design of warships on order. India has severe limitation in design capability with only IIT, Kharagpur, CUSAT, Kochi and IIT Chennai having some expertise. Vital gaps remain in design/development areas like vulnerability, survivability, stealth technologies, effects of shocks/blasts on ship construction and hydrodynamics of high spread marine vehicles and submarines.

(m) Lack of a Strong Commercial Shipbuilding Industry: Despite noticeable differences, a strong and competitive commercial shipbuilding industry has a positive impact on warship building. This is clearly evident from China where expansion and modernisation of commercial shipbuilding has vastly benefited all types of warship construction, in terms of quality, efficiency and output. In India however this correlation is absent since the commercial shipbuilding industry is weak and inefficient. Compared to China, Japan and South Korea which are the global leaders in commercial shipbuilding with an individual share of more than 25 per cent each, Indian shipbuilding industry accounts for less than one per cent of the global share.

(n) Absence of a Strong Ancillary Industry: Like in any other sector ancillary industry plays a vital role in shipbuilding in general and warship building in particular. In India the general ancillary industry for shipbuilding is vastly underdeveloped. Given the poor state of ancillary industry, it is not surprising that India's defence PSU shipyards also spend a vast amount of their resources in importing key raw materials, parts, components from foreign sources. The excessive import dependency has also a strategic underpinning and an impact on build period of naval ships.

(p) Lack of Synergy Between Public And Private Yards: A key weakness in India's naval shipbuilding is lack of synergy between public and private shipyards. Till now both of those shipyards are operating separately without combining their respective strengths. It is however noteworthy that each sector has a unique set of advantage. While the public sector has long exposure to naval shipbuilding, the private yards have greater flexibility and operational autonomy, in addition to the vast infrastructure they have created in recent years.

(q) Protection of Intellectual Property Rights (IPRs) The need to protect IPRs appears at an early stage in the relationship between yards and their suppliers. Yards have a need to disclose technical requirements and solutions in order to safely calculate the project both under technical and commercial terms. Shipyards also have to share their knowledge with classification societies, which perform a variety of functions. The relationship between yards and ship-owners is equally characterized by a direct and broad exchange of knowledge-based details of the vessel. Today, copyrights, registered designs and patents are the main instruments to protect IPRs. hence there is a need to take additional measures to ensure compliance with related IP provisions.

Way Ahead

20. Overcoming the above challenges will be critical for creating a strong and vibrant naval shipbuilding industry in India. In order to effective implement "MAKE IN INDIA" policy in naval shipbuilding, the following key areas have been indentified :-

(a) Joint Ventures and ToT :- Shipbuilders that are unable to invest enough capital to upgrade their facilities and technology could find significant benefits through strategic alliances with more technically capable shipyards to acquire technology. In some cases, leading yards might form strategic alliances in the form of JV, M&As or technical co-operation agreements, in order to strengthen their worldwide market position. These kind of projects are strategic to both local shipyards who wish to develop its capabilities and expertise, and to the technology partner who wish to expand market share and save competitiveness by securing and protecting its IPRs. The agreement on technology transfer cannot by itself only guarantee reaching the purpose of the joint venture, especially to the local partner who wishes to enhance his capabilities, without taking real steps on the ground to implement such agreements. Provided however, both parties are subject to certain legal arrangements such as strong corporate governance and internal shareholders agreement to ensure protection of both parties' best interests in reaching successfully to the purpose. In this regard, the Indian industry has made rapid progress in warship building with major world players like SAAB (Sweden), Fincanterri (Italy), DCNS (France), Navantia (Spain) setting offices in India and seeking technical collaboration with Indian Shipyards and Industry. PDOC has signed an agreement with JSC ship repairing centre Zvyozdochka , Russia for MR of life extension of 877 EKM submarines in India. Participation of global players with Indian partners, would greatly facilitate in following areas

(i) Timely completion of projects.

(ii) Enhancement of Indian shipyards capacity.

(iii) Cost competitiveness of Shipyards.

(iv) Bench marking with world class players in terms of quality.

(v) Ensuring more orders to Indian Shipyards while meeting Defence force preparedness requirement.

(b) Involvement of MSME:- Participation of MSME and major Indian Players in integration activities of shipyards will further enhance contribution of shipbuilding in overall GDP growth. With collaboration of all SME in integration activities, the shipyards capability to deliver on time and meet Defence Forces requirement would greatly increase leading to prosperity in local industry. On an average 15-20% of shipbuilding activities relates to services provided in meeting material and system integration. Apart from equipment supply, areas where MSME sector can greatly act as facilitators and partners to Indian shipbuilding industry are

(i) Block Fabrication These relates to panel fabrication, Block fabrication and consolidation, Erection, alignment and welding of units etc.

(ii) Outfitting Tremendous opportunity in various discipline of shipbuilding exist in these areas with regard to installation of equipment, lagging, painting, welding, pipe manufacturing, fittings, cabling etc.

(iii) Designing Areas for collaboration range from conversion of concept design to detail design, compartment layout plans, Electrical cabling & routing design, 3D modeling skills etc.

(iv) Production Opportunity exists areas of manufacturing of complete hull with outfitting, manufacturing of small ships like barges, fishing boats, ferries etc.

(v) Product Support Offering product support to customer by undertaking defect rectification on behalf of shipyards, guarantee work packages, refit of ships etc.

(c) Modularisation:- Defence shipyards have been building ships by launching the hull in water after welding it and thereafter the shipyard's artisans install machinery and equipment in highly cramped spaces. However, major defence shipyards like MDL and GRSE are already in the process of modernising by moving to 'modular shipbuilding' wherein 300-tonne blocks are manufactured independently along with their equipment, electrical wiring, pipelines, etc and then fitted to neighbouring blocks precisely. It is expected that MDL's modular shipyard costing `824 crore would soon be operational, and it is estimated that in future, destroyers would be constructed in 72 months and frigates in 60 months. The main goals of modular construction of warships are threefold, first to enable mission flexibility and future upgradability for enhanced service life of the ship; second to achieve synergies in procurement, integration, equipment and system testing, and parallel ship hull construction; and finally, to enable reductions in life cycle costs and costly upgrades by simplifying complexities in future upgrades. Modular construction coupled with fixed price contracts would reduce the construction periods and cost overruns.. Thus with modular construction and freezing of design in fixed price contracts, warship building in India is entering a new era of efficiency.

(d) R&D activity support: The Government should support R&D activity, especially of MSMEs, by providing assistance for conducting R&D. Ministry of MSME is launching a scheme to support R&D efforts. Defence MSMEs should be encouraged to participate.

(e) Defence Electronics: To synergize the R&D talent available in private and public sectors as well as in the academia, a Centre of Excellence for Defence Electronics should be created on a PPP model aimed at generation of indigenous IPRs. The proposed Centre of Excellence for Defence Electronics could be set up with majority of investment from the private sector based on the model followed in the telecom sector.

(f) Industry - Academia co-operation: In order to promote Industry - Academia co-operation, and introduce schemes to bring educational institutions and the industry together to facilitate innovation and product development. An Indian Maritime university needs to be established as an overarching institute to source requisite talent, both quantitatively and qualitatively.

(g) Development of Design Expertise outside the Navy: There is a need to evolve warship/submarine design expertise outside the navy and DRDO, in order to augment efforts of DND. There has been efforts to develop the design expertise by private sector shipyards, utilising the pool of retired naval officers with design experience. Setting up of National institute for R&D in defence ship building (NIRDESH) in 2010 was also a step in the right direction in order to support the Indian shipbuilding industry for design and R&D efforts.

(h) Strengthening of certification organizations: The health of the industry has a direct co-relation to the quality and robustness of the certification organizations. These organizations need to be strengthened by upgrading their facilities and skill levels.

(i) Vendor Development: DPSUs should continuously develop vendor base to ensure continuous availability of equipment for timely completion of projects. DPSUs and defence shipyards should increase the outsourcing of assemblies, sub assemblies and components, thereby building the capacity of the industry.

(j) Sector Skill Council: To fill the skill gaps, a defence Sector Skill Council could be setup in collaboration with the National Skill Development Council (NSDC).

(k) Policy Initiatives by GoI: To promote Indian shipbuilding and ship repair industry, the Union Government has already taken the following steps recently, namely:-

(i) Financial assistance policy for Indian shipyards was approved by the Government of India on December 9, 2015. As per the policy, financial assistance is to be granted to shipyards equal to 20% of the lower of the "Contract Price" or the "Fair Price" (as assessed by three international valuers) of each vessel built by them for a period of at least ten years commencing from 2015-16. This rate of 20% will be reduced by 3% every three years.

(ii) Revision of domestic eligibility criteria has been approved by the Government of India on December 9, 2015 to ensure that all the government departments or governmental agencies such as CPSUs procuring vessels for governmental purposes or for own purposes shall undertake bulk tendering for their vessel related requirements with deliveries starting from 2017-2018 and will grant a Right of First Refusal (RoFR) for Indian shipyards for such orders till 2025. From 2025 onwards, only Indian-built vessels are to be procured by them for governmental purpose or for own purpose. Similar relaxation/benefit will be applicable for repair of their vessels.

(iii) Another item, which results in higher cost to Indian shipbuilding, is taxes and duties. With a view to counter the cost disadvantage to Indian shipyards and to promote indigenous shipbuilding industry as part of the 'Make in India' initiative, the Ministry of Shipping had taken up this issue for redressal with the Department of Revenue, Ministry of Finance. Ministry of Finance has exempted Customs and Central Excise Duties on inputs utilized for the purpose of manufacture of ships vide General Exemption Notification Nos. 54/2015-Customs, 55/2015-Customs, 44/2015-Central Excise and 45/2015-Central Excise, with effect from November 24, 2015.

(iv) The preference for 'Buy Indian' and 'Buy & Make Indian' in the DPP 2013 is a major step by the MoD to promote procurement of major equipment through Indian vendors. This will also encourage the Indian industry to collaborate with foreign vendors, to achieve key/ niche technologies, and be the prime contractor. Increasing the FDI limit from 26 to 49%, and upto 100% on case-to-case basis for niche technologies, setting up Technology Development Fund, simplification of "MAKE" procedures, pruning the list of defence products which cannot be manufactured by the non Govt. agencies to a very limited number, and the national mission of 'MAKE IN INDIA' are important initiatives by the Govt to give a major boost to indigenisation in the Defence Sector.

Conclusion

21. The development of the naval shipbuilding in particular and shipbuilding sector, as a whole, has the potential to positively impact the economy including service sectors. To realize its growth potential, the sector needs to establish and achieve a critical mass. The window of opportunity presented by the ongoing boom phase needs to be capitalized to firmly ground the industry along with its ancillaries. Indian shipbuilding has substantial plans for investment of around INR 200 billion over the next 5-10 years, in capacity expansion and up gradation of the existing yards. However, this investment and consequent benefits can materialize only if supportive measures are continued by the Government to address the systemic disadvantages affecting the competitiveness of Indian shipbuilding industry.

22. In addition, proactive action by shipyards to promote ancillary build-up is critical. Addressing these disadvantages are likely to not only make the commercial shipbuilding industry competitive, but also create strategically beneficial options for meeting India's defence requirements. It is apparent that with proper policy facilitation, investment in infrastructure, building design capability and public private partnership, the shipbuilding sector can be a major manufacturing hub. The way forward is public private partnership, JV arrangements with reputed foreign OEMs and design houses with 50:50 FDI participation and bolstering our indigenous R&D capability.

23. It may be extremely difficult for India to equip all its warships with exclusively indigenously developed weapon systems because, technology in weapon systems is rapidly changing. Hence India may still have to depend on certain imported systems. However, the Indian Navy can integrate these imported systems successfully into the indigenously designed and built warships. With the above initiatives the Indian naval shipbuilding can truly be on its way to be achieve the dream of "100% Made in India" warships and submarines.

References:-

1. Indian Naval Indigenisation Plan (INIP) 2015-2030- Directorate of Indigenisation, IHQ, MoD(N).

2. Performance Audit of Indigenous Construction of Indian Naval Ships during 2005-2010. C&AGs report No. 32 of 2010-11.

3. Report on Working Group on Defence Equipment of Planning Commission for 12th Five Year Plan (2012-2017)- www.planningcommission.gov.in.

4. Momentum in Indian Naval Shipbuilding- Ritika Behal -Sep 15 - DefenceProAc /Qtech Synergy - www.defproac.com.

5. Shipyards' Turmoil - Indian Shipyards: Distress Among Limited Gains Defence And Security Of India- Dec 2012- www.defencesecurityindia.com.

6. Shipbuilding and India's Offset Policy -SN Mishra -Sep 2011- Indian Strategic.

7. India's Naval Acquisitions 1: Defence Shipbuilding in India - Dec 11 www.aviotech.com.

8. A Brief Report on Defence Sector in India - Jan 2015 ASA & Associates LLP- www.asa.in.

9. Naval Shipbuilding in India : Challenges and Way Ahead - Gurpreet S Khurana. Making Waves- Vol 18. Aug 2014.

10. Modular Design and Construction of Warships: Cdr Douglas C Deans - Jul 12 www.indiandefencereview.com.

11. Indian Shipyards -Feb 14 - www.defencesecurityindia.com

12. Design And Construction Of Warships- RAdm(Retd) KN Vaidyanathan - Apr 12- www.indiandefencereview.com.

13. Indias Warship Building Capability -RAdm(Retd) Dr S Kulshrestha- Mar 14 - SP's Naval Forces.

Author's Biodata

Cdr MA Pradeep, is serving as Senior Naval Construction Officer at COMCOS(W) Mumbai. The officer was commissioned in to the Indian Navy as a Naval Construction Officer on 01 Jan 1996. The officer has completed Bachelor's Degree in Naval Architecture and Ship Building from Cochin University of Science and Technology, Kochi, and also undergone training at Naval Shipwright School. The officer has DIIT in Warship Design and Construction from IIT Delhi. He went on to complete his MTech in Rubber Technology from IIT Kharagpur, during which he was awarded the institute silver medal and INCAB Rubber prize for the best student in Rubber Technology.

The officer has served as Assistant Manager outfitting and Assistant Manager Dry Docks and Hull preservation at Naval Dockyard Mumbai. During his tenure at Naval Headquarters at DND(SDG), he has served in Hull Structures group and Hydrodynamic group. He was responsible for launching calculations of Arihant and has contributed to various design activities, preparation of design memos and preparation of exploitation / test and trials documents, participated in HPT and undertaken analysis. The officer has also served as Staff Naval Construction Officer at HQWNC. The officer has been awarded the C-in-C commendation, VCNS commendation and CNS commendation during various tenures in the Navy.

article

15

NAVAL SHIPBUILDING - 'MAKE IN INDIA' LESSONS TO BE LEARNT

(Cdr Vinayak Srimal)

"Whoever controls the Indian Ocean dominates Asia. This ocean is the key to the seven seas in the twenty-first century, the destiny of the world will be decided in these waters."

US Rear Admiral Alfred Thayer Mahan

Introduction

1. India has a rich maritime history dating back 5,000 years. The world's first tidal dock is believed to have been built at Lothal around 2300 BCE during the Indus Valley Civilization, near the present day Mangrol harbour on the Gujarat coast. The Rig Vedas written around 1700 BCE, credits Varuna with knowledge of the ocean routes and describes naval expeditions. There is reference to the side wings of a vessel called Plava, which give stability to the ship under storm conditions. A compass, Matsya yantra, was used for navigation in the 4th and 5th century AD.

2. The earliest known reference of an organization devoted to ships and sailing in ancient India is from the Mauryan Empire of the 4th century BCE. Emperor Chandragupta Maurya's Prime Minister Kautilya's Arthashastra devotes a full chapter on the state department of waterways under Navadhyaksha (Sanskrit for Superintendent of ships). The term, nava dvipantaragamanam (Sanskrit for sailing to other lands by ships, i.e. Exploration) appears in this book in addition to appearing in the Buddhist text, Baudhayana Dharmasastra using the term, Samudrasamyanam (Sanskrit for sea voyage).

3. Sea lanes between India and neighboring lands were the usual form of trade for many centuries, and are responsible for the widespread influence of Indian Culture on other societies, particularly in the Indian Ocean region. Powerful navies included those of the Maurya, Satavahana, Chola, Vijayanagara, Kalinga, Maratha and Mughal empires. The Cholas excelled in foreign trade and maritime activity, extending their influence overseas to China and Southeast Asia.

4. However, the seaward influence of the nation saw a dramatic decline with the onset of colonizers. Post independence, the nation laid meager emphasis on building it's seaward prowess, depending on defence PSUs and assistance of developed nations to support it's seaward ambitions. Over the years, India established a defence industrial base (DIB). These entities, together with a small but growing private sector, are responsible for design, development, and production of various defence related requirements. However, the overall performance of the DIB in terms of meeting the requirements of the armed forces is below optimal. This has resulted in India spending billions of dollars each year on arms import, with the country achieving the dubious distinction of being one of the largest arms importers in the world.

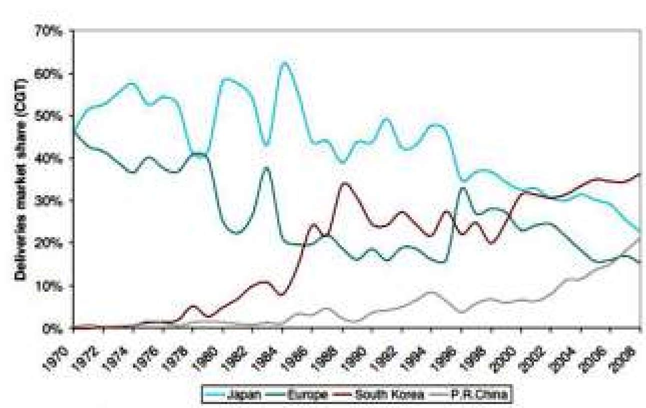
5. The demands on the Indian Navy have grown exponentially in the last decade with the government waking up to the reality of securing it's coastline and establishing it's supremacy in the Indian Ocean region. Commercial shipbuilding has also seen an upward trend in the decade. With 21 major shipbuilding facilities and numerous other minor shipyards, India has been steadily ramping up it's infrastructure. The 'Make in India' initiative therefore imparts the right momentum and direction to the Naval shipbuilding industry to take flight and establish it's rightful position as a world leader.

6. Before we dive headlong into an analysis of the Indian shipbuilding industry, we need to learn from the successful model employed by China to become a world leader in shipbuilding.

Lessons from a Neighbour : Evolution of Chinese Naval Shipbuilding.

7. The growth of the Chinese shipbuilding industry has been awe-inspiring and serves as a datum for all nascent shipbuilding programmes. The following are some facts about the evolution of the Chinese Naval ship-building industry that merit our immediate attention:-

(a) The growth of China's shipbuilding industry is more rapid than any other in modern history, involving a 13-fold increase in Chinese shipbuilding output between 2002 and 2012.



Source: Clarkson[1] (2009).

Fig 1.

(b) China was able to leap-frog some Naval development, engineering, and production steps and achieve tremendous cost and time savings by leveraging work done by the U.S. and other countries in a process of "imitative innovation". Over the next decade, Chinese analysts see their nation's shipbuilding industry as one that will become a world leader, rectifying its present weaknesses in innovation, subcomponent manufacture, systems integration, and yard management.

(c) China's shipbuilding industry is poised to make the PLAN the second largest Navy in the world by 2020, and-if current trends continue-a combat fleet that in overall order of battle (i.e., hardware-specific terms) is quantitatively and even perhaps qualitatively on a par with that of the U.S. Navy by 2030.

(d) By 2020, China is on course to build ships able to deploy greater quantities of Anti-Ship Cruise Missiles (ASCMs) with greater ranges than those systems used by the U.S. Navy.

8. The indigenization programme of both the Indian Navy and the Chinese Navy took flight in the 1980s, wherein India embarked upon design and construction of the Godavari class frigates at the Mazgaon docks. At about the same time, China's shipbuilding industry benefited greatly from Deng Xiaoping's defense conversion program, wherein the Sixth Ministry of Machine Building was corporatized into the China State Shipbuilding Corporation (CSSC) in 1982. However, the PLAN has shown exponential growth as compared to it's Indian counterpart over the last twenty five years. This can be largely attributed to the following factors:-

(a) China targeted shipbuilding as a pillar industry for national economic development and growth in other heavy industrial sectors such as steel. It leveraged labour cost advantages, imported critical technology and manufacturing best practices from world shipbuilding leaders, and targeted export sales as a means of obtaining hard currency to fuel further economic development.

(b) Relative autonomy was accorded to CSSC with direct control of 153 organizations that ranged from shipyards to technical research and design universities and authority over virtually all military and commercial shipbuilding and repair programmes. The synergy between R&D and production efforts was one of the key factors for planned progression of the shipbuilding industry. It is also pertinent to note that symbiosis between the civil and military ship building programmes under a single umbrella benefited both programmes in term of technological development.

(c) CSSC moved quickly to obtain foreign assistance and signed partnerships with private players viz. Mitsubishi Heavy Industries and British Shipbuilders to upgrade the Jiangnan and Dalian shipyards. Western ship-classification societies were allowed to inspect and provide technical certifications for Chinese-built ships for the first time, and in 1983 the China Ship Inspection Bureau formally adopted technical standards approved by Lloyd's Register-a vital quality-control credential for attracting buyers on the international market. Global certification gave the requisite credibility to China's fledgling shipbuilding industry that helped it further attract global players.

(d) Export sales were explicitly targeted as a means of generating the hard currency required to purchase higher-technology subcomponents from abroad and to sustain long-term growth.

(e) State-owned shipyards engaged in both commercial and military ship-building, thus maintaining economic parity, collaborating with World leaders in ship construction and giving wide exposure to latest trends in shipbuilding. Recent years have seen the Luyang II-class (Type 052C) air-defense destroyer emerge from Jiangnan Shipyard, Jiankai-class (Type 054) "stealth" frigates from the Hudong and Guangzhou Huangpu shipyards, and two new classes of nuclear-powered submarines from Bohai Shipbuilding Heavy Industries in Huludao. All of these classes represent notable advances in technology and complexity over previous Chinese warships.

(f) To drive requirements, PLAN leadership integrated the analysis of its two main research entities-the technically focused Naval Armament Research Institute (NARI), and the strategically focused Naval Research Institute (NRI)-to rationalize ship and weapon system design with naval strategy. The increasing diversity of PLAN mission areas (e.g., massive expansion of area air-defense) is having a significant effect on Chinese naval ship design.

(g) Efficiently integrating numerous mechanical, electrical, cargo, and habitability systems within the confined space of a ship has always been a principal challenge for naval architects and shipbuilders, and it is often the greatest difficulty in warship construction. These tasks become ever more demanding as the overall complexity of a ship increases, reaching a pinnacle in warship production due to the additional demands of weapons systems, increased redundancy, and large crews. Systems' integration a prime focus area for R&D and China is attempting to imitate and ramp up established integration models.

(h) Fostering the growth of China's currently weak ship-subcomponents' industry, lest China become merely a "world-class hull builder." This serves to provide employment to a variety of fledgling industries and provides all-inclusive and all-encompassing growth and expansion.

(j) Focus on human capital has been sustained and has yielded the desired results. Chinese universities and maritime academies now produce nearly 1,500 marine engineers and naval architects per year, roughly seven times the number of such graduates from U.S. institutions. The large and growing number of Chinese involved with and exposed to the maritime industry creates a "strategic reserve" of knowledge and experience upon which the country can draw if sustained international tension ever creates the need to expand military ship production rapidly.

(k) Construction of covered building facilities for submarines and warships to safeguard it's indigenization programmes from international espionage.

(l) Whilst procuring ships for it's commercial requirements, the Government favors domestic shipping lines such as COSCO purchasing ships from Chinese yards and provides them with discounts and economical credit for the purpose. For exports, the Government has other benefits such as VAT refund on export and providing sovereign guarantee and low margin credit to ship buyers.

9. Compared to the U.S., China has particular shipbuilding limitations in propulsion, and certain advanced weapons systems. Propulsion is the single biggest shortcoming and is unlikely to progress until China's precision manufacturing capability improves. Conventional propulsion in submarines is moving toward advanced lithium-ion batteries, possibly as an alternative to air independent power (AIP) systems. Nuclear propulsion advances-especially in power density and acoustic quieting-remain difficult to ascertain, but a key variable affecting future progress will be the degree of Russian assistance.

10. China still has to depend on imports for 60 percent of raw materials. The Chinese Government has set a target of reducing this to 30 percent by the end of the decade.

11. In conclusion, it can be surmised that with focused government efforts, synergized R&D and production agencies, participation of private players and compliance with international standards, the Chinese shipbuilding industry is on course to become the world leader in shipbuilding by the turn of the decade. The benefits of this would accrued both by the civilian populace employed in shipbuilding as well as the ambitious Naval shipbuilding programme of the PLAN.

Indian Navy Efforts : 1980-2010.

12. As brought out above, the Indian Navy's indigenization efforts took wing at about the same time as China. However, the progress over the same span of time has not been commensurate, with China taking a huge lead in the commercial and the military shipbuilding areas. The analysis brought out in the preceding paragraphs amply magnifies the areas where we have lagged behind. These could be summarized as follows:-

(a) Red tape and inadequate promotion policies for the domestic shipbuilding industry and it's ancillary industries. Due to threat perception of successive governments being limited to the land and air domains, the shipbuilding industry did not get it's due. Adequate emphasis and synergy between the commercial and warship building segments could have helped the Navy in gaining complete indigenization in the "Float" and "Move" segments.

(b) Though R&D efforts have been financed, output and productivity have not been commensurate with the pace of user requirements. As a consequence, user confidence in systems delivered by DPSUs and government production agencies has not been established. Moreover, infusion of private partnership in R&D is also yet to materialize. As a consequence, reverse engineering still remains the mainstay of R&D programmes.

(c) Uneven competing grounds dissuaded private players and hence limited infusion of competitiveness in the field. Heavy direct and indirect taxation, limitations in the spheres of operation and delayed decision making in granting of licenses further compounded the problem.

(d) Low volume of sub-components' in Naval shipbuilding preclude economy of scale, thus further limiting scope for entry of private players. Absence of commonality of equipment across Naval platforms, especially in the "Float" and "Move" segments, could not be established over the years, leading to a huge inventory. Thus manufacturing of small quantities of equipment was uneconomical for private players wherein economies of scale could not be assured.

13. Under the name of indigenization, the DPSUs were largely dependent on procurement of licenses for assembly of sub-components of imported equipment at their local premises, without any significant efforts towards indigenization. This further inhibited evolution of the defence industry and increased dependence of the DPSUs on foreign vendors.

14. The tide started to turn in the late 90s. A watershed event in the indigenization efforts of the nation was made in 1998, when India and Russia signed an inter-governmental agreement to jointly produce BrahMos supersonic cruise missile. A joint venture was set up in India with an authorised capital of $250 million, in which India had a 50.5 per cent share and Russia the rest-the equity structure designed to enable the JV to operate like a private entity for 'fast' decision-making. The enormous success of the programme in developing a niche technology triggered a new era of collaborative programmes being taken up by India, for combat and transport aircrafts, and a range of missile systems.

15. Taking the BrahMos model further, in 2007 India and Russia signed two inter-governmental agreements for the co-development and co-production of two major aircraft projects: Multi Role Transport Aircraft (MTA), and the Fifth Generation Fighter Aircraft (FGFA). As per the agreements, India has a 50 per cent investment share in both projects.

16. Concurrently, a turn of events over the last decade saw India looking beyond it's traditional partner Russia to expand it's procurement interests to other countries viz. United States, France, Italy, United Kingdom, Israel etc. India's DRDO and Israel Aerospace Industries (IAI) are currently undertaking two missile systems. These developments were a shot in the arm for the Defence forces, which were now being equipped with highly potent and reliable systems, which were world leaders in impact and technology.

17. The decade also saw the entry of a number of private players viz. L&T, Mahindra, Reliance, Tata, and global OEMs like Boeing, BAE systems and IAI entering the Indian Defence market. A major game changer was the sweeping changes in the Defence Procurement Policy in 2002, which stipulated offset obligations, wherein foreign OEMs were mandated to invest at least 30% of foreign exchange value of the contract from Indian Defence suppliers. This gave the required fillip and opened avenues for the Indian industry.

FICCI

Source: Defence Service Estimates, India Ministry of Defence; *Economic Survey 2009–2010*, India Ministry of Defence; *Report of the Thirteenth Finance Commission (2010–2015)*; Union Budget of India, India Ministry of Finance; McKinsey analysis

Fig 2.

18. It is pertinent to mention that the commercial shipbuilding industry also blossomed concomitantly during the previous decade, with the entry of private shipyards viz. ABG, Pipavav, Bharti etc. The Indian shipbuilding industry garnered 1% of the world orders, thus out-gunning other emerging competitors including Philipines, Vietnam, Brazil etc. to emerge as a force to be reckoned with. It gained a strong foothold in the niche offshore segment. Led by private shipyards - ABG and Bharati - India surpassed Norway in terms of order-book for Offshore Supply Vessels (OSVs). The Indian shipbuilding business entered the growth trajectory with an order-book witnessing a nine-fold increase in just four years.

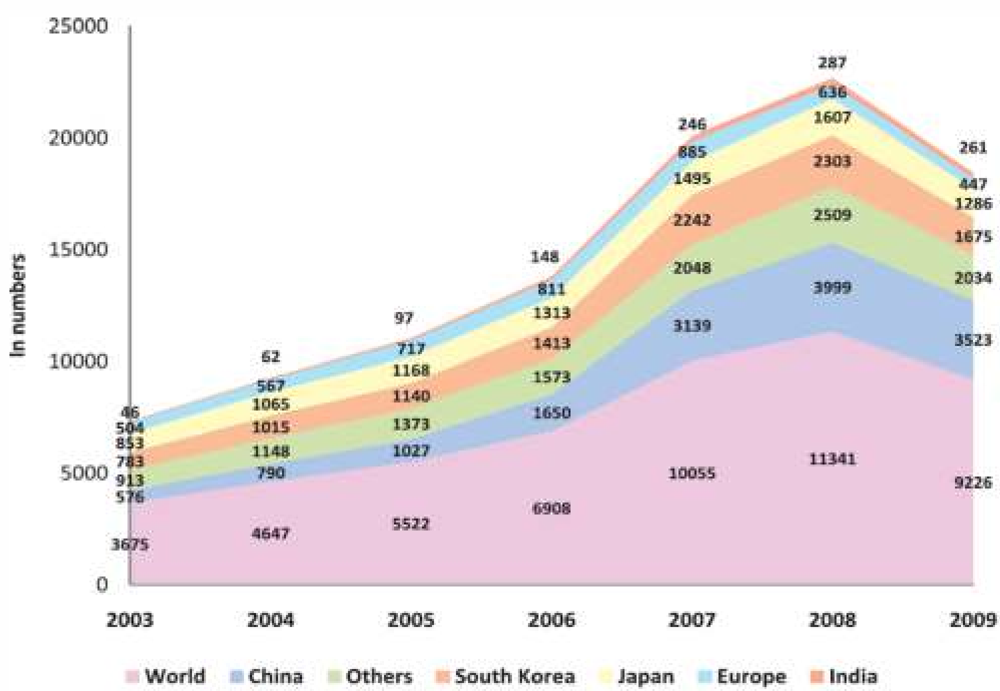


Fig 3.

Sweeping Changes : 2011-2016

19. Big success for the private sector came in May 2011 when the private shipyard, Pipavav Defence and Offshore Engineering Company (formerly Pipavav Shipyard), won a fiercely contested Naval order valued at Rs 2,975 crore for building five naval offshore patrol vessels (NOPVs).

20. The first major success in the international arms market for Indian private sector came in 2012, when Pipavav secured a major export order valued at Rs. 1192 crore from an undisclosed West African country for the supply of two Offshore Patrol Vessels. Post 2010, major Indian companies have entered into partnerships with private players to strengthen their credentials as defence suppliers.

Table 1. Indian Companies & Foreign Partners

Ser	Company	Partnership	Objective
(a)	Larsen & Toubro	Boeing	P-8I reconnaissance planes, Naval systems
		EADS	Manufacture high-end defence Electronics
		Raytheon	Upgrade of T-72 tanks
		Pratt & Whitney	Aircraft engine components
		Fincanteri	Fleet refuelling tankers, naval Systems
(b)	Pipavav	Saab	Naval combat management system design and architecture
		Babcock	Warships
(c)	Reliance Industries Ltd	Dassault Aviation	Medium Multi Role Combat Aircrafts (MMRCA)

21. In light of the lessons learnt from the Chinese ship-building industry and the steady rise of the Indian ship-building industry over the past two decades, it would be prudent to carry out SWOT analysis of the Indian shipbuilding industry at this stage to identify grey areas and debate prospective solutions.

SWOT Analysis : Indian Shipbuilding Industry

Strengths.

(a) Vast coastline and abundant natural resources. India enjoys a long coastline of more than 7,500 km long with several deep water ports serving as good locations for setting up shipyards.

(b) Defence Procurement Procedure 2013 has increased cap on FDI on defence from 26% to 49%, thus substantially enhancing the role of private players. The overall announced investment of the upcoming private shipyards exceeds INR 200 billion, all coming online within the next 5-7 years. FDI beyond 49% will be allowed on a case-to-case basis where there is access to modern state-of-the-art technology and will be subject to approval from the Cabinet Committee on Security (CCS).

(c) Due to the large number of sub-components involved and being labour intensive, the shipbuilding industry generates employment for a large number of auxiliary industries. India has domestic industries which can produce most of the raw materials required in shipbuilding. Specifically, India has competitive steel manufacturing, light engineering and IT/ITES industries which can offer the required products at economical costs.

(d) Presence of large pool of skilled professionals at most economical rates.

(e) Experience in Systems' Integration, the most vital cog in the integration of onboard systems.

(f) Expertise in reverse engineering, software, embedded systems engineering.

(g) Migration of private players from developed nations to emerging markets due to relative slump of demand in their domestic markets.

Weaknesses

(a) Policy paralysis and delayed decision making resulting in cost and time overflows and hesitation of smaller Indian firms to enter the defence market.

(b) Deficiency in heavy engineering and precision engineering skills.

(c) R&D in shipbuilding yet to gain desired momentum. R&D in shipbuilding limited to few pockets and thus not meeting the demands of the emerging market.

(d) Absence of a dedicated government agency, akin to CSSC, to integrate R&D and production efforts.

Opportunities

(a) Increased role of armed forces in maintaining internal security. Indian Navy is responsible for overall maritime security which is to be maintained with assistance of the Coast guard and state marine police. Raising of the 'Sagar Prahari Bal', establishing coastal security through Joint Operation Centres, radars' network and increased coastal surveillance through patrolling present new opportunities.

(b) New organizations for R&D in shipbuilding viz. National Institute for Research & Development in Defence Shipbuilding (NIRDESH), Indian Maritime University (IMU) etc. IMU and NIRDESH are expected to engage over 10,000 people including a large number of researchers and create over 5,000 ancillary jobs by the turn of the decade.

(c) Absorption of large pool of skilled ex-Navy personnel into shipbuilding industry.

(d) Increased participation of private players and shipbuilding ancilliaries in joint ventures, transfer of technology.

(e) Incorporation of 'Lead System Integrator' concept. A lead systems integrator is a single point-of-authority and responsibility appointed to execute a large, complex, defence-related acquisition program. LSIs can have broad responsibility for executing their programs, and perform requirements' generation, technology development, source selection, construction or modification work, procurement of systems or components from, and management of, supplier firms, testing, validation, and administration.

(f) Increased interaction with world Navies, showcasing our capabilities to the world. These opportunities could be utilized to promote sale and technical support of indigenously developed niche systems e.g. CMS, data bus etc. to friendly Navies.

(g) Private sector shipyards often have spare infrastructure capacity as compared to DPSU shipyards but lack capability to build complex warships because of their lack of experience in naval shipbuilding. DPSU shipyards can partner with private yards with spare capacities to overcome their capacity constraints.

(h) Growth in the shipbuilding industry would also foster the ship repair industry, which is an essential requirement, given the increasing volume of trade by sea and the requirement of safeguarding regional and international waters through joint patrolling and anti-piracy operations.

Threats

(a) Theft of intellectual data through direct/ indirect means.

(b) Over-dependence on foreign firms for weapons and sensors.

(c) Sub-standard quality, inadequate lifecycle support, of indigenously developed systems.

(d) Long-winding and complicated acquisition process for defence equipment. Present requirement to obtain multiple clearances covering land acquisition, environmental clearance, power and water etc., from various departments for new projects in shipbuilding acts as a deterrent to attracting investment into this sector.

(e) Lack of adequate incentives for foreign players to enter Indian markets. The South Korean government provided stimulus to FDI in the shipbuilding sector through measures such as cutting corporate taxes, providing tax incentive packages and reducing the trademark evaluation period. The Korean government has also established eight different Foreign-Exclusive Industrial Complexes (FEICs) inside national industrial complexes that enjoy a 50 year rent free lease based on the level of investments.

Indian Naval Indigenisation Plan

22. It is a widely acknowledged fact that the Indian Navy has been the pioneer in indigenization efforts amongst the three services. It has synergized with production agencies and Defence PSUs and has thus achieved almost 90% indigenization in the 'Float' segment, 60% in the 'Move' segment and 30% in the 'Fight' segment.

23. The Directorate of Indigenisation has laid out the Indian Naval Indigenisation plan 2015-2030, which is a comprehensive handbook on the current status and future indigenisation roadmap of the Indian Navy. This document is aimed to formulate the requirements of Indian Navy and lists out the equipment which can be taken up for indigenisation in the coming years.

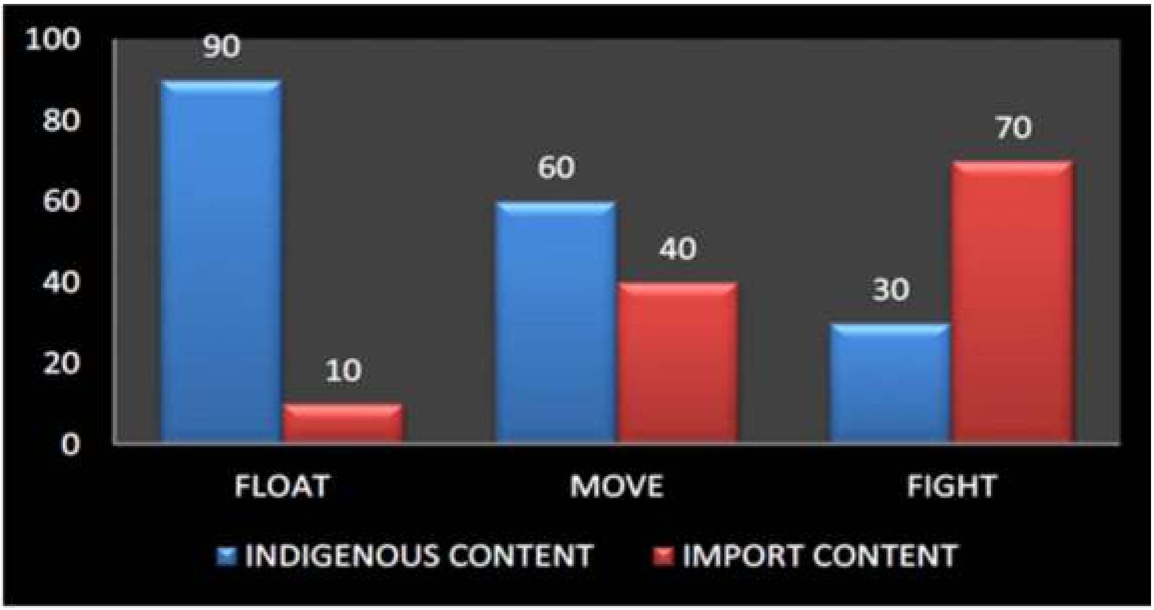


Fig 4.

24. The equipment brought out by the plan offer a vast spectrum from hull requirements to futuristic weapon systems that are envisaged to be developed through private and public partnerships over the next decade. Another important facet of the document is that it has clearly demarcated the list of COTS equipment which are available through multiple vendors with support in India and at multiple destinations over the world. This demarcation would help channelize development efforts and thus provide for a focused approach over the next decade.


Destroyers (P15A) – MDL
Nominated, Under Execution
11,400 Cr.
Destroyers (P15B) – MDL
Nominated, Under Execution
35,000 Cr.
Aircraft Carrier (P71) – CSL
Nominated, Under Execution
3,300 Cr.
Submarines (P75) – MDL
Nominated, Under Execution
23,550 Cr.
Frigates (P17) – MDL
Nominated, Delivered
3,000 Cr.
Frigates (P17A) – MDL, GRSE
Nominated
45,000 Cr.
Landing Craft Utility – GRSE
Nominated, Under Execution
2,200 Cr.
ASW Corvettes (P28) – GRSE
Nominated, Under Execution
7,000 Cr.
NOPV – GSL
Nominated, Under Execution
1,800 Cr.
LST (l) – GRSE
Nominated, Delivered
1,200 Cr.
Others – Various PSU Yards
Delivered & Under Execution
5,420 Cr.
Total Orders
INR 1,49,400 Cr.
Orders on PSUs
INR 1,38,850 Cr.
(~ 93%)

Fig 5.


NOPV – Pipavav
Contracted, Under Execution
2,975 Cr.
CGOPV – L&T
Contracted, Under Execution
1,400 Cr.
Fast Patrol Vessels – Pipavav
Under Contract Finalization
920 Cr.
Interceptor Boats– L&T
Contracted, Under Execution
1,430 Cr.
Cadet Training Ships – ABG
Contracted, Under Execution
1,450 Cr.
Floating Dock – L&T
Contracted, Under Execution
450 Cr.
Others
Contracted, Under Execution
1,925 Cr.
Total Orders
INR 1,49,400 Cr.
Orders on Pvt Yards
INR 10,550 Cr.
(~ 7%)

Fig 6.

Recommendations

25. The following is therefore recommended for growth of Naval shipbuilding:-

(a) Governmental incentives such as single window clearance, reduced taxation schemes, subsidies for generation of infrastructure etc. for promoting new entrants to the shipbuilding industry.

(b) Cultivation of SMEs and ancilliary industries supporting shipbuilding industry through suitable incentives.

(c) Synergization of shipbuilding efforts being undertaken by private and public sector shipyards.

(d) Intensify R&D efforts in shipbuilding and integrate R&D output into production.

(e) Promote lateral absorption of IN personnel into national shipbuilding programmes.

(f) Encourage joint ventures/co-production in precision/heavy engineering segments and development of weapons and sensors.

(g) Vigorously market and promote sale and lifecycle of indigenously developed generic systems to friendly foreign Navies.

(h) Enable development of the ship-repair industry to support the shipbuilding industry.

Conclusion

26. In conclusion, it can be summarized that the Indian shipbuilding industry is headed in the right direction. Close interaction and synergy between private players, DPSUs and end-users is essential to spearhead and sustain indigenization. Support and incentives from the government would foster the industry. Integration of R&D efforts from all quarters is also essential to these endeavours.

27. The Indian Navy, with it's pool of skilled manpower and worldwide outreach, is the ideal leader to ensure the success of the 'Make in India' initiative. Sustained efforts in the direction, both in terms of volume and strategic importance, would ensure that the blueprint is executed to perfection.

References

1. "Competitiveness of Indian Ship Building Industry", K. Muthuchelvi Thangam, D. Sureshkumar, International Journal of Innovative Research and Development, 2015.

2. "Make in India Programme: Industry Perspective", Raveen Janu and Karanpreet Kaur, CLAWS Journal, 2015

3. "INIP 2015-2030", Directorate of Indigenization, 2015

4. "Indian Industry Trends in Defence Shipbuilding", Cmde Mukesh Bhargava (Retd), VP L&T, 2015

5. "Indian Defence Industry: Issues of Self-Reliance", IDSA Monograph Series No. 21, Laxman K Behera, 2013 l Co

6. "Global Competition in Shipbuilding: Trends and Challenges for Europe", Rima Mickeviciene, 2012

7. "Indian Shipping Industry: A Catalyst For Growth", EXIM Bank, 2010

8. "Warship Retro-Fitment: A Road Map for Trans-National Engagement in Indian Ocean Region", Cdr G P Pande, Cdr M Goel, 2008

9. "A Comprehensive Survey of China's Dynamic Shipbuilding Industry", Gabriel Collins and Lieutenant Commander Michael C. Grubb, 2008.

10. "Indian Shipbuilding Industry: Poised for Take-off?", KPMG White paper, 2008

Author's Biodata

Cdr Vinayak Srimal is an alumnus of XV Naval Engineering Course. He has served onboard INS Godavari as ALO (NDC) and INS Ranvir as ALO (GG). Post undergoing post graduation in Communication systems at IIT, Madras, the officer was posted at WESEE as Systems Manager. The officer was part of the team which achieved platform level integration of P-17 ships and HATs and SATs of the indigenously developed CMS-17. The officer has also presented technical papers at INS Valsura and Indian Naval Academy, Ezhimala. The officer is currently serving at DSCC, Bhopal.

article 16

BUILD IN INDIA - SHIPS FOR THE WORLD (Problems and Panacea for Indian Warship Building from the MII Perspective)

(Cmde Bhupesh Tater)

Introduction

1. Theme of this Seminar; 'The Make in India Paradigm - Roadmap for a Future Ready Naval Force' couldn't be more apt, considering that the government has given it a definite push during the 'Make in India' (MII) Week that was held at Mumbai in early February 2016[i] . The Navy in itself has for long focused on indigenous ship building capability in the modern historical perspective, but it was not until the late nineties that the Indian industry started to get involved in indigenous efforts. This gathered further momentum in 2010 when the Navy and industry under the aegis of CII conducted the NAVARMS 2007 followed by NAVARMS 2010[ii] .

2. **Global Trends.** The global shipbuilding boom in the recent history commenced in 2005 wherein the world order book in terms of dwt grew by 32.8 percent.[iii] The order book clearly brought out South Korea as leader with 37.9% market share followed by Japan (28%) and China (13.6%). Also German and Polish shipyards benefited from the "full order books" in Asia whereas no such major gains were observed for Indian shipbuilders. Traditionally, the shipbuilding industry has changed supply bases to low cost destinations in the last century as new building orders witness a cyclic trend with distinct peaks and lows. New countries including India to a limited extent gained prominence, especially during boom periods[iv] . The industry has moved from the UK and US in 1950 to Europe, Japan and Korea during the 1950s and 1970s and in present day period it has brought China to the fore[v]. Warship Building has however bucked this trend to a large extent, primarily on account of limited countries having the capabilities to design and to provide the required weapon and sensor systems that go in making a warship potent.

3. Presently, the merchant shipbuilding industry is poised to move out of China[vi]. Appreciating this aspect and with the possible threat of warship building likely to follow suit soon and move to newer shores, China has brought in reforms to boost shipbuilding efficiencies for capability advances and aid to the development of the Chinese military[vii]. The UK based BAE systems was facing the threat of cancellation of the contract for three Offshore Patrol vessels from the Trinidad and Tobago Republic[viii]. At the same time it entered into a contract with Thailand under which the OPV design and shipbuilding skills were transferred to Bangkok Dock to build a variant for the Royal Thai Navy. Northrop Grumman confirmed that it will spin off its recently created Huntington Ingalls Industries Inc. (HII) subsidiary to shareholders, thus ending the US major's association with ship building[ix]. BAE Systems Australia announced a further reduction in the work force at its Williams-town Shipyard in Melbourne[x]. The Portuguese government publicly announced that it is to sell state owned shipbuilder Estaleiros Navals de Viana do Castelo (ENVC)[xi]. Australian Shipyard Forgacs is planning to reduce the size of its workforce as a result of declining naval ship building work[xii]. These trends imply that building orders and demands are cyclic and so is the growth of

shipbuilders. Also, we witness builders targeting the export market in an attempt to fill the widening gap between the level of domestic Orders and capabilities.

4. **The Indian Scenario.** So with so much of upheaval in the shipbuilding industry worldwide, do Indian yards stand a chance to survive? Well there lies an opportunity for India; both in terms of starting relationships with leading shipyards worldwide that in turbulent times are looking for partners and with the reduction in building capacities across the Globe, Indian Yards could well be poised today to be the hub for shipbuilding and warships too in the next decade or so[xiii]. As the industry finds newer shores, that country starts from simpler vessels to complex and technology intensive commercial ships and eventually warships to become the leading supplier to the World as it moves up the Value Chain. Major business houses like Reliance and L&T may have sensed these opportunities, apart from the domestic Indian market as well and announced big plans[xiv]. So is this the right time for the industry to move to India? While a confident 'Yes' may now be very apparent, there still needs a lot to be done if we have to become a global entity in shipbuilding.

5. The Indian shipbuilding Industry was represented by around 220 large and small construction and repair yards, as in 2001[xv]. The Indian yards' markets were essentially smaller craft, with larger vessels being the exception[xvi]. Further, the Indian commercial shipbuilding capacity in 2001 was a mere 0.19 million CGT[xvii]. Indian yards in past could not reap rich benefits of the global commercial shipbuilding booms in the last decade. This until now has only seen a dismal improvement[xviii]. Further, the need for a strong and capable Navy to defend India's long coastline and islands has forced an increase in Fleet in wake of days of domination ahead in the Indian Ocean Region[xix]. Consequently, with a requirement of more ships and warships coupled with shipyards across the world facing closures and reductions, India today is strategically placed not only to build its ships in India but also cater for future needs of the world[xx]. Accordingly, considerable capital investment by the government is expected[xxi], if the country is not to miss this golden opportunity. Increasingly, support and involvement of governments in facilitating these partnerships is being witnessed in the warship building programs[xxii]. The Navy too has outlined its requirements to the Industry for the next 15 years[xxiii] with the intent clearly focusing on make in India. These are bound to yield favourable results and need to be encouraged through MII and the revamped DPP.

6. Ship and warship building spawn a plenitude of processes, activities and agencies, mechanics of which are well covered in other literature and if all issues were attempted to be addressed in this paper it would lack focus. It would be appropriate to address only aspects that impact warship building by the MII initiative. Therefore, this paper will follow a general descriptive-analytical approach to review the few core procedures and aspects of warship building in our country that are impacted by the MII initiative and where feasible concurrently suggest strategies can tackle the challenges of increasing indigenous content and build capacities.

MII and Shipbuilding - Some Core Issues

6. **The Indian Policy Initiative.** The development of Indian shipbuilding industry once inspired by the nationalist goal of self reliance and establishing it as a core sector[xxiv] has over the past few decades slipped into an inertial mode. The NMDP aimed to be the second largest shipbuilding nation by 2020[xxv]. Even the ONGC[xxvi] and the blue water Indian Navy had plans to have majority of

their warships through indigenous construction planned through elaborate Defence Procurement Procedures (DPP)[xxvii]. Despite such stated and ambitious policies, indigenous shipbuilding and to a large extent warships too in terms of costs has not reached anywhere near these goals. Serious effort and an 'On Ground' translation of policy initiatives until recently were not witnessed.

7. **Shipbuilding Capability.** Where is the capability in our country to construct such a large number of ships for our own requirement, let alone export? A serious thought and introspection on these core issues at the grass root level; capabilities, capacity and productivity, infrastructure, finance and government support for Indian shipbuilding, is essential to ensure that we do not to lose this opportunity to Build Ships for the World in India. Evidence suggests that the process of development is driven by productivity growth along with capital accumulation and is a key feature of economic dynamism in current times[xxviii]. While the existing shipyards need to look into their efficiencies and technology upgrades,[xxix] new yards need to be established to build capacities, to meet the internal demands of commercial vessels and warships and to bag export orders. Emergence of Pipavav Shipyard[xxx] and its potential to build ships despite issues of licensing is a clear indication of how new entrants can be game changers[xxxi] .This effort could be jointly funded by private and public sector with due representation as new yards like Pipavav, L&T and Reliance in the East may just about meet the domestic demands, that too for a limited range and types of vessels / warships. The newer yards can thereafter be suitable classified to differentiate between the types of ships that they are capable of construction[xxxii].

8. **Shipbuilding Infrastructure.** Shipbuilding takes a long time to develop the infrastructure it needs. Investment in shipbuilding infrastructure comprises physical and intellectual arms. It needs a lot of auxiliary and ancillary industry to also come up whereas the industry needs a large order quantity from ships to develop and sustaining them[xxxiii]. Indian shipbuilding needs to work by building on expertise from others and networking[xxxiv]. Developing the shipbuilding industry does not mean producing everything yourselves. While new shipyards would bring up dry-docks, adequate cranage and the wherewithal to construct, aspects of ports and berths addressed[xxxv], the country as a whole would need to focus on other pre-requisites spanning the industrial / manufacturing sector, trained manpower and design capabilities.

9. **Industrial / Manufacturing Sector.** Shipbuilding is an unusual industry as 65 percent of value addition during building comes from other industries. Presence of a strong manufacturing and industrial sector in the regular civil market holds future potential for defence since the defence and civil sectors have a symbiotic relationship[xxxvi]. Indian advantage due to labour cost is largely offset by low efficiency, small scale operations and the purchasing of most ship components from abroad. Maritime powers, without exception, have a well established ship components industry[xxxvii]. The Indian industry needs to therefore evolve and participate more in warship projects to reverse the past reluctance that existed[xxxviii], some of which could be attributed to government's inabilities to put in place a positive framework across industries. Learning from the Chinese is essential who have put in serious efforts to develop their industrial infrastructure through government support and foreign investment. The MII strategy envisages huge investments in regular industry, defence technology and to limited extent shipbuilding[xxxix]. Such infusion of private and government expenditure would result in sprouting of manufacturing units for main engines, auxiliaries, ship

components and related ancillaries around these shipyards through private entrepreneurs[xl].

10. **Indigenous Equipment.** A substantial part of equipment manufacture in India is really equipment fabrication with shop floor drawings obtained from technical collaborators abroad (there are exceptions such as in the case of BHEL and HMT where the technology is embedded deeper), and as such there are few uncertainties arising out of the technology. A completely indigenously designed and custom-built system may take new ground and do so more thoroughly and even more efficiently than an off-the-shelf technology, but at greater initial development cost[xli]. Therefore, it could be concluded that inherent in the success of the policy of import substitution[xlii]- making everything that can be made in the country with only a secondary reference to costs and the quantities[xliii] required since sometimes these numbers certainly do not by any means encourage full ToT or licensed manufacturing, let alone 'Make in India', cannot be handled by mere administrative change or by changes in penalty clauses in the contracts with equipment suppliers especially as penalties are difficult to implement and hardly the answer.

11. Answer lies probably in letting the industry decide how much to make in India and how much to import, for the sheer power of cost competitiveness will drive them to manufacture in India[xliv], duly supported by the projected demand[xlv] and infused technology; both developed in-house as well as under ToT / MoU, royalty etc. More analysts now argue that private participation is essential in the defence sector, which is primarily technology driven and capital intensive[xlvi]. With the initiative of the government on allowing FDI[xlvii] into defence sector and participation of private players through PPP and other models, fear in defence think tank of the country, of below expectation performance by the private shipyards and industry as it is hardly specialized to meet strict military standards, hence compromising security standards is set to witness a gradual change[xlviii].

12. Participation of the civilian industry would also address the perennial question of over/under capacity amongst Defence PSUs[xlix]. India's private sector has responded to the MII drive and the growth in licence proposal reflects easing regulations in the defence sector[l]. However, there is a stronger need to move towards de-regulation[li] and encourage competitiveness especially with the aim of export. Similar process has been witnessed in China where Lin, Biao and other political leaders initiated what is known as 'civil production during peace time and 'military production during wartime'. With decline in defence demands Clinton administration developed a strategy to re-energise US shipyards for its transition from Defence construction to commercial new building. However, in our case the aim would be to make ships not only for the IN and ICG but also move beyond to cater for exports[lii].

13. **Defence Production for Export.** Damen, BAE Systems, DCNS Navantia and other European shipbuilders are targeting the highly competitive export market in an attempt to fill the widening gap between the level of domestic orders and the capabilities their yards can offer[liii]. While cost competitiveness with Asian counterparts would be challenge for the European yards[liv], many developing nations in the Indian Ocean littoral and around the African continent would welcome Indian assistance by way of acquiring patrol vessels and fast attack craft to provide for their own maritime security. India has the ability to provide these platforms in a more affordable politico-military manner than any other supplier[lv] and such strategic planning could advance our credibility

in areas still not on the global radar. At the larger national level, the strategic potentialities in the field of shipbuilding need to be nurtured in a calibrated manner and the politico-military opportunities maximised prudently. Even our neighbourhood is alive to these opportunities. Nigeria has been reported to finalize plans to buy 15 to 30 units of the Sino-Pakistan manufactured JF-17 fighter aircraft[lvi]. Indonesia PT Payal and China's CSC have already succeeded in taking on international naval contracts[lvii].

14. **Defence Technology and FDI.** When it comes to Defence, India is amongst leading countries in the world for ship design and building. However, India's private and public sector industries lack technology expertise and skills especially in electronics, sensors and naval weapons in comparison to leading countries in the World. A straight purchase by India of foreign weaponry means another import 20 years down the line when the equipment in question becomes obsolete. It is therefore imperative that the inflow of defence technology and consequently FDI should be attracted in weaponry and machinery that comprise the highest percentage of imports in terms of monetary value. Technology Inflow without restrictions on its global exploitation is the need of the hour. No retrospective law should be applicable to restrict technology exploitation. In India foreign firms need to be in control since it is their technology which is developed often at considerable cost and therefore the need to protect their intellectual property[lviii]. Many vendors consider this aspect non-negotiable and hence the demand of FDI being 51% and beyond. It should therefore be left for the various Categorisation Committees to decide on the threshold of FDI that may be permitted for de-novo Projects.

15. **Human Resource.** Today, India has largest number of non-resident and non-practicing Naval Architects. We need to create a friendly work environment and put in place the correct incentives for young graduates to take up shipbuilding assignments locally. It is near certainty that the demand for trained manpower in terms of design and construction would be on a rise to meet the known shipbuilding Projects. With hectic shipbuilding taking place alongside increased industrial activities, availability of the right and trained manpower would be a key factor in growth of shipyards. Hence to meet the ever-rising demand for shipbuilding professional it is befitting to open a dedicated Shipbuilding College, which has been long pending[lix]. It may be worthwhile to note that even the US Navy had felt this need and was late in its introduction wherein the University of New Orleans established the School of Naval Architecture and Marine Engineering (NA&ME) in 1981. Push by industry in Research and Technology as well as design would require huge investments in the human capital that necessarily would need to be sourced within the country[lx]. A strategy to enable this aspect of human capital needs, separate deliberation with policy initiatives and implementation from the government and the industry inbuilt for its success and reap benefits from the MII initiative[lxi].

Procedures and the MII

16. **Extant Procedures.** The Defence Procurement Procedure (DPP) and the Defence Procurement Manual (DPM) are the primary documents that concern the industry and cover the government's Capital and Revenue expenditure, respectively on Defence. There is no visible and direct connection between these procedures and the MII initiative. However, for the MII to succeed it is essential that

the DPP and DPM facilitate the same rather than leave the industry struggling with a myriad of procedures and consequently deny the much awaited fruition of inductions for the armed forces[lxii]. Critical examination of the DPP, DPM and recommendations of the Experts Committee set up in July 2015 on review of DPP, should be undertaken by the industry moguls, watchdogs on expenditure i.e., CGDA & CAG and their views incorporated so that procedures can be aligned to fulfil the 'Make in India' concept and make the right beginning. Structural reforms in procedures are needed to clear the path for success of the MII initiative[lxiii]. There is a need to examine in detail all rules and procedures that cover the industry while bidding and manufacturing goods for the industry and take one step at a time[lxiv] to remove impediments[lxv] to growth of country's defence industry that is attracting big players across the world[lxvi].

17. **Shipbuilding Procedures.** The DPP has provided for a separate 'Shipbuilding Procedure' which was incorporated in 2005. This has matured over the years and its current version in Chapter III of DPP 2013 covers well the acquisition and construction of warships. While only a few refinements have been proposed to fine tune the procedure further and participation of private shipbuilders encouraged[lxvii], equipment in most shipbuilding cases is still covered under the DPP. Equipment for warships and submarines is customised in accordance with the platform design and many a times warrants nomination of existing equipment to be used on new projects for standardisation and long-term support. While this would facilitate early freezing of designs[lxviii] the same is not facilitated by either the DPM or DPP. This flexibility in procedures is considered essential for smooth progress of acquisitions as well as to ensure long-term support to the equipment being fitted on such warships. Since design is being undertaken by the IHQ MoD(N) the procedures should delegate this aspect to nominate existing equipment to IHQ MoD(N).

18. **Indigenous Content.** The aspect of indigenous content (IC) has been dwelled upon at great extent in the DPP 2013 (Appendix F, Chapter I) and rightfully so. However, with the requirements laid down in great detail, it would be extremely challenging for Indian industry with foreign OEMs to comply these norms. The issue is further compounded as there is hardly any mechanism or wherewithal to evaluate, examine and accept / modify the proposals to meet these guidelines thereby delaying projects and ostensibly defeating the very purpose of these guidelines, i.e., to enable higher IC. Higher IC is a highly desirable by-product of these efforts though not the sole, non-negotiable goal. While the need to give flexibility to Categorisation Committees to recommend IC threshold has been recognised[lxix], the same for equipment that goes in shipbuilding needs a different treatment. While a total waiver may be desirable for the industry, a measured approach in terms of LC1HIC1, wherein the equipment with least cost and highest indigenisation with equal weightage to both may be a more practical approach for equipment that go into warships is recommended irrespective of the procedure (DPP /DPM) being adopted.

19. **Joint Ventures.** While DPP permits shipyards to enter into Joint Ventures, there ar no clear guidelines on how a defence JV should be approached. More often than not, the internal guidelines of shipyards / Defence PSUs, DIPP and the MoD are involved thereby making the prospects of forming JVs either not that attractive or finally not fructifying on ground[lxx]. So far only Goa Shipyard has come out with a stated framework on formation of JVs and other aspects that align the shipyard's aims to that of the MII and form a bridge with the guidelines of DPP. The aim of all three

policies of GSL is to enhance the local content/ indigenization through increased vendor/ manufacturing base, to give impetus to "MII" policy. However, while DPP and its proposed amendments encourage JVs, the same should be left for industry to decide and for a Defence PSU Shipyard, may at best be moderated by the MoD/DDP [lxxi].

Conclusion

20. A lot of ground has been covered in a short time from global trends, missed opportunities for Indian yards in commercial and warship building and the emerging market for India to be the hub of Ship/Warship Building. But, while one must also draw attention to the glaring deficiencies in the current shipbuilding infrastructure of the country, which in turn affect our warship acquisition plans, the devil lies in refining procedures for acquisitions and facilitating industry to cogenerate. What we need today is an out of the box thinking, break technological barriers and seek new frontiers that go beyond the traditional way in which shipbuilding, involvement of industry and government has been made.

21. The Indian armed forces today need an institutionalized Window to scout and seek military Technologies and Trends besides enhancing its military and bureaucratic capacities for defence acquisition. Hence internal procedures, agencies and personnel involved in warship building projects need to work with a collegiate mechanism in place to reduce time frames. The ship construction activity of our country especially that of the Indian Navy has come a long way and in an imperceptible manner, the IN today is a builder's navy. While contentious areas of capabilities of the industry to government policies on shipbuilding have been examined with remedies where possible suggested, considerations of making in India to meet internal domestic demands and Export should be at the top of agenda for any agency today.

22. The reform of indigenous warship building with an aim of exporting warships is inextricably linked to other aspects of defence procedural reforms that are radically changing the nature of relationship within and amongst the ministry of defence, the Navy, industry; both Indian and the prospective foreign OEMs, as well as the shipbuilders. All the broad based aspects covered in this paper should stimulate some debate at tackling these issues to achieve the ultimate benefits of shipbuilding boom across the world and its contribution to a growth oriented economy of our country.

End Notes

i The 'Make in India' week came to end on Thursday 18 February 2016, with the country likely to get record investments if all projects envisaged by various MoUs signed at the event come to fruition. The Promise: Rs. 15.2 Lakh Cr. 19 February 2016. The Economic Times, Mumbai pp14

ii This formal platform where the Indian industry, Navy, DRDO, MoD and the foreign defence industry interacted to work out their roles for the future in indigenous ship building for the Indian Navy resulted in a very clear study being undertaken for the formulation of the framework for participation of the industry in indigenous warship building based on the acquisition plans of the Indian Navy. The CII study in NAVARMS 2010 recommended; (a) The Indian private sector be provided a level playing field and brought into the defence production eco-system to share the load with the DPSUs to build our Navy as a truly Indian enterprise (b) Encourage Private sector to actively participate in Defence R&D projects and give financial assistance on a cost and profit sharing basis wherever required (c) Simplify Defence Production and Procurement Policies and create a single window clearance and facilitation agency for expediting approvals and licenses (d) FDI should be subject to review and extendable to 49 percent on case to case basis and even to 100% as wholly owned subsidiaries in India and (e) MoD must declare its intent that all future acquisitions would preferably be from the Buy and Make Indian Route and Buy Global would be in the rarest of the rare cases i.e., when no Indian industry is able to partner with a global OEM. Building India's Navy - Force Requirements and Indigenous Capability. A CII Study 24 November 2010

iii The Growth of 32.8% is over the previous year (2004) and stood at an all time record of 3,948 ships with 215.7 million dwt and 91.5 million CGT. Hyundai, the largest shipyard in world received orders for 257 vessels totalling 7.9 CGT. World Merchant Fleet, OECD Shipping and Shipbuilding - ISL Market Analysis 2005. SSMR Jan/Feb 2005. www.isl.org.

iv KPMG-FICCI Report on ship building shows that revenues at the 21 private yards in India have nearly quadruple from Rs. 10.17 million to Rs. 36.57 million. In the last 5 years the growth rate of private sector yards is far better than that registered by the 7 state and facilities at the present level KPMG places countries share of the Global shipbuilding industry at a mere 0.3 % by Japan and South Korea lean the industry with market shares of 38% and 32% respectively event China which really launched shipbuilding drive only in the 19 ninety's today has a market share of 20% a cost-effective labour force and the availability of ancillaries help China capture a significant share of the world market something that India is only yet beginning to realise. Shirish Nadkarni New Players in Shipbuilding Boom Future for Indian Shipbuilding. The Naval Architect March 2008 PP 72

v Many countries worldwide are now either implementing or considering ambitious shipbuilding reform programmes to increase through put, contain costs and ensure timely delivery of ships. The reforms and growth in shipyard facilities and capabilities is most evident in the development of large docks in China. In 1999 there were only two docks that could handle up to 3,00,000 dwt ships. By the end of 2002 this had risen to eight docks, with two of these being able to accept ULCCs. China's capacity has been estimated as 3.2 million CGT as against South Korean capacity of 6.5 million CGT in 2000. China's Shipyards - Capacity, Competition and Challenges. www.drewry.co.uk.

vi Chinese shipbuilders have started to see dwindling new vessel orders in 2015 from an industry that is challenged by a prolonged slump. China Shipyards Continue Downward Trend. http://www.hellenicshippingnews.com/china-shipyards-new-orders-continue-downward-trend-in-first-11-months 19 December 2015

vii China named nine additional shipyards; commercial and naval that will receive policy support as part of continuing efforts to spur consolidation and technological advances across its shipbuilding sector. These shipyards have been added to a 'White List' of 51 shipbuilders to receive state benefits such as tax rebate and easier credit. The 'White List' is intended to help develop the selected builders while accelerating the restructuring of non-selected companies. Jon Grevatt. China Looks for Shipbuilding Consolidation - Industry Update. Jane's Navy International January /February 2015 pp 32

viii The programme which has previously suffered time and cost overruns was entered into by a former Trinidad and Tobago government and the UK's VT Group in April 2007. The same platform, a modified version of the UK's River Class OPVs underpinned BAE Systems' contract with Thailand for the OPVs. Guy Anderson. Trinidad and Tobago Looks to Terminate OPV Contract with BAe Systems. October 2010 Jane's Navy International pp 5

ix The widely expected decision from one of the three options available came on 15th March wherein other possibilities were the sale or even retention of the businesses. Jane's reported in late 2010 that four private equity firms had expressed an interest in the purchase of the HII shipyards as a block. Northrop Grumman was one of the two Giants in Naval ship building in the USA the other being General Dynamics. Guy Anderson. Northrop Grumman Ends 10 year Association with Shipbuilding. Jane's Defence Weekly 23 March 2011 pp 19

x Since October 2014, the ship building work force at the Shipyard has been reduced by close to 500 people and the new announcement takes the total reductions to 600 people. In early June the Australian government made announcements about it's so called continuous build plan which is intended to address the continuing reductions in workforce across the country's Naval shipbuilding sector. The plan is centred on bringing forward two major construction programs which will begin in 2018 and is likely to require major involvement from Australian industry. John Grevatt. BAE Systems Australia Announces Further Round of Shipbuilding Layoffs. Business IHS Jane's Defence Weekly 19 August 2015 pp 23

xi This announcement made on 13th August has also the possibility of ENVC being sold even to a foreign investor. In recent years ENVC which has a workforce of 600 is understood to have suffered from high levels of debts and lack of state funding for naval procurement projects. Victor Barreira. Portugal to Sell Naval Shipbuilder ENVC - Europe. Jane's Defence Weekly 22 August 2012 pp 15

xii Job cuts at the facility which currently employees 450 people are also likely as the company's Air Warfare Destroyers for the Royal Australian Navy contract draws to a close. Jon Grevatt. Forgacs Cuts Staff as Shipbuilding Slows - Business. Jane's Defence Weekly 1 July 2015 pp20

xiii Program based collaboration with reputed shipbuilder's across the World, especially from the Western Europe or MoUs between them and Indian Industry have been the need of the hour and needs to be encouraged in similar lines as other countries. BAe Systems has established a partnership with Thailand's state and naval ship builder Bangkok Dock to support the construction of a second modified River Class Offshore Patrol Vessel. Thailand's OPV program is seen as an important enabler of local naval ship building capability. It is geared towards creating jobs and developing skills and being able to construct the vessels with minimal external help. For BAE systems the program consolidates its presence in the market as the company is also pursuing artillery programs and Military vehicle upgrade contracts in the country as well as cyber defence deals. Jon Grevatt. BAE Partners with Bangkok Dock for Second Thai Navy OPV Build - Industry Update. IHS Jane's Navy International December 2015 pp 31

xiv Under the MoU signed at Visakhapatnam during the 22nd CII Partnership Summit & Sunrise Andhra Pradesh 1st Investment Meet on January 10, the Government of Andhra Pradesh will make 1,500 acres of land available for this facility in close proximity of strategic establishments of the Indian Navy and Bhabha Atomic Research Centre (BARC). Reliance will make an initial investment outlay of Rs 5000 Crore ($800 million) in this project. This will represent the single-largest investment at one location anywhere in Andhra Pradesh. This investment is expected to generate more than 10,000 new jobs and also lead to the creation of a multi-tier array of defence ancillaries, bringing in further investment of between Rs 5000 Crore to Rs 10,000 ($800 million to $1.6 billion) and thousands of additional skilled jobs. Apart from building different categories of naval vessels for the Indian and foreign navies, this shipyard will also focus on the maintenance, refit and services of ships. Anil Ambani-Led Reliance Defence to Setup Shipyard in Andhra Pradesh. NDTV Profit. 10 January 2016. http://profit.ndtv.com/new s/corporates/article-anil-ambani-announces-rs-5-000-crore-naval-facility-investment-1264149

xv The shipbuilding industry was supporting directly or indirectly, the livelihood of nearly half a million people and a tremendous domestic opportunity existed to increase the livelihood as well as revenue within the country in terms of replacement of almost 500 merchant ships with an average age of 18 years for country's 28 established shipyards. Prof P Sambandan, Director NSDRC. Indian Shipbuilding: Present Trend and Future Prospects. Millennium Seminar by Institute of Marine Engineers (India) 19-21 July 2001.

xvi Howard M Bunch. Study of the Literature to Assess the Future of India's Shipbuilding Industry. Journal of Ship Production, Vol 19. No. 4 November 2003 pp 246-254. SNAME Publication.

xvii Sreekumar et al. Shipbuilding/Ship Repair Industry in India: Problems and Prospects. IE(I) Journal - MR, Vol 84, January 2004. pp 57-64.

xviii Shipbuilding is a labour intensive industry. The growth of the domestic shipbuilding sector, which today imports about 45 percent of its input requirements, can provide a major trigger for large-scale indigenization of heavy engineering products and ancillaries. The Indian Shipbuilding Industry has demonstrated aspirations to acquire a 7.5 percent share in global shipbuilding by 2017, which is expected to have a size of above 500 mn DWT. Analysis suggest that this would require Indian shipbuilders to invest close to INR 200 Billion in new yard capacity, which interestingly, is the current level of cumulative investment declared by various entrants in this sector. Indian Shipbuilding Industry: Poised for Take off? - Global Conference and Exposition on Shipbuilding. A KPMG - FICCI Report 2008

xix Indian Navy would have 200 warships in another 10 years, with three aircraft carriers in each of the three naval commands, for which orders have already been given to various docks in the country, a senior official said here on Wednesday. Right now, there are 136 ships and the target is 200 in the next 10 years with all shipyards in the country full of orders. PTI Nov 13, 2013. Indian Navy to have 200 warships in next 10 years. http://timesofindia.indiatimes.com /india/Indian-Navy-to-have-200-warships-in-next-10years/articleshow/25708914.cm

xx A slowdown in cuts to Defence budgets in Europe and continuing growth in the Asia Pacific region in 2015 served to counter a contraction in the Middle East and the continuing squeeze on US defence spending. Consequently, the Global defence expenditure for the year remained ostensibly unchanged at US dollars 1.653 trillion (0.3 % real term reduction compared with 2014). Regional trends suggest that unstable yet broadly positive market conditions are set to endure for the next 2 years. Accelerating growth in the Asia Pacific region and an improved Outlook in West Western Europe will be countered by the onset of cuts in Russia and the Commonwealth of Independent States. Deepening economic malice in Latin America and fiscal conservatism in the Middle East as major energy producer adjust to lower revenues. However, the Global defence expenditure growth is likely to continue to rise from 2017 to 2025 at real term average growth of about 2% by 2025. Return to Growth the IHS Jane's 2015 Global Budget Report. Jane's Defence Weekly IHS.com xxi For India to realize its objective of building the military capabilities, the Government needs to develop a comprehensive industrialization strategy for defence to coordinate the use of offsets, transfer of technology, FDI and the public and private sector defence industry in India will be critical to this industrialization strategy. Defence acquisition is a highly specialized process and needs adequately trained manpower. In India, we lack a dedicated cadre of personnel for capital acquisitions along with any specific training programs for staff involved in the acquisition process. The creation of a separate and dedicated institutional structure to undertake the entire gamut of procurement functions is required to facilitate a higher degree of professionalism and cost effectiveness in the defence procurement process. The current policy framework and contractual issues relating to through life product liability and indemnification are particularly onerous to domestic and foreign private companies. Under the current system, the liability of the supplier extends to the entire life cycle of the product, even when the product is not under the supplier's care, and is potentially unlimited. These provisions can act as a potential deterrent to active involvement of foreign suppliers. Indian Defence Sector: The Improving Landscape for US Business and Indo - US Commercial Enterprise. A KPMG - AMCHAM Report 2010

xxii Saab has stepped up efforts to position itself for Poland's naval modernization program by signing a Letter of Intent with Gdynia based Naval Shipyard SA. Cooperation with local industry is expected to be key to the Polish government's decision making and has the full backing of FMV, Sweden's Defence Material Administration. Richard Scott Saab Signs LoI with Naval Shipyard Gdynia - Industry Update. IHS Jane's Navy International December 2015 pp 31

xiii Some of the major equipment where there has not been satisfactory progress towards indigenisation are the weapons & sensors, propulsion systems (especially Gas Turbines), Marine Diesel Engines for main propulsion and Gear Boxes under 'MOVE' category, which are imported presently and holds much scope for indigenisation. IN is working closely with DRDO, DPSUs like BEL and Private Sector like L&T, Mahindra Defence Systems, Tata Power SED to bridge this capability gap, and a number of projects are underway for indigenous development of weapon & sensors as well as propulsion system controls. Indian Naval Indigenisation Plan (INIP 2015-30) Integrated Headquarters of Defence (Navy) - Directorate of Indigenisation pp 6.

xxiv The Sir CP Ramaswamy Iyer Committee in 1947 recommended that all of India's coastal trade, 75% of trade to neighbouring countries and 50% of overseas trade should be carried in Indian bottoms. Modern Economic Development - Part II. Bihir BS et al. First Edition Kitab Mahal, New Delhi 1955

xxv The National Maritime Development Policy (NMDP) envisages a complete package of measures to support the industry in order to become internationally competitive and for the country to emerge as a leading shipbuilding / ship repair nation by 2025. Maritime Agenda: 2010 - 2020 GoI, Ministry of Shipping January 2011. http://www.performance.gov.in/sites /default/files/document/strategy/Shipping.pdf

xxvi Another big customer for the shipyards' ONGC has drawn up a Rs 40bn ($876M) investment plan for buying Offshore Vessels (OSVs). The plan involves acquisition of one Multi-Support Vessel (MSVs), 17 OSVs and AHTs and two jack-up drills by 2009. It will also acquire 19 OSVs and AHTs by 2010 as per published information from senior officials of ONGC. A strong domestic market therefore exists for the consideration of Indian shipbuilders. ONGC Plans Rs. 4,000 Crore Vessel Acquisition. PR Sanjai, Mumbai. Business Standard. 10 October 2005

xxvii Revitalisation of Indian Shipbuilding Industry - A Strategic Imperative. IHQ MoD(N) 12 Mar 2008. Pp 45-46

xxviiiSince the mid 50s world over, technological progress has come into the forefront suggesting that (a) output growth in rapidly growing economies was attributable to technological progress and that (b) the forces shaping technological progress are largely economic in nature. Simrit Kaur. Privatisation and Public Regulation - The Indian Experience.

xxix It would also essentially instigate an international effort for developing acceptable naval ship compensation coefficients akin to CGT. It is believed that this would be of significant benefit to naval shipbuilders as it would enable them to benchmark themselves with other shipbuilders and see where they were positioned regarding productivity. T.Lamb, Head of Marine Systems Division of the University of Michigan Transportation Research Institute and Adjunct Professor in the Department of Naval Architecture & Marine Engineering. http://www. Educationalimages.com/it050006.htm.

xxx India's Pipavav Shipyard has entered into discussions with European defence companies with a view to make an acquisition in the near future. Pipavav's aspiration emerged a few weeks after the company secured approval from the Indian Foreign Investment Promotion Board (FIPB) on 23rd March to undertake defence production activities in competition with state owned Enterprises. The licence from FIPB was required because the company is partially owned by foreign investors. Jon Grevatt. Pipavav Plans Acquisition. Jane's Defence Weekly 20 April 2011 pp 23

xxxi The Russian government has chosen Anil Ambani's Pipavav Shipyard for a MII naval frigate order that is likely to exceed $ 3 Billion, making it the private sector's biggest-ever-warship-building project. Biggest Warship Project. Russia Selects Anil Ambani's Pipavav to Make Frigates for Indian Navy. Manu Pubby. ET Bureau. 16 Jul 2015. http://economictimes. indiatimes.com/news/defence/biggest-warship-project-russia-selects-anil-ambanis-pipavav-to-make-frigates-for-indian-navy/articleshow/48091024.cms xxxii 'U.S. shipyards are classified into first-tier shipyards, second-tier shipyards, and third-tier suppliers. First-tier yards include three major conglomerates in U.S. shipbuilding: the General Dynamics Corporation, which owns Electric Boat and Bath Iron Works; Litton Industries, which owns Ingalls Shipbuilding Company; and Tenneco, Incorporated, which owns Newport News Shipbuilding. In addition, 12 other yards make up the first tier. Second-tier yards include smaller yards, some with U.S. Navy contracts that produce other than large oceangoing vessels exceeding 122 meters. These yards construct and repair smaller vessels for inland waterways and coastal carriers. Typical ship construction includes tugs, supply boats, ferries, fishing vessels, barges, drill rigs, small military vessels, and other government-owned vessels (e.g., Coast Guard cutters). The third tier consists of hundreds of private sector and government-owned industrial facilities that design, develop, produce, and maintain subsystems and components required to support the shipbuilding industry.' Cdr Dealy David et al, Shipbuilding Industry Study Report 1996. ICAF Publications

xxxiiiKPMG - FICCI Report 2008 op.cit. Ancillary industries usually lag the development of shipbuilding industry in any country. It requires the shipyards to achieve a critical mass before globally renowned ancillary companies such as Man, Wartsila, Caterpillar and Rolls Royce establish a sizeable presence there. Even then most of these are joint ventures with leading local shipyards to mitigate risk and tie-in customers. However, India's strengths in the manufacturing sector might advance the process here. India is recognized as a global player in light engineering and a major base for auto ancillaries. Some signs of this occurrence are already visible. Man Diesel has set up an engine plant at Aurangabad and Wartsila is in negotiations with several domestic shipyards to set up a similar unit in the country. Rolls Royce is setting up an electronics and communication plant in Navi Mumbai.

xxxivOle Johansson. Govt's Aim to Become Largest Shipbuilding Nation is Not Unachievable. The Economic Times, New Delhi. 17 October 2005. pp. 17.

xxxv Maritime Agenda: 2010 - 2020. Op.cit.

xxxviA good illustration of the same is the Brazilian aviation group Embraer, which plans to convert its strong position in China's civil aircraft market in to defence as it had established domestic companies and manufacturing facilities in China to cope up with export and domestic growth in the civilian sector It now plans to extend this growth to Defence sector in order to look for new markets and utilise its manufacturing potential to the fullest rather than look at closure in few years once the civil sales have flattened out. Matthew Bell. Embraer looks to build on civil sales success in China, 23 February 2011. Jane's Defence Weekly

xxxviiThe Japanese shipbuilders, for example, get 97.8% of material inputs from domestic plants with their industry's annual output value in excess of USD 8 billion. Even the Korean ship components industry satisfies over 80% of their shipyard's requirements. India by contrast with a nonexistent and rather immature ship component industry, has to import majority of ship components from Europe, USA, Japan, Russia and Korea. Indian Shipbuilding-Whither bound? imaritime research.

xxxviiiIndia's emerging private sector has contributed only marginally to meeting the countries material requirements over the past three years (2011 to 2014) wherein only 3% to 4% of equipment supplied to the Indian Air Force and Indian Army was from the Indian Private Sector. Conversely India's eight Defence Public Sector Units (DPSUs) and 41 state run Ordnance Factory Board (OFB) plants have provided around 59% of the equipment to the two services totalling to INR 612.16 Billion over the same period. Rahul Bedi. Indian Private Sector Struggling to Gain Foothold - Business. Jane's Defence Weekly 17 December 2014 pp 18

xxxix The MII Week witnessed a business commitment of Rs. 15.20 Lakh Crores to successfully bring manufacturing, design and innovation to the centre-stage. More than 8 Lakh people visited the MII Week and other events, of which 49,743 were registered delegates. 102 countries were represented in the mega expo. Eleven sectors covering aerospace & defence, automobiles, chemicals & petrochemicals, construction machinery, food processing, infrastructure, IT & electronics, industrial equipment & machinery, MSME, pharmaceuticals and textiles were showcased. Key deals / MoUs that were concluded during the MIIW include (a) BAe Systems and Mahindra for M777 Howitzers, (b) Oracle's for 9 incubation centres, (c) Gujarat Government and Tar Kovacs Systems (France) for offshore platform to develop marine applications, (d) Tar Kovacs and Karnataka Government for ocean based renewable energy project (e) JSW for Jaigarh Port Ltd., (f) Solar Industries and Maharashtra Government for manufacturing of ammunition. (g) Rs 2,200 Crore Electronics Development Fund to finance innovations, research and development in electronics manufacturing sector. Make In India Week (15 - 18 Feb 2016) - Highlights. http://inbministry.blogspot.in/search?q=make+in+india

xl A shift in government's policy towards increased spending on shipbuilding infrastructure is sure to enhance overall growth rate of the economy as well due to its multiplier effect. Dornbusch et al. Macroeconomics. Tata Mcgraw Hill Publishing Co. Ltd., New Delhi. 2002. pp250.

xli A shrinking defence budget and re-prioritisation of procurement needs are going to hit the UK defence industry where it hurts. Initial analysis suggest that nearly 40000 different workers in the UK could lose their jobs over the next 5 years and that manufacturing in the military Aerospace, tracked armoured fighting vehicle and defence electronics sector could come to an end. The Green Paper stressed the virtues of Commercial Off The Shelf (COTS) purchases as well as widespread use of competition and bilateral cooperation to achieve value for money within a shrinking defence budget. Tim Ripley. UK Defence Industry Faces Tough Times - Analysis. Jane's Defence Weekly 28 April 2011 pp 24 xlii India has imported material worth Rs. 1.034 trillion over the past 5 years and these imports total about 65% of the country's overall military requirements. United States emerged as India's largest material supplier followed by Russia France and Israel. Conversely India's Defence exports between 2011 and 2014 totalled Rs. 18.1 million despite repeated efforts by successive administration to boost sales overseas. Indian defence exports largely comprise ordnance and small arms ammunition and items like boots, webbings and uniforms. Rahul Bedi. Indian Defence Imports Total US$ 17.25 billion Over 5 Years - Asia Pacific. Jane's Defence Weekly 10 December 2014. pp 14

xliii HAL has as on date, facilities only for assembly, test, repair & overhaul of LM2500 Industrial and Marine Gas Turbines which was originally envisaged for license production and manufacturing to meet Indian demands. This is primarily on account of limited naval requirement (24 Engines in nearly two decades) with barely five engines used by ONGC. The LM 2500 Engine - HAL, IMGT Division. http://old.hal-india.com/IMGT/Products.asp

xliv As Turkish media outlets reported on Friday, Anand Stanley, the vice president responsible for the Middle East, Turkey and Africa of the U.S.-based aircraft manufacturer Sikorsky Aircraft Corporation, said they can make Turkey their office production center to export to the Middle East and Africa in early September. Sikorsky Aircraft, which signed a contract worth $3.5 billion (TL 7.9 billion) with Turkish state-run and private companies to produce general purpose helicopters in February 2014, is now gearing up to export helicopters produced in Turkey to the Middle East and Africa. Speaking to Reuters news agency during the Istanbul Air Show, Stanley said that their Turkey office would be the production center for all regional countries from Pakistan to Africa. According to Stanley, Sikorsky Aircraft's Turkey office will be responsible for exporting to these countries as well as directing customer relations. Stanley stated that the cost of projects, which will also be used by Turkey, is $8 billion. He stressed that they would like to be a part of Turkey's growth story. Sikorsky to Move its Manufacturing Line to Turkey. Business - Daily Sabah, Istanbul 27 September 2014. http://www.dailysabah.com /money/2014/09/27/sikorsky-to-move-its-manufacturing-line-to-turkey

xlv This document titled "Technology Perspective & Capability Road Map", intends to provide the industry an overview of the direction in which the Armed Forces intend to head in terms of capability over the next 15 years, which in turn would drive the technology in the developmental process. It is based on the LTIPP of the Armed Forces. The document is being put up in the public domain in line with the vision of Shri AK Antony, Raksha Mantri, " ..to establish a level playing field for the Indian defence industry, both public sector and private sector." Industry would be expected to interact with the MoD on a regular basis and offer firm commitments in partnering with MoD in developing contemporary and future technologies as well as productionalising equipment required by the Armed Forces. Technology Perspective and Capability Roadmap (TPCR) April 2013. HQ-IDS/MoD

xlvi Deba R Mohanty. Changing Times? India's Defence Industry in the 21st Century. Bonn International Centre for Conversion-Paper 36. pp37.

xlvii India lags far behind the West, Japan, South Korea and Taiwan in the Technology Standing Index. Collaboration does not necessarily result in state-of-the-art technology coming to India. Foreign MNCs that have joint ventures in India are clear that the 49% cap on FDI is 'not un-attractive'; it will help build technologies here train local talent and skills. As far back as in 2004 key economists argued before the Planning Commission of India that hundred percent FDI in high-technology would enable India to reduce or limit its technology imports. A higher FDI should lead to full platforms being produced with minimum capitalisation, the proprietary technology can be indigenised and further developed, the foreign partner will undertake to source 50% to 70% of components / subsystems by value from Indian vendors. If it goes to 51% and beyond foreign vendors will bring in new business practices as higher limits will give them the flexibility to take a call and provide the best solution. With lower cost of labour, small and medium enterprises could benefit as they are all looking to get into the Global supply chain but lack capital and technology. Surya Gangadharan. Searching for The Ideal FDI in Defence Production. The Hindu, Visakhapatnam 24 July 2014 pp 9

xlviii With the defence sector emerging as a corner store for the MII initiative, the showcase industry event of the Ministry of Defence - The Defence Expo is set for record participation this year. The four day event taking place outside the National Capital for the first time already has registration from 843 companies with at least 44 Nations exhibiting their products. While Bharat Forge is said to exhibit its indigenously designed and developed artillery gun at the show DRDO is believed to have dispatched its Dhanush towed gun to take part at the show in Goa. India has again emerged as the world's largest importer of arms with Russia being the top supplier garnering 70% of the Indian market. India's imports account for 14% of global arms imports 3 times greater than those of China and Pakistan as per Report published by the Stockholm International Peace Research Institute (SIPRI) Manu Pubby. Record 843 Companies Register for Goa Defence Expo. The Economic Times Mumbai 23 February 2016 pp 4

xlix Since the new building demand remains cyclic in the long term it is important that both over and under capacity of yard are borne as factors while working out the infrastructure upgrades. Civilian Production has been encouraged in the Indian defence industry since the late 1950s. Mr. V K Krishna Menon initiated this programme during his time (1958-62), which saw civilian products like coffee percolators, consumer electrical items and engineering and construction equipment being produced by defence units. Maj Gen Pratap Narian, Indian Arms Bazaar, Note 12, p67-68.

l All these initiatives will require robust and committed implementation to be effective. They will also need to be supplemented with policies that seek to address shortcomings in India's Defence Sector such as tackling Bureaucracy and the procedural inconsistencies that impede competition between public and private sector companies. Nevertheless the measures introduced so far indicate that India is making steps towards strengthening its private sector and potentially spurring capability advancements. Jon Grevatt. Private Sector Responds to Make in India Drive - Business Analysis. Jane's Defence Weekly 27 May 2015 pp 21

li Export of dual-use items and technologies is either prohibited or is only permitted under a license. In Foreign Trade Policy, dual-use items have been given the nomenclature of Special Chemicals, Organisms, Materials, Equipment and Technologies (SCOMET). Export Policy relating to SCOMET items is given in Appendix 3 of Schedule 2 of ITC (HS) Classification and Paragraph 2.49 of Hand Book of Procedures Vol.-I, 2009-14. Appendix 3 of Schedule 2 of ITC (HS) Classification contains a list of all dual-use items and technologies export of which is regulated. Category 5 and Category 7 of the SCOMET List refers to the defence electronics and the aerospace sector. Export licenses are controlled by DGFT. CII Study 2010

lii The existing rudimentary defence industry would Force India to continue to import heavily for the next decade at a minimum. Hence, the procurement process should be formulated such that it becomes a catalyst for assisting defence innovation that is not the case now and this has to be the guiding principle for the DPP. No country has a financially viable defence industry catering to only the domestic market. The internal requirements are meant to justify the huge capital cost which can be amortized only through Exports. It is imperative that the government starts at Crusade to export defence items this would involve concerted efforts from all arms of the state. Military Industrial complex is not the preserve of just the public sector, it is imperative that the muzzle to disadvantaged Indian private sector be accorded effective affirmative action. Manmohan Bahadur AVM (Retd.) Make Way for Made in India. The Economic Times Mumbai 16th February 2016 pp 20

liii With construction contracts drying up and government commitments to new programmes weak at best, it would be surprising if shipbuilders across western Europe did not feel apprehension as they peer into future. As last ships ordered under existing shipbuilding programmes enter the water, there are few new orders from European navies to keep their domestic shipyards busy. Tim Fish. Western Europe Shipbuilding Industry. European Shipyards Face an Uncertain Future. Jane's Navy International October 2010, pp 47 - 50.

liv The UK's coalition government said it would put renewed emphasis on exports to try to help companies compensate for a loss of Ministry of Defence work. BAE Systems and its partners are in the middle of major export drives in India, Japan and the Middle East but their bids include significant elements of local industrial participation and assembly suggesting that UK employment will be limited to upgrades and sustainment. The real manufacturing will take place in the US and British companies will have to compete for support business to sustain US made platforms in UK service. The UK defence market will shift from being focused around manufacturing and be more centred on support. If the government sees these policies through it will be the end of the UK defence industry as we know. Tim Ripley. UK Defence Industry Faces Tough Times - Analysis. Jane's Defence Weekly 28 April 2011 pp 24

lv India's Defence exports are on track to double in value in Fiscal Year 2015-16 Defence Minister Manohar Parrikar said on 16th October 2015. His comments came two days after Ecuador announced plans to terminate a contract related to import of Indian made Dhruv Advanced Light Helicopter. The value of India's annual military Exports has been below US dollar 100 million for many years reflecting some of the capability shortcomings experienced by local industry where indigenous programs are usually delayed and over budget. The government has made efforts to represent International sales in a more positive light as it seeks to build confidence in local manufacturing and promote its MII campaign. While this target seems optimistic, one specific area of potential is in the private sector which is increasingly competitive in global supply chains with emphasis on producing components and Systems. Jon Grevatt. India's Exports Set to Double in Value says Defence Minister. Business 28 October 2015 IHS Jane's Defence Weekly pp 23

lvi While Pakistan has yet to break into exports, the extent to which domestic producers are supplying the country's armed forces is far greater than previously thought. Pakistan has gained self sufficiency in producing arms for 500,000 strong armed forces. Western defence officials noted that it has yet to significantly Step Up investments in a sector that is primarily run by the government. Pakistan is a large defence spender, and if it was to allow the private sector to bring in investments and innovation it can make faster progress. Pakistani officials dispute such suggestions and said that it would not have been possible to manufacture the JF-17 and tanks without the close involvement of the armed forces. Farhan Bokhari. Pakistan Growing Defence Industry Looks to Export - Analysis. Jane's Defence Weekly 17 December 2014 pp 23

lvii South Korean shipyards may have achieved success for the past decade by competing primarily on cost. However, the strategy of pricing products significantly below that of Rival shipyards in Western Europe may not be sustainable in the long term given the emergence across the Asia Pacific region of naval shipbuilders that can operate at a significantly lower cost. Some of these amazing shipyards such as Chinese and Indonesian shipyards may make further in roads globally considering the strong Government support in the respective countries to do so. Indeed support such as in South Korea, which has taken various steps to improve its different procurement procedures in April 2015 and revealed its intention to establish an Academy dedicated to training civilian procurement experts. The Academy is likely to be modelled on the United States defence acquisition University. Ridzwan Rahmath. Batten Down the Hatches South Korean Yards Prepare for Challenges. Feature: South Korean Naval ship Building. IHS Jane's Navy International October

2015 pp 19

lviii Spain's shipyards have been given a huge fillip with Europe's second-highest court yesterday green lighting a Spanish tax lease scheme for the local shipbuilding industry, annulling a decision by EU regulators two years ago that branded the scheme as illegal state aid. The Spanish scheme involves financing ships through a structure with two intermediaries, and allowing shipping companies to get a rebate of up to 30% on the price of vessels built by Spanish shipyards. Spanish Shipyard Financing Scheme Ruled Legal. Splash 24/7. http://splash247.com/spanish-shipyard-financing-scheme-ruled-legal

lix The proposed Ship Building College (SBC) would be in partnership with industry including shipbuilding yards. The primary beneficiaries of a SBC would primarily be the shipyards, the IN & ICG, the Classification Societies, Professional Institutes like the IE(I), AIEEE, IETE, SNDT(I), CSI and IMarE(I) etc. Industry Training could be imparted using the expertise and facilities of the stakeholders themselves. Shrivastava PKS & Tater B. Technical Education and Shipbuilding. The 22nd National Convention of Marine Engineers and National Seminar on Convergence of Technologies in Global Maritime Sector by IE(I). 19-20 Sep 2008 at Tolani Maritime Institute, Pune.

lx The UK has worked hard to secure a strong position but in the future this cannot be taken for granted without investing in Research and Technology and skills particularly in program and project management. Competing and cooperating with France Germany Italy and the US and investing in low cost sources such as India and Mexico, expanding our defence equipment export drive, improving the procurement process to reinforce our position as the lowest cost defence industry in the world, with greater outsourcing from the ministry of defence to industry and becoming a major source of skills to recreate our civil nuclear industry are essential. Our industries are ready to deliver for the UK if our politicians want to create the climate in which we can do so. The whole country will benefit in terms of jobs wealth creation security and cementing the Nation's place in the world is our future government has the foresight to deliver that beneficial climate. Ian Hidden, Chairman ADS: UK Defence Sector is Vital to UK Wealth Creation - Opinion. Jane's Defence Weekly 2 December 2009 pp25

lxi The total exports of Indian Engineering sector stood at US dollars 56.7 billion during fiscal year 2013 and are anticipated to go to U S dollars 125 million by fiscal year 2014 exports from the engineering segment have registered a compound annual growth rate of 12.6 % over the period fiscal year 2008 to 2013 where in transport equipment is the leading contributor to engineering Exports the US and Europe together account for over 60% of India's total engineering Exports emerging Trends like Outsourcing of Engineering services provide opportunities for growth engineering and design services such as new product designing product improvement maintenance and designing manufacturing systems are getting increasingly outsourced to Asian countries like India it is estimated that by 2020 India can be a US dollar 40 million market for engineering Outsourcing Services a Brief Report on Engineering Sector in India. January 2015 Satish Kulkarni ASA and Associates LLP www.asa.in

lxii India's Defence budget is likely to see a modest Hike of 9% to Rs. 2.68 Lakh Crores in 2016 -17 as against the budget for 2015 (Rs. 2.46 Lakh Crores) for all three services combined. However, the defence ministry is likely to surrender Rs. 12,400 Crores (16% of Rs. 77406 Crore amount set aside for acquisition) under the Capital Head since several projects could not be processed on time by the three service headquarters. Manu Pubby. 9% Hike in Defence Budget Allocation Likely This Year. The Economic Times Mumbai 22 February 2016 pp 20.

lxiii After more than 5 months since its official announcement the 'MII' initiative has failed to provide any concrete push to India's manufacturing or exports. It was the same old recipe of asking for tax breaks or concessions to boost manufacturing for defence production rather than being thankful of government's effort for indigenisation. Besides hiking FDI limit in defence sector, there is a demand to give financial incentive to 'MII' attractive for big defence companies. If this is what the government calls 'MII' incentives, they are nothing but repackaging of old ideas. There is no out of the box thinking or a genuine long-term vision by any of the Ministries in their proposals. Tax breaks and concessions are the oldest trick in town of incentivizing a sector. If MII has to be a success, industry has to have the visibility that their produce is sold in the market. With global economy not showing any signs of picking up, the market will have to be created in India itself. However, to achieve this task none of the bottlenecks have been removed. Mittal AK Prof GMIT et al. 'Make in India': A Visionary Campaign of Government of India. Materials Management Review IIMM December 2015 Volume 12 Issue 2 pp 19

lxiv Tiny fixes and tricks in government policy is firing up India's defence equipment making industry and have gone largely and noticed in the blare of new procurement policy and big ticket MII project. In July 2015 the defence ministry eased export regulations and stopped demanding multiple assurances on and use from foreign governments even for sale of components by Indian entities as global manufacturers source components from across the world finally integrating the systems at Central facility. Earlier rules required Indian firms to get certificate of insurance from all governments in the chain. Private companies exported military store worth 441 Crore in the first 6 months of the current financial year a fourfold increase over the last year when 132 Crores worth of exports were done in the entire financial year. The industry is hoping the Defence Minister would deliver on his statement at the ITA Global Business Summit - 'I believe that the less the government is in any manufacturing sector the faster it will progress'. He had said the nuts and bolts are now in place and the wait is on for the government to sign off orders soon Indian forces maybe firing artillery guns made by L&T or flying transport aircraft built by a TATA bus combine. Manu Pubby Armed and Ready to Fire - Made in India. The Economic Times. Mumbai 16 February 2016 pp20.

lxv It was a bold decision in May 2015 when the DAC approved the Tata Air Bus project despite it being a single vendor/bidder situation. The rationale was that though the other contenders had backed out for some reason or the other, the technical and commercial bids had been submitted in competitive environment by the consortium of Tata-Airbus. The project involved first 16 aircrafts in SKDs and manufacture of 40 more by an Indian production agency within 8 years. Incidentally it was NDA government's first DAC in July 2014 and the Rs. 12,000 Crore venture was aimed at boosting private role in defence. Rajat Pandit. A Year On, Tata-Airbus Project for IAF Yet to Take Off. The Times of India Mumbai 18 February 2016 pp 13

lxvi What we see regionally in Asia is that India represents one of the largest potential growth segments over the next 5 to 10 years. William Blair: President of Resume India Operations - Interview 02 February 2011. Jane's Defence Weekly pp 42

lxvii The Committee also reckoned that warship/ submarine construction has been hitherto undertaken by Defence shipyards. Keeping in view the future capability requirements of Indian Navy as well as Coast Guard, it has been appreciated that additionally required capacity can come from the private Indian shipbuilding industry. The existing capacity in the private Indian shipbuilding is also needed to be gainfully utilised. Facilitating 'Make in India' in Defence Sector through Defence Procurement Procedure - Report of the Experts Committee for Amendments to DPP 2013 including Formulation of Policy Framework. 23 July 2015

lxviii Ibid. pp 135.

lxix Ibid. pp 104.

lxx Aero India 2011 which country did on 13 February is notable for the sheer volume of announcements outlining both Indian and foreign defence aerospace companies that intend to establish formal joint ventures in India. The main driver of these companies' intentions to form joint ventures in India is clear. India's Defence spending is projected to grow around $ 46 billion by 2015, a rise of 41% on the 2010 budget. New Delhi has historically spent around 37% of its military expenditure on acquisitions; it continues to rely on imports but has a long stated objective to acquire from indigenous sources. Despite these encouraging signs and the Indian ministry of defence intent on continuing promotion of defence cases, evidence indicates that foreign companies are not being offered sufficient incentives to invest in India through joint ventures which suggest that only a few of the joint ventures announced at Aero India 2011 will come to fruition. Jon Grevatt. Uncertainty Over Indian Joint Ventures - Business Analysis. Jane's Defence Weekly 23 February 2011 page 22

lxxi Report of the Experts Committee on DPP. Op. cit. pp 185.

Author's Biodata

Cmde Bhupesh Tater

Cmde Bhupesh Tater joined Navy in Nov 1986 under the 10+2 Technical Cadet Entry Scheme (NEC 3) and was commissioned on 10 Nov 1989. The Engineering Officer has served onboard DSV Nireekshak, IN Ships Amba, Charag, Mysore (Commissioning Crew) and Mumbai. A postgraduate from DSSC, Wellington, he has held appointments in Headquarters, Eastern Naval Command, headed the Gas Turbine Testing & Tuning Team at Eksila and was the Chief Engineer at INS Eksila the Only Gas Turbine Overhaul Centre of Indian Navy. The Officer has also been the Executive Officer of the Premier Technical Training Establishment INS Eksila. The Officer has a rich experience of ship construction of over ten years during his two stints as Naval Engineer Overseer at Warship Overseeing Team, Mumbai and Joint Director in the Directorate of Ship Production at Naval Headquarters. The officer has been a prime contributor to preparation of naval vessel rules as part of INORC with the IRS, regularly submits technical papers and is life member of Institute of Marine Engineers (India) and Institution of Engineers (India). Cmde Bhupesh Tater is presently appointed as AGM(Materials) at Naval Dockyard, Mumbai since Nov 2015 and can be reached at bhupeshtater-navy@gov.in

article

17

NATIONAL COMPETENCE IN MARINE PROPULSION- THE ROAD AHEAD

(By Cdr MS Gopinathan, Cdr Manish Singh)

From time immemorial the people of India have had very intimate connections with the sea. They had trade with other countries and they had also built ships. In the bygone era Indian Shipbuilders with their skill and proficiency , ardour and exertions etched an indelible mark in the field of shipbuilding in India. The vessels built at Bombay at that time were superior to those built elsewhere; ***a reality exploited by all, realised by many, accepted by few but acknowledged by none....***

Aim

1. The aim of this paper is to study the existing indigenised capabilities with respect to Naval Marine Propulsion and identify scope for its further strengthening in consonance with focus on 'Make in India'. Furthermore, the paper also covers recommendations pertaining to building foreign collaboration to develop Marine Propulsion technology, with due emphasis on 'cost of doing business in India'.

Introduction

2. The history of the Indian Navy can be traced back to 1612 when Captain Best encountered and defeated the Portuguese. Although Bombay had been ceded to the British in 1662, they physically took possession of the island on 08 Feb 1665, only to pass it on to the East India Company on 27 Sep 1668. By 1686, with British commerce having shifted predominantly to Bombay, the name of this force was changed to Bombay Marine. The Bombay Marine was involved in combat against the Marathas and the Sidis and participated in the Burma War in 1824.

3. In 1830, the Bombay Marine was renamed Her Majesty's Indian Navy. Whilst the Navy's strength continued to grow, it underwent numerous changes of nomenclature over the next few decades. It was renamed the Bombay Marine from 1863 to 1877, after which it became Her Majesty's Indian Marine. In recognition of services rendered during various campaigns, its title was changed to Royal Indian Marine in 1892, by which time it consisted of over 50 vessels. The Royal Indian Marine went into action with a fleet of minesweepers, patrol vessels and troop carriers during the First World War.

4. The first Indian to be granted a commission was Sub Lieutenant D.N Mukherji who joined the Royal Indian Marine as an engineer officer in 1928. In 1934, the Royal Indian Marine was re-organised into the Royal Indian Navy. At the outbreak of the Second World War, the Royal Indian Navy consisted of eight warships. By the end of the war, its strength had risen to 117 combat vessels and 30,000 personnel who had seen action in various theatres of operations.

5. On India attaining Independence, the Royal Indian Navy consisted of 32 ageing vessels suitable only for coastal patrol, along with 11,000 officers and men. The senior officers were drawn from the Royal Navy, with R Adm ITS Hall, CIE, being the first Post-independence Commander-in-Chief. The prefix 'Royal' was dropped on 26 Jan 1950 with India being constituted as a Republic. The first Commander-in-Chief of the Indian Navy was Adm Sir Edward Parry, KCB, who handed over to Adm Sir Mark Pizey, KBE, CB, DSO in 1951. Adm Pizey also became the first Chief of the Naval Staff in 1955.

6. It was then that Indian Navy's foray into indigenisation began, over five decades ago with the design and construction of warships in the country. Today, forty eight of its state-of-the-art ships and submarines are under construction in Indian shipyards, both public and private, a clear reflection of the Indian Navy's enduring support to India's indigenous warship building endeavor. While much has been achieved in our pursuit of ship building over the past decades, the time is now ripe for launching into a new phase of self-reliance by manufacturing technologically advanced equipment within India, in pursuance of the Government of India's vision of 'Make in India'.

The Overall Need for "Make in India" Paradigm in Defence Manufacturing

7. Defence manufacturing came out of the stranglehold of Public Sector Undertakings-Ordnance Factories (PSU-OF) monopoly with major liberalisation in 2001 with 100 per cent private sector participation and the recently announced 49 per cent in Foreign Direct Investment. Policy footprints such as the Defence Procurement Policy (DPP) 2013 have created a level playing field for the private sector. Defence industry is a subset of a nation's concern to ramp up manufacturing capability. The capability of our defence industry in terms of value addition, self reliance in critical technology and policy initiatives so far and their impact needs to examined and a possible synergy between "Make in India" policy and defence industry capability needs to be brought about.

Defence Manufacturing and Challenges in Self Reliance

8. The defence services account for nearly Rs 2.29 lakh crore of the Central Government Budget which is nearly 2.5 per cent of the GDP and 13 per cent of the Central Government expenditure. The trend of allocation to revenue and capital acquisition schemes is given below.

Table 1: Service/Department-Wise Break Up Of Defence Expenditure (Rs. Cr.).

	2011-12 Actual (Rev+Cap)	2012-2013 Actual (Rev +Cap)	2013-14 Actual (Rev+Cap)	2014-15(BE) (Rev+Cap)
Army	84081.29	91450.51	99464.21	118377.62
Navy	31115.32	29593.59	33393.21	37808.46
Air Force	45614.01	50509.13	57708.63	54217.52
DDP-DGOF	(-) 456.37	(-) 267.86	1298.39	2481.99
DGQA	655.19	695.67	766.02	831.49
R&D	9893.84	9794.80	10868.89	15282.92
Total	170913.28	181775.78	203499.35	229000.00

Source: Annual Report 2013-2014, MOD

9. It would be worth to note that while the increase in the revenue allocation roughly matches with the wholesale price escalation, the capital acquisition budget has witnessed significant growth of around 20 per cent per year, far outstripping the overall trend of increase in defence expenditure.

10. Historically, India has been availing of technology through licence agreements from Russia and a smattering of Western countries. The exceptions are some of the missile systems, small arms and their ammunition and tanks where technology has been indigenously developed by the Defence Research and Development Organisation (DRDO).

Self-Reliance Trends

11. A committee under Late former President Dr APJ Abdul Kalam, the then Scientific Advisor to the Raksha Mantri, had recommended that India should ramp up this quotient from 30 per cent (1995) to 70 per cent by (2005). The Self Reliance Index has remained stagnant at around 30 per cent over the years. The need of the hour is to develop design capability in critical technologies, allocate adequate investment in R&D and develop ability to manufacture major sub-systems and components.

The Road Ahead for "Make in India" in Marine Propulsion

12. Twenty five years after it gave itself the target of "Made in India," the Indian Navy is gradually transforming from a "buyer's navy" to a "builder's navy."The Navy no longer has to order platforms from abroad and has built up the capability to build from aircraft carriers to submarines and over 48 platforms are on order in India at various shipyards. The ship-building materials, equipment and systems onboard an IN warship/ submarine, based on their role can be classified into the following three categories:-

(a) Float. This category encompasses all materials, equipment and systems associated with the hull structures and fittings.

(b) Move. Equipment under this category encompasses propulsion system and power generation diesel/ gas/ steam turbine engines, alternators, associated control systems (Integrated Platform Management System/ Automatic Power Management System), auxiliary mechanical systems like Pumping and flooding, HVAC, Firefighting Systems and other ship systems including general electrical equipment.

(c) Fight. Equipment under this category encompasses all types of ship borne weapons and sensor systems that directly improve upon the combat capability of the ship.

Main Areas of 'Move' Where IN is Facing Capability Gaps

13. IN has been able to achieve about 90% indigenisation in the 'FLOAT' category, followed by about 50-60% in 'MOVE, category depending upon the type of propulsion. Furthermore, in the 'FIGHT' category we have achieved only about 30% indigenisation. In warship building, some of the major equipment where there has not been satisfactory progress are propulsion systems especially Gas Turbines , high capacity Marine Diesel Engines for main propulsion and Gear Boxes under 'MOVE' category, which are imported presently and holds much scope for 'Make in India'. Although IN is working closely with DRDO, DPSUs like BEL and Private Sector like L&T, Mahindra Defence Systems etc, however, to bridge this capability gap the 'Make in India' initiative needs to be incorporated with foreign collaboration towards development of Main propulsion systems .

Models of Indigenisation Available

14. A study undertaken to examine various indigenisation models adopted in marine application so as to extract the best option. Some of the modes of indigenisation have been elaborated below :-

(a) **US Model.** In this model the onus of development rest on the private firm, the development cost is borne by the Govt. and the contract is awarded based on various parameters including shortest delivery time quoted by the participating firm. To quote an example, Joint Striker Fighter programme, X-32 Boeing and X-35 Lockheed Martin wherein the former lost the contract.

(b) **Chinese Model.** Taking a leaf out of the chinese approach in building their Naval shipbuilding industry brings out the fact that China has sucessfully progressed with the philosophy of Acquire followed by Reverse Engineering leading to indeginisation. Since 1985, China has acquired four retired aircraft carriers for study, the Australian HMAS Melbourne and the ex-Soviet carriers Minsk, Kiev and Varyag.In 2011, People's Liberation Army Chief of the General Staff Chen Bingde confirmed that China was constructing at least one aircraft carrier. On 25 September 2012, China's first aircraft carrier, Liaoning, was commissioned. On 31 December 2015 it was reported by several news sources that China was building a second aircraft carrier using entirely indigenous design.

(c) **Indian Model.** The models adopted in our country are summarised below:-

(i) **Govt. Model.** In this model the complete indigenisation and manufacturing responsibilities rests solely with the Govt. PSUs and Ordinance Factories. This model was largely followed in India till the recent past, however this mode of indigenisation has its limitations due to efficiency and productivity concerns.

(ii) **PPP Model.** The Public Private Partnership (PPP) platform is best suited for 'Make in India' mode of manufacturing wherein the Govt can enter into a collaborative partner-ship with foreign OEM directly or in collaboration with an Indian firm. Further the technology can be absorbed to initiate and sustain indigenisation efforts.

15. It is the measured opinion of the authors that implementation of fixed time based contracts is the need of the hour to salvage the shipbuilding industry which is presently plagued with inordinate delays. The award of contracts should not be based only on lowest price bidders. The shortest delivery period/ contract implementation period should carry due weightage in the award of the contracts. Furthermore it is also opined that PPP model for indigenisation is best suited in Indian environ as the JV is provided with the necessary Govt. policy assistance to the participating private firm, both Indian and Foreign.

Potential Partnership for Building National Competence in Marine Propulsion

16. International Industry today offers scope for their greater involvement in the Indian Defence Sector and possesses the requisite technology and building necessary infrastructure in the country for undertaking production in the field of Marine Propulsion or may be willing to invest/ share the cost of setting up of such infrastructure. The progressing of development contracts should be based on a collaborative approach between the Indian Navy/ developing agency and the Industry with the understanding that both are equal partners aiming at optimum results.

17. Many large and prominent industrial houses like Tatas, Mahindras, Reliance, Kirloskar, L&T, Godrej, to name a few, have also entered into collaborative agreements with foreign vendors for defence equipment production in the country. Considerable success has been seen in this aspect where important systems for the ships have been developed indigenously, paving the way for further collaboration in the self-reliance efforts. Success of Arihant, where there has been intensive participation of numerous large and small private players has given lot of confidence to the Navy on this aspect. Successful indigenous development of Missile, Rocket, Torpedo launchers/ loaders, Ship Stabilisers/ Steering gears, Hydraulic systems, Automated Power Management Systems and a large number of components/ assemblies by the private vendors indicates willingness and ability to partner the IN in 'Make in India' developmental efforts in Marine Propulsion.

‘Make in India' Initiative in the Conventional Propulsion Domain

18. Indian Navy currently employs three conventional propulsion modes i.e. steam plants, diesel engines and gas turbines. Sufficient developments have been made in respect to steam propulsion plants and small diesel engines. Indigenously manufactured steam turbines of M/s BHEL and main propulsion diesels of Kirloskar Oil Engines Limited are already in use onboard ships. Nuclear propulsion and Integrated Electric Propulsion are also envisaged for future ships & submarines. However, the major items being imported in respect of Main Propulsion in the ship-building programme that are still being imported are as follows:-

(a) Gas Turbines (11-15 MW and 20-25 MW).

(b) High Power Main Propulsion Diesel Engines.

(c) Marine Gearboxes (1-50 MW).

19. The analysis of the above mentioned areas of propulsion and the thrust area with respect to 'Make in India' domain is covered in the succeeding paragraphs

Gas Turbines

(a) Presently all gas turbines, fitted in Naval ships are of foreign origin. There is an urgent need to develop indigenous gas turbines.

(b) Indigenisation initiatives taken in this regard include development of a fully indigenous Kaveri Marine Gas Turbine (marine derivative of Light Combat Aircraft (LCA) gas turbine) is being pursued at GTRE, Bangalore with considerable amount of success. It has been tested to a sustained output of 12 megawatt and is likely to be fitted on future ships post completion of successive trials. The Kaveri engine has the potential to replace the Russian power plant in the foreseeable future which will be an incremental growth that India can be very proud about.

(c) Hitherto, India has bought foreign vessels (largely from Britain and the former Soviet Union -now the Russian Federation) with integral foreign engines but as the years go by more and more of its indigenously designed and constructed naval craft will be powered with Indian engines.

Gas Turbine Manufacturing-Focus Areas for 'Make in India'

(a) There is a need to develop "Make in India" initiatives in gas turbines in the range of 11-15 MW and 20-25 MW for fitment on future ships as main propulsion units.

(b) The Inter-cooled Recuperated WR 21 Gas turbine developed by Rolls Royce and Northrop Grumman offers a 30% reduction in fuel consumption and a flat specific fuel consumption curve over entire operating range, when compared to contemporary gas turbines. These GTs combine the best of diesel and Gas turbines, i.e., low Specific Fuel Consumption (SFC) at part loads and high power density and fulfils the role of both Cruise and Boost Gas turbines.

(c) Above mentioned Gas Turbines, with reduced IR signatures due to their low exhaust temperature, have to be developed view stealth consideration of warships.

(d) Adequate emphasis has to be laid on development of gas turbines with enhanced aero-thermo-dynamics. This may involve improved designs of compressors for attaining higher pressure ratios as well as better combustion chamber designs for achieving higher turbine entry temperatures, thereby achieving higher power output.

(e) Developments in the field of advanced materials for combustion chamber and turbine blades would also be required to achieve enhanced power outputs.

Diesel Engines

20. Primary requirement for the diesel engines is to have low noise levels and high availability/ reliability. Although a great degree of self-reliance in lower power range has been achieved, the high power diesel engines are largely imported or assembled in India. Indigenous manufacture/ development of high power diesel engines to naval specifications in the higher power rating will greatly reduce our dependence on imports.

Diesel Engine Manufacturing-Focus Areas for 'Make in India'

21. Following are the thrust areas wherein diesel engine manufacturing under the 'Make in India' model can be explored:-

(a) Development in the field of diesel engines are driven by stringent environmental regulations and requirements of multi-fuel operation and long service life.

(b) Technological advancements are required for reduction of emissions and improving combustion efficiency in Diesel engines.

(c) Development of technology for use of Rheological smart fluids for torsional damping in Diesel engines may be taken up for achieving better power to weight ratios and better torsional damping characteristics, across the entire power range of the engine.

(d) Prime Minister Narendra Modi's has set out on an ambitious course with South Korean major Hyundai Heavy Industries (HHI) and public sector Hindustan Shipyard Limited, Visakhapatnam, joining hands to build warships. Hyundai has designed and developed the HiMSEN engine which is part of Hyundai's ongoing efforts to provide the most practical and highest quality engines to its customers in the marine market. Hyundai HiMSEN Engine & Machinery Division is the world's largest marine diesel engine builder, supplying approximately 35% of the global marine diesel market. Hyundai HiMSEN is also a leading manufacturer of propellers, cargo oil pumps, ballast water treatment systems, and side thrusters.

(e) Another Korean firm, Samsung, will be collaborating with Kochi Shipyard to make liquefied natural gas (LNG) tankers. The said collaboration needs to be extended towards developing Marine Diesel Propulsion aggregates in India.

Reduction Gear (RG)

22. In designing a warship gearbox, special attention is required to be paid to all the parameters that could influence the noise and vibration performance of the gearbox. These design aspects, such as tooth corrections, tooth loading, gear layout, balance, lubrication and resilient mounting, requires to be taken into consideration. For efficient power transmission to the propeller, marine gearboxes should possess the following essential features:-

(a) Higher hardness of pinion and gear materials to cater higher gear tooth loadings.

(b) High efficiency by ensuring lower transmission losses and reliability.

(c) Long life.

(d) Low noise levels and vibration.

Reduction Gearbox Manufacturing-Focus Areas for 'Make in India'

23. Following are the thrust areas wherein RG manufacturing under the 'Make in India' model can be explored:-

(a) There is a requirement of gearboxes with greater indigenous content in the range of 1-50 MW for the new construction ships.

(b) Technology to Develop Low-noise Gearboxes would require development of techniques such as finite element analysis to design compact and silent gearboxes.

(c) Advanced manufacturing techniques, metallurgical processes and materials are required to be developed to meet the gearbox standards used in warship propulsion.

(d) Gearbox generated noise is a major factor in the overall under water noise signature of ship. There is a need to develop technology to manufacture silent marine propulsion gearbox in India for warship application.

(e) Presently some gearboxes of ships are being manufactured in India by M/s Elecon, under joint ventures with foreign firms such as M/s MAAG Switzerland & M/s Renk Germany.

Upcoming Areas of Interest in Marine Propulsion

24. There are several combination of modes of propulsion existing in marine propulsion, of which, the modes adopted by Indian Navy primarily includes Combination of Gas and Gas(COGAG) and Combination of Diesel or Gas(CODOG). In the recent past there has been a thrust to develop warships based on Combination of Diesel Electric and Gas (CODLAG) propulsion globally. The inherent characteristics and advantages of CODLAG propulsion is narrated in the succeeding paragraphs

CODLAG Propulsion

25. Combined Diesel-Electric and Gas (CODLAG) is a modification of the combined diesel and gas propulsion system for ships. A CODLAG system employs electric motors which are connected to the propeller shafts. The motors are powered by diesel generators. For higher speeds, a gas turbine powers the shafts via a cross-connecting gearbox; for cruise speed, the drive train of the turbine is disengaged with clutches. Some of the primary advantages of employing CODLAG propulsion are enumerated below:-

(a) This arrangement combines the diesel engines used for propulsion and for electric power generation, greatly reducing service cost, since it reduces the number of different diesel engines and electric motors, requiring considerably less maintenance.

(b) Also, electric motors work efficiently over a wide range of revolutions and can be connected directly to the propeller shaft so that simpler gearboxes can be used to combine the mechanical output of turbine and diesel-electric systems.

(c) Another advantage of the diesel-electric transmission is that without the need of a mechanical connection, the diesel generators can be decoupled acoustically from the hull of the ship, making it less noisy. This has been used extensively by military submarines but surface naval vessels like anti-submarine vessels will benefit as well.

26. MTU Friedrichshafen along with GE Marine System provided the German type 125 Class Frigate CODLAG propulsion module, which includes one LM2500 gas turbine, two electric motors and four diesel generator-sets in a combined diesel-electric and gas turbine (CODLAG) propulsion arrangement. Through MTU, GE will provide LM2500 gas turbines for four new CODLAG - configured F125 frigates, which will replace the German Navy's eight Bremen-class F122 frigates. GE LM2500s also power the German Navy's Bremen-, Brandenburg- (F123) and Sachsen-class (F124) Frigates. The LM2500 gas turbines are manufactured at GE's Evendale, Ohio, facility; propulsion system modules are manufactured at MTU's Friedrichshafen, Germany, facility. For the British Royal Navy, Paxman has provided diesel power modules for the combined diesel and gas turbine (CODLAG) propulsion system in the new Type 23 Antisubmarine Warfare frigates.

27. The above mentioned manufacturers, i.e. Paxman(diesel), GE(LM2500) and MTU are established suppliers for the Indian Navy therefore the possibility of Make in India through joint venture projects are highly probable for CODLAG Propulsion.

Propulsion System Integration

28. The propulsion system can be through a Diesel Engine, Gas or Steam Turbine or combination of these. Adequate expertise for the integration of propulsion system is not available within the country and is presently sought from foreign vendors.

29. With a large number of ships being inducted under the indigenous ships building programme, there is a need for Indian industry to acquire adequate expertise and in-house competence in Propulsion system machinery selection, design and integration. Therefore there is a tremendous scope for building 'Make in India' platform in propulsion system integration.

30. For the Vikrant Class indigenous aircraft carrier Fincantieri of Italy will be providing assistance for propulsion system integration for the aircraft carrier. A combined gas turbine and gas turbine propulsion system will power the ship. Four General Electric LM2500+ gas turbines driving two shafts will provide a total power of 80MW. The propulsion system provides a maximum speed of over 28kt. Propulsion System Integration is therefore identified as a key thrust area for 'Make in India' in marine propulsion.

Nuclear Power Propulsion

31. Nuclear power presents the ultimate AIP solution affording high speed, mobility, autonomy and submerged endurance limited only by stores capacity and crew fatigue. Development of nuclear power propulsion plants may be considered for the surface combatants of the IN. Foreign navies have offered to help build a nuclear-powered aircraft carrier with fifth generation fighters for India, which would transform its military profile in the Indian Ocean Region.

32. Having developed Arihant, India can proudly proclaim capability in the field of Nuclear Submarine construction. However the Need of the hour is to consolidate on this technology through proliferation and following the model of introspection and lessons learnt, India can further develop this technology through indigenous capabilities and undertake "Make/Made in India" developmental model.

33. India's second indigenous aircraft carrier (IAC-2), the INS Vishal, the second Vikrant-class carrier, is slowly taking shape. Recently, the Indian Navy outlined the specifications of this carrier in a letter of request issued to shipbuilders worldwide. The Navy and the country's nuclear scientists have drawn sufficient experience from their success in installing nuclear propulsion in Arihant, and that is encouraging them to replicate the technology for indigenous aircraft carriers. Notably, while the US Government is already working on sharing the EMALS (Electromagnetic Aircraft Launch and Recovery System) technology with the Indian Navy, development and complex installation of nuclear propulsion will have to be done by Indians themselves. That is where the success in installing nuclear propulsion in Arihant using low enriched uranium (LEU) offers the incentive and inspiration.

Electrical Propulsion

34. Electrical propulsion technology is maturing at a fast pace for marine applications.This technology provides considerable advantages in terms of higher efficiency, increased flexibility in installation, improved survivability, lower noise signatures, reduced maintenance and manning

requirements and considerable savings in through-life ownership costs. Due to these inherent advantages, commercial shipping has already adopted this technology extensively, and the technology is being increasingly adopted for warship applications. Advanced navies like the US Navy, Royal Navy and French Navy already have in place major programmes for adoption of this technology, and in the not too distant future, this is expected to become the standard technology for naval propulsion packages. Therefore due impetus needs to be given towards 'Make in India' initiative in electrical propulsion.

35. The Indian Navy has floated a US $2.6 billion domestic tender for construction of four landing platform docks (LPDs) and bids were sought from domestic shipyards, Larsen & Toubro (L&T), Pipavav Defence and Offshore Engineering, and ABG Shipyard.The ship will be powered by electric propulsion systems and have an endurance of 45 days with a maximum sustained speed of not less than 20 knots. The service will select a winning design based on the low bidder. State-owned Hindustan Shipyard Ltd. (HSL) then will build two LPDs based on that design and the winning company will build two.This will be India's first attempt to build the 20,000-ton vessels.

36. Limiting involvement to only domestic shipyards, despite having no experience in building LPDs, is an extremely wise decision; LPDs are relatively less sophisticated than high-end destroyers and provide a perfect opportunity for domestic private industry to upgrade their skills in warship construction. Private shipyards which have made huge investments in developing modern state-of-the-art shipyards will be able to prove their credentials for undertaking larger and more sophisticated projects.

Growing Industry- An Invitation for "Make in India”

37. The indigenous warship building industry is also characterised by limited participation by private entrepreneurs in the country. However, with the large number of future induction planned for expanding both the warship building as well as the commercial shipbuilding, the future of Indian shipbuilding provides substantial growth opportunities to any foreign participation for the Make in the Marine Propulsion field campaign. In the advanced shipbuilding nations, such participation is effectively the launch pad for indigenisation. In recent years, some private companies have made progress in the field of warship building.

Conclusion

Lessons for India's Defence Industry

38. The defence industry, be it public sector or private, has to be part of the national manufacturing policy mosaic. The defence sector will have to work with other civilian sectors. There is opportunity aplenty in areas such as aerospace and ship building where there is considerable civilian and military market. Due thrust needs to be given towards building design capability to manufacture critical subsystems .

39. The manufacturing sector has to be encouraged by providing lucrative economy of scale; the classical example of this is the development of Arihant. Joint Venture with foreign OEMs and design houses will require bolder policies such as FDI ceiling higher than 50 per cent and the political will to mentor and hold together the different stakeholders who are often at cross purposes. The Prime Minister has set his foot in the right place. The Ministry of Defence, however, has to match his steps, and strive for better synergy with other manufacturing sectors to make "Make in India" the mantra for the days ahead. Furthermore, as brought earlier the PPP model is the most optimal option for progressing 'Make in India'.

40. The thrust is to increase share of manufacturing from the current level of 15 per cent of Gross Domestic Product (GDP) to 25 per cent and create additional employment opportunity of ten million per year. This has led a few cynics to observe that, "There is a lot of sizzle but where is the steak?" Columnists such as Swaminathan Iyer are of the view that "Make in India" is only an outcome and not a policy while Governor of RBI Raghuram Rajan is of the view that the government is putting too much of thrust on export-led growth and should give primacy to "Make for India". However what is germane to the debate is the "cost of doing business" in India.

Way Ahead

41. The recommendations and suggestions towards policy implementations and thrust areas to facilitate the ease of doing business in India in order to promote "make in India" initiative in Marine propulsion towards developing national competence are summarised below:-

(a) Make in India in Marine propulsion sector must be seen as Design in India.

(b) Private industry needs the assurance of indigenous procurement to be financially viable.

(c) Private industry must be allowed to build capacity to kick start exports, based on already government funded R&D and products developed.

(e) Design a procurement procedure which is not only looking after financial correctness but also caters to technology needs. One way of doing this could be to make offset requirements meet nation building activities. In this way foreign companies may feel less threatened and promote more indigenous funding to R&D.

(g) There is a lot of complementarity in systems used for aerospace and shipbuilding sectors for main propulsion system. Ship and aircraft engines, propulsion units for missiles, are made by and large by same companies. The offset policy of DPP should take advantage of these commonalities and leverage India's big ticket acquisitions to get key technologies and improve India's self reliance quotient substantially.

42. In order to achieve the above, political concessions would be required and continuation of favourable policies by all governments in the future for the next 30 years is paramount. Following policy changes are envisaged for providing impetus to 'Make in India' regime in Marine propulsion systems:-

(a) **FDI Policy.** In order to promote 'Make in India ' in marine propulsion Govt. needs to further liberalise the FDI policy for the foreign OEMs for setting up business in India in partnership with public/ private players because OEMs want to have a major say in the management of manufacturing. The announcement to scale up the FDI limit from 26 per cent to 49 per cent in the last budget has been a welcome step in this direction. For India to become a major manufacturing hubs in the field of ship building, a very liberal FDI policy and providing high modicum of 'Ease of Doing' business in India is the need of the hour.

(b) **R&D Allocation.** Besides the FDI policy, adequate investment in R&D and technology funding in field of Marine Propulsion by making enhanced allocation to Defence Technology Fund in the budget will ensure seriousness in the area of Research and Development. The allocation to DRDO is around six per cent of defence expenditure, the same needs to be enhanced iaw successive parliamentary committees recommendation of ten per cent.

(c) **Manufacturing.** Manufacturing accounts for 14 to 16 per cent of the GDP with 85 per cent of employment in unorganised sector. Therefore manufacturing in the field of shipbuilding and marine propulsion will contribute significantly to the employment sector and GDP. Govt. policy revamp is required to aid the National Manufacturing Zone (NMZ) 2011 policy to build Center-State synergy, assistance in land acquisition and environmental clearances.

(d) **Export Promotion.** Policy change is also required in the field of export to ensure 'Make in India' in the field of marine propulsion is also lucrative from the export point of view for a foreign firm investing/ setting up a manufacturing facility in India. Almost 50 per cent of China's GDP growth is attributable to to export factor productivity growth.

43. Raghuram Rajan's call for "Make for India" to supplement "Make in India" is an extremely welcome alternative. It is apparent that with proper policy facilitation, investment in infrastructure, building design capability and public private partnership, the shipbuilding and marine propulsion manufacturing sector can be a major manufacturing hub. The offset policy should not be myopic and defence specific but should try to harness the commonality between civil and military segments.

Endnotes

1. Understanding 'Make in India' in the Defence Sector, Lieutenant Commander L Shivaram , (Retd) Journal of the United Service Institution of India, Vol. CXLV, No. 601, July-September 2015.

2. Indian Naval Indigenisation Plan (INIP), Directorate of Indigenisation IHQ, MoD(N), New Delhi.

3. Indian Industry Trends in Defence Shipbuilding, Cmde Mukesh Bhargava (Retd) Vice President Larsen & Toubro Limited 12 Jun 2015

4. Genesis of Indian Navy, www.indiannavy.nic.in

5. Make in India: Challenges Before Defence Manufacturing, SN Mishra,Issue Vol. 30 1 Jan-Mar 2015.

6. Reach new heights: Naval engines and marine propulsion system, www.cassindia.com.

7. Dr V Bhujanga Rao (VBR), Director General, Naval Systems and Materials, Defence Research and Development Organisation (DRDO), Ministry of Defence, interview with India Strategic (IS).Published: December 2013.

8. www. Wikipedia. Org.

Author's Biodata

Cdr M Sarath Gopinatahan

Cdr M Sarath Gopinatahan. The Officer was commissioned in the Indian Navy in 2001. He is an alumnus of the National Defence Academy. His academic qualifications include M.Tech in Marine Engineering, B.Tech in Mechanical Engineering and BSC in Computer Science. The officer has served onboard INS Talwar, Trishul and Prabal. The officer, in past has undertaken R&D projects in the field of the 'Linear Control Model Design for Kaveri Marinised Gas Turbine' at GTRE Bangalore and Resistance and Powering Calculation for Amphibious Futuristic Infantry Combat Vehicle at DIAT Pune. The officer has also presented research papers at various national level technical symposiums, out of which his paper in the field of 'Improving Gas Turbine Efficiency Using Alternative Regenerator Configuration' was adjudged first at BITS Pilani. The officer is presently posted at Center of Excellence (Marine Engineering) at INS Shivaji Lonavala.2.

Cdr Manish Singh

Cdr Manish Singh.The Officer was commissioned in the Indian Navy in 2003. His academic qualifications include BE (Mechanical) and M.Tech in Industrial Tibology & Maintenance Engineering from IIT Delhi. The Officer has served onboard INS Ranvijay and INS Ranvir as Assistant Engineer Officer and Senior Engineer Officer respectively. The officer has also carried appointments as Trial Officer at GTTT (V) and Deputy Director Naval Design at IHQ MoD(N)/DND(SDG). The officer is presently posted at Center of Excellence (Marine Engineering) at INS Shivaji Lonavala as HoF (Courses).

article

18

NAVAL SHIPBUILDING - STRATEGIC PARTNER FOR 'MAKE IN INDIA'

(By Cdr Vikrant Gokhale)

Introduction

1. In the year 2014, India under the leadership of Hon'ble Prime Minister Narendra Modi embarked on an ambitious mission of 'Make in India'. It is an initiative of the Government of India to encourage multi-national, as well as domestic, companies to manufacture their products in India. It is envisaged that India would emerge, as the top destination globally for foreign direct investment, surpassing China as well as the United States. The major objective behind the initiative is to focus on job creation and skill enhancement in 25 sectors of the economy. In addition, the program is focused on improving the export and reduce the gap between import and export. This will lead to reduction in India's dependence on dollar there by increasing the power to bargain.

2. The inclusive growth of nation can be achieved through growth and progress of manufacturing sector as is evident from global examples like Germany. We also have local examples like automotive cluster around Pune giving tremendous impetus to growth in the region. Therefore, development of manufacturing sector is a must to propel Indian Economy at the top of global economies. The purpose of this paper is to bring out how defence shipbuilding can contribute to meet the envisaged goal of 'Make in India' as brought out above.

Shipbuilding in India

3. India was flourishing in shipbuilding till the arrival of the European powers on Indian shores and Indian shipyards at places like Agashi, Dabhol, Diu, Daman, Surat, etc., were building ships (primarily wooden hull) of over 1,200 burthens tons. This condition deteriorated with the setting in of British rule and non-experience of Industrial Revolution (in terms of steel and metal shipbuilding) owing to colonisation. Shipbuilding activity was strongly discouraged under British rule for obvious reasons. Once India lost its control over the Indian Ocean, the economic power equation changed as India's trade was predominantly maritime.

4. Though ***IN*** realised this fact immediately after independence and Naval Design Bureau was established in 60's, owing to global conditions and Govt policies, private shipbuilding industry did not grow at the same pace and did not evolve to the same level as world shipbuilding industry. ***IN*** commissioned first indigenously developed warship in 80's and thereafter has been continuously constructing warships of better design and world class quality. However, it needs to be understood that ***IN*** warships have been constructed till very recently only in DPSU shipyards. Presently, India has eight public sector shipyards and around 13 well known and established private shipyards who are in the business of building ships and have delivered ships of varying sizes and complexities. Out of eight public sector shipyards, two are under MoS, four are under MoD and remaining two are

state PSU's. However, limited number of private shipyards have the capability to build ships of length more than 100 mtrs. Also, these private shipyards are mainly involved in the construction of small vessels such as OSV, AHT, MSV, mini BC etc.

5. Currently, more than 40- 45% of the ***IN*** ships are more than 20 years old and 10-15% ships are less than 10 years old. This figure will reach to a value of 30-35% by the year 2020 as lot of new ships are on the anvil. As per information available in public domain, 'Approval of Necessity' (AoN) has been accorded for construction of more than 61 warships and auxiliary vessels including yardcraft by Ministry of Defence (MoD). Therefore, there exists a tremendous opportunity for business growth in Defence shipbuilding.

6. India has a global shipbuilding share of 1.3% approximately and ranks sixth when the world shipbuilding output in terms of Compensated Gross Tonnage (CGT) is considered. On the other hand, China, South Korea and Japan together account for 85% approximately of world shipbuilding output in terms of CGT. At the share of 1.3% only, the Indian Shipbuilding Industry is worth about 7.3 lakh Cr as per Assocham report in the year 2014.

7. Cdr S Navneethakrisnan, in his book titled 'Prosperous Nation Building Through Shipbuilding - In Pursuit of Leadership', has clearly brought out that the nations that had made shipbuilding as their strategic / core industry at the right time in their growth phases have been able to make their economy grow faster. South Korea is an excellent example of the success story. At the end of World War II, Great Britain was the dominant ship building nation and at the turn of 20th century, China, South Korea and Japan together account for 85% approximately of world shipbuilding output in terms of CGT. This remarkable transformation was possible due to various factors like development of technology and skilled labor intensive industries, the creation of technology intensive clusters, the development of human capital and the specialization of high-tech industries. This makes the available business opportunity of Defence Shipbuilding an ideal candidate for leading the 'Make in India' campaign of the Govt.

Historical Perspective from IN's Point of View

8. As discussed earlier, indigenous shipbuilding commenced in early 60's and today we have made substantial progress towards becoming a Builders Navy from a Buyers Navy. In last 15 years, India has made more ships in India than she has imported from outside. Defence Procurement Procedure (DPP) came in existence in early 2000 and private players were encouraged for participation in shipbuilding. Though it was a slow start and Govt was still in the process of understanding and grappling with the nuances of shipbuilding, most of the issues were resolved / streamlined by the time DPP 11 came in to effect. As the initial private participation was limited to building of auxiliary vessels, it has borne spectacular fruits over a span of last 7-8 years. More than 50 auxiliary vessels including yardcraft (self-propelled / non propelled) have been inducted in the ***IN*** entirely from the private shipbuilding yards. However, same is not the case for bigger ships. The other reason for this being the global economic slump which occurred in 2009 onwards. The Shipbuilding industry in India has been hard hit by this economic downturn and is still struggling to recover from the same.

Make in India-Shipbuilding

9. In order to bring the shipbuilding in correct perspective, it's essential to understand the ship building process. The ship is a floating and moving platform to carry cargo and in addition, fighting platform, in case of Navy. The hull is primarily made of steel which is the first process in the construction followed by fitment and integration / outfitting of various systems like, propulsion, steering, cargo storing and handling, crew accommodation and associated systems etc. All these require raw material and finished goods in various forms. On an average, more than 300 raw and finished materials are required during the construction of a commercial ship and the number goes even further when the warship is considered. Moreover, cost of this material alone amounts to more than 60% of the cost of the ship. End to end processing of all this material i.e. from ordering till completion of fitting onboard is undertaken by the shipbuilder in his yard. Thus, shipyard can be considered as a massive factory / business process, wherein raw materials which are output of several industries is received as input and a final product called a ship is given out post processing which may include manufacturing as well as services. The money received by the shipbuilder, thus braches out or feeds various other industries / ancillary industry.

10. The shipbuilding itself is a human capital intensive process and generates employment. Also, setting up and maintenance of infrastructure essential for the shipbuilding also leads to continuous availability of employment opportunity. In addition, the money flowing out of shipyard towards the purchase of raw material which is the finished product of ancillary industry leads to additional manufacturing efforts. This generates opportunities and direct employment in the ancillary industry leading to growth. Thus, money from shipbuilding flows to shipyard's human capital and in addition to the ancillary industry thereby enabling people to purchase of consumer goods and services. This spurs the growth at grass root level. This in turn creates the 'Pull Effect' on the demand in the entire chain. A direct simili can be draw with the automobile industry where finished product is an amalgamation of various raw products from other ancillary industries, thereby spurring growth in the area. The example being automobile industry in and around Pune and Chennai, where setting up of automobile plants has led to tremendous growth in the area.

11. The shipbuilding industry is not a strategic industry only for this reason but also for the fact that the finished product is further used for the purpose of movement of cargo which is another major growth contributor. So, we also must understand the difference between a factory producing a product like automobile and shipyard producing the ships. Some salient points are as follows: -

(a) Shipbuilding is extremely labour oriented and an assembly line can't be set up for ship production as each ship defers in its design from the other and is meant to fulfill different roles / requirements.

(b) The number of industries associated with shipbuilding process is significantly more than the ones required for automobile industry.

(c) Number of services associated with shipbuilding industry is also significantly more than that of automobile industry.

(d) The remuneration / money outflow in case of shipbuilding industry is also significantly higher than that of automobile industry.

12. However, the last point brings us to the core issue at hand which this paper is trying to discuss. The number of units sold in an automobile industry is far more as compared to that of shipbuilding and hence, it is essential that the shipbuilding volume has to be high to accrue the benefits as brought out in previous paragraphs.

13. We have clearly established the fact that shipbuilding is a core industry which can spur the growth in the manufacturing sector. Now we will analyse the shipbuilding process from the point of view of 'Make in India' as brought out at Para 1 above. As brought out earlier, the cost of material used in the shipbuilding is more than 60% of the cost of the ship. So we can divide the cost for shipbuilding in two distinct parts for cost analysis i.e. material cost and other cost. Material cost can be further broken down as cost of major machinery and equipment in order to assess the percentage of indigenous content. Table below gives the list of industries that supplies raw material to the shipyards along with the respective percentage of the raw material in the total material cost:

Table 1. Breakup of Cost of Material

Ser	Type of Industry	Percentage of Total Cost of Material
A	B	C
(a)	Steel	20.00
(b)	Anchor, Windlass and shipping machinery	8.65
(c)	Fabricated metal products	5.48
(d)	Cranes and gangways	2.20
(e)	Life-saving equipment	1.51
(f)	Fire-fighting systems and chemicals	2.25
(g)	Electrical, electronics and communication systems	17.85
(h)	Air conditioning and refrigeration systems	5.47
(j)	Deck covering, insulation and paints	6.15
(k)	Engine, DG sets and related machinery	15.43
(l)	Pumps, motor, propulsion systems	4.00
(m)	Pipe and tubes	8.01
(n)	Industrial valves	3.00
	Total	100.00

[Source: Report on the shipbuilding sector "Economic benefits and benchmarking government support across countries", (India: KPMG Advisory Service, 2007) pp. 128-129]

14. The remaining 40% of the cost of the ship can also be broken down as shown in the following table: -

Table 2. Breakup of Total Cost

Ser	Description	Percentage of Total Cost of Ship
A	B	C
(a)	Labour costs	22-25%
(b)	Other costs	5-8%

[Source: Analysis of multiple past competitive contracts available with DSP]

15. We will further analyse the cost of material wrt indigenous contents for commercial ships and ***IN*** ships in a generic manner based on the past experience. Table below shows the material cost with % of indigenous content: -

Table 3. Breakup of Indigenous Content

Ser	Type of Industry	Percentage of Indigenous Content	
		Commercial	IN
A	B	D	E
(a)	Steel	0-2%	100%
(b)	Anchor, Windlass and shipping machinery	90%	100%
(c)	Fabricated metal products	90%	100%
(d)	Cranes and gangways	50%	50%
(e)	Life-saving equipment	-	-
(f)	Fire-fighting systems and chemicals	10-15%	70-80%
(g)	Electrical, electronics and communication systems	10-15%	30-40%
(h)	Air conditioning and refrigeration systems	30-40%	70-80%
(j)	Deck covering, insulation and paints	10-20%	70-80%
(k)	Engine, DG sets and related machinery	20-30%	50-60%
(l)	Pumps, motor, propulsion systems	-	20-30%
(m)	Pipe and tubes	60%	80-90%
(n)	Industrial valves	30-40%	80%

16. It can be seen from the above table that the indigenous content of the commercial ships produced in India at present is less than 30%. Also, it appears that the ***IN*** ships have indigenous contents of more than 70%, the major component of weapons on the warships is not catered in this discussion. So, out of the 60% material cost of ship, only 30% i.e. about 18% of the cost is only ploughed back in the Indian industry and remaining 42% of the cost is imported. Moreover, though it appears that ***IN*** ships indigenous content is more, the weapon content which is specific to warships has not been factored in the above tables. As a rule of thumb, more than 30% to 40% of the project cost in case of a warship is weapon content and the same is being kept out of the purview of this paper. Notwithstanding the same, still there exists a scope for indigenisation in warships.

17. From the above analysis it can be seen that shipbuilding industry can generate tremendous opportunities for the manufacturing sector in terms of heavy engineering sector. We can say that automobile sector is responsible for development of light engineering sector and shipbuilding is responsible for development of heavy engineering sector. So, commensurately, the job opportunities and returns will also be on the higher side.

Growth Catalyst - Defence Shipbuilding

18. As brought out earlier, ***IN*** shipbuilding is heavily dependent on DPSU's and at present capacity of the DPSU shipyards, it is unlikely that they will be able to meet ***IN***'s requirement in a time bound manner. On the other hand, private shipbuilding yards are struggling to find business owing to the global economic downturn and hence additional capacity for shipbuilding is readily available. Also, to kick start the economic activity on a large scale it is essential that Govt spends in capital and infrastructure in a big way. It is in this area, that the Defence Shipbuilding can be a tool which can cater to these economic requirements.

19. We have already discussed as to how the investment in shipbuilding can generate 'Pull effect' on the demand of ancillary industries and have also brought out the requirement of high shipbuilding volume in order. With more than 61 warships and auxiliary vessels including yardcraft scheduled for construction in the coming decade, we feel that it is the right catalyst available for spurring the growth. In the succeeding paragraphs we will discuss the ways in which defence shipbuilding can become the catalyst essential for speeding up the growth under 'Make in India' policy.

20. We have already brought out the 'Capacity Constraints' of DPSU shipyards and idle capacity available with private shipbuilding yards. DSPU shipyards have built up the expertise, infrastructure and resources over a period three decades. With full order books till 2025 and natural limitation owing to geographical location etc. their capacity enhancement is not feasible in near future for meeting the ***IN***'s projected requirements thereby generating inherent delays in the delivery schedules. Therefore, outsourcing is the most appropriate solution in such a scenario. Due to policy limitations and in the absence of clear guidelines, DPSUs were constrained to follow the route of outsourcing. However, with the publication of 'Guidelines for Outsourcing and Vendor Development' by Department of Defence Production (DDP) in May 2015, a clear way has emerged under the 'Make in India' initiative. DPSU shipyard like M/s GSL has already undertaken the outsourcing of work under this policy with hand holding of local shipyards. This has not only

ensured that the non-core job is outsourced but has also given employment to the local shipyards thereby overcoming the limitation of capacity constraint.

21. As brought out earlier ***IN*** ships are of vintage and with the induction of more and more sophisticated platforms the requirement of maintenance of the fleet is also going to go up. At present, ***IN*** operates and maintains its own fleet with the help of Naval Dockyards and Repair Yards located on eastern and western coasts. However, with ***IN***'s ambition of operating a blue water navy, it is essential that such maintenance facilities are extended beyond the existing locations. However, there exists an inherent limitation in terms of setting up of new infrastructure and resources as the same is time and resource intensive. Moreover, the existing resources themselves are not sufficient to meet the current requirements leading to delays in maintenance cycle. Also, with the efforts of ***IN*** to purchase warships from private shipyards on competitive basis, the requirement of building up of relevant maintenance expertise will be time and cost intensive. So, it is high time that ***IN*** should look at Refit Maintenance as outsourced Turn Key activity. Though, Naval Dockyards are currently offloading labour intensive parts of ongoing warship refits, the co-ordination efforts and critical resources are getting tied up and needs to be looked at from a fresh perspective. Various ways in which this can be achieved is by getting into AMC contract with the shipbuilder or complete turnkey refits. Though, ***IN*** is already doing turnkey refits with DPSU shipyards and a limited number of private shipyards, it is essential that a new model is evolved under 'Make in India' initiative to partner with increased number of private shipyards for outsourcing refit maintenance. Quality, which is the most important issue, can be tackled by way of concluding running AMC's post refits for longer duration by the same shipyard, thereby ensuring their commitment to work. This will have two advantages. First, in terms of freeing up of critical ***IN*** resource which can be gainfully utilized for maintenance of operational weapon intensive platforms. Second, this will ensure sustained work availability for private shipyards thereby keeping the 'Pull Effect' of demand on ancillary industry intact.

22. Though initial handholding and favourable policies are essential requirement of this approach, the 'Make in India' initiative can get a boost in terms of skill development and employment creation. Further, the private shipyard running AMC for repairs can be tasked to provide 'Mobile Repair Teams' at desired locations in case of maintenance requirement where currently Naval Resources are put to use. This will further compel the shipyard to do a quality job in order to avoid wasteful expenditure and will reduce the additional non-core job handled by ***IN*** personnel.

23. ***IN*** has published Indian Naval Indigenisation Plan (INIP) for next decade or so which gives a clear cut idea to the private industry for planning of various related activities. State Govt (like Maharashtra) has already published Maritime Development Policy (MDP) in Feb 16 which entails creating more Greenfield Ports, Building Jetty's, Coastal shipping and Interways, Shipyard and Coastal Economic Zone (CEZ). This CEZ's will be provided with land at nominal rates by the state Govt and will be supported by suitable tax sops in order to make them competitive in the world market. Though these zones will be export oriented, it should also meet the *IN* requirement as a spin-off.

24. In order to achieve robust growth in the manufacturing sector, shipbuilding has already been considered by the Govt as a key area and Projects like 'Sagarmala' have already been conceived. Some of the key initiatives under the ambit of 'Make in India' campaign is discussed in the subsequent paragraphs.

(a) Granting status of Infrastructure Industry. The shipbuilding industry has been categorized as Infrastructure industry. Therefore, the benefits like low interest loans are now available. By nature, shipbuilding is a capital intensive and long gestation period process where the final product is only one and till delivery there are no tangible deliverables. Hence, availability of loans on low interests will make Indian Shipbuilding globally competitive.

(b) Supporting the Ancillary Industry. The ancillary industry which has developed over the period of last three - four decades for supporting the raw material requirement of ship building has limitations wrt to continuous availability of orders. This is majorly attributed to the non-availability of continuous orders by the shipbuilders. If more shipbuilding orders are to be received, then shipyard has to remain globally competitive. Promulgation of policies like MDP by states will go long way in supporting and nurturing ancillary industry. Niti Aayog Vice Chairman, Mr. Pangariya has already advocated the need for setting up of such zones for tapping the benefits of export oriented manufacturing near deep-draft ports (Times of India, 12 Feb 16). This will not only lead to increasing the employment for the youths but will also have intangible benefits of growth of supporting services like accommodation. It can be seen from the example of top shipbuilding nations like China and Korea that the shipbuilding industry along with the ancillary industry has been set up in close vicinity of each other for facilitating availability as well as reducing the ordering cost for shipyard.

(c) Multi-skilling of Human Resource. By nature of the shipbuilding, the human resource required for work has to be from a diverse category. The jobs involved range from unskilled labour to super specialty workers. Therefore, there exists an immense potential for the employment for a wide variety of human resource. However, continuous availability of employment can only be guaranteed by way of availability of shipbuilding orders.

Conclusion

25. Government of India under the initiative of 'Make in India' has brought out various policy changes to promote the manufacturing growth in the country. ***IN*** as a part of Govt is well poised to take advantage of these policy changes. In consonance with DPSU shipyards, the outsourcing can be increased to overcome the capacity constraints thereby cutting down the delivery times. Further, with a paradigm shift envisaged towards outsourcing refit maintenance to private shipyards on a turnkey basis along with running AMCs for maintenance will go a long way in bringing up the private shipbuilding industry as well as freeing up critical resources of the ***IN***. Encouraging more participation of private shipyards will push the DPSUs towards a more competitive environment thereby improving their performance in turn. The need to understand the shipbuilding as a strategic industry towards achieving the aim of 'Make in India' cannot be overemphasized. Though Govt has

already initiated the steps in this direction, it is also essential that ***IN*** realises the need for capacity augmentation through private industry partnership. This will not only meet ***IN***'s requirement but will also ensure that a support mechanism is available in times of requirement at distant shores where the true capability of the Blue Water navy lies. This will also ensure that the necessary momentum is given to the private shipbuilding industry in India to realise the larger dream of becoming a power in the Indian Sub-continent.

Author's Biodata

Cdr Vikrant Gokhale

Cdr Vikrant Gokhale is an alumnus of the 13th Naval Engineering Course. He is an MTech in Information Technology from Indian Institute of Technology, Kharagpur. The Officer's sea appointments include SEO, INS Nireekshak and Engineer Officer of INS Porbandar and INS Kora. His other appointments include Staff Duties at INS Shivaji as Instructor in two separate stints. Presently, the officer is posted at IHQ MoD(N)/ DSP as a Joint Director and is looking after the acquisition of yardcraft for IN.

article 19

NATIONAL COMPETENCE IN MARINE GAS TURBINE PROPULSION – WAY AHEAD

(Cdr CHV Sudhakar)

Introduction

1. Indian Navy is the largest custodian of Marine Gas Turbines in the country with capabilities spreading over various facets such as installation, operation, exploitation, maintenance, repairs and overhaul of the GTs. Since the induction of Petya-class ships in 1968, Gas Turbines propulsion has gradually become the main stay of marine propulsion in the Navy over the last 50 years. Also, Indian Navy is operating both eastern and western origin Gas Turbines. As on date, as many as 140 Gas Turbines are being exploited on various Indian Naval ships across the eastern and western sea boards for Main Propulsion as well as Power Generation.

2. The three major components of a gas turbine are the compressor, the combustor and the turbine. Design of each of these components in itself is a very complex process and therefore marrying such complex designs into one unit called a Gas Turbine engine is extremely challenging and intricate evolution. The path to meeting the objective of a successful design of a Gas Turbine is through a combination of R&D, innovation, development of new materials and coatings, and improved engineering and manufacturing techniques.

3. In this paper, an attempt has been made to evaluate the technological competence available in the country presently to produce Gas Turbines for military applications. Initially the basics of a Gas Turbine are discussed starting from the thermodynamic cycle and then, the fundamentals of Gas Turbine design philosophy adopted generally all over the world are presented. Subsequently, capabilities pertaining to design competence and material technology available in the country today with leading players like GTRE, HAL and BHEL have been studied. Finally, certain way ahead have been discussed including the role Indian Navy could play in facilitating indigenous Gas Turbine design and manufacturing in India.

Gas Turbine Design Philosophy

4. The major elements of gas turbine design philosophy are the evolution of designs, geometric scaling, and thorough preproduction development. The evolutionary designing is a highly successful approach and will continue to be the basis for further progress. One of the examples for evolutionary approach is the development of a family of a particular component of a Gas Turbine, for instance, an axial-flow compressor whose flow, pressure ratio, and efficiency can be improved in several discrete steps, while retaining the proven reliability of existing designs. The evolutionary design process consists of the following steps:-

(a) Parametric representation

(b) Geometry construction

(c) Mesh generation

(d) CFD solution

(e) Data extraction and functional evaluation

(f) Optimisation

5. **Geometric Scaling.** Geometric Scaling of both compressors and turbines is based on the principle that one can reduce or increase the physical size of a machine while simultaneously increasing or decreasing rotational speed to produce an aerodynamically and mechanically similar line of compressors and turbines. Application of scaling allows the development of the product line by the use of proven compressor and turbine designs. This results in constant temperatures, pressures, blade angles, and stresses. Additionally, important cycle parameters are maintained, such as pressure ratio and efficiency.

6. **Development.** Development involves design analysis, quality manufacturing, testing, and feedback from field experience. This philosophy is usually well supported by substantial investment in development and test facilities. There are several other important considerations which have produced the combination of construction features found in many heavy-duty gas turbines world over. The subjects of fuel flexibility, packaging, and maintenance are the important design considerations.

Challenges in Components of Gas Turbine

7. **Compressor.** In the compressor section, air is compressed to many atmospheres pressure by the means of a multiple-stage axial flow compressor. The compressor design requires highly sophisticated aerodynamics so that the work required to compress the air is held to an absolute minimum in order to maximize work generated in the turbine. Of particular interest in the design of any compressor is its ability to manage stall of its aerodynamic components. In starting the gas turbine, the compressor must operate from zero speed to full speed. It is essential that the varying air flow within the compressor be so controlled that damage does not occur from avoidable stalling during part speed operation, and that stalling is absolutely prevented at full speed.

8. During low speed operation, the inlet guide vanes are closed to limit the amount of air flowing through the compressor, and provisions for bleeding air from the compressor are provided at one or more stages. This reduces the strength of the stalling phenomena during part speed operation, which avoids compressor damage. The compressor aerodynamics are such that at full speed operation, no stalling should occur. Because sufficient margin exists between normal operating

conditions and those conditions which would result in stall, gas turbines are to be designed such a way that they do not experience stall phenomena during normal full speed operation.

9. **Combustion Chamber.** The combustor of a gas turbine is the device that accepts both highly compressed air from the compressor and fuel from a fuel supply so that continuous combustion can take place. This raises the temperature of the working gases to a very high degree. This combustion must take place with a minimum of pressure drop and emission production. The design of combustion chamber should cater for both the aforesaid factors simultaneously namely, combustion at high temperature and at constant pressure. And the design is to be well supported by appropriate materials and cooling technology to withstand such high temperatures.

10. **Turbine.** The very high temperature gases flow from the combustor to the first stage turbine nozzles. It is in the turbine that work is extracted from the high pressure, high temperature working fluid as it expands from the high pressure developed by the compressor down to atmospheric pressure. As the gases leave the combustor, the temperature is well above that of the melting point of the materials of construction in the nozzles and first stage buckets. Turbine design should cater for extensive cooling of the early stages of the turbine to ensure adequate component life. Besides, the metallurgical aspects and thermal barrier coatings become inseparable part of the design of a turbine.

Metallurgical Considerations for GT Components

11. **Compressor.** Titanium, due to its high strength to weight ratio, has been a dominant material in compressor stages in Gas Turbines. Titanium content has increased from 3% in 1950s to about 33% today of the GT weight. Unlike predictions made for requirements of ceramic and metal matrix composites for GTs, predictions made for titanium alloys have come true or even surpassed. High temperature titanium alloys have found extensive application in aeroengines. Castings are used to manufacture the more complex static components. Forgings are typically used for the rotating components.

12. Today, the maximum temperature limit for near-? alloys for elevated temperature applications is about 540° C. This temperature limitation for titanium alloys mean the hottest parts in the compressor, i.e. the discs and blades of the last compressor stages, have to be manufactured from Ni-based superalloys at nearly twice the weight. Additionally, problems arise associated with the different thermal expansion behavior and the bonding techniques of the two alloy systems. Therefore enormous efforts are underway to develop a compressor made completely of titanium. Titanium alloys are required that can be used at temperatures of 600° C or higher. This has been the impetus for extensive research and development work in the area of elevated temperature titanium alloys.

13. **Combustion Hardware.** Driven by the increased firing temperatures of the gas turbines and the need for improved emission control, significant development efforts have been made to advance the combustion hardware, by way of adopting sophisticated materials and processes. The primary

basis for the material changes that have been made is improvement of high temperature creep rupture strength without sacrificing the oxidation/ corrosion resistance. Traditionally combustor components have been fabricated out of sheet nickel-base superalloys. Hastelloy X, a material with higher creep strength was used from 1960s to 1980s. Nimonic 263 was subsequently introduced and has still higher creep strength. Both these alloys are Nickel based superalloys. As firing temperatures further increased in the newer gas turbine models, HA-188, a cobalt base superalloy has been recently adopted for some combustion system components for improved creep rupture strength. Nickel based superalloys 617 and 230 find wide application for combustor components.

14. **Turbine.** Austenitic iron-base alloys have been used for years in aircraft engine applications for turbine discs and these alloys have been produced through the conventional ingot metallurgy route. Powder Metallurgy (PM) processing is being extensively used in production of superalloy components for gas turbines. PM processing is essentially used for Nickel-based superalloys. It is primarily used for production of high strength alloys used for disc manufacture which are difficult or impractical to forge by conventional methods. With the advent of advanced of gas turbine engines with much higher firing temperatures and compressor ratios, it became necessary to utilize a nickel-base superalloys for the rotors. The use of this material provides the necessary temperature capability required to also meet the firing temperature requirements in the future.

15. Component forgeability problems and hot work ability requirements led to the development of cast nickel-base alloys. Casting compositions can be tailored for good high temperature strength as there is no forgeability requirement. Further the cast components are intrinsically stronger than forgings at high temperatures, due to the coarse grain size of castings. The major failure mechanism for gas turbine airfoils involved nucleation and growth of cavities along transverse grain boundaries. Elimination of transverse grain boundaries through directional solidification of turbine blades and vanes made an important step in temperature capability of these castings. Use of DS superalloys could improve the turbine blade metal temperature capability relative to the conventionally cast superalloys.

National Competence in Gas Turbine Design

16. Over the last 50 years, a number of initiatives have been taken to dwell into the field of Gas Turbine technology by various agencies. The organizations which made concerted efforts in the field of designing a Gas Turbine and have successful designs to their credit include Gas Turbine Research Establishment (GTRE), Hindustan Aeronautics Limited (HAL) and Bharat Heavy Electricals Limited (BHEL). A look at the credentials of these organizations, R & D work they are involved in, success stories and reasons for failures will give a fair idea of where we stand when it comes to designing and producing a Gas Turbine.

17. **GTRE.** Gas Turbine Research Establishment is one of the pioneering Research and Development Organizations whose main charter is to design and develop gas turbine engines for military

applications, besides carrying out advanced research work in the area of gas-turbine sub-systems. They have the capability of undertaking conceptual design and performance prediction of gas turbine engines & sub-systems to meet the aero & marine requirements. Some of the successful designs of GTRE include GTX37-14U after-burning turbojet, the first jet engine to be designed entirely in India and a turbofan derivative, GTX37-14UB subsequently. The GTRE returned to turbojet technology with the greatly redesigned, but unsatisfactory, GTX-35. This establishment embarked on an ambitious project of designing and developing an indigenous gas turbine engine for military applications, namely 'Kaveri' and later attempted to marinise the same. Details about 'Kaveri' engine are discussed in the succeeding paragraphs.

18. **Kaveri Engine.** 'Kaveri' is the name christened for the ambitious project of developing an indigenous gas turbine engine for the Light Combat Aircraft or Tejas fighter of the Indian Air Force. The project took off in late eighties and as of 2014, 13 prototypes of Kaveri engines (including 4 prototypes of Kabini (Core) engines without the variable inlet guide vanes (IGV)) have been developed. Further on, 2050 hours of test flight of engines has been undertaken. 27 flights for 55 hours duration have been completed on testbed of IL-76 aircraft. Kaveri Engine was integrated with IL-76 Aircraft at Gromov Flight Research Institute (GFRI), Russia and flight test was successfully carried out up to 12 km maximum forward altitude and a maximum forward speed of 0.7 Mach No had been recorded.

19. **Kaveri Marine Gas Turbine.** The closest our country has reached to producing a gas turbine for marine propulsion was through the KMGT project. Using the core of the Kaveri aeroderivative engine, the scientists of GTRE have added Low Pressure Compressor & Turbine as a gas generator and designed a Free Power Turbine to generate shaft Power for the maritime application. The KMGT has been tested at ND (V) test bed which is capable of testing the Gas Turbines up to 25 MW of shaft power through a reduction gearbox and a water brake dynamometer.

The engine has been tested to its potential of 12 MW at ISA SL 35°C condition which is the requirement for propelling the SNF class of ships. During the trials, the KMGT reached the rated power as per design, however the GT could not sustain at rated power for the requisite duration. KMGT has not seen the light in view of plaguing issues pertaining to TET, shortcomings on metallurgy of hot section components and cooling technology. Therefore, the country has a long way to become self-reliant in the technology of gas turbines for ship propulsion and join the elite club of Marine Gas Turbine designers e.g., USA, Russia, UK and Ukraine.

20. **Reasons for Delay of Kaveri.** Some of the reasons contributing to the delay in Kaveri project, as projected by the Govt, are listed below:-

(a) Inadvertent delays related to ab-initio development of state-of-the-art gas turbine technologies.

(b) Technical/ technological complexities.

(c) Lack of availability of critical equipment & materials and denial of technologies by the technologically advanced countries.

(d) Lack of availability of test facilities in the country necessitating testing abroad.

(e) Non availability of skilled/ technically specialized manpower.

(f) The engine has been able to produce thrust of 82 Kilo Newton but what the IAF and other stake-holders desire is power between 90-95 KN.

21. **HAL.** The R&D wing of HAL has been playing a vital role in the design and development of Gas Turbine Engines in India through their dedicated Design Complex, namely, Aero Engine Research & Design Centre (AERDC). It has successfully designed, developed, produced and type certified aero engines like PTAE-7 engine for Lakshya aircraft & GTSU-110 starter engine for LCA (Tejas) which are in operation. The Centre started functioning in the year 1960 as a hub of engine research and development with the aim of achieving self reliance in design and development of Gas Turbine Engines and Test Beds in a climate of growing professional competence. Leveraging on this experience end to end services right from preliminary design to the final product manufacturing and testing are offered.

22. **BHEL.** BHEL has a huge clientele in the industrial gas turbine sector employed for power and process industries. With over 100 machines and cumulative fired hours experience of over four million hours, BHEL has supplied Gas turbines for Power utilities, IPPs, Process industries in India and abroad encompassing Co-generation plants, Combined Cycle plants and turnkey projects. The PSU has to its credit experience of manufacturing gas turbines of power rating 32 MW to 450 MW all of which are serving various industries in the country. BHEL's clientele also includes power, petroleum and process industries employing gas turbines in Oman, Vietnam, Saudi Arabia, Italy and Malaysia. All matching equipment like generators, compressors, etc. manufactured in-house and design of combustion systems are carried out as per international emission norms.

Metallurgy for Gas Turbines in India

23. Establishments like GTRE, HAL and BHEL have in-house R & D centres dedicated for progress of metallurgical advancements. The premier establishment involved in development of metallurgy for defence applications is Mishra Dhatu Nigam Limited (MIDHANI). Over the years, MIDHANI has developed the technological ability for manufacture of very wide range of advanced metals and alloys of over 100 grades under one roof to meet the need of strategic and commercial sectors. As of today, these premier organizations have grown to take a lead position in indigenisation of critical technologies and products to render support to several programmes of national importance and hi-tech segments of Indian industry.

24. Particlularly, MIDHANI has started offering its core competence of developing and manufacturing custom alloys tailor-made to suit the specific requirements of customers for their

critical applications. Some of the alloys which have been developed and readily offered are highlighted below:-

(a) Titanium based alloys which can be employed for compressor blading and other cold section components like BT 14, Ti 15 etc.

(b) Nickel based superalloys which are utilized in making the combustion hardware like Hastelloy X, Nimonic 263, Nimonic 90.

(c) Other Nickel based superalloys with superior heat resistance properties tailor made for manufacture of turbine components.

25. Competence to design a Marine Gas Turbine. A close look at the history of advent of gas turbine technology in the world reveals that during the World War II, it was the desire to make a gas turbine for military applications that fuelled the progress of GT R & D. After the war, certain other factors like availability of abundance of natural gas as fuel for power generation, restructuring of the power sector and need to reduce the NOx emissions were the driving forces for advancement in gas turbine technology. Though the driving forces for technological progress at different points of time in the last 70 years were different, they all converged into advancement in cooling technology and metallurgy & materials for gas turbines. Post World War II, although the thrust was on development of industrial gas turbines, technology percolated to other applications like aero engines and marine gas turbines.

26. Therefore, the most important lesson learnt from the history is that advancement in gas turbines technology in a particular field did not get confined to that field alone. Instead, it was gradually adapted for other applications as well. This fact, coupled with the success stories of various agencies in designing gas turbines for military/ industrial applications, brought out in the preceding paragraphs, projects confidence that as a country, we do have the competence to take the capability of designing & developing a gas turbine for marine propulsion further. Although the indigenous designs and the in-house metallurgy and materials have come a long way, there are shortcomings in technological aspects and support facilities like those discussed incase of Kaveri engine which need to be addressed. The possible way ahead encompassing the present shortcomings and various other futuristic options have been discussed in succeeding paragraphs.

Way Ahead

27. **Continual Efforts on R & D.** A thorough evaluation has been carried out of what is required to design a marine gas turbine and where we stand as a country towards achieving that goal, in the earlier part of this paper. It becomes evident that there exists a gap between the technological requirements to design and manufacture a gas turbine and our competence in the related fields. The road to bridge the gap between these two aspects is consistent efforts in research and development by all the involved agencies. The time tested concept in the field of gas turbine research, namely, the "building block" approach may be adopted. In this concept, research is not

aimed at constructing and testing complete engines, but instead in improving the core components. This approach will focus the R & D efforts to develop the compressor, combustor, and turbine as a unit suited to a range of future engines.

28. **Joint Ventures.** While the R&D for indigenous technology continues, collaborations and joint ventures with the leadings OEMs of marine gas turbines is the order of the day and need to be explored aggressively. The country has seen many a successful story in joint ventures like KOEL - Cummins diesel engines, Hero - Honda motorcycles, Kawasaki - Bajaj two wheelers and many more. The startling feature in the examples quoted above is that the Indian OEMs have fully become independent of their foreign partners and are rolling out the products which are meeting the standards and expectations that are already set for them in the market. Some of the joint ventures initiated in the past in the field of gas turbines include GE - HAL, BAeHAL Software Ltd, Indo Russian Aviation Ltd, Snecma HAL Aerospace Pvt. Ltd, HALBIT Avionics Pvt. Ltd etc. Some of the futuristic ideas pertaining to the joint ventures are elaborated below:-

(a) **Collaboration of Foreign OEMs with PSUs.** Having garnered experience of almost half a century in operating gas turbines of Russian/ Ukrainian origin, we should look at taking up joint ventures with the OEMs of these GTs. The joint ventures should aim at Transfer of Technology on pre-decided timelines. While the collaboration would be between the foreign OEM and a PSU on Indian side, the end user will be IN. It is therefore prudent that IN occupies the driving seat in initiating and progressing these joint ventures.

(b) **Collaboration of Foreign OEMs with Private Industry.** While much has been proposed for joint ventures between foreign OEMs and PSUs, collaborations involving the private industry cannot be left behind. The power generation industry moghuls like TATA, Reliance, KOEL, ESSAR etc could be offered encouraging business prospects by the Govt to take up development and manufacture of gas turbines.

(c) **Better Interaction amongst the PSUs.** There is an inescapable need for the PSUs involved in gas turbine technology to interact with each other and share each other's R & D efforts and knowledge. The difficult nature of the problems related to R & D of gas turbine technology necessitates a cooperative approach among otherwise competitive businesses.

29. **Interaction between Industry and Academia.** The technological shortcomings discussed in the earlier section are of such nature that they are beyond the reach of individual organisations or companies who have limited funds to improve their own design systems. There is a need to establish a consortium with an aim to establish an empowered body to provide impetus to various academic and other research institutions including industry in the country in specialized areas of advanced and futuristic gas turbine engines technology. GTRE has already taken a National Initiative titled "Multi-centric Gas Turbine Enabling Technologies (GATET)". We need a few more initiatives on similar lines.

30. The consortium may be built around the common industry-wide problems in the gas turbine fraternity. The consortium may be structured with participation from the IITs and other universities, PSUs involved in development of gas turbines, potential & enthusiastic private companies. The steering committee may have representation from the stake holders as well as from the Indian Navy and Indian Air Force. This concept will facilitate breaking down of multidisciplinary problem effectively into key research areas. Industry may be encouraged to provide some portion of the funding for the research projects approved by the steering committee which would be conducted mostly at universities. This arrangement would allow the individual firms to leverage their investment since the funding is shared by many.

31. University researchers in the consortium would need data to develop models to address the plaguing issues and the participating companies would need models that could be practically implemented in their existing design systems. Turbine performance data, such as force and flow measurements and detailed component geometries, can be transferred from companies to researchers through subcommittees overseeing individual projects. The subcommittees will facilitate closer interaction between the technology developers and the technology users, providing opportunities to clarify the objectives and validate the new tools. Additionally, review meetings and conferences will go a long way and strengthen the small community of dedicated experts.

32. Role of Government.

(a) The most lucrative market the Govt may project for the prospective indigenous GT manufacturers is the industry of civil aviation which is growing in the country. The performance of aeroderivative gas turbines will largely be enabled by the engineering successes sustained in the lucrative aircraft engine market. The role and impact of industry-government partnerships, led by the military and bolstered by the rise of commercial aviation, will be the key factor and will directly impact the evolution of aeroderivative gas turbines.

(b) Private industry will build on knowledge gained from military and commercial applications to repurpose aircraft/ marine GTs for electricity generation and mechanical drive applications, including oil and gas pipelines. Firms will be leveraging their knowledge and investment in aircraft engines to explore industrial gas turbine applications.

(c) The Govt should offer an encouraging business model for the enthusiastic firms and sell the point that big profits are on the horizon for firms who understand gas turbine technology well enough to balance tradeoffs and improve performance along all dimensions: power, efficiency, reliability, maintainability and cost.

(d) The Govt should seriously consider gas turbine technology as a viable option in the power sector. Extreme shortage of coal in the near future and encouraging reports of natural gas reserves in the country are the critical factors which can spur the migration from coal based thermal power plants to natural gas based GT power plants.

(e) One of the reasons highlighted by the Govt for debacle of Kaveri engine was non availability of skilled/ technically specialized manpower. Inorder to have a pool of technically competent people in GT research, it is necessary to tap the talent at an early stage. Therefore, a lot of thrust needs to be given on Gas Turbine Technology at UG/ PG level and students are to be encouraged to take up studies related to the Gas Turbines. It is proposed that Gas Turbine technology be included as a branch (not merely a course or subject in the curriculum) in the IITs and other leading Engineering Universities.

(f) The Govt also projected that denial of technologies by the technologically advanced countries was another reason for failure of Kaveri GT. The recent initiatives taken by the present Govt in building the bridges of friendship with other advanced countries can be viewed as an opportune development. Therefore, this is the right time to include 'Sharing of technology and R & D efforts in the field of Gas Turbines' as one of the agenda points in the MoUs being signed with various countries owning advanced GT technology.

33. Role of Indian Navy.

(a) The Navy's competitive procurement process should drive the initial gas turbine development. R&D efforts led by the Navy in partnership with gas turbine manufacturers should aim to drive innovation, largely through new management and engineering approaches to marine gas turbine development.

(b) The Navy can encourage the prospective Indian GT manufacturers by the multitude of engine orders which will motivate the competing firms to develop advanced designs. The Navy can play an important role early on to help advance aeroderivative gas turbines both by demanding a robust product and supporting the engineering and testing to further demonstrate durability.

(d) The Navy should drive all the collaborations right from drawing the SOTRs, selecting prospective OEMs across the globe, short listing them based on technical evaluation of their capabilities & credentials and finally kick starting the venture. IN should be fully involved along with the prospective PSUs at all the critical stages in the venture. IN should have conspicuous presence as Overseeing Teams during the process of development and manufacturing of marine GTs at the PSUs/ firms. On the similar lines of GTRE, IN may consider posting personnel with relevant experience and expertise to these PSUs.

(e) In order to co-ordinate such niche research towards developing indigenous solutions, it is proposed to set up a Naval Research Organization (NRO). Through this organization, Navy can network with academia of the country and drive research which would eventually cater for developing the necessary technology for design and manufacturing of Gas Turbines in India.

(f) While discussing the reasons for the failure of Kaveri engine, it emerged that the lack of availability of test facilities in the country necessitated testing the GT abroad. This factor alone has the potential to slow down the R&D efforts considering the penalties of time and money it would impose. Therefore, it is proposed that the existing Marine GT test facility available at Naval Dockyard (Visakhapatnam) be augmented with state of the art technology and developed into an independent and universal Marine Gas Turbine test facility which can be customized to test a Marine GT of any make with minor modifications.

34. **Cross Leveraging of Technology.** Nuclear, Space and Defence are the three drivers of high end indigenous technology in India. India has made tremendous progress in developing indigenous technology to cater for Nuclear and Space requirements. Successful launching of multiples satellites and design/ development of indigenous nuclear power plant are testimonies to our capability. Therefore, there is no reason why we cannot design and develop indigenous Marine/ Aero Gas Turbines. Towards this, it must be focused to leverage expertise from Nuclear/ Space sectors for developing indigenous technology for Gas Turbine Manufacturing in India. In order to bring these three sectors together, it is proposed that a joint consortium be set up wherein free flow of information between three sectors can be seamlessly ensured.

References

1. Travis R. Doom, ***Case Studies on the Government's Role in Energy Technology Innovation - Aeroderivative Gas Turbines***, American Energy Innovation Council (202) 480-9121 (August 2013).

2. Darian Unger and Howard Herzog, ***Comparative Study on Energy R&D Performance: Gas Turbine Case Study***, Final Report for Central Research Institute of Electric Power Industry (1998).

3. Sumit Sharma, Ajay Sharma and Megha Sharma, ***Gas Turbines - Current Scenario & Future Prospects in India***, International Journal of Scientific & Engineering Research, Volume 6, Issue 8 (August 2015).

4. ***"Vision 2030" Natural Gas Infrastructure in India***, Report by Industry Group For Petroleum & Natural Gas Regulatory Board (2012).

5. Michael R. Curtis, ***"The Innovation of Energy Technologies and the U.S.National Innovation System - The Case Of The Advanced Turbine System"***, U.S. Department Of Energy Washington, D.C. (December 2003)

6. www.midhani.gov.in

7. www.bhel.com

8. www.hal-india.com

9. www.drdo.gov.in

10. en.m.wikipedia.org

Author's Biodata

Commander CHV Sudhakar is an alumnus of 101st NDA Course and a graduate in Mechanical Engineering from the Naval College of Engineering. His sea tenures include Senior Engineer Officer, INS Ranvijay, Assistant Engineer Officer, INS Rajput and ERWKO, INS Ranjit. He also served as Deputy Director at IHQ MoD(N)/DND(SDG) and Divisional Officer at INS Shivaji/DOT. The Officer has done his MTech in Materials Science and Engineering from IIT Kharagpur and is currently serving as Senior Trials Officers at Gas Turbine Testing & Tuning Team(V).

article

20

NUCLEAR PROPULSION FOR NAVAL PLATFORMS: THE NAVY'S PERSPECTIVE

(By Capt Vikram Bora & Cdr KJ Singh)

Introduction

1. Marine platform design and systems integration has always been a complex process involving multi-faceted, multi-functional activities. Add to this the design of a 'Marine' nuclear reactor and thereafter its integration with the platform, and the complexity of the process increases manifold.

2. Nuclear propulsion provides the advantages of large periods of continuous submergence, very high endurance, high propulsion powers and speeds, and a virtually 'uncompromisable second strike capability' in the scenario of a nuclear attack. It also brings with it the attendant issues related to the design and construction of safe and miniature reactors, their integration with the marine platform, complex materials and heavy shielding requirements, prolonged cooling down periods, and issues related to radiation safety.

3. Submarines use Diesel-Electric or Nuclear / other Air Independent Propulsion (AIP) systems for propulsion. All these systems are viable, in vogue and all are capable of further improvement. However, of all these only the nuclear system can provide virtually unlimited endurance, exploitation at higher speeds and elimination of exposure to airborne Radar detection. In the case of large surface combatants like Aircraft carriers, nuclear power provides high propulsive power and long endurance, whilst also catering for the requirement of short bursts of very high electric power for aircraft launch systems on certain state of the art platforms.

4. Nuclear power uses atoms, the smallest particles of an element, to produce an enormous amount of energy. Nuclear systems for marine platforms consist of a steam propulsion plant in which the reactor assumes the functions of a boiler. Heat is drawn continuously from the nuclear reactor and is used indirectly, to raise steam. The steam is then used to run the main propulsion / power generation turbines and other auxiliary machinery.

5. From a historical perspective, the role of Industry in the development of naval nuclear propulsion programs has been an important one. What is even more remarkable is that commercial rectors for the generation of electric power in the United States evolved from the submarine reactor program. In Dec 1945, the US Navy under the stewardship of Admiral Hyman G Rickover embarked on an ambitious plan for the design and construction of a nuclear submarine fleet. Towards this, the services of two of the largest American manufacturing firms viz, Westinghouse Corp and General Electric were enlisted. A development program based on a concept using highly enriched Uranium as fuel and pressurized water as both Moderator and Coolant was initiated in 1948. The USS Nautilus, the first nuclear-powered submarine resulting from this program, was

launched in Jan 1954 and commenced sea trials a year later. On her first voyage, Nautilus travelled completely submerged in the Atlantic for more than 1300 miles. Since that time, nuclear energy, as a form of propulsion for naval platforms has come a long way.

6. The paper aims at providing a basic overview of a typical marine nuclear propulsion plant. It also aims at identifying the technical challenges associated with the design, development and operation of Nuclear Propulsion Plants for naval applications. Whilst the Industry is already actively involved in system / equipment development and shipbuilding, it is felt that it could play a bigger role in certain areas related to nuclear propulsion for naval applications. Some of these specific areas where industry could play a bigger role have also been brought out in the paper.

Nuclear Propulsion Plant for Naval Platforms

7. **Advantages of Nuclear Power for Naval Platforms.** Following are the advantages of a nuclear power plant for a naval platform :-

(a) Virtually Unlimited Endurance: The limitation in this case would not be due to the propulsion system requirements but rather due to limited endurance of the crew and habitability or logistics factors. The nuclear fuel stock practically ensures unlimited sailing range and besides this, obviates the requirement of refueling from shore or afloat ships, besides dispensing the need of onboard fuel tanks to a large extent.

(b) Requirement of Surfacing for Submarines: Despite the fact that diesel electric plants have undergone significant improvements over the years, the limitation to periodically surface for charging of batteries still exists. Nuclear submarines, on the other hand, can stay submerged and thereby be less prone to detection for very long periods of time.

(c) High Speeds: Due to high aggregate power of the nuclear power plants, the nuclear powered platforms are capable of developing high speeds.

(d) The nuclear reactor provides power not only to the main steam turbines and generators, but also to other equipment and devices. The reactor ensures the reliable power supply from a 'single source'.

8. **Typical Marine Nuclear Propulsion Plant.** The propulsion plant of a nuclear-powered marine vessel uses a nuclear reactor to generate heat. The heat comes from the fissioning of nuclear fuel contained within the reactor. Since the fissioning process also produces significant radiation, shields are placed around the reactor so that the crew and surroundings are protected. Based on design features, type of coolant and moderator, nuclear power plants may be classified as follows:-

(a) Pressurised Water Reactor (PWR)

(b) Pressurised Heavy Water Reactor (PHWR)

(c) Boiling Water Reactor (BWR)

(d) Liquid Metal Cooled Reactor

(e) Gas Cooled Reactor

(f) Organic Liquid Cooled Reactor

9. Marine nuclear propulsion plants use a Pressurized Water Reactor design that has two basic systems: the Primary system and the Secondary system. The Primary system circulates ordinary water in an all-welded, closed loop consisting of the reactor vessel, piping, pumps, and steam generators. The heat produced in the reactor core is transferred to the water, which is kept under pressure to prevent boiling. The heated water passes through the steam generators where it gives up its energy. The primary water is then pumped back to the reactor to be heated again.

10. Inside the Steam Generators, the heat from the Primary system is transferred across a watertight boundary to the water in the Secondary system, also a closed loop. The Secondary water (which is at relatively low pressure) produces superheated steam. Isolation of the Secondary system from the Primary system prevents water in the two systems from intermixing, thereby keeping radioactivity out of the secondary water. In the Secondary system, steam flows from the steam generators to drive the main propulsion turbines (which turn the ship's propellers) and the turbine generators (which supply the ship with electricity). After passing through the turbines, the steam condenses back into water, and feed pumps return it to the steam generators for reuse. A typical marine nuclear propulsion plant is shown in Fig. 1 below.

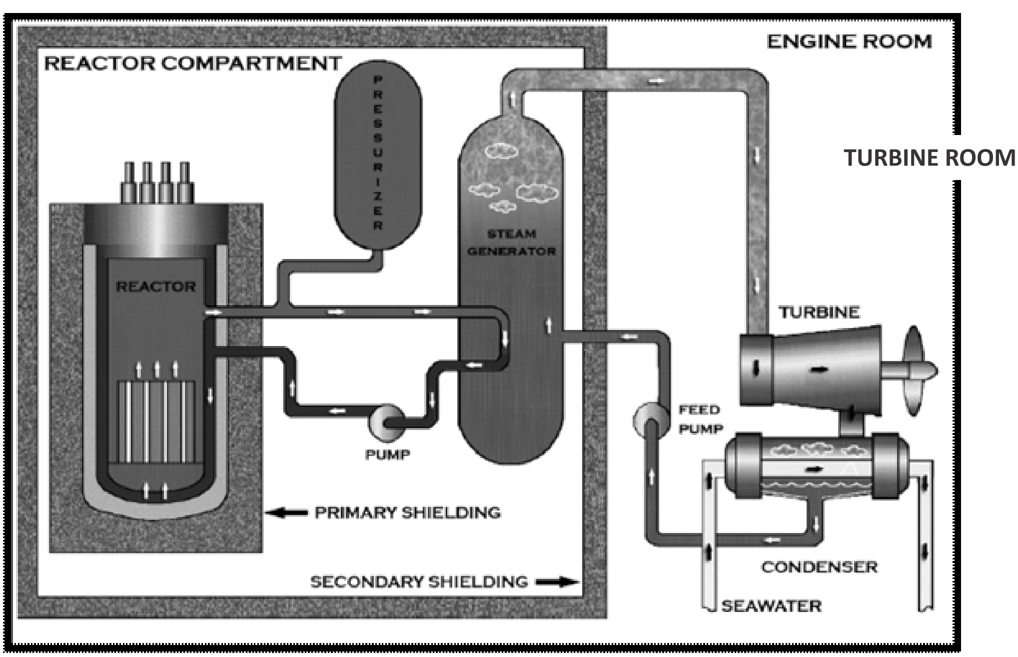


Figure 1. Typical Marine Nuclear Propulsion Plant.

FICCI

Components of a Marine Nuclear Propulsion Plant

11. The most preferred option for marine application, a Pressurised Water Reactor (PWR) uses enriched Uranium as fuel and light water, both as Coolant and Moderator. The primary coolant circuit needs to be pressurized in order to increase the boiling temperature of the Coolant so as to achieve higher coolant and thereby higher steam temperatures. A good energy / volume ratio of a marine PWR is achieved by enriching the Uranium fuel. Natural Uranium is mostly U238, with a very small amount of the radioactive isotope U235. By contrast, marine PWR fuels, whether metal or oxide, are given a very heavy loading of U235. This enrichment serves two purposes - it keeps the core size small; yet puts enough reactivity into it to give the vessel an un-refueled endurance equivalent to the time span between major refits. The challenges here are to ensure a safe approach to criticality and sustained operation over the specified power range, safe shutdown and adequate cooling of the reactor under normal operating conditions and accident scenarios, and an intrinsically safe design with inherent safety features, all within the space and weight constraints of a typical naval platform.

12. The main components of a typical marine nuclear propulsion plant are follows:-

(a) **Reactor Pressure vessel (RPV).** Usually a robust steel vessel containing the reactor core and Moderator / Coolant, but it may be a series of tubes holding the fuel and conveying the coolant through the surrounding moderator. Fig. 2 shows a typical Reactor pressure vessel along with the Control rod assembly.

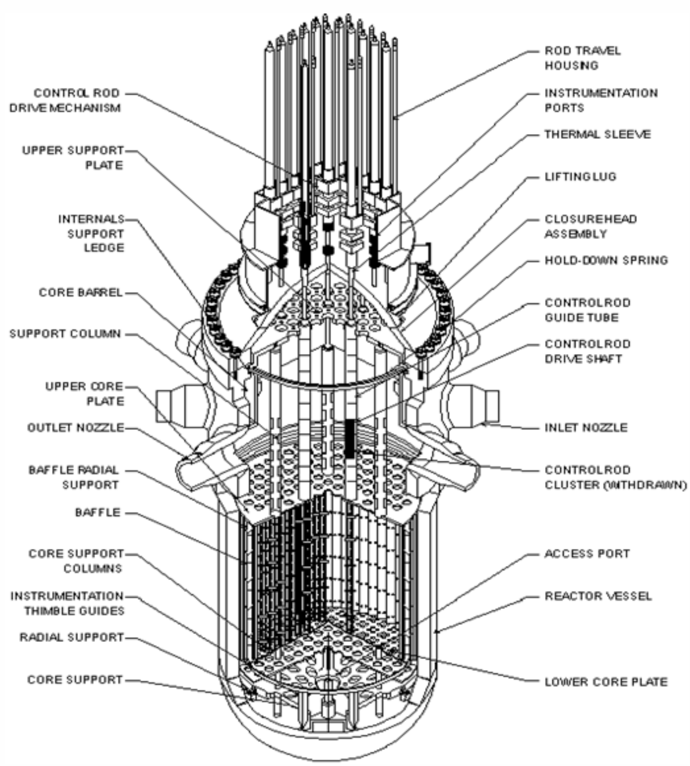


Figure 2. Typical Reactor Pressure Vessel

(b) **Fuel.** Uranium is the basic fuel. Usually pellets of Uranium Oxide (UO2) are arranged in tubes to form fuel rods. The rods are arranged into fuel assemblies in the reactor core.

(c) **Moderator.** Material in the core which slows down the neutrons released from fission. The 'slowing down' of neutrons is essential to get them in the Thermal range so that they are capable of causing further fission. The Moderator is usually water, but may be also be Heavy Water or Graphite.

(d) Coolant. A fluid circulating around the reactor core so as to transfer the heat from it. In light water reactors the water moderator also functions as the primary coolant. In the case of BWRs, there is secondary coolant circuit where the water becomes steam. (See also later section on primary coolant characteristics).

(e) Control rods. These are made with neutron-absorbing material such as Cadmium, Hafnium or Boron, and are inserted or withdrawn from the core to control the rate of the nuclear reaction, or to stop it. In some PWR's, special control rods are used to enable the core to sustain a low level of power efficiently.

(f) **Steam Generator.** Inside the steam generators, the heat from the primary system is transferred across a watertight boundary to the water in the secondary system, also a closed loop. The secondary water (which is at relatively low pressure) boils, creating steam. Isolation of the secondary system from the primary system prevents water in the two systems from intermixing, keeping radioactivity out of the secondary water.

(g) **Containment.** The structure around the reactor and associated steam generators which is designed to protect it from outside intrusion and to protect those outside from the effects of radiation in case of any serious malfunction inside. It is typically a thick concrete and steel structure.

Technical Challenges

13. Stringent norms and guidelines are in place for the design and development of Nuclear plants and associated components. Further, the design, construction and selection of equipment for marine, and especially Naval platforms is governed by a unique set of specifications and operational considerations. A nuclear propulsion plant on a naval platform has to conform to both the above requirements. The challenges associated with the design, development & integration of a marine nuclear propulsion plant are highlighted in the succeeding paragraphs.

14. **Design Challenges.** Unlike land based power plants, marine based propulsion has a peculiar requirement of assured performance and safety onboard a platform which is subjected to continuous rolling and pitching. In addition, unlike land based plants, the requirement of frequent and rapid variations in power makes the design of the nuclear power plant and its control system onboard a naval platform even more challenging. Coupled with this are the corrosive marine environment, shock and vibration considerations and the constraints of space and volume. Further, Reactor shutdown mechanisms cannot rely on gravity to drop control rods into the core as in the

land based reactors that always remain upright. The internals of a Naval reactor remain inaccessible for inspection or replacement throughout a long core life, unlike a typical commercial nuclear reactor, which is opened for refueling roughly every eighteen months.

15. The design of nuclear components viz Boilers, Pressure vessels and piping is governed by the stringent norms of ASME BPV Code Section III (Rules for Nuclear Facility components). The code gives rules for selection of materials, design, fabrication, examination, testing and norms for over pressure protection of components and piping. ASME BPV code Section III classifies the nuclear components as Class1 to 3 according to their nuclear safety significance. Primary circuit components, such as the reactor vessel, steam generators and primary pipe work, are designated as Class 1 components as their failure could lead to significant radiation release. Components whose failure could disrupt or put in danger the stability of the plant are designated Class 2. Class 3 components have a lesser nuclear safety significance and their failure would have a limited impact on the stability of the plant. These standards demand a stringent and conservative design approach, use of specialized and high quality materials, special welding and fabrication techniques and rigorous testing and Quality Assurance procedures. These requirements are more stringent vis-à-vis the conventional power plant industry, and therefore call for specially qualified manpower and special infrastructure / facilities for taking up projects in the Nuclear Industry.

16. The major difference between naval platforms and merchant ships, leading to different effects while sailing in similar environmental conditions, is their operational profile. Naval platforms must be capable of withstanding defined sea states, without any decrease in their fighting ability and must also retain a high standard of operational effectiveness under all scenarios. Naval platforms are designed to inherently meet the following requirements:-

(a) Assured performance in the presence of six degrees of ship motion, significant of which are roll and pitch.

(b) Ability to withstand shock loads.

(c) Appropriate material and metallurgical composition to withstand corrosion and erosion over their designed service life.

(d) Assured performance when submerged /partially submerged and subjected to harsh marine environment.

(e) High temperatures and humidity levels in machinery spaces.

(f) Utilization of seawater for cooling systems/ heat exchangers.

(g) Attenuation of airborne and structural borne noise by appropriate vibration mountings and acoustic enclosures.

(h) Modularity in design to assure high level of maintainability in heavily congested machinery spaces.

17. Naval equipment are designed to withstand harsh marine environment and are generally built to Naval Engineering Standard (NES) or Navy specific standards. Some of the characteristics that

differentiate Naval equipment from general purpose equipment are Shock standards, Environmental testing as per JSS 55555 and EMI/EMC testing. The various standards to which equipment is required to be developed along with the testing procedures are specified in the Specification of Technical Requirements (SOTRs) of individual equipment.

18. Material challenges.In a modern light water reactor, there are over 25 different metal alloys within the primary and secondary systems. Additional materials exist in the shielding, containment structure and control equipment. Depending on the specific application, these materials are subjected to different forms of degradation and therefore have an important role in the safe and efficient operation of a nuclear power plant. For example, core internal structures and supports are subjected to high temperatures, the primary coolant chemistry and irradiation effects. These Stainless Steel structures may experience irradiation induced hardening, radiation-induced segregation and changes to their microstructure. Commonly used materials for different nuclear power plant components are tabulated below in **Table 1**:-

Table 1: Commonly used Materials for Nuclear Components

Sl	Component	Material used
(a)	Reactor pressure vessel	Alloy steel, Clad 308, 309 SS
(b)	Steam generator	Low alloy steel, Tube alloy 600MA, 600TT
(c)	Reactor coolant pump	Hi Str A286, Structural 304, 316SS
(d)	Core structures	304 SS
(e)	Fuel cladding	Zr alloy
(f)	Control rod drive mechanism	Alloy 600 MA, 690 MT
(g)	Primary piping	304, 316 SS
(h)	Turbine	Low alloy steel, Cr Steel, 403 SS
(i)	Condenser	Ti or SS tubes, Carbon Steel (Structure)
(j)	Secondary system piping	Carbon Steel
(k)	Main steam range	439 Ferritic Steel

Equipment Specific Challenges

19. **Reactor Pressure Vessel.** The RPV is one of the most important components of the nuclear plant as it contains the core of the reactor and also forms a critical barrier for containment of radioactivity. A typical Reactor Pressure Vessel is shown in Fig 2.The RPV, through its life, is subjected to high temperatures, pressures and neutron fluence rates, and therefore has to have a very high level of reliability and structural integrity. The main problem associated with neutron fluence is the reduction in ductility of the RPV over a period of time due to neutron irradiation. Another aspect related to RPV design is that due to irradiation and inaccessibility, inspection / maintenance of the RPV is not feasible throughout its service life. These considerations call for selection and use of high quality materials of construction and weld consumables, sophisticated welding techniques and a conservative design approach of the RPV.

20. **Steam Generators.** Steam generators are the heat exchangers which use the heat from hot coolant from the reactor core (high pressure) to form superheated steam in the secondary loop (low pressure). Unlike the land based power plants with big steam generators, a marine steam generator is much smaller in size and is expected to generate superheated steam through an intricate network of cooling coils which provide higher heat exchange area. In addition to high heat transfer coefficient, steam generator cooling coils are required to be strong enough to cater for high pressure of the reactor coolant. The majority steam generator systems originally used Alloy 600 (a Ni-Cr-Fe alloy), although service experience showed many failures in tubes through the 1970s. In the last 30 years, most steam generators have been replaced with Alloy 690, which shows more resistance to stress-corrosion cracking. In addition to the base material, there are weldments, joints, and varying water chemistry conditions leading to a very complex component. Stress-corrosion cracking is found in several different forms and may be the limiting factor for component lifetime.

21. **Reactor Coolant Pumps.** Pumps are used for circulating the coolant across the reactor core. These pumps are critical in terms of safety. In addition to circulating reactor coolant these pumps are also a mode of residual heat removal from the core during shutdown of the reactor. These pumps are also maintenance free and are not expected to fail in any condition. As a general practice, pumps of 'Canned Motor Design' are used for this application.

Integration of Nuclear Propulsion Plant in Marine Platforms

22. All critical components of the steam generating unit of a nuclear propulsion plant are located in close proximity so as to prevent the risk of leakage due to loss of system integrity and minimize piping losses. The combined assembly holding the components is termed as Aggregate and is akin to a modular construction philosophy. An integrated Steam Generating Unit typically used for marine application is shown in Fig 3. The assembly of the Aggregate is always undertaken in a specially designed dust free and clean enclosure. On complete assembly, the Aggregate is lowered/ rolled into the containment. The service life of the Aggregate has to match that of the platform on which it is installed. On the Secondary side, a similar concept can also be applied, wherein the main

turbine and other auxiliaries are assembled together in a single structure, which can then be either lowered or rolled onboard for final integration with the platform. Special infrastructure and specifically skilled manpower are required for carrying out these high precision and complex operations. Critical components visible in the assembly are Reactor Pressure Vessel, Steam Generators, Reactor coolant pump(s) and associated piping.

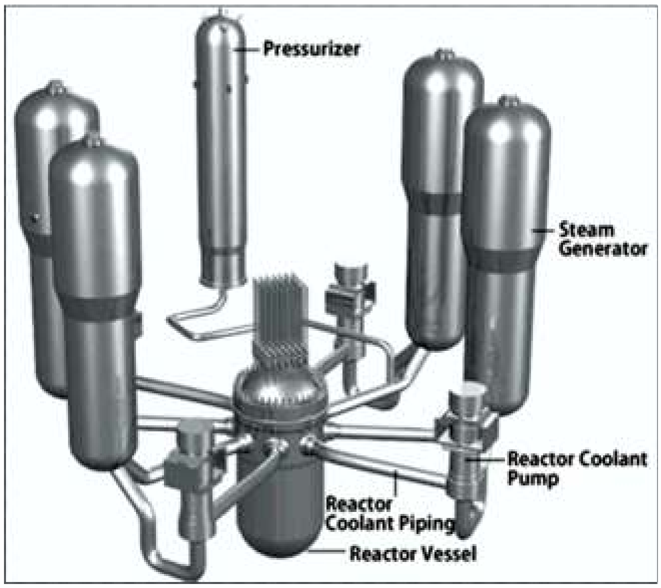


Figure 3. Integrated Steam Generating Unit.

AERB Guidelines on Radiation Monitoring and Radiation Protection

23. The Atomic Energy Regulatory Board (AERB) has been entrusted with the responsibility of laying down standards and enforcing rules and regulations as per the Atomic Energy Act, 1962 for ensuring safety of members of the public and occupational workers as well as protection of environment from the affects as a result of nuclear related activities. Nuclear facilities in India are under the ambit of the AERB.

24. Handling and disposal of active components and waste is an important aspect in the Nuclear Industry. It requires special infrastructure and qualified manpower to carry out these activities satisfactorily. Storing and disposing of the irradiated components/ equipment post completion of service life is an important aspect which has to be catered for by the Industry. Handling and disposal of radioactive waste is guided by the Atomic Energy (Safe Disposal of Radioactive Wastes) rules, 1987.

25. Further, specific norms are laid down for setting up any nuclear facility with regard to infrastructure, radiation monitoring and radioactive waste disposal. Safety guides promulgated by the AERB pertaining to the different aspects related to Nuclear Power plants are listed in Table 2 below.

Table 2: AERB guides on Nuclear Facilities

Sl	Safety code	Description
(a)	AERB/SC/G	Safety Code on Regulation of Nuclear and Radiation Facilities
(b)	AERB/SC/S	Code of Practice on Safety in Nuclear Power Plant Siting
(c)	AERB/SC/D	Code Of Practice on Design for Safety in Pressurised Heavy Water Based Nuclear Power Plants
(d)	AERB/SC/O	Code of Practice on Safety in Nuclear Power Plant Operation
(e)	AERB/SC/QA	Code of Practice on Quality Assurance For Safety in Nuclear Power Plants
(f)	AERB/SC/DC	Safety Code on Nuclear Power Plant Decommissioning
(g)	AERB/SS/F	Safety Standard for Fire Protection Systems of Nuclear Facilities
(h)	AERB/SC/RW	Safety Code on Management of Radioactive Waste
(i)	AERB/SS/CSE	Civil Engineering Structures Important to Safety of Nuclear Facilities

26. Any public or private shipyard that embarks upon the construction of a nuclear propelled platform in the future would need to follow the above mentioned norms and guidelines.

National Competence in Design & Manufacture of Nuclear Propulsion Components

27. Over the last few decades, the Industry has gained considerable experience in the design and development of equipment and systems for marine applications and also for land based nuclear plants. Certain specific areas related to nuclear propulsion for naval applications, where the Industry could play a bigger role are indicated below:-

(a) Advanced metallurgy for high temperature and pressure applications, particularly for radiation environment

(b) Technology for production of low alloy steel forgings for pressure vessels

(c) Titanium welding and fabrication technology

(d) Development of bellow-seal valves

(e) Development of Canned motor pumps

(f) Manufacturing and testing facilities for Control rod drive mechanisms

(g) Hardware and software development for power plant control systems

(h) Nuclear instrumentation

(j) Development of Stealth technology

Way Ahead

28. Nuclear propulsion is an area of technology which is essential for any Navy aiming for a global presence. The technology has enormous potential, both for surface combatants and submarines. However, there are technical challenges associated with the development of Nuclear Propulsion Plants for naval applications and there also exists a degree of dependence on foreign players for certain key areas of technology in this field. Whilst the Indian Industry is already actively involved in system / equipment development and shipbuilding, it is felt that it could play a bigger role in a number of areas as brought out above. Make in India will help and ensure self reliance and technological growth of the Indian Navy, Industry and the country as a whole. The Navy-Industry partnership, with complementing strengths, will form a win-win combination towards achieving self-reliance in the field of nuclear propulsion for naval platforms.

References

[1] Nuclear Reactor Engineering by Samuel Glasstone & Alexander Sesonske.

[2] IAEA - Design of the Reactor Core for Nuclear Power Plants for protecting people and the environment. Safety Guide No. NS-G-1.12.

[3] AERB - Policies Governing Regulation of Nuclear and Radiation Safety. Jul 2014.

[4] AERB safety guidelines no. AERB/NRF/SG/IS-1 (Rev. 1) Dec 2011.

[5] Development of Nuclear Propulsion for Marine Applications: A Comparative Study by Cdr Vikram Bora & Cdr RM Singh. Oct 2009

[6] AERB safety code no. AERB/NPP-LWR/SC/D. Design of Light Water Reactor based nuclear power plants. Dec 2014.

[7] AERB safety guidelines no. AERB/NRF/SG/EP-2. Preparation of Off-Site Emergency Preparedness plans for Nuclear installations. Oct 1999.

[8] AERB safety code no. AERB/SC/S. Code of Practice on Safety in Nuclear Power Plant Siting.

Author's Biodata

Capt Vikram Bora (41745-Z) is an alumni of 6th Naval Engineering Course of the Naval College of Engineering at INS Shivaji. He was commissioned on 27 Nov 1993 in the Marine Engineering Branch in the Indian Navy. He completed his post-graduation in Nuclear Technology from BARC, Mumbai in 2002. The officer served as Engineer Officer, INS Gomati in 2011-12 and thereafter as DGM (Auxiliaries and Steam) at Naval Dockyard, Mumbai from 2012-15. The officer is presently serving as Director at the Directorate of Naval Design (Submarine Design Group) at IHQ MoD (N).

Cdr KJ Singh (42460-Z) graduated from the Regional Engineering College Hamirpur (H.P.) as a Mechanical Engineer. He is a Direct Entry Short Service Commission Submarine Officer. He was commissioned on 11 Aug 2003. He completed his Masters in Nuclear Technology from HBNI, Mumbai in 2012. The officer has served onboard INS Sindhughosh as Senior Engineer Officer and Onboard INS Sindhuraj as Engineer Officer and has also held appointments at Naval Dockyard Visakhapatnam and Ship Building Centre, Visakhapatnam. He is presently posted at the Directorate of Naval Design (Submarine Design Group) as Joint Director.

article

21

INTEGRATED FULL ELECTRIC PROPULSION FOR NAVAL SHIPS - CHALLENGES, ROADMAP AND EXPECTATIONS FROM DEFENCE INDUSTRY

(By Capt Lavneesh Dhawan & Cdr C Sahane)

Aim

1. The role of Indian Navy has undergone several transformations over the years, from limited range deployments in the 50s to a truly Blue Water Navy. In the last decade the role of the Navy has been expanded to include coastal security and protecting our economic interests in the Maritime Zone of India. In order to meet the National objectives of Maritime Security, it is imperative that the Navy grows not only in scale, but also acquire superior technologies to maintain an edge to stay ahead of adversaries. The growth of the Navy by means of new acquisitions is based on the MCPP and the cutting edge technologies required for future Ships and Submarines are guided by the recently published document 'Science and Technology Roadmap'. This, coupled with the Navy's vision of 'March to Self Reliance', can only be achieved with a robust Industrial base within the country, and a successful and seamless partnership between the Navy and Industry. The recent initiatives by the Ministry of Defence and Govt of India to promote the Indian Defence Industry for Make in India' are going to give a major boost to the indigenous Naval Ship and Submarine building programme.

2. The aim of this paper is to focus on the need to understand and develop technical expertise in the country related to design, development, maintenance and operations of electrically propelled future generation Naval Ships by means of development of Defense Industry through Information Exchange and Transfer of technology agreements with globally established equipment manufacturers encompassing various aspects of Electric Propulsion. The paper suggests a preliminary strategic roadmap for induction and development of 'All Electric Propulsion' for Naval ships with specific long-term recommendations.

Evolution of Marine Propulsion Systems.

3. Towards the end of the 20th century, the coal burning boilers were replaced by FFO and thereafter by Diesel. Subsequently Internal Combustion Engines (ICE) emerged as suitable successors for merchant fleet and Naval application as a more robust, reliable and far more efficient propulsion option. What cannot be ignored however, is that man's best efforts have always emerged from wars and the aim to gain supremacy over his rival. It is a well documented fact that the most landmark advances in technology have been driven by wars. Be it the advent of jet engines and gas turbines or the first major application of all electric propulsion with the development of submarines. While the U boats and submarines were rumored to have shifted the balance of the battles during the world wars, the concept that emerged from them led to a revolution in itself.

4. Electric drive has a long history dating back to the early 1900s and is used on several platforms, including submarines. The diesel-electric power plant is widely used on submarines allowing the boats to propel themselves underwater while on battery power. However, the electric motor and power conversion technology of the 1960s and 1970s was not sophisticated enough to compete with the advances made in mechanical drive. As a result, the early electric-drive submarines were much slower and more difficult to maintain than their mechanical-drive peers.

5. Since the 1980s, many improvements have been made in electric motors, motor drives, and semi-conductor conversion devices. Modern high-strength magnet materials allow new compact permanent magnet motor designs to provide power sufficient for ship propulsion in a package small enough to make it a viable replacement for the mechanical drives. Permanent magnet motors are being developed for a variety of ship propulsion applications. New solid-state power electronic switching devices allow electric propulsion systems to achieve a level of stealth not possible with even the most advanced mechanical drive. The rapid pace of improvement in these devices will further allow the Navy to upgrade the motor control capabilities installed in tomorrow's platforms without having to replace the entire propulsion motor and drive at great cost.

6. With the advent of high power density motors and drives, IFEP has been a major propulsion change for warships. However, there is likely to be an impact on the remainder of the electric warship. Current generations of marine prime movers operate on one of two power speed characteristics either the constant speed required by electrical machines that generate a fixed frequency or the propeller law required for direct mechanical drives. An electric warship prime mover need not be constrained by the ship's power speed curve, but neither does it need to be a fixed frequency. Technology provides the opportunity to optimise for efficiency.

All Electrical Propulsion (AEP)

7. In today's conventional propulsion systems, power is generated by a diesel or gas turbine engine, which mechanically powers the propeller shaft through a series of reduction gears. Ship's service generators convert mechanical energy into electrical power for combat systems and other loads. In an integrated electric power system, the propulsion and auxiliary generators are replaced with only main generators as the prime movers. These main generators convert all the available power into electrical power, which is then sent to a common electrical bus for allocation.

8. Through flexible distribution and switching architecture, the common electrical bus can supply electrical power to both non-propulsion and propulsion electrical loads and instantly redistribute power as necessary. For propulsion, electrical power from the bus is sent to a motor drive (often referred to as a motor controller), where the voltage and frequency of the electrical energy are modified to operate the propulsion motor at a desired speed. The propulsion motor then converts the electrical energy delivered by the motor controller into mechanical energy to rotate the propeller shaft.

9. As is evident from Fig. 1 below the rigid alignment of reduction gears and a long shaft required by mechanical drive is replaced by the flexibility of an electric motor and a short shaft. Cables, instead of a shaft, connect the turbines to the propulsion motor and provide architectural flexibility for the designer to make space available for payloads, improve the ship's stealth, and ease construction and maintenance. More importantly, because the power of an integrated electric system is consolidated on a common electrical bus, the power previously reserved exclusively to propel the ship at high speeds is now available for other uses when high-speed propulsion is not an operational requirement.

10. The advantage of the electric warship over conventional propulsion configurations (COGAG/ CODAG) that is virtually impossible to quantify, is the flexibility of layout. Conventional mechanical

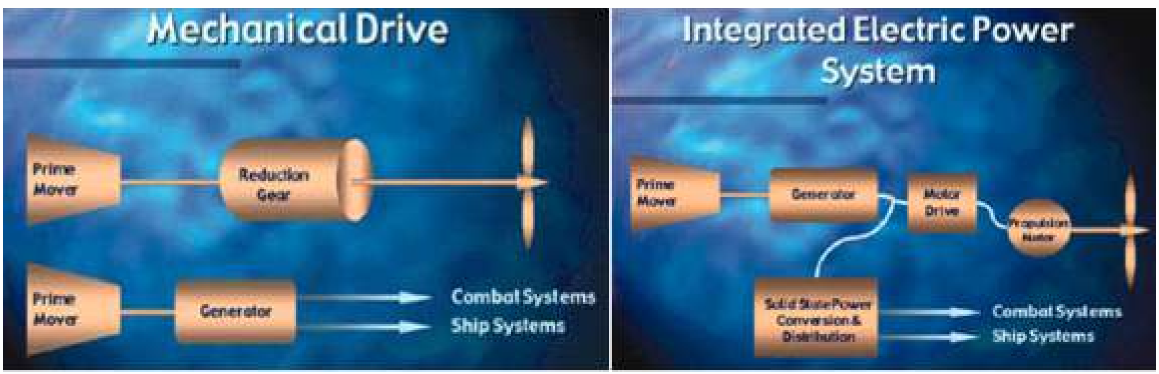


Fig 1: In contrast to a mechanical drive system, an integrated power system requires fewer prime movers and offers significant architectural flexibility

drive installations suffer the tyranny of the shaft line', ie the gearboxes and prime movers must be located such that they are aligned with the shaft and this leads to the traditional arrangement, with exhausts well forward from the stern. In frigate hull forms the prime movers are close to halfway down the length of the vessel. With the electric warship the small propulsion motors can be well aft, with short shafts inside the hull or, if the motor is small enough, mounted outboard in pods. With cable as the only interconnection the prime movers can be mounted anywhere in the ship, adjacent to maintenance routes, where they are least likely to suffer action damage or where they are least likely to stimulate vibration or put noise energy into the sea.

Need for All Electric Propulsion for Naval Ships

11. 'Integrated Full Electric Ships (IFEP) offers significant design and technical advantages as well as operational superiority. All electric propulsion is a natural choice for a long list of ship types, for reasons such as, fuel savings, emission reductions, redundancy, low noise and vibration signatures, ease of operation / maintenance, optimum space utilisation and lesser manning requirements. Moreover, IFEP has a lower 'Life Cycle Costing' (LCC) than a conventionally propelled ship. The implications of lowered LCC are multifold viz. increased force levels, greater ease of obtaining sanction for induction programmes, and the option of leveraging the innate 'Green' benefits for economic advantage. Also, the unified modular system architecture of IFEP along with increased

automation and reduction of auxiliary systems contribute to a very substantial augmentation of overall increase in reliability, stealth features and survivability. Detailed attributes and advantages that makes IFEP as a preliminary strategic technological choice for Indian Navy are given below :-

(a) **Commonality of Equipment.** The total power required for propulsion and other general ship support functions can be provided by one common set of generators. There is no longer a need for specific electrical power plants for ship service or for additional cruising speed diesels as in a Combined Diesel or Gas (CODOG) propulsion configuration. Electrical energy can easily be added up. The number of electrical prime movers can therefore be optimized with respect to expected cruising/ speed profile.

(b) **Reduced Moving Parts** Use of electric propulsion results in significant reduction of reciprocating or rotating machinery onboard a ship. The use of flexible cables as transmission media for electrical energy obviates the requirement of long rotating propeller shafts. Propulsion motors with small diameters can be located more aft, thus drastically limiting the requirement of support bearings and brackets. The shafting can be removed altogether by application of podded propulsion.

(c) **Redundancy of Gearboxes** With electrical propulsion there is no longer any necessity to use mechanical gear boxes, which are a considerable source of noise.

(d) **Location of Noise Sources** Prime movers in these platforms can be practically located well above the waterline, thereby having the advantage of significantly reduced radiated noise. The fact that there is no direct connection of propeller shaft and prime mover results in reduced stresses and vibrations. Moreover, as the main components of AES can be installed nearly anywhere on board, this concept can also be realized on surface combatants with unconventional hull forms such as SWATH (Small Water-plane Area Twin Hulls), SES (Surface Effect Ships) or Trimarans that are best suited for low noise uses.

(e) **Optimised Utilisation of Prime Movers** The ease of adding up the electrical energy enables the minimal number of prime movers to be used, depending on the cruising profile. Excess power generated by a source can be utilised by supplying it to auxiliary systems, thus eliminating the need for secondary generators.

(f) **Economy of Operations** Helps reduce the life-cycle cost by lowering expenses on fuel and also maintenance costs on associated equipment.

(g) **Reduced Noise Levels** Advancements in motors, like the development of permanent magnet motors, also significantly reduce electric hum and noise.

Electric Propulsion in IN

12. The concept of electric propulsion in the Indian Navy dates back to the induction of conventional dieso-electric propulsion for submarines. The second area of operations where the IN

delves into the electric propulsion paradigm is INS Amba, a submarine support vessel inducted in 1968 which had an Electric Propulsion System, although in the Low Voltage (LV) ranges. Unlike LV range technology, IFEP is based on MV. The development in concomitant technologies has largely influenced the modern All-Electric Ship (AES). Research on the AES concept is being aggressively pursued by a closed, select group of navies in collaboration with a well-developed defence industry in the backdrop of enormous political and financial backing. Only few advanced Navies in the world possess combatants with Integrated Full Electric Propulsion (IFEP) today.

Indian Navy Multi Role Support Vessel Programme (LPD)

13. Considering the fact that the IFEP technology is being exploited onboard modern day warships of foreign navies today, the Indian Navy has planned to induct 04 LPDs based on this technology, these vessels are likely to join the IN stable within the next few years. Induction of this technology has to be well planned and executed so that the equipment can be maintained and exploited in the most efficient and effective manner. Formulation of Policy on Maintenance of IPS and IFEP and its related power system components represent a level of technology and application hitherto not seen in the IN. Therefore maintenance challenges that these systems present, needs to be planned by formulation of clear policy well in time prior induction of this technology into the Navy.

14. These LPDs would powered by Integrated Full Electric Propulsion package and is envisaged to consists of following major components :-

(a) HV Diesel Alternators.

(b) HV and MV Switchboard.

(c) Propulsion Motors, Converters and Transformers.

(d) Bow thrusters along with drive transformers, converters and motors.

(j) Propulsion Control System.

15. **Broad Technical Requirements for IFEP Components for LPD**

(a) **HV Diesel Alternators** HV Generators of appropriate voltage or any suitable HV as per requirement are envisaged to be used along with suitably powered prime mover.

(b) **Bow Thrusters** Bow Thrusters commensurate with the size/ displacement along with drive transformers and thrusters for station keeping to enable better manoeuvrability

(c) **Propulsion HV Motors and Converters** Suitable AC continuous duty induction/ synchronous motor, along with Propulsion Drive Converters and dynamic braking system.

(d) Main Switchboard (HV MSB) and LV Switchboard The main MV switchboard as per IFEP design requirement and LV switchboard for 415V along with suitable transformers and other components.

(e) Propulsion Control SystemThe propulsion control system in addition to the conventional control facilities is envisaged to have following additional features :-

(i) **Propulsion motor speed and Torque control** In addition to the propulsion variation requirement, the required torque will also be governed by means of internal safety signals such as over temperature and external such as propulsion limitation system and process limitation such as thrust bearing maximal torque during astern rotation etc.

(ii) **Propulsion Limitation System** This system planned to be independent or combined with power management system which should be designed to adjust the propulsion power request in line with the power plant available power and would mainly consist of following sub systems :-

(aa) **Anti-Overload Limitation** Monitoring of each generators active and reactive power to limit the propulsion torque to avoid generator overload. This system shall take care of power plant by anticipating the frequency and voltage variations due to transient loads of the network.

(ab) **Anti-Black- Out Limitation** In the event of major problems such as trip of several DAs at the same time, the propulsion power is supplied by remaining operative generators which will then be highly transiently overloaded and could cause a chain reaction and black out. An anti black out system needs to be incorporated to continuously monitor and control the requested power in case of variation in voltage/ frequency.

IFEP - Indigenisation Plan for IN

16. The Indian Naval Indigenisation Plan (INIP-2015) document published by MoD in 2015 also spell out the future requirement of IFEP. While the considerable progress has been achieved toward indigenization and production of components related to the conventional propulsion plants (excluding Gas Turbines), the modern day Integrated full electric propulsion technology is relatively new to the Indian Navy. However, most of the elements required for this technology in warship applications are already available in international and the Indian commercial market. Indigenous production and high capacity power electronics/ HV/ MV systems design capabilities are planned to be developed though ToT route

Induction and Development Roadmap for IFEP in IN

17. IFEP technology is gaining a strong foothold in the field of Marine Propulsion and with its planned induction in the IN onboard LPDs, there is requirement to harness this technology and accrue maximum benefit from the same. This will pose new challenges that need to be addressed in a timeframe commensurate with the induction of this technology. The tasks involved in this will include the following:-

(a) Development of onboard operation, maintenance and repair philosophy.

(b) Development of new training programme and restructuring of existing Training programmes and augmentation of training facilities.

(c) Development and setting up of necessary infrastructure at repair yards to repair and maintain MV/ HV components. This is required to be undertaken in consonance with the respective shipbuilding projects to ensure concurrent availability of the maintenance infrastructure and obviate gaps between induction of platforms and support infrastructure.

(d) Formulation of procedures and methodologies for acceptance, trails and testing/ tuning of electric propulsion equipments and associated subsystems.

(e) Development of R&D programmes in the field of IFEP for Gradual adoption and planned transition to future technologies

(f) Development of new safety procedures and fire fighting techniques along with associated training infrastructure.

Requirements/ Expectations from Defence Industry

18. The active participation of Indian Defence Industry and R&D establishments will be critical for developing the requisite baselines of expertise and infrastructure for production, future maintenance and repair of IFEP systems. From a global perspective, the Indian defence military-industrial complex is reasonably mature and experienced in dealing with development, delivery and field support for advanced technology intensive systems such as IFEP. The active participation of commercial and military ship end-users, shipbuilders, classification societies, machinery and equipment manufacturers, research institutes, universities, and other organisations must further add to the overall efforts of indigenous development of IFEP technology to a level that permits effective application and support future Electric IN ships. Towards this development in the following fields is expected from Indian Defence Sectors :-

(a) Development and production of different types of advanced MV and HV propulsion motors.

(b) Development and production of motor speed control and power conditioning equipments.

(c) Development of technologies aimed at improving efficiency and reliability of the various components of the power conditioning system like transformers, rectifiers, converters, Pulse Width Modulator etc.

(d) Development and production of power distribution/ management, equipments.

(e) Development of new and effectiveness fire fighting systems/ techniques inside High Voltage (HV) compartments.

(f) Development of simulators, land based training facilities and De-risking/ Technology demonstration facilities.

(g) Development of the expertise in the field of Propulsion system integration for all electric propulsion and optimization of design.

(h) Development and production of advanced personal protection equipments (PPE) for working on HV/ MV equipments and systems

(j) Development of advanced tools, test equipments and calibrators.

(k) Development of Fuel Cell based power generation and 'Stored Energy Concept' for 'All Electric Propulsion' ships.

(l) Development of Research and Training Facilities by OEMs.

Conclusion

19. The technologies supporting the electric ship concept continue to move forward and further incremental advances in efficiency and operational effectiveness are expected as IN is planning to emphasis on migration from conventional to 'Integrated Full Electric Ships (IFEP)' in near future. Also, stricter environmental legislation and emission norms will dictate norms for electric ships to a greater extent than ever before and therefore there is a need to develop an all round expertise in the field of electric propulsion ships.

20. The commercial and civil industry worldwide has achieved significant success in the field of design and development of propulsion and power generation components for electric warships and similar development of Indian Defence Industry would be of great help to IN whilst handling challenges related to induction, development and operation of future generation electric warships. The blue print for future Navy is firmly anchored on Indigenisation and self reliance and therefore, priority needs to be accorded for developing, integrating, inducting and managing high-end electric ship technologies indigenously or with partnership of established foreign OEM for enhancing the domestic industrial base.

References

1. An Integrated Electric Power System: The Next Step by ADM Frank L. "Skip" Bowman, USN

2. Electric Propulsion: A Strategic Choice for The Indian Navy. Commander PS Vombatkere.

3. White Paper on Integrated Full Electric Propulsion for Naval Ships, Directorate of Marine Engineering, IHQ MoD (N).

4. Integrated full electrical propulsion system (IFEP) operation and maintenance philosophy for the Indian navy. Project Study by 21st TMC course.

5. Indian Naval Indigenisation Plan, DOI Document – 2015.

6. The State-of-the-Art of Integrated Electric Power and Propulsion Systems and Technologies on Ships. Dr. Timothy J. McCoy and Dr. John V. Amy Jr.

7. The electric warship then, now and later. C G Hodge BSc MSc CEng FIMarEST FREng & D J Mattick BSc CEng MIET FINucE FIMarEST.

8. Electrical Propulsion in the Low Carbon Economy Ian Whitelegg, Richard Bucknalla

9. The State-of-the-Art of Integrated Electric Power and Propulsion Systems and Technologies on Ships Dr. Timothy J. McCoy and Dr. John V. Amy Jr.

10. Report on Advanced Naval Propulsion Technologies Directorate of Marine Engineering, IHQ MoD (N).

11. Extract of Minutes from India-United states joint technical group (JTG) meeting 17 august. 13-14, 2015.

12. Indigenisation in Indian Navy - An overview. Cmde Aseem Anand Additional Director, Defence Machinery Design Establishment.

13. The Electric Warship VII - The Reality. Commander GT Little, Royal Navy Eng(Hons), MSc, MCGI, psc(j), Royal Navy, Commander SS Young, MSc, CEng, MIMechE, Royal Navy, and Commander JM Newell, BSc, MSc, CEng, FIMarEST, Royal Navy No. B2 Journal of Marine Design and Operations.

Author's Biodata

Capt Lavneesh Dhawan was commissioned into the Engineering Branch of the Indian Navy in Jan 1997. The officer completed his BE (Mech) in 1996 from INS Shivaji, Lonavla. His afloat appointments includes tenure as AEO onboard INS Udaygiri, Senior Engineer Onboard INS Brahmaputra and CDR 'E' tenure onboard INS Betwa. The officer's ashore appointments include, Joint Director at Naval Dockyard (Mb), Joint Director at DIT and DND (SSG). The officer is presently posted as Director at DME at IHQ MoD(N).

Cdr CA Shahane, was commissioned into the Engineering Branch of the Indian Navy in the year 2002. He has completed his BE (Mechanical) in the year 2001 from MGM College of Engineering, Nanded (Maharashtra) and MTech in Mechanical Engineering from Defence Institute of Advanced Technologies (DIAT, DU) in 2013. His afloat appointments includes tenures as Assistant Engineer Officer onboard INS Talwar, Engineer Officer onboard INS Vidyut and Senior Engineer Officer onboard INS Talwar respectively. The ashore appointments held by the officer was Deputy project Director at INS Shivaji Lonavla. The officer is presently posted at Directorate of Marine Engineering at IHQ MoD (N).

article

22

MAKE IN JAPAN TO MADE IN JAPAN: INDIGENISATION LESSONS FROM THE IMPERIAL JAPANESE NAVY 1880- 1941

(By Rear Admiral Sudarshan Shrikhande)

In your opinion, what is the major difference between the Imperial Japanese Navy and the JMSDF?
The name[1].

Anonymous Lieutenant Commander, JMSDF
(Command & Staff Course, Maritime Staff College, 2005)

Introduction

Although Japanese governments of the early 20th century had begun working quite closely with the British government in London and with the Colonial government in India (during Curzon's time), it was, strangely the Imperial Japanese Navy's unambiguous victory over the Tsarist Russian Navy at Tsushima during the ongoing Russo- Japanese War of 1904-1905, that perhaps impressed many Indians including a young Jawaharlal Nehru and Mohandas Gandhi[2]. Nonetheless, the story that I shall try and narrate this afternoon is not about the political outcomes of this very decisive battle at sea, nor about the strategy and tactics of the Imperial Japanese Navy (IJN) but about the way in which this Navy, and effectively a newly energized Japan consequent to the Meiji Restoration (1868), went about making a 'Make in Japan' fighting navy that in the next twenty years was well on the way to becoming a 'Made in Japan' force. By the end of 1920s, the IJN was a self-reliant navy in its true sense. They had achieved 'Jiritsu' (self-reliance, or 'swavalamban' in Hindi) under some very challenging circumstances and beginning from an almost novice level of technical achievement and technical education at the start of the Industrial Age. In 1870, Japan could be said to be well behind colonial India in most parameters. Moreover, it would not be incorrect to say that Japan, at the dawn of the Meiji era in 1868, or even perhaps in the 1890s was still more disadvantaged than India was at the dawn of her own freedom in 1947. How did they do it? How did the Japanese nation and her navy first ignite and then sustain the fire in their belly to overcome their odds? How did they continue to “Bend(ing) Adversity” as the title of a fine book suggests and which was pointedly reviewed by Shri Ram Madhav under a title “Make in India, Learn From Japan”?[3] What indeed could we learn from something that began nearly a century and a half earlier and still be considered of relevance today as our own nation begins its quest to “Make in India”? Let me try and bring you the story.

---

[1]Alessio Patalano, Post-war Japan as a Sea Power (New York: Bloomsbury, 2005), 61. The book end note explains that this was quoted from Namae nomi, Anonymous Lt commander, JMSDF, 20 August, 2005. The book provides an excellent review of the linkages between the IJN and JMSDF in terms of spirit, tradition and legacy. On page 31, the author writes “ As a former naval officer put it after the Pacific War, in the Japanese navy an officer was a 'patriot, a seaman and a gentleman'... “ The story being attempted in this paper is underwritten by a sense of patriotism that permeated through most activities in the indigenisation of the IJN.

[2]Sudarshan Shrikhande,”Fear, Honour & Interest: The Wake And The Bow Wave of the Dynamics of the Indo-Pacific” in Perspectives of the Indo-Pacific Region: Aspirations, Challenges And Strategy, ed Sandeep Dewan (New Delhi:United Service Institution of India, Vikas, 2014), pp 78-80. Nehru as a young student in England suddenly visualized 'Indian freedom and Asiatic freedom from the thralldom of Europe.' In Africa, as relatively unknown lawyer, Gandhiji predicted 'so far and wide have the roots of Japanese victory spread that we cannot now visualize all the fruit it will put forth.' As Viceroy, Curzon, too, feared that 'the reverberations of that victory have gone like a thunderclap through the whispering galleries of Asia'.

[3]Ram Madhav, “Make in India, Learn From Japan: Post-war Japan bent adversity into opportunity. Can Team Modi do the Same?”, Indian Express, August 1, 2015, 15. This writer was inspired to read the remarkable book reviewed in the newspaper; David Pilling, Bending Adversity: Japan and the Art of Survival (London, Penguin, 2014).

FUKOKU KYOHEI : Rich Country, Strong Army[4]

The Essence

Fukoku Kyohei was a simple, yet clear slogan that was in some ways an apex policy guideline for Japan in its quest to becoming a great power. The restoration was a de facto revolution that altered the structure of their feudal society. For this, "manufacturing a sense of national identity became essential."[5] Pilling summarises the Meiji ethos thus: "As such, their determination to learn from the west was often wholly practical. Japan must learn how to make trains, guns and floating battleships mastered by westerners, not because they were inherently honourable things to do, but because they were the tools with which they could stand up to western aggression. Their working thesis: know thine enemy."[6] Importantly, Fukoku kyohei was not a bumper sticker for Japan; it was a guiding principle for achievement.

Guns and Floating Battleships: Kaigun

In this paper, we shall confine ourselves to the indigenisation of the IJN although the overall achievements of Japan from 1870s and once again, from the ashes of the Second World War are equally inspiring. The Nihon Teikoku Kaigun—the Imperial Japanese Navy— was in its infancy around the time of the US Civil War. "(It), however, did not have the precursor of tradition, the naval infrastructure, or the industrial backing that the Americans did. Within forty years Japan had reached fifth place in the world's navies and, by 1920, was clearly in the third place. In another 20 years it was prepared to challenge the U.S. Navy and, in the three and a half years of naval war that followed, the Japanese Navy gave a good account of itself against the greatest naval force on the globe. This was a remarkable achievement."[7] In comparison, the (Royal) Indian Navy, and India were better poised in 1947 for rapid growth and indigenisation than Japan was in the early years of the Meiji era. Therefore, where should we ought to be in 2047 which is but just thirty-one years away? The IJN provides us some pointers.

The Beginnings of Foreign Collaboration & "Make in Japan"

Apart from seeking Dutch help in starting a small naval training centre at Nagasaki in the late 1850s, a few years after Commodore Perry's visit to Tokyo in 1853, the major step was in obtaining French help in setting up the Yokosuka Navy Arsenal in 1865.[8] The Kaigun's childhood was quite problematic. It often was considered subordinate to the Navy; was sometimes starved of funds; and the political leadership did suffer what we now call bouts of sea-blindness. In the next few

---

[4] *David Pilling, Bending Adversity: Japan and the Art of Survival (London, Penguin, 2014)316. This was a slogan from the Meiji era that the current Japanese Premier Shinzo Abe makes clear links to as he steers his country once again to greatness.*

[5] *Pilling, Bending Adversity, 50.*

[6] *Pilling, Bending Adversity, 66-67.*

[7] *David C. Evans and Mark R. Peattie, Kaigun: Strategy, Tactics, and Technology in the Imperial Japanese Navy, 1887-1941 (Annapolis, USNI Press, 1997) xx. This remarkable book has provided the author of the paper with a deep understanding of the Kaigun in much of its complexity encompassing the "dos and don'ts" at the levels of strategy, operations, tactics and the intimate connections with technology.*

[8] *Evans and Peattie, Kaigun, 5. The Yard built a few ships to French designs. The Shogunate also purchased some French ships outright that were sail and steam powered. None of these were large 'first rates". A French naval architect, Verney set it up. Japan celebrated the Yard's 150th anniversary recently.*

years, the IJN gravitated towards the British Royal Navy (RN). While the choice of partnering with the RN made good sense, it is likely that the belligerent behaviour of a British squadron's bombardment of the port of Kagoshima (1863) during the so-called Anglo-Satsuma and Shimonoseki wars of 1863-64 ironically helped in the shift.[9]

"Skill Japan". Some of IJN's early leaders realised that people and their skills were critical. They "were quick to exploit this situation, recognising that the mid-century revolution in naval technology made technical competence as important as the traditional skills of seamanship...to give initial priority to the education and training of officers and men rather than to the acquisition of additional naval units."[10] We need to note here that the importance given to education, training and skill development was a common thread at all levels in Japan. Not only the Kaigun, but the fledgling Yards owned by the Navy, private yards, most industries and newly set up research laboratories put in men and precious money into skilling. This required foresight as well as sagacity especially when neither success nor profits could be taken for granted. This paper shall illustrate, in the case of the Mitsubishi Nagasaki Shipyard, how skill- building led from a capacity to absorb technology to evolve into hardware that was ultimately Japanese and often better than the imported or license- produced precursor.[11] An understanding of the Japanese environment in the Meiji epoch shows us that the spirit of Fukoku kyohei, Rich country, strong army, seems to have been much more than a slogan; it was a driver for indigenisation. We could pause and consider what could have been the impact of a nation-wide, serious effort beginning in 1947-48 towards "Skill India"? Was India's independence any less significant than the Meiji Restoration in 1868?

Building a "Swadeshi" Navy and not Merely Hulls

In examining the progress towards "Made in Japan", (Nihon-sei)[12], it would be accurate to state that from the earliest years of the Meiji era, the IJN's leadership seemed to be quite clear that a self-reliant navy would need to be Japanese in all its manifestations: Float, Move and Fight. They were under no illusions that this would be quick or easy, but they were very determined that it would need to happen. Further, they were very quick to appreciate the technological progress that was taking place in European navies as well as in the USA. At this stage, just a few illustrations provide evidence of their perspicacity. Their efforts towards development of turbines and higher pressure boilers: the Move component; secondly, in visualising the benefits that wakeless torpedoes with longer ranges could bring to surface ships or improved fire-control systems to gunnery and torpedoes, as well as world class optical devices: the Fight component; and the potential of leveraging foreign help to make long- range submarines that could—and did-- range into the Pacific as well as Indian Oceans: the Float component.[13] The road was neither easy nor the results of their

[9] *Shrikhande, in Perspectives, 81.*
[10] *Evans and Peattie, Kaigun, 10.*
[11] *Yukiko Fukasaku, Technology and Industrial Development in Pre-War Japan: Misubishi Nagasaki Shipyard 1884-1934 (London: Routledge, 1992). The book is based on a doctoral thesis of the role played by Mitsubishi's Nagasaki Yard. It enables an excellent insight into the methods by which the Japanese gave shape to a self-reliant IJN.*
[12] *Translation provided by Samik Sikand, language -research scholar based in Japan. According to him, "Make in Japan" could be translated as "Nihon de seizou suru".*
[13] *Author's research shows that the examples as given in the referenced books ibid, and subsequently richly demonstrate their resolve to move simultaneously on Move-Float-Fight fronts.*

efforts necessarily spectacular. Nonetheless, the wisdom of simultaneously progressing on all fronts is inarguable. The need for so doing was felt from the early days of the Restoration. However, in many ways, the fleet under Admiral Tojo's command at Tsushima in !905 was still a “Made in Europe” fleet for the major ships including their “move and fight” elements. At the same time, many of the smaller ships, some of the major ships' armament as well as ordnance, were a combination of “Make/ Made in Japan.” Importantly, while the battle of Tsushima Strait was a very short one, the Russo- Japanese War lasted for two years. Again, while it did not deeply participate in the First World War as a key belligerent, it was more than a mere bystander to the expenditure of blood, treasure, and ordnance. IJN patrolled the Mediterranean with a squadron of destroyers; other officers were embarked in RN ships during the war and sent detailed reports. Lessons learnt were incorporated into the very same Float-Move-Fight constituents of a navy's overall punch. In fact, Japan became an exporter of many engineered items like railway rolling stock, merchant ships and ordnance to Britain in this period. Japan seems to have acquired a grasp of wars lasting much longer than the initial optimism of a quick victory by war planners. Licensed- production could and did provide the initial means to ultimate Jiritsu (self-reliance), but were not felt to be adequate as a long-term answer or as a sustainable way to becoming a great power.

Naval Aviation: Not Merely Fly, but also Move and Fight

Early Bird Vision. The mental agility of much of IJN's leadership as well as the vision some of them had in recognising the potential of military aviation was quite remarkable. **Today, it is fashionable—but also right—to think of adopting and adapting to disruptive technologies ahead of their “activation”** dates; but often societies, nations, companies or navies fail to do so. Aviation was one such disruptive development. Between 1903, when the Wright brothers flew at Kitty Hawk and the IJN's 1909 “decision to develop a capability in this new medium”, there was not much that seemed viable in aviation that could be a realistic naval fighting instrument.[16] The focus of this paper being ship and of course, submarine- building, aviation aspects are only briefly mentioned below.(For this author, this is a related area for study and also has similar and equally significant pointers for our own country as military aviation also moves towards “make in India” and to “swadeshi”.)

Fly, Move and Fight. As in the case of ships and submarines, **the IJN saw aircraft as a conglomeration of systems that all needed to be made indigenously**. Ultimately, the large seaplanes (eg the Kawanishi H8K1), Nakajima B5N Type 97 carrier attack bomber, the Aichi D3A Type 99, carrier dive bomber, a famous fighter like the Mitsubishi A6M2 Model 21 Type 0 (“Zero”) or the Mitsubishi G3M2 Model 22 and G4M1 model11 bombers were technologically advanced, reliable and cost-effective.[17] In terms of “Move”, the engines made by Nakajima and Mitsubishi Kinsei, were versions of Curtiss and Pratt-Whitney imports. **These were not always better than the ones being developed and flying in US or British aircraft but sufficed in view of the constraints in**

[16] *Mark R. Peattie, Sunburst:The Rise of Japanese Naval air Power 1909-1941 (Annapolis, USNI Press, 2001)1. One of the authors of Kaigun, ibid, Peattie presents a detailed account of IJN's aviation achievements and ultimate failure. Read in conjunction with the details given in Kaigun, the book seems especially useful.*

[17] *Peattie, Sunburst and Evans & Peattie, Kaigun. Observers of the current Indian defence media may recognise that the Shinmaywa company offering the US-2 amphibian for manufacture in India was the Kawanishi company in Imperial Japan.*

materials, closure of technology infusion from the West and pressures of war itself. Importantly, for Japan, they were "swadeshi". In terms of aviation ordnance, the IJN used its own Arsenals towards developing and making bombs and torpedoes as well as smaller calibre ammunition for aircraft cannons. It could leverage the considerable expertise it developed for large caliber gun ammunition as well as torpedoes. Eventually, the private sector was co-opted for production of ordnance of several types.

However, Lack of Jointness! A reader should not get an impression that sagacity permeated all decision-making in the IJN. The navy was quite reluctant to work in tandem with Japanese Army aviation to achieve better research, design and development, cost- savings and even combat-training outcomes as well as in ordnance manufacturing. Much more could have been achieved had the overall relationship between the Army and Navy been better. Japanese occupation of China and subsequent operations in WW II provide some egregious examples of lack of joint planning and execution between the services. For instance, the Japanese Army, had to build escort carriers converted from merchant ships and crewed by civilians to protect its logistics convoys at sea!

Apex Structures and Policy Matters for Jiritsu (Self-reliance)

Kaikoku Nippon. Is it just a coincidence that the phrase "Maritime India" used for a Summit held in Mumbai earlier this week (14-16 April, 2016) or is there something to learn from Kaikoku Nippon, Japanese for "Maritime Japan"? In 1885, the Japanese navy kick- started this campaign "to magnify the Japanese presence in the west Pacific through increased naval strength and the construction of a modern merchant marine. The public enthusiasm resulting from this effort helped to contribute significant support within the government for the modernization and expansion of the navy."[18] We should also note that Alfred Thayer Mahan's similar attempts at educating the American political leadership, the people as well as the officers of his own navy was still a few years away. (Mahan's best- known book was published in 1890). The propaganda helped maintain a focus, furthered by Japan's growing ambitions as well China's efforts to thwarting the former's aspirations in Korea; on the need for technological infusions; larger budgets; as well as the enhancements of Navy Arsenals and private companies in commercial as well as naval shipbuilding. Actually, this campaign followed, not preceded, naval reforms. In 1872 a separate Navy Ministry was formed which initially had largely civilian officers. Admirals, with experience at sea, soon were inducted and slowly their influence increased. Saigo Tsugumuchi, a Satsuma politician was a wise Navy minister (thrice: 1885, 1887-90 and again during 1893-98), a superb talent- spotter and ***"his support and engagement to those younger officers dedicated to its modernisation"*** resulted in a young officer like Yamamoto Gombei (not to be mistaken for the better known Yamamoto Isoroku of WW II fame) having a 40-year period in which to leave his mark not only on the IJN as an admiral, but as Navy minister and twice as Prime Minister.[19] Yamamoto "***stripped the navy of its deadwood, battled the army for public attention and government support, and induced the Japanese Diet to provide funds for a major battle fleet***.[20]

---

[18]*Evans and Peattie, Kaigun, 19.*

[19]*Kaigun, 20-21. Yamamoto stands in the pantheon of admirals like Tirpitz, Fisher, Gorshkov, Rickover, Arleigh Burke who all rocked the boats of their own navies mainly as peacetime admirals and displayed the vision that prepared their navies for any future wars. They all had longer than customary tenures and generally did well for their navies. In the case of Fisher or Zumwalt, history gave them greater respect than their contemporaries were willing.*

[20]*Kaigun, 21.*

Organisational & Personnel Reforms. "Skill Japan," as we have seen earlier, was pursued everywhere. The IJN was no exception. The new Academy at Etajima broad-based its selection on merit rather than class.[21] This was not a small or an easy transition for a traditional society and needed the shake-up of the Restoration for it to be possible. Technicalisation was also pursued. A few decades later, these officers formed the nucleus of not only their own Navy Arsenals/ Yards but of many companies as well and some actually founded their own. Nakajima corporation was one such. A Navy Staff evolved, in parallel with the changes taking place in the Royal Navy. Although the IJN interacted with many navies in Europe, sent a few officers to US Navy colleges/ schools, it cooperated most with and patterned itself on many training methods of the RN. An Indian reader may well imagine that the IJN was an intellectually poor organisation, given the strict discipline, bushido code or environment of deference. **In those early years, in fact, the opposite was true**. Navy Minister Saito encouraged the formation of the ***Sukosha***, a naval officers' professional organisation in 1896. The US Naval Institute had been formed in 1873. The RN did not form an equivalent until 1912. Even so, the British Naval Society was a small informal group of Young Turks that was quite frowned upon by the RN's conservative leadership more often than not. The Sukosha had "leading bureaucrats, editors, bankers, businessmen, and Diet members."[22]

Political (Policy) Alignments. This paper does not have the space to go into the consequences of Japanese victories in the 1894-95 war with China where, despite new possessions, the situation became tense with Russian ambitions in the Far East to get greater access to Pacific coast's warm-water ports and for the expanding the Trans- Siberian Railway. Japan feared the "Tri-partite" alliance between France, Germany and Russia. Not being strong enough, it ceded some territory and influence to Russia despite being the victor. "Fukoku-kyohei" once again became more important and resulted in clear preference for an alliance with Britain and British help in buying ships in Europe and for "Make in Japan." As Evans says, "it was the Anglo-Japanese Alliance of 1902, largely naval in its implications, that assured Japan freedom of action without the interference of other maritime powers and encouraged the Japanese navy to think of dominating East Asian waters."[23] Although the relationship with France weakened, the IJN continued to study them closely and even interacted with Germans. As such, no windows were closed for naval technological infusions despite shifting political winds.

Naval Plan 1896. Yamamoto Gombei's 1896 Plan called for a 260,000-ton navy over a ten-year period. Salient aspects of this plan were:

- Four battleships (two "buy in Britain; two license- built in Japan). These were to be stronger and more powerful than what the British yards initially offered. Qualitatively, these ships had to be better than the "state-of-the art"). This remained a IJN principle even in foreign design negotiations.

---

[21]*Kaigun, 10. An Academy was initially set up in 1869 near Tokyo. In 1888 it moved to its location at Etajima where it stands even today. Alessio Patalano, in his book, Post-war Japan as a Sea Power (New York: Bloomsbury, 2005), (qv footnote 1) describes how the present JMSDF maintains its spiritual connections between today's Academy with that of the IJN's era.*
[22]*Kaigun, 24.*
[23]*Kaigun, 53.*

- Four armoured and four protected cruisers. Interestingly, IJN managed to have two cruisers of Armstrong-Vickers design built one each at the German Vulcan Works, Stettin and one at St Nazaire, France! What was difficult enough to do domestically, they managed among three countries!

- Destroyers: 23; Torpedo boats: 63. Most of these were built in Japanese Yards, mainly private. Navy Arsenals were tooled to build larger ships.

- Expansion of Japanese yards, repair and training facilities.

- Capabilities- based planning and a clear understanding that today's allies may not be tomorrow's friends.

- This plan and follow-ons became quite dynamic due to newer possibilities, technological developments, more/ less money and greater domestic shipbuilding consequent to growing industrialisation.

- An insistence on compatibility of gun turrets and ammunition across classes for better ease of "make in Japan" and for repairs.[24]

Forging a Nation: Leveraging Research, Design & Development

Whole of Country Approach to Technology. In the Foreword to Dr Fukasaku's thesis, the guides succinctly observe "***that competitive advantage is not God given. Japan's shipbuilders assimilated and in some time surpassed, foreign best-practice technology, and became a major world force in the industry. But this process of technological accumulation took time and involved industrial firms, and academic and financial institutions, as well as government policies. It was very different from the assumptions of strategic trade theory, that governments can create a competitive advantage by giving firms a quick pre-emptive nudge down the learning curve***."[25] The other important aspects of an integrated approach by Japan to science and technology based on Dr Fukasaku's study of Japan and specifically the Mitsubishi Nagasaki Shipyard (MNS) enable interesting inferences. A word about this Yard may be in order here. The Nagasaki Yard of the Government was leased to the relatively young Mitsubishi corporation in 1884. This company was already manufacturing some merchant ships, engineering machinery and railway equipment. Today in India we might call it the culmination of a Public- Private Partnership (PPP) model. The MNS study enables us to bring out the following broad points on science and technology:

- Technology imports and development of indigenous technology were concurrent and complimentary. There is not much merit in emphasising a "late-comers" advantage in leveraging current technology. Japan in general, and Mitsubishi in particular did not have any such facilitation. Western collaborators did not happily or easily enable technology transfer (TOT).

---

[24] *Kaigun, pp 53-63. From Chapter 3, Preparing for Battle.*
[25] *Yukiko Fukasaku, Technology and Industrial Development in Pre-War Japan: Mitsubishi Nagasaki Shipyard 1884-1934 (London: Routledge, 1992). In Foreword by Professors Freeman and Keith Pavit.*

➢ **"Thus the problems associated with transfers of technology were seen to reside with the suppliers, while the recipient firms and countries remained their passive victims...The crucial problem is to stimulate the development of capabilities to absorb, adapt and improve imported technology, so that, needed technologies can be supplied indigenously."**[26]

➢ **Learning by doing is rarely enough** because a company can remain at the same level or make only very little actual progress. Such firms have to go on to developing their own R&D "to relate that experience to knowledge and skills acquired elsewhere...***hence the importance of investing in R&D and training to generate skills and knowledge***."[27]

➢ Acquisition of knowledge requires costly effort at the company level and support from institutions. **MNS did the former and benefited from the latter**.

➢ **Technology Learning v/s Technology Creation**. Indian audiences would be interested in the sharp observation of the author which is quoted here:

- ➢ "ITLC (independent technology learning capacity) which corresponds to the capability to assimilate foreign technology and ITCC (independent technology creating capacity) which corresponds to the capability to adapt to change, to explain the mediocre technological performance of India, whose policy as well as social sentiment stressed the latter, while neglecting the former....This corresponds to...'know how' and 'know why' capabilities in which the former refers to the ability to operate imported production processes, while the latter corresponds to the ability to change product or process technology."[28] (Note: An honest assessment would indicate that although this observation dates to the early 1990s, the situation is not much improved today in our defence public or private sectors after the passage of over two decades.)

➢ **Control of Technology Flow**. A less- known fact about the Ministry of Trade and Industry (MITI) that has been highlighted by Pilling was that the "Ministry that was subsequently credited by many with overseeing Japan's economic renaissance was a direct descendant of the Ministry of Munitions. In that incarnation it had beseeched Japanese companies to work together for the purpose of increasing weapons production. Now the bureaucrats of MITI rallied Japan's industrial potential in the interests of peacetime revival.[29] Japan's national goal and focus in the late Meiji period and soon thereafter for rapid industrialisation required scientific frameworks that "facilitated industrial rather than basic research. By so doing, the government successfully integrated science and technology into the national system."[30]

➢ **Steel: "The Food of Industry**."[31] An example of the state as an enabler was the impact the lack of right quality steels on indigenous warship construction for major ships during the early

---

[26]Fukasaku, Mitsubishi, 2.
[27]Ibid, 5.
[28]Ibid, 6.
[29]Pilling, Bending Adversity, 86.
[30]Fukasaku, Mitsubishi, 11.
[31]Pilling, 86-87. The phrase was used once again by MITI after it was set up to revive Japan after the WW II destruction. It became the food for the spectacular revival of the shipping industry; the automobile and railway sectors. When the JMSDF started building its own warships, the expertise in terms of quality and the handsome quantities available came in handy!

years of the 20th century. A government steel mill was set up in 1901 with German skills and foreign capital. Japanese R&D in metallurgy helped them make lighter armour, more agile gun-turrets and aluminium fuselages (subsequently).[32]

➢ **Industrial Policies**. Surprisingly, the Ministry of Agriculture, Noshomusho, took the lead in the late 19th century and also was a precursor of sorts to the MITI. Over the next two decades, that included the impetus provided by the First World War, the governments coordinated capital goods manufacturing. In fact, by the end of the war in 1918, half of Japan's machine tools were "swadeshi." Electrification was largely completed by then and gave a boost to chemical and fertilizers, stimulating food- independence and agriculture exports. Lest a reader believe that Japanese companies needed hand-holding or prodding, the opposite was true. in **The passion for *Jiritsu* was so high companies** that they figured out that first, if they themselves built or bought domestic machine tools, their costs would come down; **second, re-tooling would be easier; third, wider application** would be feasible in complimentary/ related industries of shipbuilding, railways, vehicles, farm machinery etc. **Fourth, they were fired up enough to allow themselves to be coordinated by the government in a manner quite different from the system implemented in Leninist and Stalinist Russia**. Difficulties of imports during WW I; the imminent collapse of the Anglo- Japanese Alliance (1902-1922); increased tensions between the US and Japan and the overarching theme of Fukoku-kyohei all helped kindle and sustain this spirit that can be seen in today's Japan as well. **Japan could not have become a great power if the levers of technology, policy formulation, military hardware were to be in one or more foreign capitals**.[33]

➢ **Laboratories and Universities**. Space constraints do not permit deeper treatment of the way in which Japanese governments set up research laboratories in various disciplines and fields. As Dr Fukasaku details in her book, between 1870- 1900, the government founded 13 research institutes; from 1900-1935 it began with the important Industrial Research Institute and established thirty others as well. **Some of these were affiliated to government departments** but many were with universities and polytechnics. In some, like the Institute for Physical and Chemical Research (Riken, for short), "University professors were appointed as researchers...(it) was indeed a **'national enterprise' which responded to the policy of strengthening government-university-industry links for industrial development**. Fundamental research was done at Riken, but greater emphasis was placed on industrial research which could be commercialised."[34]

➢ **Military R & D Linkages with Universities and Corporations**. The Imperial Army as well as Navy were very cognisant of the need for in-house R&D and for working in league with national R&D laboratories as well as helping company- steered design and development. Fukasaku

---

[32] *Fukasaku, 20-23.*

[33] *Author's interpretation based on Pilling, Fukasaku, Evans & Peattie, Buruma and Auer. The last, James E. Auer, has helped significantly as an American naval officer in the post WW II period in the reestablishment of a Navy in the form of the JMSDF. His book, The Postwar Rearmament of the Japanese Maritime Force, 1945-71 (Praeger, New York, 1973) is perhaps the best reference work by a participant and empathetic observer on the early years of the JMSDF. A student of today's JMSDF perhaps cannot ignore this book of reference.*

[34] *Fukasaku, Mitsubishi, 79- 82.*

notes that the army and navy together set up "The Temporary Balloon Research Committee…in 1909…(that) became the Aeronautic Research Institute of the Tokyo Imperial University in 1916."[35] Officers were appointed to do R & D in the ARI. For the IJN, the Naval Technical Department (NTD) encouraged applied research in private companies. For instance, Mitsubishi set up a company cum lab for optical research on weapons and sensors on a demand from the NTD. Learning from Krupp's R & D in 1913, the Nagasaki yard set up **the Jikkenba, (literally, "factory for experiments**). It had a fairly large number of people all engaged in research, design and development. Several dozen reports were compiled every year. Dr Fukasaku significantly observes that even during the recession years, the number of researchers as well as reports and designs did not automatically decline even when company laid off workers as "**indicative of the importance the shipyard attached to research during the years of recession**."[36]

"Skill Japan": What Did the Yards Do For Technology Imports and Training?

We have already seen the efforts made for "Skill Japan" at the larger levels of policy and in terms of IJN's personnel reforms. More could have been said about education reforms at the school and university levels that were as vital but cannot be given space here. The approach of the Mitsubishi Nagasaki Shipyard (MNS) for "**Skill Mitsubishi**" as explained by Dr Fukasaku, however, could be taken as a template for other Japanese companies. She devotes an entire chapter to "Technology Imports at MNS" that spans from employment conditions for foreigners; their own overseas missions for skill acquisition; rationale for import of machinery and materials; purchases of manufacturing and sales licenses. Another chapter similarly covers "**Education and Training at MNS**" that also explains national level education in marine engineering and naval architecture; enterprise-level training programmes; on- job training of MNS workers; the apprentice schools; the way engineers were recruited and trained in–house for specific areas; and participation in professional societies.[37]

Technology Imports at MNS. [38]The Meiji government did employ numerous foreigners in several areas in the industrial age and especially so in shipbuilding. From several hundreds in the 1870s, the numbers declined to fewer than a hundred in the Meiji government by 1900, largely in the Kobusho, i.e. Ministry of Engineering and Public Works. After this, foreigners in government employment were mainly in universities. **Foreigners in the *Kobusho* "were agents of technology transfer" whose important duty was to train Japanese counterparts to take over**. Vitally, the employment of foreigners at very high salaries was not an open ended or ill- defined plan. (We shall see later how this applied in the IJN when they used foreigners, mainly Germans, for the galvanising of modern submarine construction in the 1920s.) Before the Nagasaki Yard became a private enterprise as MNS in 1884, all foreigners, mainly French and British, had left. Mitsubishi transferred in some

---

[35] *Ibid, 83.*
[36] *Ibid, 91.*
[37] *Ibid, Chapter 3 on Technology Imports at MNS, pp 39- 56; Chapter 4 on Education & Training, pp 57-78. Managements of Indian shipyards and of other defence enterprises in public or private sectors would benefit from careful examination of this template to see how much is being done or how to enhance skill building and getting the most out of foreign technical collaboration.*
[38] *This and the next section on Training is based on Fukasaku's book except where otherwise indicated.*

experts from its Engine Works in Yokohama and recruited some more rather quickly. They held most engineering positions and were made to train replacements soon. By 1900, many foreigners had been asked to leave. Apart from the quest of self-reliance, and the high salaries demanded, an important reason, and perhaps familiar in contemporary circumstances everywhere, was that "the foreigners were ungenerous in sharing their knowledge and the essential construction works were done secretively."[39] Other aspects of technology exports are summarised as follows:

- Overseas missions by MNS were numerous in the first few decades. They were mainly engineers and technicians. The advantages these people brought ranged from inspections on site to learning about technologies to be imported; production processes; drafting of license agreements; managerial and cost- accounting systems; awareness and individual absorption of collateral technologies and processes not part of expected outcomes.

- Due to such missions and those by the IJN and other companies, Japan positioned itself to become aware early enough to realise the impact turbines could make to "Move" components; the R & D taking place in Germany and Britain on fire control systems; or the disruptive possibilities of military aviation as seen earlier in this paper. Of note is that this was possible because the right levels of members constituted such missions with knowledge, dedication and often, youth on their side.

- Hard bargains were driven into some of the license agreements. For example, imports of Parsons turbines had clear clauses for training and rights to manufacture subsequent examples with export possibilities. The IJN used its "goodwill" with the RN to leverage financial benefits for the supplier to get long-term benefit to Japan. Great effort was put into "reverse engineering" of turbines and this was supplemented by the theoretical data on impulse blade technology from Germany. This seemed superior to MSK engineers spending time in Germany to the more empirical approach of the British.

- MNS spent creditable effort in making available journals, books and membership of international professional societies to its employees. This may seem an insignificant point, but how many Indian DPSUs, PSUs or even private companies are willing to untie red-tape to enable these benefits? If red-tape is not a consideration, are companies uniformly happy and ready to put tangible money into the possibly intangible benefits of knowledge acquisition by these methods? These may be questions to ponder over.

Education & Training at MNS. Engineering and naval architecture became priority areas for the "Kobusho". From the Imperial College of Engineering, Tokyo, by 1907, 41 percent of the 191 graduates joined private shipyards and 36 percent joined the IJN and government. Marine engineering courses were started there in 1897.[40] MNS' contribution to education and training and, consequently deriving benefits from it, are briefly given below:

---

[39]Fukasaku, 43.
[40]Fukusaka, 61. This writer has not yet made a comparison of equivalence in colonial India in 1907 for these disciplines. It is quite likely that the numbers even in the 1950s may not have been very high or the employment prospects of such graduates bright.

- Japan had passed a Vocational Educational Ordinance in 1899. In accordance with its provisions and bettered as initiatives at company level that were not all mandated, MNS set up Mitsubishi Kogyo Gakko (MKG, Secondary Schools) in the same year for young boys who could volunteer to join Mitsubishi firms if they so wanted. Many did. Idealism, patriotism, nationalism brilliantly combine with pragmatism in the founding directive of MKG:

    - o ...the development of shipbuilding industry affects not only the profits of the firm, but also national strength...the most urgent matter for the development is the training of technicians who possess appropriate skills and knowledge in shipbuilding technology...to develop their knowledge in application of engineering in order to form the basis of the development of the industry which in turn will serve the public interest of the nation."[41]

- MNS helped many MKG graduates become engineers because of their individual aspirations However, once other institutions proliferated, MKG was somewhat downgraded to a workers' school in 1919 under an overall scheme of the Mitsubishi Technical Education Foundation. These apprentice graduates were mainly employed in Mitsubishi's growing factories and yards even as the company afforded them future growth as engineers and highly skilled technicians. Today, many of these measures would not be possible at enterprise- level but are certainly ever required at the governance levels and this realisation seems to be part of the vigour of "Skill India" that needs to stay the course in its implementation.

- Short term training programmes at various levels were widespread at Mitsubishi. Some of these were arranged abroad for special skills, in electric welding as an example. Pay incentives were offered for doing well in company exams, courses and advancement often resulted as skills were demonstrated.

- Infusions of naval officers into Mitsubishi (as well as other companies) was valued greatly because they bought user- inputs and end- awareness.

It may thus be seen that a company such as Mitsubishi consciously and otherwise participated in and likewise benefited from national skill building and technological progress. This is one way of looking at the actualisation of Fukoku-kyohei.

The Leander frigate construction programme of Mazagon Docks Ltd (MDL) in the 1960s and all through the '70s provides a good example of some of this. Although the first major warship construction programme in India, it was rather well managed by later standards in terms of skill building. As per the official history of the Indian Navy, for the Leander project, more than 150 workers and technicians of MDL were sent to Vickers for training from six months to two years. For the Type 209/ 1500 submarines built in the 1980s under license from HDW, Germany, a larger number were trained and with excellent results. **These MDL employees absorbed much and returned to work and train others**.[42] Imagine how difficult it would be to get approvals for similar numbers today? It is understood that for the Project 75 submarines, the numbers have been in low double- digits. What if several more dozens of workers and technical supervisors, draughtsmen and engineers were to be sent and then return and not only work with greater knowledge and passion but also train other colleagues more effectively?

---

[41] *Fukasaku, 66.*

[42] *GM Hiranandani, Vice Admiral (Retd), Transition to Triumph:Indian Navy 1965-1975 (New Delhi, Naval Headquarters, 1991) 39-56. The data given for the Type 209 and Project 75 Programmes was informally conveyed to this writer by an MDL official who did not want to be acknowledged.*

FORGING THE KAIGUN (NAVY)

Public and Private Sector Shipyards. Having thus far seen how a resurgent nation was being forged, attention can be once again turned to shipbuilding. From the early days, Japanese warship building predominantly commenced in government yards but in very small numbers. For the 1896 plan, the assessment was that about "**90 percent of the 234,000 tons of naval construction contracted for the ten years beginning 1896-97 was to be foreign built (mainly British) and, when completed, would comprise 70 percent of the Japanese fleet**."[43] The Navy Arsenal from near Tokyo (Tsukiji) was moved in 1896 to a new site at Kure and expanded facilities were built up; Sasebo was set up in 1897. Kure, in fact addressed not only Float but Move, and Fight equipment as well. Japanese engineers developed the Miyabara boiler which was simpler and more robust than imported versions. By 1912, it began to develop its own turbines. In that year, its first turbine equipped capital ship, the Ibuki, joined the fleet. It may be noted that HMS Dreadnought, the first warship to put to sea with a steam turbine was then just over seven years old.[44] "**Working from basic foreign designs or information, the Japanese developed the Yamanouchi quick-firing cannon, the Oda mine, the Makimura torpedo, and the Kimura radio telegraph**."[45] R&D on explosives received attention and resulted in much innovation. *Shimose* powder and the *furoshiki* shells were early examples of an important field for "*swadeshi*" where Indian Ordnance factories as well as the private sector failed post- Independence.[46] The private sector, which had started building merchant steamships, also moved into this business opportunity. This was not unusual. **Many European private shipyards were "dual use**." In fact, in a very important book "Navies and Shipbuilding: the Strained Symbiosis", the authors put it well in the preface: "**This is…our central theme, that of mutual dependence between navies and shipbuilding (and, by extension, the component manufacturers feeding the shipbuilders**)."[47] Major private yards from the early Meiji era were Mitsubishi, Kawasaki, Uraga and Ishikawajima, joined a few decades later by Mitsui and a few others. **Four of these remain major shipbuilders for JMSDF as well as for merchant marines to this day**! An example of the battle- cruiser Kongo (now spelt Kongou in her latest incarnation in the JMSDF) whose keel was laid in Britain in 1911illustrates many important attributes of Japanese astuteness and determination. This is discussed in the next section.

The Kongo Template[48]

Buy One, Make Three! The RN's induction of the Invincible- class battle cruisers led to IJN also wanting four that would be better than the British versions. The British however, soon built a much

[43]Evans, Kaigun, 60.
[44]Evans, 159.
[45]Evans, 63. The end-notes do state that industrial "espionage" may have played a role in indigenisation. This would not have been unusual at all. In the world of military hardware, the "west" was engaged in this with some amount of energy in the 19th & 20th century. Katherine C. Epstein documents some instances in her book, Torpedo: Inventing the Military- Industrial Complex in the United States and Great Britain (Harvard, 2014).
[46]Evans, 63. The elaborate infrastructure of the Indian Ordnance Factories or the expertise of private players like the Indian Explosives Ltd was never really exploited for any cutting edge research or even for any major import substitution of military explosives and shell development. When compared to the resolve and passion shown by the Japanese, our failures are even more egregious.
[47]Daniel Todd and Michael Lindberg, Navies and Shipbuilding: The Strained Symbiosis (Westport, Praeger,1996) viii The preface also has a brilliant analogy of the Nautilus of Jules Verne fame as a demonstrator for the way in which shipbuilding turned out to be an aggregating business and Captain Nemo as the aggregator.
[48]This section is derived from Kaigun; Allessio Patalano, Post-war Japan as a Sea Power; also, Peter Hore, Battleships (London, Lorenz Books, 2005). Substantial inputs are from Kaigun. Inferences are this writer's.

larger battle cruiser HMS Lion at an impressive 26,270 tons. The IJN quickly revised its proposal and asked Vickers to make the Kongo at 27,000 tons displacement. Vickers at Barrow thus launched Kongo in record time in May 1912. IJN had made its decision to build the other three in Japan. The Hiei at the Yokosuka Yard (built in 1865 with French help, it may be recalled) mainly with imported materials; the Haruna at Kawasaki, Kobe; and the last, Kirishima at Mitsubishi, Nagasaki. **These two were built with almost entirely Japanese materials.**

Significance. The Kongo was the last capital ship built in a foreign yard. The decision to **cut umbilicals with British yards must not have been an easy one, least so because Britain was an ally and had become accustomed to Japanese orders**. Secondly, Japanese navy/ private yards had not built such large ships. Thirdly, there was the problem of material sourcing and imports from Britain. Fourthly, the IJN had asked for many modifications especially in the up-gunning of calibre to 14-inch from the British 12- inch guns. The distribution of three ships in three yards seems somewhat inefficient. However, there were good reasons for this. Among them:

- ✓ The ships were built faster since more dock space, work force and wharfage was available.
- ✓ The overall cost may have been higher than building them in sequence in one Yard. However, time is often the biggest saving in costs and this did happen. It is also quite likely that these were built at an overall reasonable price and perhaps cheaper than if supplied by Vickers as a four- ship order.
- ✓ Further, there was a much quicker ramping up of skills in three yards that would subsequently use them for other ships. Would it be wrong to say here that it must have been more than a mere coincidence that three of the four of the JMSDF's current Kongou class DDGHMs were again built at the Mitsubishi Nagasaki yard in the 1990s?
- ✓ It gave the Navy ministry and staff the education required in managing a large project in time; in sourcing materials quickly; in identifying local major and ancillary suppliers.
- ✓ It contributed handsomely to "Skill Japan" that led to confidence in building aircraft carriers, converting some battle cruisers to battleships or other battle cruisers to aircraft carriers.

Conversion Refits of the Kongo Class. It might be useful to see how and why the IJN converted Kongo to a battleship (BB) and how the overall confidence enabled them to take on some very interesting role- changes or major capability/ survivability alterations to their ships and submarines. In all these endeavours, the Navy's Technical Department was enmeshed with its own and private yards; with research labs regardless of ownership; and with its own Naval Staff to incorporate rapid changes needed **in a period wherein the technology- strategy- operations- tactics dynamics and hence force structure reviews required alacrity from all**. However, it should be understood that there were shortcomings in decision making due to incomplete understanding; turf issues within the IJN; shortage of money; tightening of technology denial regimes even with the British who had been close partners; and, increasingly, resources as Japan's isolation became sharper.[49] Of note, the Japanese were willing to experiment and learn from their errors at least in the context of hardware. The confidence for modernisation refits that led to the Kongo class transforming into battleships had actually evolved through rapid design changing ability that the Navy and private yards had developed and due to the industriousness that could now be taken for granted. The limitations imposed by the Washington and London Treaties resulted in impetus for far more inventiveness, improvisation and innovation. In India, two organisations that would understand this inventiveness better would of course be the Atomic Energy Department and the Indian Space Research Organisation that have both operated in technology denial regimes of severity and the urgency to achieve a high level of self-reliance for important national purposes. The IJN, thus accumulated significant capabilities in modernisation for oil- burning instead of coal or coal- plus oil mixed boilers. Treaty restrictions necessitated lighter alloys for armour protection, better designed bridges, mast and funnels; improved bombs and longer range torpedoes. "While they could and did construct new classes of warships, it was cheaper, in a time of leaner naval budgets, to refit and reconstruct existing naval units to deal with or take advantage of these developments."[50] Alterations and Additions (A's & A's in Indian Navy parlance) included major changes to ships like increasing gun elevation in heavy turrets for greater range; anti-torpedo armour; seaplane launch catapaults, deck armour, etc.[51] The Kongo class went through two modernisation refits, during 1927-32, and again in 1933-1940. They got improvements to their "Float & Fight" via deck armour, lengthening and reshaping of stern, increasing gun elevation to as much as 43 deg to give greater range with the same calibre, addition of torpedo bulges and for launch/ recovery of float planes, improved Japanese fire control for main batteries and torpedoes . "Move" included new Kampon boilers and turbines of indigenous manufacture that doubled power and speed increased from 26 to 30.5 knots. **They became virtually new ships of a different class after the second refits**.[52] Private yards played important roles in converting smaller ships like light cruisers and destroyers as well as submarines to have greater capabilities. **They also leveraged their merchant ship skills to convert some into carriers and other types of warships including auxiliaries. Thus, it can be seen that major conversions of ships in all aspects, Float- Move- Fight requires, and benefits from, all the skills required for constructing new ships but often is achieved at a lower cost. Put another way, major refits benefit shipyards as a way of spreading load onto their infrastructure, investment and people while reducing load on government budgets.**

Submarine Construction in IJN

It was really as a consequence of the First World War that the IJN determined to use submarines actively for its future Pacific strategies. It had cooperated with Britain in this regard and set up a

---

[49] *Kaigun, 176: "With the tightening control of information concerning warship design by the British during the war (despite the IJN's cooperative deployments, we may note), the Japanese were forced back on their own designs and spent much of the rest of the war experimenting with hull forms, and bridge, torpedo tube and ordnance arrangements." The Indian experience of very little design information beyond what is necessary for build- to-print ship or submarine and aircraft building may be both a combination of technology denial by the supplier country/ company, inadequate demand side pressure for enabling absorption of technology and the absence of a roaring fire in the belly for ultimate indigenisation.*

[50] *Kaigun, 245.*

[51] *Ibid, 245.*

[52] *Ibid 276.*

submarine school in 1920 at Kure and soon thereafter the First Submarine Division was formed under an intrepid officer, but not qualified as a submariner, Rear Admiral Suetsugu Nobumasa.[53] Initial construction was on a British design "K class" and had long legs at 20,000 miles. However, engine defects disappointed the IJN. Fortuitously, as reparations, it received via Britain, seven German U-boats. Of these, five were of modern design. These were minutely studied by Japanese engineers and architects. **They "provided vital data from which to design new and formidable classes of submarines**."[54] IJN quickly sent many officers to Germany to study U- boats carefully and to obtain access to optical technology for periscopes. According to another account, around 800 German technicians, engineers, U boat crewmen of Weimar Germany were brought to Japan to help in kick- starting construction of truly modern fleet submarines.[55] Submarine construction in Japan had some distinguishing features which are briefly discussed below:

- With long range as an important requirement, the KD-2 launched at Kure Arsenal in 1922 was already better than many USN boats in terms of surface speed and range. Follow-ons were much improved and built from 1924- 1939.

- Kawasaki built even better J-class ocean cruisers based on the German U-142 class built by Krupp. They had an astonishing 24,000mile range and endurance of 60 days.

- While experts from Germany helped, the same philosophy that guided all government organs about foreigners applied here as well. "During the first two years of their contract (with Kawasaki), the (German) engineers bore the brunt of the preparation of the working drawings of the submarines. As various submarines were completed, however, Japanese staffs gradually took over the work, until a finally distinctly Japanese type of submarine was evolved."[56]

- Work on submarine diesels also proceeded well and from largely imported engines in 1920s.By 1930, indigenously designed, improved versions were going to sea. It was "double the horsepower for engine weight when compared to four-cycle, single- acting engines in US submarines…but were more difficult to maintain."[57]

- Submarine munitions capitalised on surface ship and aerial torpedo developments and during WW II some very good torpedoes were deployed by the IJN in all dimensions.

- Innovative usage of submarines was envisaged. They were built/ modified to carry scout planes for reconnaissance; with fairly large calibre guns, and as logistics boats in the later stage of the war. While the ultimate benefits are questionable, and their strategy of submarine operations quite flawed, the innovations demonstrated technical expertise, resolve and ability to do so quickly.[58]

---

[53] *Kaigun, 214.*
[54] *Kaigun, 215.*
[55] *David W. Grogan, Operating Below Crush Depth: The Formation, Evolution, and Collapse of the Imperial Japanese Navy's Submarine Force in WW II (Kkindle edition) p 18, location 355.*
[56] *Kaigun, 217.J*
[57] *Kaigun, 216.*
[58] *Based on Evans, Kaigun and Grogan, Crush Depth.*

Ø Today, the JMSDF continues to produce quite large and modern conventional submarines that are built at the Kobe yards of the very same Mitsubishi and Kawasaki companies. Skills can be part of not only a nation's but also a company's "DNA" in a sense, the devastation of WW II notwithstanding.[59]

Yards Constructing IJN Warships in 1941

A tabular review of Japanese Yards would be helpful at this stage having covered the role they played in forging the IJN. The Navy had four construction and refit yards at "Yokosuka, Kure, Sasebo and Maizuru (a fifth, at Ominato, only handled repair work) and eight commercial yards. Private yards had played a major role in Japanese naval construction since the late nineteenth century. **Their prime position stemmed from the Japanese navy's consistent support of the nation's commercial yards as a vital strategic industry**."[60] In 1941, when Japan went to war with the United States, the yards were making classes of ships as follows:[61]

Shipyard	Warship Category
Navy Yards	
1.Yokosuka	Battleships, Fleet Carriers, Heavy Cruisers, Submarines
2. Kure	Battleships, Heavy Cruisers, Submarines
3, Sasebo	Light Cruisers, Destroyers, Submarines
4. Maizuru	Destroyers, Submarines
Private Yards	
Mitsubishi (Nagasaki)	Battleships, Cruisers
Mitsubishi (Kobe)	Submarines
Mitsubishi (Yokohama)	Special ships
Kawasaki	Carriers, Cruisers, Submarines
Ishikawajima	Destroyers, smaller craft
Uraga	Destroyers, smaller craft
Fujinagata	Destroyers, smaller craft
Mitsui	Submarines, smaller craft

[59] *KStephen Saunders, Janes Fighting Ships , 2013-14(UK, IHS, 2014).*
[60] *Kaigun, 361.*
[61] *Adapted from Kaigun, 362.*

In terms of distribution of work, 59 percent of 1,794,000 tons was privately built between 1926 to 1945 and 41 percent was in Navy yards. This was a double-edged sword because merchant ship construction by private yards slowed to a trickle and had a telling effect on Japan's ability to wage war against a logistically powerful enemy like the US. A reader should also consider that most of the major belligerents in both world wars continued to construct ships either wholly or partially in government/ navy shipyards. This continues to have merit even if many of the same countries now depend wholly or predominantly on the private sectors for construction, maintenance and modernisation.

Integrity as an Ever- Important Factor

Overall, any student of the Japanese attribute of “bending adversity” whether consequent to major earthquakes (for instance, the 1923 major quake which affected, among other things, Navy yards and private shipyards); or the indomitable morale until a few days before the final surrender in 1945; or the response to tsunami and nuclear accidents of recent times, would not be wrong to underscore the importance of the sense of discipline and the pervasiveness of resolve and integrity in their society and organs of governance. Corruption, therefore, is more difficult to imagine. Indeed, in the story we examine in this paper, this was largely true but with one major exception. It concerned the very same Kongo class that has been extolled in earlier sections of this paper.

“The Siemens Affair” & the Fall of a Government. In a coming together of internal disgruntlement within a collaborating firm, intrepid reporters in England and in Germany, as well as broken promises in payment of “commissions”, information was leaked about “a scandal involving naval officers (in the Navy Ministry) of high rank who were found to have received a rebate on a cruiser and wireless equipment purchased by the Japanese Navy from the German firm Siemens. The 'Siemens Affair' was followed by a similar scandal of greater magnitude, when it was disclosed that Mitsui Busan had bribed naval officers to make sure that the Navy would order a battle-cruiser, Kongo, from Vickers of Britain. As the House of Lords decided to cut the government budget of the Navy, Admiral Yamamoto Gombei (described earlier) resigned (as Prime minister) in the spring of 1914.”[62] It was the start of the First World War that prevented the cancellation of the Kongo “buy foreign, make in Japan” programme since construction was well underway in Japanese yards. But it did cause the IJN's corps of officers a lot of shame but with salutary effects as a result.

Profits as a Motive but Deferred Profits as a Necessary Step

Some of the companies that participated in the military side of “Make in Japan” were already in the engineering business and, to some extent, had technical capacities and capabilities that could be turned in another direction. However, they did not always have deep pockets. Moreover, some of the companies that formed later, especially in aviation, or in optics, etc, were what could perhaps today be called “start-ups”. Profits did not seem assured and certainly not in the short term in most cases. Neither were the volumes to be such that the order books would be full. As seen earlier, this required companies to have patience and dual capabilities; enterprise-level training as well as R & D

[62] *Tsushichi Tzusuki, The Pursuit of Power in Modern Japan 1825-1995 (UK, Oxford,2000)188.*

to not only do what the IJN asked them to, but come up with products that the navy might genuinely want. But, what about profits? The quote from Mitsubishi's leadership about "public interest" did drive companies. It underlines the fact that patriotism is not only a government's virtue but also a peoples' virtue. Pilling could be quoted here because the acceptance of deferred profits worked well even in the early years of the Meiji era as it did after 1945. In a good analysis of Japanese companies, Pilling quotes an American consultant, "The fact that companies were not beholden to their shareholders, in his view, enabled them to play a longer game…Profits are for now or later. Westerners want their profits now. Japanese want growth now and profits later." Pilling continues, "That view enabled Japanese companies, liberated from quarterly earnings targets, to prioritise market share…From steel and shipbuilding to cars and semi-conductors, that is exactly what they did."[63]

Globalisation for Trade; Indigenisation for Defence

The Japanese case for their Imperial period shows that protectionism is a reality and a requirement for defence industries. It has been so and will continue to remain so even in the case for the United States. Various laws and other provisions mandate this and the exceptions to these are in very insignificant areas where imports are permitted. The oft-cited examples of Rolls Royce North America and BAE as exceptions, in fact, reinforce the rules. Many of the larger powers are, and understandably so, unabashedly protectionist in the defence sector. Even under the ambit of a close alliance like the ones between the US and UK or US and Japan, this is clearly seen. The early steps taken by the IJN recognised this reality and sought to leverage foreign assistance to the extent that it could be leveraged on its way to jiritsu (self-reliance). The way in which the Japanese Self-Defence Forces have leveraged close cooperation with the US and license manufactured much of the "Move and Fight" hardware while designing and developing their own hulls for ships and submarines brings them to a readiness level for a second stage of Jiritsu should they so desire and should the overall strategic situation enable/ dictate this to happen. (It is often said that Japan is just a screwdriver turn away from many things. This paper partially illustrates why this may be correct and what brings them to this stage?) Many of the platforms that form the "float/ fly/ drive" categories are also being increasingly designed and developed in Japan. This underscores the long-standing tradition in Japan of what we may perhaps call "Japanese Designed, Developed and Manufactured" after the long- overdue "Indigenously Designed, Developed, and Manufactured" (IDDM) category in the new Defence Procurement Policy, 2016.

At the Same Time, Some Don'ts!

This study also demonstrates some areas where the Japanese examples illustrate some pitfalls.

Too Many Classes of Ships Can be Bad The differences in approaches between US Navy programmes and the IJN's was that the American navy produced more numbers per class thus obtaining savings in design and development efforts and costs; production savings; spreading

---

[63] *Pilling, Bending Adversity, 91.*

production of the winning class across Yards. The IJN did do some of this especially in spreading orders among competing private yards and its own. However, had it built fewer classes of ships, they could have built more with the same resources. Evans analyses the example of destroyers, but this applied to battleships, carriers, cruisers and even submarines and aircraft that the Japanese built. The numbers per class in the US increased steadily with Benson- class at 32 (1937-1940); Livermore class at 64 (1938-41); Fletcher-class at 119 plus 126(1940- post WW II). The US built 502 destroyers in seven Navy and twelve commercial yards. Japan produced 177 destroyers of more classes between 1921-1945. Consequently, the numbers per yard were also lesser on an average at just 5-6 hulls. Also, unlike the American insistence on greater standardisation of "Move" factors, the IJN had greater diversity in propulsion plants. **The USN could issue one SOP for steam plants of 321 destroyers of different types**.[64] (Analogous to the IJN, the Soviet Navy, in the post world-war period, also had a proliferation of ship and submarine classes within the same role definitions. While some of the equipment for float and fight was standardised across classes and even types, there was a wide spread in propulsion plants (move) and too many design variations in float aspects.)

Accidents Due to Design Flaws. There were some instances where the enthusiasm shown for newer designs and in increasing the overall combat power of several types of ships, resulted in accidents, some very severe. One senior naval architect, Captain Hiraga had already made a mark by making IJN ships lighter to comply with Treaty restrictions on displacement yet with adequate firepower. But he objected to pressures in the case of the Furatka class cruisers in the topweight that would be added by too many torpedo tubes.[65] Nonetheless, the issue of topweight plagued many designs and led to stability problems as increasing equipment got installed on the superstructure and masts for fire control, sensors and anti- aircraft guns. One torpedo boat, Tomozuru never recovered from a roll in heavy seas in March 1934. In the introspection that followed, the chief designer, Rear Admiral Fujimoto resigned. However, Admiral Kato Kanji of the Navy General Staff, who had insisted on addition of capabilities, was not blamed![66] Similar problems once again resulted in many deaths and damage to many ships of the Fourth Fleet while riding out a typhoon. The bow sections of two destroyers broke off but they did not sink. Apart from the typhoon, many design flaws came to the fore. Ships were modified and some new ones under construction were redesigned and hence delayed. **Ultimately, all this had long-term impact on the force availability during Japan's decision to go to war in 1941**.[67]

Build an Effective Force Structure, Not a "Comforting" One. The IJN, like other navies of their time, had a combination of conservative admirals as well as ahead- thinking ones. In some ways, in IJN, the battleship lobby retained the upper hand even when the crying need was to have built more carriers and submarines. **Valuable resources in terms of money, steel, design and development effort, yard space, men, were consumed in very capable, innovative battleships that although better than any others, did not really influence any battles or operational/ strategic outcomes.** These varied resources could have been reassigned to carriers, destroyers, more submarines,

---

[64]*Kaigun, 366- 370.*
[65]*Kaigun, 225-226.*
[66]*Kaigun, 242-243.*
[66]*Kaigun, 244-245.*

tankers and certainly merchant ships. **It mirrored the errors that Hitler and some of his admirals made with the "Z-Plan" that diverted planning, R & D and material resources. The realities of what would be an effective navy as opposed to a "desired" navy that imitated others, resulted in scrapping the plan just after it got started. Force- structuring, requires a dispassionate analysis of what might work for tomorrow's threats at the operational and tactical levels so as to achieve possible future strategic objectives that take into account current and developing threats of tomorrow's possible adversaries. Logically, the optimisation has to be done considering the larger spectrum of warfare**. The IJN's example at the strategic and operational provides a good case study for this conundrum.

Conclusion

In a sense, this story about the Imperial Japanese Navy does not really have a happy ending from the viewpoint of their nation during the Second World War. **This does not however, diminish the value to us today for the lessons or pointers that have been drawn out in the sections above**. While templating all the steps taken by the Japanese governments, or the IJN and their shipyards in the public as well as private sectors may not be advisable, this case study provides us adequate justification for some of the steps that have been taken in the recent past and some pointers for what more could be done. These are summarised below.

Japanese resolve from the earliest years following the Meiji Restoration in 1868 for ***Fukoku –Kyohei*** (Rich Country, Strong army) and the quest to be counted as a great power, provided themselves with a **sustained over-arching vision**. In turn, this "**fire in the belly**" enabled them to take this exhortation **from a slogan to concrete policy formulation and implementation all through**.

The early realisation that Jiritsu (self-reliance), for all needs of the Army and Navy was necessary, facilitated the leadership in setting the IJN on the right path. In 1868 or even in 1880s, **Japan lagged behind even colonial India** in many parameters including technical infrastructure, education, railways, etc. Neither was it a rich nation. **Perhaps the corollary to it never being too early for achieving Jiritsu in defence hardware, is that it is never too late to achieve "swavalamban" either.**

The methods in which Japan and the IJN interacted with foreign governments, navies, companies and experts needs to be comprehensively studied and adapted to our times with greater focus. Just as their interactions led to tangible and steady attainment of the "make in Japan" goals they set for themselves, **Indian entities, public and private companies must also leverage these very associations for Indian gain**. It would be appropriate to remember that most foreign partners who have been associated with defence hardware needs for India have themselves been essentially self-reliant or have become nearly self- reliant for some decades. **Why should India be bashful about this goal?**

Technology denial "regimes" have perhaps existed for a very long time in some form or the other. The IJN's and Mitsubishi Nagasaki Yard's experience above was not, nor will remain unique. **What is denied but needed would need to be designed and developed**. Like the de facto "JDDM" examined in this paper, "**IDDM" for India is the ultimate way to reach a sufficiently high level of self-reliance and must be the prime source of future needs.**

Consequently, **transfer of technology is predicated not on the willingness of the supplier to so transfer**, since there is most often no great advantage on the foreign government or its companies to really do **so, but on the "demand" side insistence on such transfers**. For this to happen, the receiving country has to have the ability not only to absorb the technology, but to proactively and robustly set about doing so. **Further, the tendency to exaggerate licensed production or partial manufacture of some hardware as transfer of technology should be avoided at all costs**. As demonstrated by the IJN, licensed production/ build- to- print ought to lead to very high "made in India" percentage of each platform/ system in "make in India" production with foreign partners. Where necessary, every leverage in India's interest must be deployed for genuine sharing of information and for TOT. **Ultimately, absorption of technology rather than TOT is what enables technology transfers**. Indian private and public companies involved in defence manufacturing should, therefore, **want to absorb technology. This would be a smarter business model because it would be the prime path to these very companies becoming exporters of IDDM rather than remaining facilitators for foreign companies to continue to "make and make even more" in India.**

Indigenisation has to be assessed via more meaningful parameters such as:

- Criticality of technology to overall effectiveness of the hardware.
- A long-term view on overall money saved. In the short term, it would often be necessary and worth the while to indigenise even if at a higher cost.
- Import substitution of raw materials, tooling, forgings, etc.
- **Assured value addition through technology absorption**, production of improved versions and collateral benefits in other areas. Also, in terms of jobs created/ foreign specialists sent back, skills achieved etc.
- **Ability to move from being in the global demand chain to creating a valuable space in the global supply chain for "defence solutions"**.[68]

A ship or submarine has to be seen as a composite and integrated system with **float-move-fight attributes that all need simultaneous attention and indigenisation**. The IJN's efforts in this as well as in aviation for **fly- move- fight attributes**, was nothing short of extraordinary. **Only if India demonstrates the ability to satisfy herself in all these areas, will our public and private companies together be able to enter the global demand chain.**

To achieve the above for herself and for our friends elsewhere, strong **partnerships between public and private defence firms would be very necessary**. In the US, Japan, UK, France, Soviet Union, their government owned yards were critically important for a long time. **The government can pay a higher price, absorb losses for achieving self- sufficiency, or have occasionally idle infrastructure if inescapable, but private firms cannot do it as easily. India's quantitative requirements may also be such that retaining DPSUs would always make good sense**. The issue of lack of sustained orders has, in any case, been a major reason why so many aerospace and other defence firms have experienced so many mergers and acquisitions.

---

[68]*Based on this writers contribution as a key researcher and team member, writer for an earlier report on indigenisation of the aeronautics sector. The leader is a renowned expert in aviation circles.*

While global trade regimes as also economic wisdom often make protectionism difficult and/or disadvantageous, the defence trade is largely protected by those that hold the keys. Japan protected its shipping manufacture through tax and import- protection in the 19-20th centuries; encouraged switching between naval and commercial shipbuilding. Many "supply" side governments zealously protect their defence firms against imports in key areas while pushing exports. Japan did this for its naval ships, ordnance and commercial ships during WW I while doing everything it could to wean itself off defence imports as shown in this paper. Quite obviously, defence trade—if it can be called that-- would remain fundamentally different from general global trade.

A key area where we can, and must, take a leaf out of the IJN, is in indigenisation and innovation of ordnance. They made good progress in all types of shells including innovative underwater trajectory against battleship armour, advanced explosive compounds, and really long range, high speed torpedoes (the Type 91) and air delivered ordnance. They became early exporters but cut back when their own needs overwhelmed them. Their case shows that while they achieved qualitative levels, they were short of ammunition almost throughout the Second World War. **Indigenisation and further development of all types of ordnance including missiles and other smart munitions could be accorded the highest priority. Few "coming wars" have ever been short ones with any assurance of victory in any case. Ordnance, therefore, has quantitative needs that provide qualitiative value.**

Developing human resources via national and enterprise-level education and training is the key to developing defence sector skills. The users' skills while wearing the nation's military uniform has to be matched by the engineer, technician and worker wearing overalls while "making in India" in Yards and factory floors. The Japanese efforts at dynamically enmeshing government, university, polytechnic, IJN, and company levels were truly noteworthy and we must emulate them. **Implementing "Skill India" would become a long-term investment and contribute to profits beyond the horizon**. One just has to see the way Japan (or Germany) rose from their devastation and "bent adversity". It was the skills that they had built assiduously in the inter-war years and even before the First World War that enabled their revival and a seat once again at the high table.

Related to the above, the efforts put in at the same levels, including by Mitsubishi in applied R & D, points to the need for even more companies to look at R & D as a totally required input- cost to generating products as well as profits. The point cannot be over-emphasised.

The IJN's path was perhaps unique for its time, but its efforts at self-reliance, and national efforts at skill building are reflected in many steps taken by China and the Chinese Navy.

On profits itself, Japanese companies and ethos often showed the way for Japan and could do the same for us. Could Indian companies think of "Growth now, profits later" as did the Japanese? Perhaps we can; certainly we must.

Finally, the Imperial Japanese Navy's story did begin well even if it commenced in an environment of great difficulties. Repeatedly, Japan and the IJN surmounted their challenges and bent adversity. Today, the JMSDF is once again a powerful, modern and expanding navy that endeavours to have ***Jiritsu*** once again. Japan is pursuing a very different, cooperative grand strategy different from the belligerent aspirations of the Imperial era. But some of the very same resolve shown then seems to influence it today. **In that sense, the unnamed Japanese officer quoted at the head of this paper was not only right. We may also acknowledge that even if the IJN's story did not end well, its success at self reliance could inform and influence our own navy's quest for "*swavalamban*."**

Author's Biodata

RADM Sudarshan Shrikhande (DOB 28 Jun 1959) finished his schooling in De Nobili School, Dhanbad; a graduate of NDA; commissioned on 01 Jul 1980. His early sea tenures were in IN Ships Taragiri, LCU-L32, Rajput. From 1985 to 1988 he completed an ASW Weapon and Sonar Engineering Course at the Soviet Naval War College, Leningrad (St. Petersburg), graduating with distinction for his M.Sc. in Weapon and Sonar Engineering and served as ASWO/Ops officer of INS Ranvir for nearly four years. Further service at sea was in command of INS Nishank, XO of INS Delhi and CO, INS Kora. His shore appointments included instructor ASW School, Commander War Room, NHQ/ New Delhi, Director Indian Naval Tactical Evaluation Group and Directing Staff/ College of Naval Warfare. He was the Defence Adviser in HCI/ Canberra (Australia) concurrently accredited to Fiji, New Zealand, Papua New Guinea and Tonga from 2005-2008. He commanded INS Rajput in the Eastern Fleet from Apr 2008 – May 2009. On promotion to Flag Rank, he was ACNS (Foreign Co-operation & Intelligence) at NHQ until Aug 2010. He was a selected member of the IN's Strategy Council from 2008- 2011. His previous appointment was as Chief of Staff, SNC from Aug 10- Aug 12 and as ACIDS (Fin &Plg)/ HQIDS until Apr 14. From Apr 14 to Oct 15, he was Chief Staff Officer (Sea Vector) at HQSFC and also officiated as Deputy C-in-C/ SFC for some time.

He graduated from the Defence Services Staff College in 1995 and was awarded the Scudder Medal by Madras University for his MSc (Stat Studies) and Peter Mitchell (Third) Prize from Australian Navy. He graduated from Naval Higher Command Courses at the College of Naval Warfare, Mumbai. He is also a 2003 graduate of the US Naval War College, Newport, Rhode Island, where he was the first foreign officer to graduate with highest distinction, was class president and was awarded the "Robert Bateman" and "Jerome E Levy" prizes and the "James Forrestal" Seminar Prize. He has been awarded a MPHIL from Mumbai University in 2014. He has been accepted into the Mumbai University - NWC PhD programme.

He writes regularly for military magazines and has been teaching a capsule of eight lectures on the works and ideas of the Masters of Strategy and RMA at the NWC, Goa for the NHCC, and at the DSSC.

He is married to Dhara who is now a home maker. They have two daughters, Gayatri, 28, is married and working in Mumbai and Urshila, 24, is an MBA in marketing and also works in Mumbai.

His seniority as RAdm is 28 Jan 2009.

LIST OF PAPERS

Sl	Author	Designation	Paper Topic
1.	Cdr Nitin Saxena	FNAO, HQ FOCWF	'Naval shipbuilding' through 'Make in India' perspective
2.	Cmde Pravin Rajpal Lt Cdr Melin Aravind	SPS & SO(NA), SOT, Mumbai	Conventional submarine building through "Make in India" perspective
3.	Cdr M S Kapoor	SO to CWP&A	A solution to the Autonomous Vehicle Navigation
4.	Capt Nagesh Lt Cdr J Karthik Lt Cdr Conorad Michael	WPS, NCO & NLO, WOT Dahej	Indigenous Naval Shipbuilding at Private Shipyard
5.	Col S K Jaini	CDM	Naval shipbuilding through 'Make in India' perspective
6.	Capt Gaurav Doogar	CDM	National competence in marine propulsion - the road ahead (The Naval Perspective)
7.	Capt (IN) Sujit Baxi	CDM	Make in India and Timely Delivery of Ships
8.	Lt Cdr Naveen Mavi	Valsura	Naval shipbuilding through 'Make in India' perspective
9.	Lt Cdr N Mahajan	Valsura	National competence in marine propulsion
10.	Capt Manoj Jha	NWC	Naval Shipbuilding through 'Make in India' - Way Ahead?
11.	Capt SS Chaudhry Capt GS Sidhu	NWC	National Competence in Marine Propulsion - The Road Ahead
12.	Capt Jasvir Singh	NSRY Karwar	India's Shipbuilding Industry - Future Market Leader with 'Make in India' Paradigm?
13.	Commander A K Pandey Cdr Sunil Korti	Vajrabahu	Make in India - Way Ahead for the Indian Navy
14.	Cdr MA Pradeep	Vajrabahu	Naval Shipbuilding : Through 'Make in India' Perspective
15.	Cdr Vinayak Srimal	DSCC, Bhopal	Naval Shipbuilding - 'Make in India' Lessons to be Learnt
16.	Cmde Bhupesh Tater	Naval Dockyard, Mumbai	Build in India - Ships for the World (Problems and Panacea for Indian Warship Building from the MII Perspective)
17.	Cdr M S Gopinathan, Cdr Manish Singh	INS Shivaji	National Competence in Marine Propulsion - The road Ahead
18.	Cdr V VGokhale	DSP	Naval Shipbuilding - Strategic Partner for 'Make in India'
19.	Cdr CHV Sudhakar	GTTT (V)	National Competence in Marine Gas Turbine Propulsion - Way Ahead
20.	Capt Vikram Bora & Cdr KJ Singh	DND (SDG)	Nuclear Propulsion for Naval Platforms: The Navy's Perspective
21.	Capt Lavneesh Dhawan Cdr C Sahane	DME	Integrated Full Electric Propulsion for Indian Navy - Challenges, Roadmap and Expectations from Defence Industry
22.	Rear Admiral Sudarshan Shrikhande	FoDC	Make in Japan to Made in Japan: Indigenisation Lessons from The Imperial Japanese Navy 1880-1941

About FICCI

Established in 1927, FICCI is the largest and oldest apex business organisation in India. Its history is closely interwoven with India's struggle for independence, its industrialization, and its emergence as one of the most rapidly growing global economies.

A non-government, not-for-profit organisation, FICCI is the voice of India's business and industry. From influencing policy to encouraging debate, engaging with policy makers and civil society, FICCI articulates the views and concerns of industry. It serves its members from the Indian private and public corporate sectors and multinational companies, drawing its strength from diverse regional chambers of commerce and industry across states, reaching out to over 2,50,000 companies.

FICCI provides a platform for networking and consensus building within and across sectors and is the first port of call for Indian industry, policy makers and the international business community.

For more information, please contact:

Vivek Pandit
Senior Director & Head -
Energy / Defence & Aerospace

Bhaskar Kanungo
Deputy Director
Defence & Aerospace

FICCI
Industry’s Voice for Policy Change
Federation House , Tansen Marg, New Delhi 110001
E: vivek.pandit@ficci.com, bhaskar.kanungo@ficci.com
T:+91-11-23354801, +91-11-23487276
F:+91-11-23765333
W: www.ficci.com