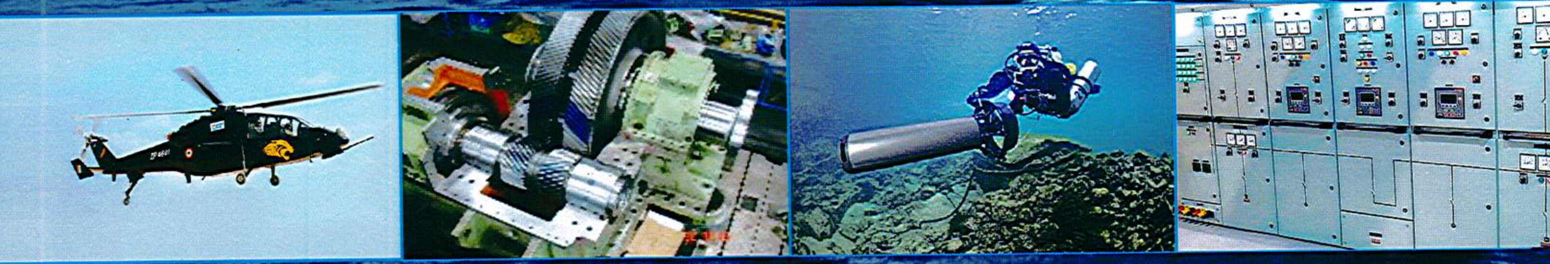
Indian Naval Indigenisation Plan (INIP)

(2015-2030)



DIRECTORATE OF INDIGENISATION IHQ MOD (NAVY)

PREAMBLE

The 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 indigenisation 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'. Recognising this, the Indian Navy has embarked upon an initiative to evolve a guideline document, the "Indian Naval Indigenisation Plan (INIP) 2015-2030", to enunciate the need for developing various advanced systems for its platforms. This document supersedes the Indigenisation Plan published in 2008 for the period 2008-2022.

This document is aimed to enable indigenous development of equipment and systems over the next 15 years. It attempts to formulate the requirements of Indian Navy and lists out the equipment which can be taken up for indigenisation in the coming years. It is expected that release of this plan would further synergise Indian Navy's relationship with the industry and encourage all sectors of industry to come forward and participate in indigenous development of weapons, sensors and other high end equipment for the Indian Navy, thereby making the nation self-reliant in this vital domain of defence technology.

CONTENTS

CHAPTER 1- INTRODUCTION

1.1 The specific roles of the Indian Navy in future would continue to extend across the entire spectrum of security of the nation; from peace keeping, through the low intensity segment to high-intensity conventional hostilities up to and including nuclear conflict. The Indian Navy will necessarily need to perform its varied tasks in the expanding presence of neutral and multinational/ extra regional forces in the Indian Ocean Region (IOR). In the last two decades, the capabilities available with our potential adversaries have grown considerably and are forecasted to only improve with time. The Indian Navy would therefore acquire adequate deterrent war fighting capabilities.

1.2 In the past, the Indian Navy has had to acquire military technology through import from diverse sources. Requisite expertise also had to be created for their operation and maintenance. This option had to be exercised since our own research organisations and industry had not developed any major military systems within reasonable time frame to reach technological relevance in the domain of warfare. This lack of credible R&D in military sciences and technologies, inadequate amalgamation between R&D and manufacturing sector, near absence of an integrated approach amongst users, designers and manufacturers have been some of the important reasons for our inability to achieve satisfactory levels of self- reliance in the defence technologies. Further, issues such as unviability view economy of scales and technology-denial regimes, etc., have also been major factors affecting the development and manufacturing of home grown military technology and equipment.

1.3 As a long term strategy we need to identify need-based functional domains and relevant technologies required for the next 15 years (ie., 2015 – 2030) so as to channelize the indigenous efforts to accomplish self-reliance in the domain of cutting-edge defence technologies. Indian Navy’s Directorate of Naval Design has designed over 80 ships since the commencement of indigenous ship building programme in the 1970s and 48 state-of-the-art ships and submarines are under construction in Indian shipyards, both public and private, as on date. However, there is still a need to evolve a sound plan for technology development and production mechanism for complex shipborne systems. Therefore, the Indian Navy has embarked upon development of shipborne systems through two routes; one to harness the R&D potential at DRDO and the other through 'Transfer of Technology (ToT)' with industry partners. Over a period of time, while the technology absorption has matured in certain areas, a large gap still exists in the development of critical technologies, viz., system engineering, materials, hi-tech components and advanced manufacturing processes.

1.4 The Indian Navy has acquired adequate expertise in the hull design and construction of various types of warships. In the field of propulsion systems (barring marine Gas Turbines) and related auxiliaries, support services like air conditioning, refrigeration, etc., adequate expertise and production capabilities are available in the country, perhaps due to commonality of requirements of the civilian sector. We are also reasonably self-sufficient in power generation and distribution systems, communication systems, Combat Management Systems, Sonars and Electronic Warfare Systems.

1.5 Although we possess design capabilities and to some extent the production base, considerable performance enhancements are required in the field of Under Water weapons and sensors, Multi-function Radars, IT based systems, etc., as their critical subsystems and components are of imported origin.

1.6 The role of the indigenous industry in the defence manufacturing sector cannot be over emphasised. The entire industrial might of the country, whether it is the public sector, the Defence Public Sector Units (DPSUs), the large private industries or Medium, Small and Micro Enterprises (MSMEs), needs to partner to achieve the goal of self-reliance of the Indian Navy. They should become the stakeholders of the plan and provide not only the needed technical knowhow and share their vast manufacturing experience, but also bring the IN's concepts and proposed capability to fructification in the form of world class defence hardware that would serve the needs of the Indian Navy.

1.7 Commitment to self-reliance through indigenous development, is a subject of the larger goal of combat readiness. Therefore, till indigenous equipment are available, we have to continue with the acquisition programme to meet our specific and current operational requirements so as to constantly remain battle worthy. Simultaneously, for the short-term requirements, we have to depend on the current indigenous efforts, and use the available technologies and effect marginal improvements wherever available.

1.8 Naval systems are inherently technology intensive and require substantial investment of time, money and resources. The Indian industry, including the private sector, therefore, needs to play its role in meeting needs of the Indian Navy.

1.9 **Submarine Equipment & Systems**. Submarine equipment, being much more stringent in material specifications, has had limited success towards indigenisation. However, in the recent years, support from industry has been a crucial factor in development of various systems and equipment for use onboard submarines. The support has come forth from across the industry spectrum, right from large industrial houses to smaller MSME, and has been an encouraging factor in the realms of Navy.

1.10 **Categorisation of Ship's Equipment**. The ship-building materials, equipment and systems onboard an *IN* warship/submarine 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.

1.11 **Items Being Imported for Shipbuilding**. The major items used in the ship-building programme that are still being imported are tabulated below:-

(a) **Float Category**.

Ser	Type of Equipment
(i)	Arrestor Wires for Flight Operations on Aircraft Carriers
(ii)	Aircraft Lifts
(iii)	Items for Replenishment at Sea (RAS) Operations
(iv)	Composite Superstructures
(v)	Paints for Underwater Hull, Flight Deck and Radar Absorption
(vi)	Composite Foldable Aircraft Hangar Door
(vii)	Bow Sonar Dome
(viii)	Glass for Windows on Ships' Bridge

(b) **Fight Category**.

Ser	Type of Equipment
(i)	Surface to Air Missile
(ii)	Surface surveillance radar [Buy & Make (Indian) in progress]
(iii)	Air Early Warning Radar [Buy & Make (Indian) in progress]
(v)	Satellite Communication System (SATCOM)
(vi)	Aviation Control Suites
(vii)	Fire Control Systems
(vii)	Integrated Mast & Control System for Submarines
(ix)	(aa) Mine Hunting (ab) Portable Diver Detection Sonars [(Buy and Make(Indian)]
(x)	Light and Heavy Weight Torpedoes
(xi)	Towed Array Sonars
(xii)	Unmanned Aerial Vehicles/ Remotely Operated Vehicles/ Autonomous Underwater Vehicles
(xiii)	Global Positioning Systems, Inertial Navigation Systems

(c) **Move Category**.

Ser	Type of Equipment
(i)	Gas Turbines (11-15 MW and 20-25 MW)
(ii)	Main Propulsion Diesel Engines
(iii)	Complex Marine Gearboxes (1-50 MW)
(iv)	Shafting
(v)	Propellers – Both Fixed & Controllable Pitch
(vi)	CFC Free Fire Fighting Systems for Magazines & Machinery Spaces

1.12 **Main Areas Where *IN* is Facing Capability Gaps**. As brought out above, *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. However, in the 'FIGHT' category we have achieved only about 30% indigenisation. Some of the major equipment where there has not been satisfactory progress 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.

1.13 *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.

1.14 **Potential of Partnership in Overcoming Constraints**. The Indian private sector Industry today offers scope for their greater involvement in the Defence Sector and possesses the requisite skills and infrastructure for undertaking defence production 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.

1.15 Many large and prominent industrial houses like Tatas, Mahindras, Reliance, Kirloskar, L&T, Godrej, etc., to name a few, have set up special verticals to handle defence related businesses. Some of them have also entered into collaborative agreements with foreign vendors for defence equipment production in country. Some success has been seen in this aspect where some 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 considerable 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 indigenous developmental efforts.

1.16 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 some of the initiatives by the Govt to give a major boost to indigenisation in the Defence Sector.

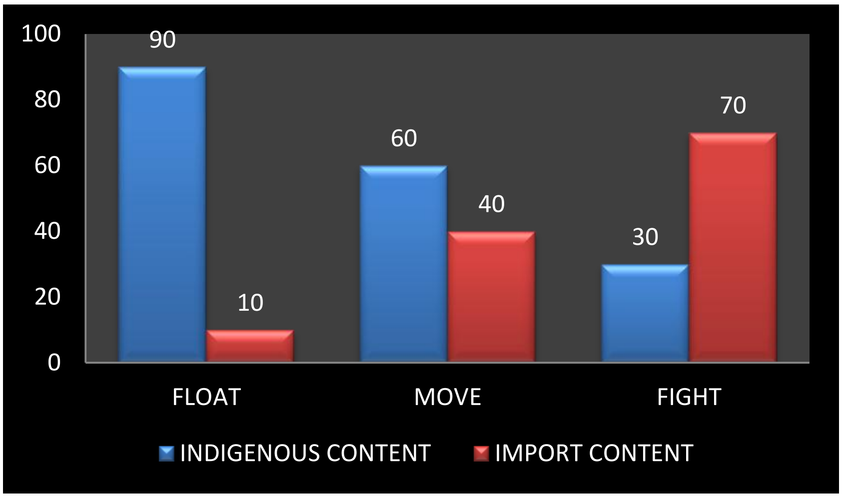
1.17 The Navy as a customer, the designers of equipment and systems and the industry as a supplier need to have a clear understanding of the requirements and the plan for induction and indigenisation. Keeping this in focus, the '15 Year Indigenisation Plan' was first prepared and promulgated in 2003, in keeping with the induction plan of new platforms. The plan was later revised and repromulgated in 2008 for period 2008-2022. The Indigenisation requirements of the IN have now been revised based on current requirements with respect to new induction ships and submarines and life cycle support imperatives of the existing IN platforms.

1.18 Present status of various indigenisation activities has been included for maintaining continuity and to avoid duplication of efforts. Also, to focus efforts of development agencies a forecast requirement of equipment and systems has also been worked out and placed at Appendices ‘A’ to ‘E’. Proposed projects through DRDO/ Industry under ‘MAKE’ category are also listed at Appendices ‘F’ & ‘G’.

CHAPTER 2- INDIGENOUS DEVELOPMENTS SO FAR

Background

2.1 The equipment and machinery fitted on board ships in the three categories of Float, Move and Fight has been indigenised to the extent of 90%, 60% and 30% respectively. The analysis of these categories indicates that while sufficient self-reliance has been achieved in the first category and reasonable in second category, there is a large shortfall in the third category. The current indigenous content of the three categories of warship equipment is depicted in the graph below.



2.2 **Major Systems Indigenised**. The major equipment and systems developed indigenously by *IN* as part of various ships building programme are as follows:-

(a) **Float**

Ser	Equipment/ Material	Indigenising Organisation
(i)	Hull Construction Materials	DRDO/SAIL/ESSAR/BALCO, M/s Krishna Industries
(ii)	Hangar Doors and Shutters	M/s L&T
(iii)	Anchor Capstans / Windlass	M/s HH Group, M/s Geeta Engg
(iv)	Davits and Boats/ Rigid Inflatable Boats (RIBs)	M/s HH Group, M/s Fibroplast, M/s SHM Shipcare, M/s Hemant Engg

(b) **Move**

Ser	Equipment/ Material	Indigenising Organisation
(i)	Steam Turbine	M/s BHEL
(ii)	Boilers	Naval Dockyard, Mumbai, M/s Thermax
(iii)	RO Plants	M/s Rochem, M/s Technoprocess
(iv)	Pumps	M/s Best & Crompton, M/s Alekton, M/s BE Pumps
(v)	HP Air and AC Compressors	M/s ELGI Compressors, M/s ACCEL
(vi)	AC and Ref Plants	M/s Voltas, M/s KPCL, M/s ACCEL
(vii)	Stabiliser System	M/s Veljan Hydrair, M/s L&T
(viii)	Gas Turbine Generator (GTG) Control System	M/s BEL
(ix)	Gas Turbine (GT) /GTG Starting Rectifier	M/s Precision power
(x)	Steering Gear	M/s Veljan Hydrair
(xi)	Motors and Power Generation & Distribution Equipment	M/s Narhari Motors, M/s Marine Electricals
(xii)	Submarine Batteries	M/s Exide, M/s HBL
(xiii)	Inertial Navigation System	DRDO/ RCI

(c) **Fight**

Ser	Equipment/ Material	Indigenising Organisation
(i)	Electronic Warfare Systems	M/s Bharat Electronics Limited(BEL)
(ii)	Sonars	NPOL
(iii)	Gun Fire Control System	M/s BEL
(iv)	Anti-Submarine Warfare Fire Control System (ASW FCS)	M/s BEL
(v)	Supersonic Missile System	M/s BAPL
(vi)	Close in weapons and Super Rapid Gun Mount	OFBs/ BHEL
(vii)	Torpedo Tube Launchers	M/s L&T/ MDS

Ser	Equipment/ Material	Indigenising Organisation
(viii)	Combat Management System	WESEE/ M/s BEL(Gad)
(ix)	Data Link & Net Centric Operation (NCO) Equipment	M/s BEL
(x)	Weapon Systems Integration	WESEE/ M/s Elcome Marine, M/s Data Patterns, KELTRON
(xi)	Chaff launchers	OFB/MTPF
(xii)	CCS/VCS	M/s BEL
(xiii)	HF/VLF Receivers	M/s BEL
(xiv)	HF Transmitters	M/s BEL/HAL
(xv)	V/UHF sets	M/s ECIL
(xvi)	Main Broadcast /Sound Reproduction Equipment	M/s Phi Audicom, M/s Linea Engg

2.3 **Specific Equipment and Systems Developed by Directorate of Indigenisation (DOI)/ Indigenisation Units (IUs)**.

(a) Retractable Stabiliser Systems

(b) Gas Turbine (GT)/ Gas Turbine Generator (GTG) Starting Rectifier.

(c) Digital GTG Control System

(d) Deck Hydraulic Systems.

(e) Steering Gear Systems.

(f) Electro-hydraulic Controls for Bow & Ramp Doors of Ships.

(g) Extraction Trolley and cross piece for Missiles.

(h) **Indigenisation by IUs**. Using a systems approach, indigenisation of a large number of marine engineering and electrical/ electronic components like valves, compensators, pumps, shafts sleeves, coolers, air reducers, blowers, impellers, heat exchangers, instrumentation, PCBs, etc has been completed.

CHAPTER 3 - MARINE ENGINEERING

3.1 The Private industry has indicated its willingness to partner ***IN*** in its effort for indigenous development. Over past few years there has been considerable success in Indigenising major systems like steering gear, stabiliser systems, gear boxes, deck machinery etc. as replacement for imported ship fits, as well as major ship/ submarine building programme for Navy. It has given large confidence and will lead to further boost to partnership in the future projects. Almost all major equipment and systems such as propulsion plants, prime-movers for power generation, air conditioning and refrigeration plants employed on board ships are specifically designed for marine application or are adapted (marinised) from successful commercial models.

3.2 Warship equipment 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.

(d) Assured performance when submerged /partially submerged and subjected to harsh marine environment.

(e) Wide temperature variation in machinery spaces.

(f) Attenuation of airborne and structural borne noise by appropriate vibration mountings and acoustic enclosures.

(g) Modularity in design to assure high level of maintainability in heavily congested machinery spaces.

(h) Reliable operation in the presence of high levels of humidity, with large Mean Time Between Failures (MTBFs).

(j) Utilisation of seawater for cooling systems/ heat exchangers.

3.3 Engineering equipment can be broadly classified into following categories:-

(a) Main Propulsion Equipment (Gas Turbines, Diesel Engines, Nuclear/ Steam/ Electric Propulsion).

(b) Prime Movers for Power Generation Equipment.

(c) Auxiliary Equipment (Pumps, A/C & Ref Plants, HP & LP Air Compressors, Hydraulics & other ship systems).

(d) Machinery Control Systems/Equipment.

(e) Miscellaneous Equipment (Lifts, Firefighting Systems).

Main Propulsion Equipment

3.4 The main propulsion plant of a warship should have the following essential characteristics:-

(a) Capability of high 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) Reversing capability.

(e) High power to weight ratio

(f) Compact and modular construction

(g) Low Noise.

3.5 Indian Navy currently employs the 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.

3.6 **Gas Turbines.** Presently all gas turbines, fitted in Naval ships are of foreign origin. There is an urgent need to develop indigenous gas turbines. Indigenisation initiatives taken in this regard include induction of General Electric's LM 2500 gas turbine on the basis of its licensed manufacture in India with progressive increase in indigenisation. Development of a fully indigenous Kaveri Marine Gas Turbine (marine derivative of Light Combat Aircraft (LCA) gas turbine) is also being pursued at GTRE, Bangalore.

3.7 **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 range has been achieved, the high power diesel engines to Naval specifications 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. In addition to above the following specific requirements also exist:-

(a) **Motor Boat Engines**. The Survey motor Boats (SMB) and the Rigid Inflatable Boats (RIBs) are powered by diesel engines in the power range of 100-250 HP. These engines are to be of lightweight and rugged in design and having a high Mean Time between Overhaul/ Failures (MTBO/ MTBF). The survey motorboats are operated at sea for 8 to 10 hours continuously.

(b) **Non Magnetic Engines**. The minesweeping vessels are fitted with non-magnetic 250 HP engines. Due to the specific role of the ships, it is essential that their engines are with non-magnetic characteristics. Presently, no indigenous diesel engine manufacturer is manufacturing non-magnetic engines.

3.8 **Reduction Gear**. For efficient power transmission to the propeller, marine gearboxes should possess the following essential features:-

(a) Higher hardness of pinion and gear materials with attendant higher gear tooth loadings.

(b) High efficiency and reliability.

(c) Long life.

(d) Low noise levels.

3.9 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 India by M/s Elecon, under joint ventures with foreign firms such as M/s MAAG Switzerland & M/s Renk Germany. There is a requirement of gearboxes with greater indigenous content in the range of 1-50 MW for the new construction ships.

3.10 **Air Independent Propulsion (AIP) Solutions for Submarines**. Indian Navy is also exploring AIP solutions for powering submarines as it offers considerable tactical flexibility. Operational considerations like low noise, shallow water capability, size and manoeuvrability issues have garnered Navy's interest in non-nuclear AIP solutions. Indigenous competence in this field is at a very nascent stage and is required to be built up to the range of 225 to 250 KW for retrofitment on the existing submarines/ incorporation in the new designs.

Prime Movers for Generators

3.11 **Diesel Engines, Steam Turbines and Gas Turbine Prime Movers**. Diesel engines, steam turbines and gas turbine prime movers are presently used onboard IN ships for power generation. Diesel engines in the medium power range (50KW - 1500KW) are used for power generation. Steam turbines are used for generating power in the range of 500 KW to 1000 KW.

3.12 Indigenous development / licensed production of **diesel engine** and **gas turbine prime movers** in the higher power range (1 to 3 MW) will enable import substitution and also provide prompt and reliable product support for the Navy.

Machinery Control Systems

3.13 **Machinery Control Systems**. To ensure substantial indigenisation design of all machinery control systems shipbuilding programme 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. For existing ships, conversion to indigenous equivalent designs has also been planned in a phased manner. M/s L&T has taken up indigenisation on this front.

3.14 **Engineering Instrumentation**. Directorate of Marine Engineering (DME) Specifications have been formulated for indigenisation and standardisation of all engineering instrumentation. Compliance to these specs is mandatory for supplying instrumentation for the new construction ships and also for replacement of the imported instrumentation fit for the ships in commission.

Auxiliary Equipment

3.15 **Shafting/ Controllable Pitch Propellers (CPP)**. Some headway has been made in indigenous development of fixed pitch propeller shafting systems with foreign collaboration where the critical components such as propeller, stern tube bushes, ‘A’ Bracket Bushes, Plummer block bearings are still being imported. The import content in case of CPP shafting systems is much higher. There is need to indigenously develop CPP shafting systems with a greater indigenous content of critical component for the future indigenous ship construction projects.

3.16 **Propeller Shaft Sealing Arrangements**. At present shaft seals are being imported from foreign firms viz. Deep Sea Seals, UK etc. There is a need to develop a reliable indigenous gland sealing arrangement for the shafting system of the new construction ships and also for replacing the imported assemblies installed on existing ships.

3.17 **Stabilisers/ Steering Gears**. Considerable success has been met in the development of steering gear and stabiliser systems. Systems for retrofitment for SNF and G Class ships have been successfully indigenised and installed onboard. Most of the new construction ships are being fitted with indigenous systems. Firms like L&T, Geeta Engg, Veljan Hydrair, etc., have partnered in the development of these systems.

3.18 **Propulsion System Integration**. 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. 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.

3.19 **Air Conditioning and Refrigeration.** Air conditioning plants requirement in Navy ranges from 30 tons to 500 tons capacity. Indigenous manufacturers are providing the lower range AC plants. Although Indian manufacturers are capable of supplying the higher range AC plants, the import content for such plants is in the order of 50-70%. Firms like M/s Kirloskar Pneumatic Company Limited (KPCL) & M/s Johnson are the firms who have been associated with Navy for supply of these equipment. Also, there is a requirement to indigenously develop screw compressors for higher capacity AC plants.

3.20 **HP Air Compressors.** The capacity, pressure and quality of discharged air of an air compressor is dependent on the end use onboard ship. HP compressors have been indigenised to a great extent and have replaced the imported compressors of existing ships. However, there exists a large inventory of Soviet origin compressors of varying discharge pressure (200 to 400 bar) and capacity (upto 100 cubic mt / hour) and there is ample scope for indigenous substitution in this field.

3.21 **Control Air Compressors**. Some of the Indian firms have successfully proved and supplied their control air compressors for Leander/Godavari class ships. Ample scope exists for the requirements of new construction ships and replacement of imported compressors for ships in commission.

3.22 **Desalination and RO Plants**. The RO plants are being procured from indigenous source like M/s Rochem & Technoprocess, which also has large import content. There is a requirement to develop additional indigenous sources of supply of the RO plants with considerable reduction in import content.

3.23 **Centrifuges**. A large number of Russian Origin Lube Oil and Fuel centrifuges are presently in use on board ships. Indigenisation of fuel oil centrifuges is in progress. Efforts are in hand to identify/ develop indigenous sources for manufacturing of lube oil centrifuges of capacity 1000 to 4000 litres per hour as replacement for Soviet origin centrifuges.

3.24 **Centrifugal Pumps**. Fire pumps, AC and Ref plant seawater pumps, dewatering pumps, and fresh water pumps of Russian origin are fitted on ships. These pumps are of discharge pressure ranging from 2 kgf/cm² to 12 kgf/cm² and capacity 10 tons per hour to 250 tons per hour. Indigenous substitutes of these pumps have been developed through reputed Indian pump manufacturers. The volumes involved are quite substantial and should prove attractive for more Indian industry players to venture and meet the growing demands for new construction ships and replacement for imported pumps on existing ships.

3.25 **Gear/Screw Type Pumps**. Gear and Screw pumps are widely used on board for conveying POLs and combustible fluids due to their less turbulent pumping action. Some of the Indian firms like M/s Alekton and Tushaco Pumps have indigenised these pumps. However, given the large numbers and diversity of the pumps there is ample scope for other manufactures to venture in his field.

3.26 **HP Air and Hydraulic System Valves**. Some HP Air and hydraulic system valves for high-pressure application (up to 400 bar) which were not available indigenously and imported from UK and Russia for IN ships and submarines have now been indigenised through firms like M/s Caltech. However, sufficient scope exists for the large variety of these valves and these could be taken up for development by Indian valve manufacturers.

3.27 **Sea Water System Valves**. Sea water system valves are widely used in the critical systems of ships viz. fire main system, cooling water systems, pre-wetting system, ballasting/ de-ballasting systems etc. There is a recurring demand for valves in large numbers of sizes 25 mm to 250 mm. Navy has specified Nickel Aluminium Bronze (NAB) valves for all the sea water systems. This relatively low technology but high volume field presents an attractive opportunity for the industry to step in and supply reliable and quality products for Navy’s current and future requirements.

3.28 There exists a need to initiate indigenisation of equipment and its spares to attain self-sufficiency and preclude dependence on the foreign firms for ships procured from foreign countries, viz., Vikramaditya.

However to begin with, indigenisation of spares/ components of critical equipment/ systems need to be initiated, so that indigenous replacements of equipment/ parts are available during the ship's first Medium Refit (MR).

3.29. Boiler tubes, refractory items, certain steam auxiliaries and MD pumps fitted onboard western origin ships like 'G' class, 'B' class and Viraat have been successfully indigenized in the past.

3.30 Further indigenisation of certain items related to Engineering equipment/ systems have already been initiated for INS Vikramaditya. The present status is indicated below:-

(a) Identification of indigenous equivalents/ sources for Russian origin and Customer Nominated Equipment (CNE) POLs.

(b) Identification of indigenous equivalents/ sources for 18 chemicals and consumables.

(c) Owing to criticality of boiler fuel pumps, components/ sub-assemblies of boiler fuel pumps which are susceptible for indigenisation has been initiated.

(d) Development of 16 types of mechanical seals specific to the ship by Ms General Seals, Mumbai has also been initiated.

(e) Identification of equivalents for Russian origin bearings viz ball, roller, single row etc through M/s Bharat Trading Corporation, Mumbai has been initiated.

Indigenisation Envisaged

3.31 The list of equipment for which spare parts/ components could be taken up for indigenisation are as follows:-

(a) Complete Boiler tubes and refractory

(b) Turbo Driven steam auxiliaries

(i) Turbo-driven Fuel Pumps

(ii) Turbo Blower Units

(iii) Feed Condensate Booster Turbo – driven Pumps

(iv) Turbo-driven Main Circulating Pumps

(v) Turbo-driven Oil Pumps

(vi) Turbo-drive of AC Plants

(c) Feed Water Pumps

(i) Automatic Working Water Pumps

(ii) LPSG Feed Pump

(iii) Condensate Feed Pump

(iv) Pump for boiler chemical treatment

(v) Hand Pump for boiler dosing

(vi) Proportioning Pump for boiler dosing

(vii) Condensate Feed Pump for TA

(d) Lub oil and sea water coolers fitted on various machinery

(e) Fuel Pumps

(i) Fuel Pumps

(ii) Fuel transfer Pumps

(iii) Stripping pumps

(iv) Manual Pumps for Aviation Category Fuel (AVCAT)

(v) MD fuel pumps

(f) Lub oil pumps

(i) Transfer Pumps

(ii) Hand Pumps

(iii) Hand Pumps

(iv) Motor-driven Oil Pumps

(v) Oil Pumps

(g) Sea water pumps

(i) Pump of various capacities

(ii) Hand Pumps

(iii) AC Condenser Sea Water Cooling Pumps

(iv) Seawater Circulating Pumps

(v) Fire Pumps

(h) Fresh water pumps

(i) Chilled Water Pump

(ii) Fresh Water Pump

(iii) Pumps for demineralized water system

(iv) Pump for fresh water

(j) Desalination plant pumps

(i) Pumps of various capacities

(ii) Mineralisator Pump

(k) Bilge system Pumps

(i) Main Drainage Pumps

(ii) Pumps of various capacities

(iii) Portable Pumps

(l) Hydraulic Pump

(i) Pumps of various capacities

(ii) Transfer Pumps

(iii) Manual Pump

(iv) Variable discharge Pumps

(v) Hydraulic Pumps for Aircraft Arresting Gear and Lifts

(m) Shafting components like bearings, thrust pads etc.

(n) Lub oil coolers, condensers and evaporators of MDAC, TDAC and ref plants.

(p) Valves fitted in freshwater, feed water, sea water and other auxiliary systems.

(q) Component level items of Boiler and Turbine Aggregates control systems.

(r) Filters of lub oil system.

3.32 Similarly, the maintenance of hull equipment onboard IN Ships also needs to be looked at in the short/ long term perspective as given in succeeding paragraphs.

3.33 **Habitability, Ventilation and Air Conditioning (HVAC)**. In the short term indigenisation of various components of the HVAC system needs to be taken up.

3.34 **Hull Equipment**. Considering the extensive operational profile of Aircraft Carriers, the following hull equipment may need to be replaced during the 1st Medium Refit :-

(a) Davits.

(b) Boats.

(c) Various components of Lifts.

(d) Various Winches

(e) WT Doors and Hatches

3.35 The boats will be replaced as a part of the periodic review. The boats would need integration to the davits thereafter.

NBCD Equipment.

3.36 Development of fixed FF system for machinery compartments is being progressed by Centre For Fire, Explosives and Environment Safety (CFEES). The production of this system may also be progressed by industry in partnership with the developing agency.

3.37 Similarly development of fixed FF system for Magazines is being progressed by BEL Kotdwara. The production of this system may also be progressed by industry in partnership with the developing agency.

Forecast Requirements

3.38 A list of forecast requirement of Engineering equipment and systems for the next 15 years is placed at **Appendix 'A'.**

CHAPTER 4 - ELECTRICAL/ ELECTRONIC SYSTEMS

4.1 A large number of electrical /electronic equipment for installation onboard have been developed and supplied by the Indian Industry. Products like Microprocessor Based Air Circuit Breakers, Automated Power Management System (APMS), 1MW Generators, Command and Control Systems, Multi-Function Displays, ATM based data bus, Control System for Remote Control Target Boat (RCTB), Rotary and Static Converters/ inverters etc have been indigenised by industry and are used onboard ***IN*** ships.

4.2 Greater participation of the industry for production of the under mentioned Electrical/ Electronic equipment, merits consideration :-

Navigational Aid Equipment

4.3 **Gyros**. Indigenous Ring Laser / Fibre Optic gyro.

4.4 **Logs**. Indigenised through M/s Keltron.

4.5 **Echo Sounder**. Indigenised through M/s Keltron.

4.6 **GPS**. Indigenous Satellite Based Navigation systems with compatibility for GPS/ GLONASS/ IRNSS/ GAGAN

4.7 **Electronic Chart Displays (ECDIS)**. ECDIS equipment provides the necessary ability to select, display, and interpret relevant information, including the use of navigational functions associated with route planning and monitoring; and knowing what proper action to take in case of malfunction. The equipment is being sourced as Commercial Off the Shelf (COTS) equipment.

Communication Equipment

4.8 **INMARSAT**. SATCOM terminals are required in UHF, S, Ku and C bands for the communication. Presently UHF & S band terminals have been sourced indigenously. Efforts are required to indigenously develop SATCOM terminals in the C & Ku bands also.

4.9 **Communication Sets**. Most of the communication sets in VLF, V/UHF, HF frequency ranges are being sourced through import initially and later being produced/ services through ToT through PSUs like HAL, BEL, ECIL etc.

4.10 Although these highly technology/ capital extensive systems are generally taken up for development through DRDO or other PSUs, Industry may partner with these organisation for development of sub-systems and assemblies.

Power Generation & Distribution (PGD) Equipment

4.11 **Automated Power Management System (APMS)**. The system is sourced from approved Indian vendors as part of Main Switchboard.

4.12 **Microprocessor Based ACBs**. These breakers are being sourced from approved Indian vendors as part of switchboard.

4.13 **Soft Starters**. The starters are being procured from approved Indian vendors as part of associated mechanical systems.

4.14 **Static Frequency Converters**. The equipment is supplied by Indian vendors like M/s AEC, Thane, L&T & Static Transformer, Indore.

4.15 **New Generation Zero Maintenance Batteries**. Batteries for Submarine applications are being sourced from Indian vendor M/s Exide. Batteries are being developed for Submarine application through M/s Exide & HBL. Higher capacity batteries based on latest technologies would be required for new generation Submarines.

4.16 **New Generation Helo Starting Rectifier.** The systems are supplied by L&T, M/s Static Transformer Indore & AEC Thane.

4.17 **GT Starting Rectifier**. The systems have been indigenously developed by M/s Precision Power Products.

4.18 **Rotary Convertors**. The systems have been developed and being supplied by Indian Vendors M/s KEC & M/s ELMOT.

4.19 **Automatic Fire Detection System with Intelligent Sensors**. The system is being sourced from approved Indian vendors.

4.20 **Energy Efficient Fluorescent Lights**. The lamps are being supplied by approved Indian vendors for ships in commission.

Sensors/ C^3 Equipment and their Integration

4.21 **Integration of Surveillance/ Weapon Delivery Systems**. Induction is being undertaken through multi-vendor approach. Some of the Indian vendors assessed by Navy having capacity and capability as prospective Combat Management System (CMS) developers include M/s Tata Power Company Limited (TPCL), Tata Advanced Systems Limited (TASL), M/s BEL, L&T Strategic Electronics Division (SED), Tata Consultancy Services (TCS) and Pipavav Defence & Offshore Engineering Company (PDOECL).

4.22 **Navigational Radars**. These radars are generally extremely low power CW radars with complex signal processing and capable of detecting targets without being picked up by EW systems. These are being supplied as COTS item by multiple Indian vendors.

4.23 **Command & Control System**. Command, Control and Communication (C^3) system is an information system which incorporates strategic and tactical systems like a combat direction system, tactical data system, or warning and control system with associated human function. The increasing need for responsive Command & Control systems is being driven by the rapidity with which weapons can be deployed. In a complex multi-threat combat environment, automated combat direction systems make it possible for people to deal with a large number of targets and compressed reaction times of modern warfare. The complex C^3 functions required to keep track of hundreds of friendly, neutral, and enemy ships, aircraft, and weapons, would be impossible by manual methods. Some of the Indian vendors assessed by Navy having capacity and capability as prospective developers include M/s TPCL, Tata Advanced Systems, M/s BEL, TCS etc. C^3 systems are required to be developed to incorporate following areas in support of commanders engaged in command and control:-

(a) Reconnaissance and Surveillance.

(b) Environmental Observation and Forecasting

(c) Intelligence Analysis

(d) Electronic warfare

(e) Navigation

(f) Management

(g) Strategic and Tactical Weapons Deployment

(h) Logistics and Supply

4.24 **<u>High Speed Data Link</u>**. The indigenous Data Link system has been developed using combination of in-house expertise (WESEE) and M/s BEL. The system has been inducted onboard ships.

4.25 In order to address the long term supportability issues of Ships procured from foreign countries, replacement of complete equipment/ components/ modules of certain non-technology intensive general purpose equipment may be considered by Indian Industry.

4.26 Some of the potential vendors identified for development for electrical equipment fit onboard IN Ships are as given below:-

<u>Item/ Eqpt</u>	**<u>Potential Vendors</u>**
Auto Change Over Switch	M/s Precision Power Products, Aurangabad
	M/s L&T, Mumbai
	M/s Marine Electricals, Mumbai
	M/s GEII, Mumbai
Main Switchboards and Weapon Switchboard	M/s L&T, Mumbai
	M/s GEII, Mumbai
	M/s Siemens Ltd., New Delhi
	M/s Maine Electricals, Mumbai
Cables	M/s Radiant Cables Ltd, Hyderabad
	M/s NICCO Corporation Ltd, Kolkata
	M/s Universal Cables Ltd, New Delhi
	M/s Servel Udyog Pvt. Ltd., New Delhi
	M/s Siechem Technologies Ltd, Pondicherry

Item/ Eqpt	**Potential Vendors**
Lanterns/ LED Based Lighting	M/s Ray Enterprises, Ambala
	M/s Mcgeoth Marine, Mumbai
Light Fittings/ Navigational Lights	M/s Manish Industries, Kolkata
	M/s Issac Engineering Works, Kolkata
	M/s Arvin Industries, Mumbai
	M/s Ray Enterprises, Ambala Cantt
	M/s Fabricon, Mumbai

Forecast Requirements

4.27 A list of forecast requirement of Electronic/ electrical equipment and systems for the next 15 years is placed at **Appendix 'B'.**

CHAPTER 5 – WEAPONS, ARMAMENT AND SENSORS

5.1. The Indian Navy is poised to grow significantly in the upcoming few years with the induction of a large number of ships, submarines and aircraft. These platforms would need to be equipped with state-of-art weapons and sensors to meet the required capabilities enshrined in MCPP. Equipment under this category are predominantly under the "FIGHT" category and are the backbone of any modern warship. These equipment are the ones which give an edge to any Naval platform and could assert superiority in the area of operation by use of these weapons and sensors. The requirement of these equipment is based on the maritime security imperatives, mapped to a definite developmental timeframe. The thrust and emphasis on indigenous development is the Navy's prime driver for articulating the intended approach.

5.2 The process of development of these systems is quite involved and is carried out appropriate professional Directorates at IHQ MoD(N) in conjunction with the design/ development and production agencies. Therefore most of the weapon systems present in Navy and those being inducted are procured from foreign Original Equipment Manufacturers (OEMs) or Indian DPSUs. However, the weapon system being developed by DRDO have significant quantity of modules/ sub units sourced from foreign OEMs especially in the niche technology areas like RF and Microwave Power Modules. Further, frequent failures have been experienced in these modules and the sourcing them from OEM entails large hurdles due denial & sanctions, therefore, greater thrust has been given to indigenisation of critical spares.

5.3 Optimum self-reliance is of vital importance for both strategic and economic reasons. In order to synergise and enhance national capabilities in producing state-of-the-art systems or equipment within timelines and price lines that are globally competitive, all viable approaches such as formation of consortia, joint ventures and public-private partnerships are necessary. If for some reasons, indigenisation of systems is not possible, either due to shortfalls in available expertise/ technology or due to prolonged development activities, the option to go in for imports of limited quantity followed by indigenous production through ToT, would needs to be considered by utilising the 'Buy & Make' route.

5.4. Private industry has been involved in manufacture of various missile, rocket and torpedo launchers. A number of missile handling equipment has also been manufactured by industry and is used onboard ships. However, the number of vendors is limited and larger participation may be considered. Some of the firms like M/s L&T, Mahindra Defence, Tata Power Strategic Electronics Division (SED) have ventured in this field and successfully partnered Navy in development of these launchers and handling equipment.

Forecast Requirements

5.5. A list of forecast requirement of Weapon spares for the next 15 years is placed at **Appendix 'C'**.

CHAPTER 6 – SUBMARINE EQUIPMENT AND SYSTEMS

6.1 Private industry has partnered in indigenisation that has been undertaken by the Navy for the submarines. A large number of firms have been associated with the development of various systems and sub systems for the Submarines. Successful development of this kind of project has given Navy enough confidence in the Indian Industry and displayed that such complex technologies can be evolved with concerted participation of the various lead stakeholders. This has further led to change in approach by the Navy to involve Industry for the support of the existing platforms for which most of the equipment was being imported till very recently.

Existing Submarine/Equipment

6.2 Some examples of indigenisation, which have been undertaken in the recent past include:-

(a) Hydraulic oil accumulators.

(b) Fuel flow meters.

(c) Various system filters.

(d) Various pumps.

(e) Various types of cables.

(f) Submarine batteries.

(g) System coolers.

(h) Various types of sensors and indicators.

6.3 Equipment/ systems envisaged for fitment on indigenous underwater platforms, are as listed below:-

(a) High Density Valve Regulated Lead Acid Batteries for Submarines.

(b) Compact High Capacity Turbines.

(c) Main Motor Generators.

(d) Propulsion Motors.

(e) Non hull penetrating Submarines Masts.

(f) Optics for Submarine masts.

(g) Integrated Sonars.

(h) Control and Monitoring Systems based on Versa Module Europa (VME) / Programmable Logic Controllers (PLCs) with fibre optic backbone.

(j) Inner and outer Exhaust Flap Assemblies.

6.4 **Technologies**. Major technologies relevant to underwater platforms which may be taken up for development are enumerated below:-

(a) Phosphoric Acid Fuel Cell Technology for Air Independent Propulsion.

(b) **Acoustic Signature Management**. The following equipment / systems need to be developed towards acoustic signature management onboard submarines:-

(i) Raft Mounting System for propulsion system and auxiliaries.

(ii) Anechoic tiles, Submarine acoustic coating and other types of submarine acoustic coatings such as vibro-damping coatings and silencers.

(iii) Tuned Mass Dampers & Pneumatic Shock Mounts for < 200 kgs equipment.

(iv) Enhanced shelf life Rubber Shock Mounts.

Project -75/ 75(I) Submarines

6.5 The construction of submarines under the Scorpene project is progressing at Mazagon Dock Limited (MDL) under ToT from DCNS, France. Further, construction of platforms under P-75(I) is also being taken up in India. This has offered an excellent opportunity for indigenisation of equipment and systems as per the provisions of the contracts. Equipment and systems proposed to be indigenised are as follows:-

(a) Different types of pumps.

(b) AC Plants.

(c) Ref Plant.

(d) De-Mineralised Water (DM) Plant.

(e) Accumulators.

(f) Various types of filters.

Forecast Requirements

6.6 A list of forecast requirement for submarines is placed at **Appendix ‘D’**.

CHAPTER 7 – AIRCRAFT HANDLING EQUIPMENT

7.1 With the planned induction of the 2nd Aircraft carrier, Industry support is being sought for the development and maintenance of various handling equipment onboard these class of ships. Large number of equipment for handling aircrafts/ arms/ ammunition onboard ships are required by Navy. Some of the equipment used onboard and being imported presently which need to be indigenised and may be taken up for development by the Indian Industry are enumerated below:-

(a) Ship Based Hoisting and Lifting Equipment (Aircraft / Vehicle Lifts and Cranes)

(b) Automatic Aircraft Landing System (Microwave / Electronic ACLS) for indigenous fixed wing Aircraft

(c) Carrier Based Fixed Wing Aircraft Arrester Wire Recovery System

(d) Aircraft Catapult Launch System

(e) Flight Deck & Hangar Fixed Fire Fighting System

(f) Rail-less and Wireless Aircraft Traversing System

(g) Telescopic Hangars & Foldable Hangar doors

Forecast Requirements

7.2 A list of forecast requirement for Aircraft Handling Equipment is placed at **Appendix 'E'**.

CHAPTER 8 – DIVING AND SPECIAL OPERATIONS EQUIPMENT

8.1 Special Operations and Diving equipment, by virtue of the specialised nature of job, inherently need to be based upon high end technology. However, these are required in limited numbers and have a limited shelf life. Keeping the aforesaid in mind, the following equipment have been identified for indigenous production :-

(a) Night Vision Equipment (NVEs) with advanced optics and various sizes, based on application

(b) Air Diving Sets with Full Face Masks (FFM) for diving operations up to various depth and capable of stand-alone as well as Surface Demand modes

(c) Unmanned Aerial Vehicles (UAVs) with capability for passing information beyond the line of sight, Micro UAVs with negligible visual and sound trails, etc.

(d) Under Water Diver Lamps, complying to weight/ buoyancy restrictions, diving certifications and light intensity requirements for efficient diving operations.

CHAPTER 9 – NAVAL AVIATION EQUIPMENT

9.1 The indigenisation activities in the Naval Aviation commenced in 2005 wherein thrust and emphasis was laid on achieving 'self-reliance' utilising indigenous resources with an ultimate objective of developing substitutes to ensure limited dependence on foreign suppliers. In recent years, deliberate efforts and emphasis have been made towards indigenisation of aircraft spares, repair processes and test facilities through following levels of sustenance:-

(a) Micro - Obsolescence Management and Import Substitution

(b) Macro - Reduce dependence on foreign OEM, Enhance Capability

(c) Futuristic - Major indigenisation projects, Buy and Make (Indian)

9.2 In Naval Aviation, activities towards indigenisation have been pursued for nearly two and a half decades. To establish a streamlined procedure towards indigenisation of air stores, a document titled "PINAS" Procedure for Indigenisation of Air Stores" was initially promulgated. Subsequently, Manual for Indigenisation of Air Stores (MINAS) was subsequently, promulgated in 2009 covering all aspects in the indigenisation process of air stores including DPM-09 provisions. Indigenisation of airborne stores is mainly based on its classification as flight critical / non flight critical.

(a) **Flight Critical (FC)**. Those items whose malfunction would jeopardize the airworthiness / safety of the aircraft and/or crew in flight are covered under Flight Critical. Items fitted on engine, flight controls, fuel systems, flight instruments etc generally belong to this category. The airworthiness certification for the said items is accorded by Centre for Military Airworthiness and Certification (CEMILAC) through respective Regional Centres for Military Airworthiness (RCMA).

(b) **Non Flight Critical (NFC)**. These are Non Flight Critical items pertaining to airborne stores, GSE items, tools, test equipment etc. The airworthiness certification for the said items is accorded by Naval Aeronautical Quality Assurance Services, Kochi (NAQAS).

9.3 **Partnership with Indian Industry**. The Indian private sector has seen an exponential growth in defence aviation sector with the programmes such as Light Combat Aircraft (LCA) and Advanced Light Helicopter (ALH) and UAVs in the recent past. In addition there is active involvement of private industry in collaboration with DRDO and DPSUs in developing different platforms and systems for the naval aviation. The field is ever growing in both Macro and Micro levels of indigenisation. The various upgrade programmes of naval aircraft and systems are progressed with Indian Industry support. A few examples are IFF, ESM Systems, Communication systems including SATCOM, Network Centric Capabilities etc. At micro level the focus has been to achieve obsolescence management and import substitution to avoid OEM dependency. In these cases the indigenisation approach has been platform centric, with long term perspective. A few examples are Batteries Tyres, Brake units, Multi-functional Displays (MFD) etc.

9.4 **Challenges and Opportunities**. The challenges of small fleet of platforms and associated business volume notwithstanding, a steady progress has been made on indigenisation in naval aviation, with support from DRDO, DPSU, CEMILAC and Indian Private Industry. The challenges and opportunities in this regard are as brought out

(a) **Micro**. Obsolescence management of and sustenance of legacy platforms such as Long Range Maritime Reconnaissance (LRMR) aircraft TU 142M and IL38SD and KV 28 ASW helos of Russian origin and western origin platforms such as Seaking ASW helo and Sea Harrier, carrier borne VSTOL fighter. The indigenisation efforts have not been restricted to one-to-one replacement of imported items, but are aimed at improving operational efficiency and reliability through re-engineering, ab-initio design and technology enhancement. Approximately 730 by type spares have been indigenised till date and over 100 are in the pipeline.

(b) **Macro**. Greater focus is on long term sustenance, increased self reliance and enhanced capabilities on new generation platforms such as MiG- 29K carrier borne fighter, Hawk AJT, KM 31 ASW helos and P8I LRMR aircraft. In addition to indigenisation of systems and items, setting up in country Deep Repair Facilities (DRF) in partnership with Indian Industry is being actively pursued.

(c) **Futuristic**. Future induction of platforms would be largely based on Buy and Make (Indian) concept such as NUH and NMRH helos. Traditional concepts of Deep Repair Facilities (DRF) within services / DPSU would have to be complemented or replaced with capabilities in Indian Production Agency (IPA) through their MRO facilities and Performance Based Logistics (PBL) concepts. Such new concepts present its own challenges and opportunities for Naval Aviation and the Industry.

CHAPTER 10 – PROJECTS COMPLETED/ PROPOSED WITH DRDO/ PRIVATE INDUSTRY

10.1 Navy is also proposing development of certain technology intensive projects through DRDO. Navy has been having continuous synergy meetings with DRDO clusters for progressing the development of certain equipment/ technologies. The aim is to achieve the desired outcomes in a time bound manner with active participation of all stakeholders. Some equipment have also been identified for development through Private Industry under 'MAKE' categorisation provisions of Defence Procurement Procedures – 2013 (DPP). Although these are at very nascent stages and would be persued in the course of the current IN indigenisation plan.

10.2 A list of Equipment identified/ short listed for development through DRDO/ Pvt Industry is placed at Appendix 'F' & 'G' respectively.

10.3 Similarly, a number of equipment for new construction ship have been developed through DRDO/ Pvt Industry efforts, as also certain equipment in trials stages and nearing induction in Navy. These indigenous equipment are being installed onboard indigenously constructed Indigenous Aircraft Carrier (IAC)/ Anti Submarine Warfare (ASW) Corvettes and other ships. List of these equipment is placed at **Appendix 'H'** and **'J'** respectively.

CHAPTER 11 - FUTURE TECHNOLOGIES

11.1 Development of core military technologies indigenously will significantly enhance naval capabilities. Therefore, a need exists to study the trends of technological advancements in order to invest in inducting them, rather than trying to catch up.

11.2 Future wars will be characterised by deployment of unmanned weapon systems, robotic soldiers and sophisticated machines which can operate in all environments. Space, cyber space and asymmetric dimensions are likely to assume greater importance and advancement in critical technologies, sensors, robotics, communication and electronics are paving way for future warfare. Some of the technologies that are likely to have defence related applications in the future are:-

(a) Robotics and Artificial Intelligence.

(b) Sensors (Photonics, Laser, MEMs, DEW).

(c) Material Technology (Stealth, Meta metals, High strength structural).

(d) High Energetics (Explosives, Anti-mater, Thorium Tech).

(e) Fusion Technology.

(f) Space Technology.

(g) Missile Technology and Hypersonics.

(h) Nano Technology.

(j) Bio-technical Weapons.

(k) IT and Cyber Warfare Technology.

(l) Unmanned Weapon Delivery Systems.

(m) Ocean acoustics for littoral waters.

(n) Networking technologies for air and undersea applications.

(p) Bio-fuels for ships and aircraft.

11.3 Future warfare will be characterised by a high degree of jointness, interoperability and speed of information flow. Technological superiority is the decisive factor in future battles and technological self-reliance is the key to India's emergence as a global power. As the future wars will be essentially technology driven, there is a need to infuse state-of-the-art technologies in partnership with the Indian industry and prepare our human capital to optimally exploit them to generate maximum combat power. Some of the technologies of today which will be the backbone of tomorrow are illustrated in the succeeding paragraphs.

Computation and Automation

11.4 **Background**. High-performance and fast computation capabilities have already emerged as essential ingredients for almost every conceivable application; such as management, networking, decision making, equipment performance enhancement, design and training & simulation studies. Advances in related technologies are continuously driving towards more and more miniaturisation, increase in computational speed and power, and lowering of costs, a trend that will continue at a rapid pace during the current century. Powerful and smaller computers will enable development of more compact and powerful weapons, sensors, and crucial systems. Technological advancements in Artificial Intelligence (AI) and fuzzy logic will help in making advanced decision-making and decision support systems available. Further, automated systems have already found their way on board naval platforms for management of machinery, power and battle damage assessment systems. With the advancements in computation and sensor technologies, together with the advancements in Micro Electronic Mechanical Systems (MEMS) and nano-technologies, the next 20 years will witness an increased availability of sophisticated automated systems for a wide range of naval applications. Thus, **computers, microprocessors, and related software that provide computation and automation capabilities are among the most important technologies** that will impact the entire spectrum of technologies related to the Navy, and thus will strongly influence the future performance of the Armed Forces. Automated systems hold tremendous potential for providing highly reliable performance to naval platforms, with reduced manning requirements, reduced platform size without compromising on capabilities, increasing surveillance, intelligence gathering and warfare conducting capabilities and minimising exposure of personnel to hostile actions.

11.5 **Technology Trends**. The impact of computation in future naval operations is expected to be enormous. Combined with advanced distributed sensors, computation will be the primary enabler for achieving and exploiting complete situational awareness and will provide more and more computational power to the processing and interpretation of the digitised sensor signals. Sensing elements will become fully integrated with their supporting digital computer hardware to produce smart sensors or sensors-on-a-chip. More systems will become adaptive, processing in real-time the observed signature, and, altering their system parameters in response to the observations to optimise their actual performance. Fusion of data from multiple sources, extraction of meaningful information contained therein, real-time control, and high accuracy will result in considerable optimisation in the effectiveness of future naval operations.

11.6 **Automation Technologies – An Example**.

(a) A possible example of Automated Technology would be the Integrated Platform Management Systems (IPMS). New construction ships are already being fitted with IPMS for control and monitoring of platform-wide machinery and systems including propulsion, power generation and distribution, auxiliaries, damage control, steering and stabilisation. At present, group of ‘dumb’ sensors are connected to the processors with intelligence residing primarily in the central processor. With the significant increase in processing power and memory and reduction in the price, embedded processors will penetrate virtually every I/O point and thereby make each of them an intelligent ‘appliance’. For example, an intelligent motor should be able to provide more information such as its history, part number, specifications, operating instructions, diagnostics, repair instructions, replacement alternatives, alarm messaging, pre-failure warnings, etc. Presently this information resides in the documents or with the experts. A significant intelligent characteristic is diagnostic, not only after the failure has occurred, but also predictive (before the failure) and advisory (providing maintenance instructions). This kind of ‘intelligence’ will reside not only in the central processor but will be embedded in the equipment itself.

(b) **Unmanned Vehicles**. Unmanned Vehicles will progressively find increasing use in the naval applications. **Unmanned Aerial Vehicles (UAVs)** launched from shore / ships provide tremendous potential and force multiplication for reconnaissance, surveillance, co-operative engagement and as platforms for autonomous weapon release. Rapid evolution of technologies related to increasing mission pay-loads, improving sensors (including sensors combined with weapon systems) and aeronautical technologies (navigation, autonomous control, propulsion) make UAVs very valuable tools for a variety of naval operations. The operational spectrum of these UAVs will include reconnaissance, C^2, target discrimination and identification, battle damage assessment, data transfer, Electronic Counter Measure (ECM), Electronic Support Measure (ESM), Electronic Counter Counter Measure (ECCM) and combat support / identification in case of shore bombardment and amphibious operations. UAVs will act as force multiplier and represent the 'eyes' of naval units in the future, providing them the possibility to see in real-time-over-the-horizon. They may in future be used in-lieu of helicopters for certain roles.

(c) **Unmanned Underwater Vehicles (UUVs)**. These vehicles would enhance operational capabilities of naval forces in underwater warfare, reconnaissance, and surveillance. Potential UUV missions include shallow-water mine reconnaissance and counter proliferations in harbours. The USN has already acquired a Long-term Mine Reconnaissance System (LMRS), which is a submarine launched and submarine recovered counter-mine system. Future capabilities of UUVs would also include ability to carry a limited range of weapons for attacking detected targets. In the future, surface ships operating in littoral waters can be expected to encounter novel threats like intelligent sleeping mines, frogman, miniature submarines, intelligent torpedoes, etc. Counter-measures will need to include artificial, remote-controlled 'fish', equipped with explosive loads that can be activated through acoustic means.

Sensor Technologies

11.7 **Introduction**. Consistent and precise battle space awareness is an essential requirement of naval forces. The Indian Navy uses a wide range of electromagnetic, acoustic, Nuclear, Biological, Chemical (NBC), mechanical, environmental and temporal sensor systems. These are essentially required for surveillance, acquisition and assimilation of information related to the location and movement of friendly, neutral and hostile forces, including their identification. Developments in technology related to semi-conductors, super conductors, computers, signal processing algorithms are resulting in the increasing availability of high performance sensors with improved range, resolution and fidelity. While considerable indigenous R&D efforts are already in progress in various areas, these need to be pursued in a more focused manner for overcoming existing technology gaps. It is relevant that considerable commonality of technologies exist in realizing various types of sensors, and therefore R&D efforts in various associated technology areas need to be shared among various different projects.

11.8 **Electromagnetic Sensors**. These include the complete range of Radars, ESM/ECM, IR and Laser systems. Dedicated DRDO labs are already undertaking R&D activities in these areas, and considerable success has been achieved in specific areas. However, this effort needs to be provided the desired impetus for early realization of critical state-of-the-art sensors for naval requirements. Important areas for sustained indigenous R&D effort are broadly outlined below.

Radars

11.9 With their all-weather, long-range capabilities for detection and tracking, radars will remain the primary electromagnetic sensor on naval platforms. A revolution is already taking place in radar technology with the availability of high power solid-state electronics replacing conventional Traveling Wave Tubes (TWT), replacement of rotating radar dishes with steerable solid state arrays (providing increased reliability and scanning speeds), faster processing and digitization for returning radar signals, smarter algorithms for improving signal processing, reducing clutter and false alarms, Track while Scan (TWS) capabilities, capability to tracks much larger number of targets simultaneously, identifying targets and providing motion analysis. Future radars will utilize solid-state phased arrays antennae for almost all frequency bands, with increasing use of active multi-function radar systems. Signal processing will be almost entirely digital beam forming, confining the analog microwave portions to the extreme front-end interface of the antenna with the outside world. Signals received at the antenna elements will be digitized at the element after minimal analog processing and passed on in digital form over wideband fibre-optic links to convenient remote locations for further signal processing, doing away with the requirement of wave-guides. Similarly, during transmission, digitally created waveforms will be generated and distributed via fibre-optics to individual antenna elements where Digital to Analog (D/A) conversion and Monolithic Microwave Integrated Circuit (MMIC) based power amplification will take place.

11.10 Major application areas that need to be pursued through in-house R&D efforts include the following:-

(a) Development of Multifunction Phased Array Radars.

(b) Development of Synthetic Aperture Radars (SARs).

(c) Development of Low Probability of Intercept (LPI) Radars.

(d) Development of Millimetre Wave Radars (MWR).

Emerging Trends in Underwater Sensors

11.11 **Active Sonar**. Submarines are increasingly becoming stealthier, limiting the traditional advantage of passive narrow-band processing. The trend of utilising active sonar operation, especially in the context of littoral warfare using multi-static operation with transmission from a platform or buoy exploited by all other sonar systems in vicinity, will gain tactical usage. Development of active sonar systems with multi-static capability, efficient receiver designs to overcome reverberation and low frequency transducers will therefore continue to receive more and more attention.

11.12 **Low Frequency Active Sonars**. Lower frequency could result in increased ranges due to low propagation losses. However, this is also handicapped by increased ambient noise and size of arrays. In near future (03-05 years) the frequency of active Hull Mounted Sonar would reduce even further. The advantages of any further reduction in transmission frequency, especially in the coastal tropical water would have to be weighed, before undertaking development of very low frequency sonar systems which will lead to bulkier arrays and significant increase in costs.

11.13 **Passive Sonars**. Passive sonar operation is an attractive option in deeper waters with low frequency of operation. The submarine sonars would essentially remain passive systems with flank and towed arrays to enable operation below 300 Hz. Efficient array systems with Left / Right ambiguity resolution, advanced classifiers and passive Target Motion Analysis would have to be developed.

11.14 **Mine & Obstacle Avoidance Sonar**. Mine hunting and obstacle avoidance sonar would necessarily need to use high frequencies for better target resolution and acoustic image processing for target classification. Improvement of ranges at higher frequencies will be a major challenge. This is a vital area where indigenous development has not made any significant progress. Demand of higher spatial and range resolution would require development of synthetic aperture sonars. Offline data-base management system would be another important dimension of mine sweeping requiring significant impetus.

11.15 **Air Borne Sonars**. Dunking sonars which employ low frequency active operation (1.5 – 3 KHz) would continue to perform the key role in underwater surveillance systems. The use of dunking sonar in multi-static active operation would require networking with ship-borne systems. Sonobuoys will provide cost-effective surveillance tools with development of Vertical Line Array DIFAR Buoy (VLAD), Directional Frequency Analysis and Recording (DIFAR), Command Activated Active Sonobuoys (CAAS) apart from passive buoys with LOFAR & DEMON processing available at present. The sonobuoy technology will have significant use in the field of harbour defence networks also. These technologies need to be exploited to develop appropriate sensors for the Indian Navy.

11.16 **Non Acoustic Sensor System**. Alternate methods of underwater detection using Magnetic Anomaly Detection (MAD), satellite images and lasers will compliment acoustic detection. MAD will provide confirmation on detection of targets by acoustic means. Satellite imagery, both optical and from Synthetic Aperture Radar (SAR) will provide advance and panoramic detection capability.

<u>Weapons</u>

11.17 The technological developments in the field of electronics, warfare, ammunition and data processing are continuously changing the nature of the threats to naval platforms. Highly potent air-defence systems, anti-ship weapons, mines, torpedoes, and soft-kill weapons are becoming available to our potential adversaries including non-state actors at a low cost. The offensive and defensive capabilities on naval platforms will, therefore, need to be suitably configured with hard-kill and soft-kill weapons operating in networked environment with Co-operative Engagement Capabilities (CEC).

11.18 Indigenous R&D effort, therefore, needs to be directed towards development of suitable missiles, guns and soft-kill weapons for AMD, precision longer range missiles for offensive action against ship and land targets, guns with suitable ranges for providing Naval gun fire support and anti-ship and anti-submarine torpedoes.

<u>Anti-Ship Missile Defence</u>

11.19 Technological advances will result in the development of highly manoeuvrable, stealthy, subsonic, and / or supersonic anti-ship ballistic and cruise missiles which the potential adversaries could be expected to possess. Many of them will be sea skimmers that would provide very little reaction times for employing effective defensive measures. Further, these missiles will be delivered from platforms at beyond the visual and stand-off ranges. Credible missile defence capabilities will, therefore, need to include quick –reaction high-performance Surface-to-Air Missile (SAM) systems, high rate of fire Close-in Weapon System (CIWS) guns and, in future, the employment of Directed Energy Weapons (DEW).

11.20 **<u>SAM Systems</u>**. SAM systems will continue to be the back bone of Anti-Missile Defence (AMD) systems. However, their capabilities and effectiveness would need to be significantly enhanced for providing credible AMD. Development / acquisition of SAM systems, with longer range, detection and CEC, are therefore essential to enhance the standoff ranges and serve as deterrence to the launch platforms.

11.21 **CIWS Guns**. CIWS guns will continue to remain the last means of defence within the inner boundary of kill zone of SAM systems. The AK-630 gun has been standardised as the CIWS gun for the Navy. However, with threats becoming increasingly stealthy, manoeuvrable, and supersonic, their performance improvements will need to be pursued. These include increasing the firing rate and developing improved ammunition such as Advanced Hit Efficiency and Destruction (AHEAD) ammunition.

11.22 **Co-operative Engagement Capability (CEC)**. Effective wide-area defence capability necessarily needs to be provided by linking together better de-coupled sensors with ship-based SAMs and fighter-based Air-to-Air Missiles (AAMs) to overcome the platform Line-of-Sight limitations. The de-coupled sensors could be on other manned / un-manned platforms, or could be space-based. Such systems will provide surveillance information, including high-quality fire-control data at longer ranges for increasing reaction time for counter measures and for beyond Line-of-Sight guidance. CEC would enable to utilise the best means available to the battle groups for detecting, tracking, and destroying such threats.

Attack and Fire Support Missions

11.23 In order to prosecute threats and provide Naval Gun Fire Support (NGFS), precision anti-ship missiles, land-attack missiles and suitable calibre guns with appropriate ammunition need to be developed / procured. Suitable small calibre guns are also required for engaging small craft, boats, etc., when operating in the littoral environment or engaging non-state actors in policing / low intensity conflict roles. Anti-Ship and Land-Attack Missiles should be capable of being launched from ships, submarines and aircraft.

11.24 **Attack Missiles**. Due to their longer ranges and inherent accuracies, cruise and sea-skimming missiles launched from ships, submarines and aircraft will remain the most effective and potent means for engaging enemy warships and land targets. However, as the surveillance, ECM and AMD capabilities of our potential adversaries are expected to improve, they will need to be countered by longer range, stealthier, faster and smarter missiles with enhanced ECCM facilities.

11.25 The cost of guidance subsystem generally dominates the weapon cost. Typically, guidance electronics may be half of the total cost of the weapon. Therefore, the reduction of the cost of guidance electronics is of utmost importance. Infra-Red (IR) and video seekers, one-way (command) data links, GPS, and new Inertial Measurement Unit (IMU) weapon navigation systems tend to be low-cost components. Two-way, high-data-rate links and long-range radar seekers are examples of high-cost components of a guidance system. System designs that utilise lower-cost components, standardised across weapons using similar components can significantly contribute in lowering the costs and hence need to be pursued.

11.26 **Guns**. Extending the barrel and recoil of conventional guns could enhance the range by a few kilometres. Conventional guns, however, have inherent limitations in the velocity of projectile and the range that can be achieved. The limits of gas expansion prohibit the launching of unassisted projectiles to velocities greater than 1.5 km per sec and, therefore, the ranges that can be achieved are limited.

11.27 Considerable research is already in progress in developed countries for the development of Extended Range Guided Munition (ERGM) projectiles for larger calibre (127 mm, 155 mm and even larger) guns. The ERGM projectile with ranges up to 70 miles, with in-built GPS and INS, are expected to be available within the next decade. 155 mm shells with additional rocket motor drive and in-built intelligence are also under development and are expected to provide maximum ranges of up to 200 miles. This will significantly enhance shore bombardment and NGFS capabilities of warships and need to be indigenously developed.

11.28 **Kinetic Energy Weapons**. Land-attack missiles are obviously not a cost-effective option for applications where a large amount of fire power is required. An affordable extension of the gun-ranges, therefore, requires an unconventional approach. It is in this context that the development of Kinetic Energy Weapons such as the Electro-magnetic (EM) rail gun assumes importance. Experiments have demonstrated that the projectiles could be accelerated to achieve speeds up to 2.5 km per second. It is projected that hypersonic velocities of up to 6 km per second could be achieved. The EM rail guns can deliver the capabilities of hypersonic missiles at gun-like costs and has the potential to meet every Naval Fire Support requirement. The kinetic energy weapons provide considerable advantages in terms of high projectile velocity, lethality, safety, enhanced ammunition carrying capacity, and enhanced ranges. As related technologies mature, they are also expected to become cost-effective. Development of pulsed power sources is a critical bottleneck in the realisation of EM rail gun. In the interim, Electro-Thermal-Chemical guns which require considerably lesser amount of pulse energy could be attempted to enhance the range of existing guns.

Soft-kill Weapons

11.29 **Directed Energy Weapons (DEWs)**. Technology developments in future generation anti-ship missiles will make them increasingly difficult threats for countering with the conventional SAM systems. Hence, the role of Directed Energy Weapons (DEWs), which operate at the speed of light, assume increasing importance. They use a beam of concentrated electromagnetic energy or atomic or sub-atomic particles primarily as a direct means to damage or destroy the intended target. With progressive miniaturisation of electronics, MEMS technologies, availability of high-power components, increased computation power, DEWs can provide tremendous potential for undertaking both offensive and defensive operations. As an example, compact DEWs mounted on aircraft or remote vehicles can be used to severely degrade an adversary's electronics, surveillance, command, control, and communication capabilities. Indigenous DEW programme for the development of such weapons, therefore, needs to be accorded high priority. The technology areas, which need attention, broadly include the following :-

(a) **Laser Weapons**. They use a laser beam of concentrated energy to directly damage or destroy the intended target. In the next 5-10 years, laser weapons are expected to be deployed on naval surface ships as Close-in-Weapon Systems, and provide effective defence against anti-ship missiles. High-energy lasers are already under advanced stages of development in the USA, China, Russia and Israel.

(b) **High-Power Microwave (HPM) Weapons**. Unlike the directed energy laser weapons, which aim to physically destroy the target, the HPM weapons use the high-power electro-magnetic energy to disrupt the performance of sensitive electronics in computer, communication, and electronic systems.

11.30 The DEWs operate at the speed of light, and hence are immune to the directional errors or gravitational effects, and permit precise and adjustable targeting by varying the amount of energy directed towards the target. Technological developments in related areas are also expected to reduce the costs of these systems, making them more and more affordable.

Underwater Weapons

11.31 Torpedoes, rockets, and mines are commonly used Underwater Weapons. However, the basic limitation of the torpedo is its speed which makes it liable to detection, tracking, and destruction. Higher speed torpedoes, therefore, need to be developed. Further, the range of ship/air /submarine-launched torpedoes also needs to be increased. Development of the light-weight/ portable mines that can be launched from air, and ASW rockets will also need to be progressed to counter underwater threats.

Command, Control, Communication, Computers, Intelligence, Surveillance, Reconnaissance and Network Centric Operations - C^4ISR and NCO

11.32 Effective Command and Control is an essential ingredient for conduct of naval operations, both in peace and in war. With improvements in surveillance capabilities, communications, weapon application and networking technologies, timely availability of all relevant information for conduct of naval operations is no longer a constraint. Emerging Command and Control systems will be valuable assets for managing the entire battle space with emphasis shifting from platform centric operations to network centric operations. Cooperative engagement capabilities will seek to exploit the range advantage provided by modern weapons and networked sensors, which may be decoupled from the weapons platform. ‘Network Centric Operations’ is emerging as a tremendous force multiplier, which will enable availability of all relevant information in near real-time to decision makers permitting substantial compression of time lines for decision making.

Command & Control Systems

11.33 The architecture of new generation Command and Control Systems will need to be modular and scalable with adequate built-in redundancies. They will need to be integrated with a host of equipment with varying interface protocols. The architecture shall support 'plug and play' features for ease of integration. The software will need to include expert algorithms with AI and auto-learning features to support fast decision making, and meeting the requirements of changing scenarios. Most importantly, the application software should provide for network centric operations and subsequently upgradable to incorporate Cooperative Engagement Capability as we transit from platform-centric to network-centric operations.

Communication

11.34 The *IN's* aspirations to become a truly blue-water Navy in next few years will become a reality only if Naval commanders at sea are able to synchronize and integrate high-tempo operations anywhere in the world. This in essence would require global end-to-end information exchange among the units as a critical mission capability and would serve as a force multiplier for worldwide readiness, mobility, responsiveness, and operations. This information exchange would need to be provided by a network of efficient communication systems.

11.35 The most important requirement of naval communications is ship-to-shore and extended-range (beyond line of sight) ship-to-ship communications. The extended ranges and extended durations of ship deployments create unique challenges and complexities. These need to be met, in general, by satellite communications (SATCOM) resources. Communication systems will need to support voice, data and video exchanges, with capabilities such as video conferencing. High demands will be placed on capabilities of the communication network. Network centric operations and cooperative engagement would require tremendous bandwidths, which cannot be met by conventional communication systems. This trend is certain to continue and supplying a dedicated channel to each communication task will become increasingly untenable.

11.36 **Technology Status and Trends**. Advances in C^4ISR have been driven by the tremendous improvements in the field of communication technology, primarily driven by the commercial sector. Communications technology encompasses transmission, networks, applications development, and terminal/ application equipment. Communication transmission technology has already progressed from wire line to all digital and optical fibre or digital microwave. Networks are now electronically switched and have progressed from circuit-switched hierarchical configurations for telephony and data to packet-oriented data networks. Communications applications and related termination equipment now form a virtual continuum, expanding from traditional messaging and telephony to data, imagery, and live video. Progress in encoding methods for data compression continues, and asymmetrical approaches are being made in many applications, wherein brief queries to databases, for example, elicit voluminous responses of graphic or other data. Developments in the following areas of communication are required to be pursued:-

(a) **SATCOM PCS**. 100% indigenised SATCOM Personal Communications Systems (PCS) for global service for handheld telephones with capability to exchange voice, video, and high-speed data links worldwide would need to be developed.

(b) **Software Radios**. Software programmable radios, which would operate on frequencies ranging from HF to UHF need to be developed. While work is in progress by a tripartite group, the project is much delayed.

(c) **Communication sets with Higher Bandwidth**. While data communications with capability to transmit/receive data up to 19.2 kbps is being implemented through Link II, these are to subsequently be extended up to 128/256 kbps.

(d) **VLF Communication**. There is a need to upgrade the existing VLF communication setup for improved communication from shore to submarines.

(e) **Security Overlay and Interoperability**. All new development communication systems must have in-built security overlay. Problems of interoperability between sets could be overcome by designing software based standard algorithms as generic overlays.

11.37 **<u>Tactical Data Links</u>**. Tactical Data Links (TADIL) are considered as the arteries of Net Centric Warfare (NCW). TADIL for information exchange between the land, sea and air assets are required to be developed for an effective C^4ISR system. Development of suitable Data Link equipment indigenously, with enhanced capabilities, needs to be pursued.

11.38 **<u>Intelligence, Surveillance and Reconnaissance</u>**. Intelligence must be able to provide timely, usable, detailed intelligence to allow naval forces to out-think and out-manoeuvre enemy forces. However, the information gathered is also required to be disseminated to the relevant units at sea in near-real time and in a format, which could be readily utilised for effective decision-making. We need to develop means to download the extremely large amount of data / information collected in real-time and disseminated to the relevant units. This would require high speed modems and reliable, high-bandwidth communication backbone.

11.39 **<u>Network Centric Warfare</u>**. A C^4ISR system is in effect a network of systems at platform level with linkages to the outer world through tactical data links. The technology now exists to integrate all such platforms by a high speed, high bandwidth network so that the firepower of all netted units can be effectively utilised. Network Centric Warfare or Operations is already a reality and needs to be pursued. Towards this, the important technologies that need to be developed include tactical data links, networking and development of higher capacity algorithms for Command & Control systems that would facilitate in decision support.

11.40 **<u>Co-operative Engagement Capability (CEC)</u>**. The key to CEC is to evolve a Common Operating Picture (COP) and make it available across the units. The concept of CEC is particularly relevant during a theatre-level operation or during a joint operation like amphibious operation and involves sharing of resources between the ships of a Task Force and other arms of the Forces. It allows all available information from all the sensors such as radars, sonars, EW equipment and the weapons systems to be used against an adversary. CEC comprises hardware and software that enables real-time distribution and fusion of weapons and sensor data so that individual units can also act as a unified force. This implies that all the CEC equipped units would utilise identical algorithms to create a tactical display. The main advantage would be greater reaction time for forces as there would be an early detection of targets. However, robust communication systems with high bandwidths, resistant to electronic countermeasures with a highly accurate positioning system would be the prime requirement of CEC.

11.41 **Common Information Grid**. Since the C^4 aspect of the NCO would enable all the relevant units to obtain a common picture of the battle space, the units would be operating on a common information grid. The common information grid would provide the decision makers with information, planning and analysis tools to make appropriate and timely decision.

11.42 **Weapon Grid**. The weapon grid can enable increase the combat power by exploiting high levels of awareness through utilisation of high-speed automated weapon-target pairing algorithms. These algorithms can rapidly determine near-optimal weapon-target pairings after taking into account the threat and resources available e.g. number of remaining targets, remaining rounds, and the probability of kill of remaining rounds.

11.43 **Interoperability**. In order to harness the advantages of network centric operations and cooperative engagement capability, it is essential that the command & control systems, tactical data links, associated communication systems, algorithms used for data fusion and data presentation are standardised or at least be interoperable. Though feasible, this is a major challenge, as it requires that the current systems are downward compatible with existing (legacy) systems and will be upward compatible with future inductions. It is essential that the requirement of interoperability is adequately addressed at the time of new inductions.

11.44 **Network Security**. Protection of C^4ISR systems/ NCO systems against deliberate or inadvertent, unauthorised acquisition, disclosure, manipulation, loss or modification of sensitive information will have to be ensured. Development of secure firewalls and guards that need to be continuously upgraded to match the dynamic threat scenario will need to be undertaken. Capabilities such as automatic network intrusion detection and response will also need to be developed. The data encryption techniques like key distribution and management by public crypto system or by private crypto systems also assumes significance. The field of normal security techniques like frequency hopping and spread-spectrum still needs to be realised to their full potential. Further, in case of local breach of network security, there should be a provision for dynamic allocation of computing resources while at the same time isolating the affected system.

11.45 **Disaster Management System**. A full-fledged disaster management system needs to be developed so that valuable data generated over a period is not lost due to intentional/unintentional disaster. Data storage and recovery systems locally or in remote locations need to be accordingly put in place.

Propulsion and Power

11.46 **Gas Turbines**. 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. 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 Diesel and Boost Gas turbines. Such Gas Turbines, with reduced IR signatures due to their low exhaust temperature, have to be developed. The LM 2500 Gas turbine is to be upgraded to 7000 SHP to enhance the efficiency of the propulsion system. 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. Developments in the field of advanced materials for combustion chamber and turbine blades would also be required to achieve enhanced power outputs.

11.47 **Diesel Engines**. Developments in the field of diesel engines are driven by stringent environmental regulations and requirements of multi-fuel operation and long service life. Technological advancements are required for reduction of emissions and improving combustion efficiency in Diesel engines. Development of technology for use of Rheological 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.

11.48 **Air Independent Propulsion (AIP)**. The trends in the area of non-nuclear AIP propulsion system have been mainly focused on development of Stirling engines, the MESMA steam turbine system and fuel cell power packs. Further, operational considerations like low noise levels, shallow water capability, size and manoeuvrability issues had rekindled interest in non-nuclear AIP solutions. It confers tactical flexibility by cutting down the indiscretion ratio thereby improving the survivability of a non-nuclear submarine. Development of these technologies would also reduce the dependence on fossil fuels.

11.49 **Nuclear Power Propulsion**. 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 developed for the surface combatants of the *IN*.

11.50 **Fuel Cells**. Fuel cell technology is receiving considerable attention worldwide as it provides a viable AIP solution. The fuel cell power packs may be developed for submarine main propulsion as well as energy sources for various prime movers. The various types of fuel cells are elaborated as follows :-

(a) **Proton Exchange Membrane Fuel Cells (PEMFC)**. The electrolyte in the PEM fuel cell is a thin polymer membrane (such as poly perfluorosulphonic acid, Nafion™, which is permeable to protons, but does not conduct electrons, and the electrodes are typically made from carbon. Hydrogen flows into the fuel cell on to the anode and is split into hydrogen ions (protons) and electrons. The hydrogen ions permeate across the electrolyte to the cathode, while the electrons flow through an external circuit and provide power. Oxygen, in the form of air, is supplied to the cathode and this combines with the electrons and the hydrogen ions to produce water. Each cell produces around 0.7 volt, in order to generate a higher voltage a number of individual cells are combined in series to form a structure known as a fuel cell stack. PEM cells work at high efficiencies, producing around 40-50 per cent of the maximum theoretical voltage, and can vary their output quickly to meet shifts in power demand. These are already available commercially for low power applications and can be used to provide back-up power supplies.

(b) **Alkaline Fuel Cells (AFC)**. The alkaline fuel cell uses an alkaline electrolyte such as potassium hydroxide. NASA originally used such fuel cells on space missions. The electrochemistry is somewhat different in that hydroxyl ions (OH^-) migrate from the cathode to the anode where they react with hydrogen to produce water and electrons. These electrons are used to power an external circuit then return to the cathode where they react with oxygen and water to produce more hydroxyl ions. Alkaline cells operate at a similar temperature to PEM cells (around 80°C) and therefore start quickly, but their power density is around ten times lower than that of a PEM cell so they are more bulky. These are the cheapest type of fuel cells to manufacture. However, their temperature requirements and size considerations restrict their utility for naval applications.

(c) **Direct Methanol Fuel Cells (DMFC)**. The direct-methanol fuel cell (DMFC) is similar to the PEM cell, as it uses a polymer membrane as an electrolyte. However, a catalyst on the DMFC anode draws hydrogen from liquid methanol, eliminating the need for a fuel reformer. Therefore pure methanol can be used as fuel. These are still under development and may have utility as back-up supplies for low power applications.

(d) **Molten Carbonate Fuel Cells (MCFC)**. Molten carbonate fuel cells use either molten lithium potassium or lithium sodium carbonate salts as the electrolyte. When heated to a temperature of around 650°C, the salts melt and generate carbonate ions, which flow from the cathode to the anode where they combine with hydrogen to give water, carbon dioxide, and electrons. These electrons are routed through an external circuit back to the cathode, generating power on the way. The high temperature at which these cells operate enables them to internally reform hydrocarbons, such as natural gas and petroleum, to generate hydrogen within the fuel cell structure. At these elevated temperatures there is no problem with carbon monoxide poisoning, and the platinum catalysts can be substituted for less expensive nickel. The excess heat generated can also be harnessed and used in combined heat and power plants. These fuel cells can work at up to 60 per cent efficiency and this could potentially rise to 80 per cent if the waste heat is utilised. Development work needs to be undertaken to improve their efficiency, as these hold good promise for naval applications.

(e) **Phosphoric Acid Fuel Cells (PAFC)**. Phosphoric acid fuel cell (PAFC) consists of an anode and a cathode made of a finely dispersed platinum catalyst on carbon and a silicon carbide matrix that holds the phosphoric acid electrolyte. Phosphoric acid cells work at slightly higher temperatures than PEM or alkaline fuel cells - around 150 to 200°C - but still require platinum catalysts on the electrodes to promote reactivity. The anode and cathode reactions are the same as those in the PEM fuel cell with the cathode reaction occurring at a faster rate due to the higher operating temperature. This increased temperature also imparts a slightly higher tolerance to impurities and phosphoric acid cells can function with 1-2 per cent carbon monoxide and a few ppm of sulphur in the reactant streams. Phosphoric acid cells though having lower efficiency and requirement of warming up time, have advantages like simple construction, stability and low electrolyte volatility. These have high potential for providing high power outputs, suitable for naval propulsion systems including remote vehicles.

(f) **Regenerative Fuel Cells (RFC)**. This technology works on the same basis as a conventional PEM cell. The difference is that the regenerative cell also performs the reverse reaction that is electrolysis. The water generated in the fuel cell is fed to a solar powered electrolyser where it is separated into its constituent components of hydrogen and oxygen, which are then fed back to the fuel cell. In this way a closed system is formed which does not require external hydrogen generation. Dependence of these fuel cells on solar power may rule out their utility for naval applications.

(g) **Solid Oxide Fuel Cells (SOFC)**. Solid oxide fuel cells operate at 800 to 1,000°C and use a solid ceramic electrolyte, such as zirconium oxide stabilised with yttrium oxide, instead of a liquid. These cells can reach efficiencies of around 60%. Energy is generated by the migration of oxygen anions from the cathode to the anode to oxidise the fuel gas, which is typically a mixture of hydrogen and carbon monoxide. The electrons generated at the anode move via an external circuit back to the cathode where they reduce the incoming oxygen, thereby completing the cycle. These cells are resistant to poisoning by carbon monoxide as this is readily oxidised to carbon dioxide. This removes the need for external reforming to extract hydrogen from fuel and these cells can again use petroleum or natural gas directly. Development of such fuel cells is still in an infancy stage.

11.51 **Fuel Possibilities**. Most types of fuel cells (FC) ultimately require hydrogen as a fuel source which can be generated in a number of ways, either from renewable sources, such as solar power, or from hydrocarbons, such as natural gas or alcohols, by reforming. It is possible to supply hydrogen gas directly and store in tanks on the vehicle. The alternative option is to use liquid fuels and generate hydrogen within the fuel cell itself by the use of on-board reformers.

11.52 Of all the AIP systems under development, the phosphoric acid fuel cell is widely accepted potentially as the most viable solution. Fuel cells allow direct noiseless generation of electric power with much better efficiency than existing power plants. Efforts would have to be made to indigenously develop such fuel cells for marine applications.

11.53 **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, 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.

11.54 Most of the elements required for adoption of this technology in warship applications are already available in the international market and indigenous commercial market. Though no special R&D efforts are required for adoption of this technology, indigenous production and high capacity power electronics related systems design capabilities need to be built up through the ToT route. The progressive development in fuel cells and super-conduction technology will make the electrical propulsion option more attractive.

11.55 **Marine Engineering Systems**.

(a) **Computational Fluid Dynamics (CFD)**. CFD for aerodynamic (low-noise) fluid flow in ducts and pipes needs to be taken up for advanced studies. The flow-induced noise through pipes and ducts constitutes a major component of the overall underwater noise emanated from the ship besides contributing to adverse habitability conditions on board. Irregular flow patterns are also the main factors for high wear rate of the pipe and ducting systems. Tools such as CFD can be employed for optimal design of ducts and pipes to attain better fluid flow characteristics leading to reduced noise levels, lesser wear rate and better heat transfer.

(b) **Technology to Develop Low-noise Gearboxes**. Noise generated from a gearbox contributes considerably to the overall noise level of the ship. Techniques such as finite element analysis should be developed to design compact and silent gearboxes. Advanced manufacturing techniques, metallurgical processes and materials are required to be developed to meet the silent gearbox standards.

(c) **Advanced Motion Control Systems/ Motion Interceptors for Roll and Pitch Stabilisation for Naval Platforms**. The motion interceptor is primarily a plate extending below the transom, which intercepts the flow of water. It reduces the flow velocity locally thereby increasing the pressure on the hull and generating a lift force. The forces generated by blade immersion are controlled to provide trim and list stabilisation and damping of pitch and roll rate accelerations. An interceptor system comprises of a sensor package, central processor, display unit, hydraulic power pack, servo controller/ manifolds, actuators and interceptor blades. The interceptors are ideally suited for high-speed crafts for speeds above 25 kts. The same concept could be developed for the entire speed range for exploitation of the surface combatants. The advantages of the motion interceptors over the existing stabiliser systems are lightweight, low power and non-vulnerability to damage.

11.56 **Production and Design Technology**.

(a) It is essential to develop technology for use of air-lubricated bearings for use in high-speed turbines, which will be the power package for most of the future frontline warships. Air lubricated bearings would offer advantages of reduced friction levels, operating temperatures, longer life due to lower wear rate and enhanced SFC.

(b) Developments in design and manufacturing technology would help in arriving at futuristic aspects of shipbuilding and repair yard technology. Some areas of potential development are as follows:-

(i) Analytical tools, viz., Bond graphs for machine design.

(ii) Advanced machining technologies for manufacturing components.

(iii) Computer-aided production, planning & control relevant to warship aspects.

(iv) Investment casting technology.

Warship Design

11.57 **Introduction**. The Indian Navy has a large on-going ship construction programme with majority of the ships being constructed indigenously. Indigenous ship construction activities have basically utilised conventional hull forms, largely utilising ferrous materials such as carbon steel, low alloy steel and cast irons. Non-ferrous materials like aluminium, titanium and copper alloys are also being utilised for limited applications. Emerging technology trends in warship design, material sciences and stealth technology are set to revolutionise warship building, providing platforms with better speeds and sea keeping qualities, higher equipment package density without compromising on weight to power ratio, enhanced stealth features, reduced maintenance efforts and more comfortable living conditions within the platforms.

Advanced Navies are already making rapid strides in various associated areas towards enhancing their capabilities. The Indian Navy also needs to be the prime mover for indigenous development & early realisation of such capabilities. This assumes urgency keeping in view of the large gestation period of these and resultant ship building efforts.

11.58 **Hull Forms**. At present, our indigenous ship-building programme is predominantly based on conventional Mono-hull forms. Development in new hull forms are expected to open up a wide range of possibilities in designing ships for different operational roles, with better sea keeping capabilities, higher speeds, larger pay loads and improved survivability. Basic hydro dynamic research on Trimaran Delta Hull in this regard is being progressed with NSTL. Certain important newer hull forms are broadly outlined in the succeeding paragraphs.

11.59 **Air Cushion Vehicles (ACV)**. ACVs riding on a cushion of relative low-pressure air, with speeds in excess of 80 knots are already available in the international market. These vehicles have enormous potential for fast attack missions, over-the-beach assault capabilities and even mine-hunting. Landing Craft Air Cushion (LCAC) have already emerged as key ingredients for amphibious operations with its inherent ability to launch assaults from extended ranges against almost any beach head.

11.60 **Surface Effect Ships (SES)**. The SES, like the ACV utilises pressurised air cushion to reduce resistance to motion. These incorporate rigid catamaran – style side hulls to enhance stability and manoeuvrability. High speed and improved sea-keeping make them suitable candidates for fast attack missions, and this hull type is less susceptible to below water level mine explosions compared to Mono-hulls.

11.61 **Small Water-plane Area Twin Hull (SWATH)**. This hull form has a pair of fully submerged hulls on which slender struts are mounted to support a cross-structure. In addition to providing better sea keeping quality compared to Mono-hull vessels, SWATH exhibits less fall-off in speeds with increasing sea state. This hull form permits providing big-ship platform steadiness and ride quality in smaller vessels, with ability to sustain high proportion of normal cruising speed in rough head seas. SWATH ships are expected to have less than 50% water-plane area compared to Mono-hulls of equivalent displacement.

SLICE hull, a derivative of SWATH, with four strut hulls, or pods, are also under development and are claimed to provide higher speeds compared to Mono-hulls with the same power, lower installed power and fuel consumption for the same speed, higher flexibility in strut/hull arrangements and lower wake signature at high speeds. SWATH mine hunters are already under design by some countries, and, in future, may also be utilised for deploying and recovering remote vehicles.

11.62 **Catamaran**. Vessels with two parallel and abreast hulls attached to a common deck have been demonstrated commercially to exhibit better performance than mono-hulls in a speed range of 35 to 40 knots. At present, their use is limited for restricted/ coastal water applications due to their inferior sea keeping qualities in the open-seas. However, design improvements and derivatives like trimaran and pentamaran hulls have promising potential. Littoral Combat ships based on trimaran hull, high speed corvettes and versatile frigates designs utilising pentamaran hulls are already on the drawing board in certain countries.

11.63 **Other Hull forms**. Various other newer hull forms like Delta hulls, Planing Hulls, M Hull forms and Hybrid Hull Forms are also under extensive investigation by other advanced navies.

Stealth

11.64 Incorporation of stealth features in warships is gaining increasing importance to counter emerging threats due to rapid advancements in the field of sensor technology, signal processing and intelligent ammunition. Concepts such as integrated topside systems and vertical launch weapons for reducing RCS, development of acoustic silencing techniques for underwater signature reduction and cooling techniques for IR signature reduction are receiving increasing attention in ship design / construction. The process of building-in stealth in new constructions necessarily needs to commence at the drawing board stage itself. The stealth programme for the *IN* started with the design of P-17 class ships and expertise acquired needs to be built upon and carried forward for future ship constructions. Important aspects that need to be covered for realising stealthy warships are broadly outlined in the succeeding paragraphs.

11.65 **Radar Signatures**. Structural surfaces and corners, deck fittings, weapon mountings, Masts, radar antennae, communication antennae, etc., are good reflectors of EM energy and contribute to increasing the RCS of ships. RCS reduction techniques involve suitable shaping of upper structures including multi-surfacing, rounding of corners, concealment of high EM energy scatterers and use of special radar absorbent / transparent materials. Existing knowledge base on RCS management needs to be continually developed for implementation on new constructions. While RCS minimising measures are best incorporated in new constructions, development of suitable radar absorbent paints would enable some degree of RCS reduction on existing ships also.

11.66 **Acoustic Signatures**. Radiated noise of ships and submarines could be structure-borne (machinery, propeller, shafting, gears, transformers etc.), airborne (machinery) and water-borne (propeller, underwater openings, flow noise). Incorporation of suitable noise suppression measures, therefore, needs to be emphasised during ship design and construction. Measures incorporated include design of machinery seatings, low noise propellers with high cavitation speeds, system pipes arrangements, noise isolation acoustic / pads, flexible deck and bulkhead glands, use of flexible bellows / couplings, raft mounting of noisy equipment, etc. Noise signatures of current and future platforms can be reduced substantially by use of double mounting of equipment, use of further suitable sound and vibration isolation materials, isolation techniques and active vibration and acoustic signature control. Reduction of hydrodynamic flow noise and delayed onset of cavitation are also to be consistently worked upon. New propulsion concepts are also evolving for reducing acoustic emissions, with integrated electrical propulsion being a forerunner. While certain noise reduction techniques are already being incorporated in new constructions, progressive improvements need to be targeted. This therefore remains another focus area for indigenous R&D and equipment selection / installation.

11.67 **Infrared (IR) Signature**. Principal sources of IR signatures are exhaust arrangements, impingement of exhaust gases on ship structures creating hot spots and hot superstructure surfaces due to radar heating. Controlling IR signature involves reducing the emissivity of exhaust gas outlet and plume and exposed hot surfaces. Since, hot spots are easy to detect, these need to cooled or screened from direct view of IR detection sensors. Use of IR suppression devices for hot exhaust gases, low emissivity paints, foil-covered windows, shaping hull and superstructures to reduce sunlight reflection, etc., are some of the conventional measures being adopted to reduce IR signatures. Emerging trends include alternate exhaust arrangements like shipside / transom exhaust arrangements with exhaust gas cooling by water injection, Hybrid IR suppression system like eductor-diffuser integrated with water injection systems, good thermal design principles, application of proper ventilation and insulation to exterior bulkheads to reduce outer skin temperatures, plume cooling, active cooling of hot surfaces with sea water, water mist systems, etc. IR measures are accordingly being incorporated in new design ships with developmental work being progressed through DRDO.

11.68 **Miscellaneous**. Emerging technologies are also being adopted for management of magnetic signatures, underwater EM signature and Extremely Low Frequency Emissions (ELFE) from Impressed Current Cathodic protection (ICCP) systems.

Materials

11.69 A variety of materials are required for ship construction/ upkeep. These range from structural steels to composites and encompass insulation materials, deck covering materials, materials for piping and fixtures, coating door and latches, deck blocks, cable chains, main machinery, sonar domes and paints for surface protection. Until recently we were completely dependent on imported steels for warship construction. While this situation has now been remedied to a large extent, continual R&D effort is required for developing emerging exotic materials, composites and paints.

11.70 **Ship Building Steel**. DMR 249A steel has been recently developed successfully for indigenous ship building programme. Production in adequate quantities and of required specifications is required to meet all future requirements of new construction and repair. Steel for submarine construction is still being imported and needs to be developed indigenously.

11.71 **Weld Consumables**. Sources need to be developed to make weld consumables for Manual Metal Arch Welding (MMAW), Submerged Arch Welding (SAW) and Metal Inert Gas (MIG) welding for various steels in our inventory, including indigenously developed steel.

11.72 **<u>Composites</u>**. High grade composites need to be developed for the following:-

(a) Fabricating items such as doors, hatches, ventilation flaps, hanger shutters etc.

(b) High grade Carbon Fibre Reinforced Plastic (CFRP) composites for masts, super structures, which can thereafter be suitably integrated with the main hull to provide stealth and reduce top weight of warships.

(c) CFRP composites are also required for indigenous fabrication of sonar domes.

(d) Propellers for ship as well as torpedoes based on composite materials are required to be developed in order to improve stealth features.

(e) Suitable composite armour materials also need to be identified / developed to provide protection for personnel against small and medium calibre arm firing. These materials can be embedded in panels which can be fitted at select locations on-board or slung on the side of the craft, and would not affect the endurance and speed of the vessel.

11.73 **<u>Rubber Seals</u>**. High quality rubber seals with good weathering properties for doors, hatches, ventilation flaps, scuttles, etc., also need to be developed to meet stringent NBCD requirements.

11.74 **<u>Polymers</u>**. Polymer rubbing strakes to substitute wooden rubbing strakes for ships and polymeric light weight structural composite dock blocks to substitute teak wood capping of dock blocks need to be developed to reduce dependence on teak wood.

11.75 **<u>Titanium</u>**. Due to its inherent properties, use of titanium has major advantages in fabrication of structures such as sonar domes, high pressure pipelines, etc. Indigenous development in these areas needs to be pursued.

11.76 **Cladded Metals**. Cladded steels are excellent materials with both strength and chemical resistant properties. These are particularly suitable for battery storage compartments, which are highly prone to electrolytic corrosion/erosion.

11.77 **Direct Metal Deposition**. Casting complicated shaped items through conventional moulding techniques suffers from large rejection rates. New techniques in fabricating 3-D forms utilise direct metal deposition techniques, using LASER cladding. Consequently, dimensional accuracies are assured and rejection minimized. Technology in this field needs to be built up.

11.78 **Metallic Foams**. Metal foams have the potential to be used as sandwich/honeycomb material for minor bulkheads providing noise and weight reductions.

11.79 **Stealth Materials**. Development of stealth materials and paints like radar-absorbent materials, radar-transparent materials, radar-opaque optically transparent materials need to be progressed. In addition development work also needs to be progressed on Radar Cross Section (RCS) reducing techniques like camouflage screens, Radar Absorbent Sheets/ coatings, etc.

11.80 **Anti-Fouling Materials**. Anti-fouling materials like Electroless antifouling pellets, with appropriate biocides need to be developed for use in gratings of sea tubes/sea chests. This would be a contributory measure, amongst others, towards increasing inter-docking intervals.

11.81 **Coating Materials**. The issue of life extension will be a critical one for the Indian Navy of the future. In addition, coatings reduce drag, increasing speed and range. The development of silicon-based coatings with natural anti-fouling agents will be required. In most instances, these coatings will be self-cleaning through the action of water flow across the hull.

11.82 **Marine Materials**. There is a continuing need for stronger, easily weldable, and less expensive steels for ship and submarine hulls. Steel-alloy designs based on first principles with controlled microstructures and predicted mechanical properties are required in the near future. An achievable goal is 130 kips per square inch (ksi) yield-strength steel with high-fracture toughness that can withstand stress-corrosion cracking and fatigue-crack propagation. By using basic atomistic principles to model stress-corrosion cracking, greater understanding of stress-corrosion effects can be achieved. This knowledge can be extended to the design of new steels. A combination of new materials such as Ultra-Low Carbon Bainite (ULCB) and High-Strength Low-Alloy (HSLA) steels will yield significant advantages in strength and corrosion resistance. Titanium and titanium alloys exhibit good fracture toughness, corrosion resistance, high-temperature strength, and low magnetic signature. Titanium alloys for maritime aircraft offer as much as a 50 percent weight savings as compared to aluminium parts. Ti-Al0v is used extensively in air frames today, but higher-temperature titanium alloys such as alpha-2, g, and orthorhombic titanium aluminides have to be developed and offer improved temperature capability beyond the 700° C limit of current production alloys. The new alloys would have ductility in the range of 2 to 4 percent, which is adequate for most manufacturing processes. Titanium Matrix Composites (TMCs) consisting of titanium alloys reinforced with silicon carbide fibres may provide significant performance improvements, particularly for use in high-temperature engines.

11.83 **Special Materials**. Future naval systems will require technological advancements in the areas of superconductors and magnetic materials, organic materials and coatings, energetic materials, and high-temperature semiconductors. Naval applications for superconductivity include:

(a) Superconducting magnets for electrical motors and ship propulsion.

(b) Superconducting magnetic sensors for mine detection.

(c) Superconducting magnetic systems that store energy for burst power.

(d) High-Q cavities for high-resolution radar system.

(e) Low-power analog and digital circuits.

11.84 Further technology developments in materials engineering, manufacturing, and systems integration will be needed for realizing the benefits of superconductivity in naval applications. Since the discovery of High Temperature Semiconductors (HTS) in 1986, numerous applications have emerged, including superconducting cables, transformers, motors, and energy-storage devices. HTS conductors are typically fabricated as a multi-filamentary flat tape. These conductors use a ceramic precursor powder placed in a silver billet. The billet is then formed into a thin filament using commercial deformation processes, and multiple filaments are then placed into a silver tube and deformed again into a bundle of filaments. These steps are repeated until the conductor contains the appropriate number of filaments. The conductor is then rolled into a flat configuration and heat treated to transform the ceramic precursor into a superconductor. This process is referred to as Oxide Powder In Tube (OPIT). OPIT conductors have shown linear performance improvements over the last 10 years, and manufacturing costs have steadily declined. It is now required to develop the next generation of HTS-coated conductors. Coated conductors use a thin film of HTS deposited onto a substrate; they exhibit significant performance gains as compared with OPIT conductors and can be significantly less expensive to manufacture.

11.85 **Engine Materials**. Materials to be used for future naval engines should have reduced weight, increased temperature capabilities, improved mechanical properties, and better corrosion and oxidation resistance. Such high-performance materials include organic matrix composites, titanium alloys, and inter-metallic compounds. For turbine components, Nickel Aluminium (Ni-Al) polycrystalline materials could be extended so that they are available in a single-crystal form. Inter-metallic compounds, along with titanium-based metal-matrix composites such as TiAlNb with Silicon Carbon (SiC) fibres, may be useful for compressors. Static engine components will require high-modulus inter-metallic compounds such as g-TiAl. The high-temperature capability of super-alloys based on Ni-Al is expected to meet the 2,000°C requirement.

11.86 **Magnetic Materials**. Improved magnetic materials will be required for magneto-optic devices and high-sensitivity, low-cost magnetic sensors to be utilised as magnetometers, radio-frequency antennas, and biological and chemical sensors. Improvements in material properties through enhanced processing techniques and modelling will enable these applications.

11.87 **Advanced Energetic Materials**. The naval forces, in addition to improved warhead explosion devices, require a competitive edge in the power and range of missiles. Advances in techniques for the synthesis of very dense organic compounds that are highly substituted with energetic groups will be required. The approach will be computationally based initially, followed by a synthesis simulation and prototype production. Continued development of new chemical processes to produce novel energetic materials and improvements of initial chemical processes to produce novel structures economically and environmentally are essential.

11.88 **Organic Materials–Flame-resistant, High-temperature Organic Composites**. Polymers and polymeric composites are required for superior flame-resistant and high-temperature properties. These proposed materials are phthalonitrile-based composites with thermo-oxidative stability up to 500°C. These novel flame-resistant materials will enhance ship and submarine safety.

11.89 **Smart Materials and Sensors**. Smart materials technology consist of the application of ferromagnetic, ferro-electric, and ferro-elastic materials, better known as shape-memory alloys, as mechanical actuators and/or sensors to improve the performance of components, structures, and systems. It is envisioned to integrate smart materials with nano-scale electronic processors resulting in mechanically and electrically adaptive elements. Many proposed systems will benefit from the utilisation of smart sensors. For example, smart sensors could increase the performance and efficiency of personnel and equipment in areas such as condition-based maintenance. Overall, a full assessment of smart materials and MEMS materials will need to be carried out. System integration including data sampling, networking, and communication issues will have to be addressed. Smart materials on the micro-scale will be combined with electronics on the nano-scale to form smart sensors, all as part of a micro-nano-electronic technology thrust.

11.90 **Nano-Phase Materials**. A new emphasis in material science centres on the nanometre (10^{-9} metre) size regime, which is intermediate between the well-studied macroscopic and atomic size regimes. The understanding of structural and compositional features in the nanometre size range will facilitate the control of the magnetic, electrical, and optical properties of materials. Nano-phase or nano material is an area of prime importance for future naval applications, especially with the expected conversion of most ships to integrated electric power and propulsion systems. Magnetic nano-materials may offer dramatically improved performance for magnetic-storage applications. The enhanced strength of nano-phase coatings and the potential for improved mechanical behaviour of consolidated nano-crystalline has obvious applications in the area of structural materials. One important example is the super-plasticity of nano-crystalline materials, a property appropriate for missile nose cones and armour. Nano-phase materials could be combined with nano-scale electronics to produce a new class of sensors able to achieve ultra-high-speed and low-power dissipation. The capacity to carry out high-resolution lithography capable of manufacturing devices with critical dimensions on the order of a nanometre is required before nano-phase materials technology can become practical for naval applications. Other related technologies that will require further development before nano-phase materials can be widely deployed include plasma-etch technologies and interconnects for quantum electronics. In photonic systems, nano-phase structures will enable the development of nonlinear optical systems or possibly smart nano-sensors that are optically interconnected to form a highly capable meta-sensor.

11.91 **Structural Materials**. Structural materials are widely used in naval systems, and some applications, such as engine components and ship structures that are exposed to salt water, are quite demanding. The future trend in the development of new structural materials will be to integrate functionality into the structure. An example of this type of integration would be the development of a submarine hull that contains embedded MEMS devices to maintain laminar flow around the hull and embedded networked conformal sensor arrays for both acoustic (sonar) and non-acoustic sensing. Improved strength and stiffness are always desirable in structural materials, and such improvements may become available through the engineering of covalently bonded materials or, alternatively, though the use of thin lamellar structures that combine high strength and high modulus with a designed-in anisotropy to fit the specific application.

11.92 **High-temperature Structural Materials and Coatings**. High-temperature materials and coatings, include metal composites, ceramic-metal composites, inter-metallic alloys, and carbon-carbon composites. They are amenable to low-cost synthesis through the application of computational materials design and useful in a number of applications including aircraft engine components. Metal-matrix composites will meet most of the requirements for materials that can withstand temperatures up to 500° C. Oxide materials, such as the yttrium aluminium oxides are needed for systems, which require components to withstand 1,000 to 2,000° C. Metallic and ceramic surface coatings are currently used to improve the performance, prolong the service life and reduce maintenance of advanced turbine materials. Protective coatings used in aircraft, marine, and power generation turbines to increase operating temperatures extend component life by providing protection from high-temperature oxidation and high-temperature corrosion. Advances in ceramic coatings will be required for future naval systems. In the temperature range of 1,500 to 2,100°C, materials such as silicon carbide, silicon nitride, and other systems are able to limit oxidation will be needed. Microwave and laser processing technologies have to be developed for these difficult-to-shape materials. For systems above 2,000°C, carbon-carbon composites, diamond-like coatings, synthetic-diamond thick films, and carbides such as boron tetra-carbides and titanium carbides will be needed.

11.93 **Processing and Synthesis of High-temperature Structural Materials**. Technologies that may enable the manufacture of high-temperature structural materials are rapid solidification (splat cooling) and electron-beam evaporation. These techniques will allow the development of lamellar composition and functionally graded materials. Methods of processing of fibre with a polymer matrix that combine joining processes with material synthesis will be needed.

11.94 **Newer Materials**. In the future entirely new and enhanced materials are expected to be designed and manufactured using a computational approach and atomic seal understanding of material physical and mechanical properties. Monoplane materials, smart materials, heterogeneous materials, superconducting materials, high temperature materials, functional materials are a few examples which have high potential for Naval applications.

Appendix-A

FORECAST REQUIREMENT OF EQUIPMENT AND SYSTEMS
MARINE ENGINEERING EQUIPMENT

Ser	**Equipment**	**2015-20**	**2021-25**	**2026-30**	**Total**
1.	Complete Boiler tubes and refractory	04	08 sets	08 sets	20 sets
2.	Lub oil and sea water coolers fitted on various machinery	10	20 sets each	30 sets each	60 sets each
3.	Shafting components like bearings, thrust pads etc	04	08 sets	16 sets	28 sets
4.	Lub oil coolers, condensers & evaporators of Motor and Turbo Driven Air Conditioning and & Refrigeration Plants	02	04 sets each	04 sets each	10 sets each
5.	Valves fitted in freshwater, feed water, sea water and other auxiliary system.	50	150	300	500
6.	Components level items of Boiler and Turbine Aggregates control system.	02	04 sets each	04 sets each	10 sets each
7.	Turbo-driven Fuel Pumps	02	02	02	06
8.	Turbo-Blower Units	02	02	01	05
9.	Feed Condensate Booster Turbo-driven Pumps	02	02	01	05

Ser	Equipment	2015-20	2021-25	2026-30	Total
10.	Turbo-driven Main Circulating Pumps	02	02	02	06
11.	Turbo-driven Oil Pumps	02	02	02	06
12.	Turbo-drive of AC Plants	02	02	02	06
13.	Automatic Working Water Pumps	02	12	02	16
14.	Pumps (of various capacities)	10	10	20	40
15.	LPSG Feed Pumps	02	02	02	06
16.	Condensate Feed Pumps	02	02	02	06
17.	Pumps for boiler chemical treatment	02	02	02	06
18.	Condensate Feed Pumps	02	04	02	08
19.	Hand Pumps for boiler dosing	02	04	02	08
20.	Proportioning Pumps for boiler dosing	02	04	02	08
21.	Condensate Feed Pumps	02	12	02	16
22.	Fuel Pumps	02	08	02	12
23.	Fuel Transfer Pumps	05	05	05	15
24.	Stripping Pumps	05	05	05	15
25.	Manual Pumps for AVCAT	02	09	02	13
26.	Motor Driven Fuel Pumps	04	08	04	16
27.	Fuel Transfer Pumps	02	02	02	06
28.	Hand Pumps (Varying capacities)	05	05	05	15
29.	Motor-driven Oil Pump	02	04	04	10
30.	Oil Pumps (Varying capacities)	10	10	10	30
31.	AC Condenser Sea Water Cooling Pumps	02	08	04	14

Ser	Equipment	2015-20	2021-25	2026-30	Total
32.	Seawater Circulating Pumps for TA	02	06	04	12
33.	Sea Water Pumps	10	10	10	30
34.	Chilled Water Pumps	04	08	08	20
35.	Fresh Water Pumps	02	02	02	06
36.	Mineralisator Pumps	02	02	02	06
37.	Main Drainage Pumps	04	16	08	28
38.	Portable Pumps	04	08	08	20
39.	Pumps (Variable discharge type)	03	06	06	15
40.	Hydraulic Pumps for Arresting Gear	02	02	02	06
41.	Pumps for Aircraft lifts	02	04	04	10
42.	Boats and Davits	02	08	05	15
43.	WT Doors and Hatches	60	120	120	300
44.	Low Frequency Shock & Vibration Mounts	03	05 slip sets	05 slip sets	13 slip sets
45.	Low Noise auxiliary equipment i.e. Magnetic Bearing Compressors and Canned Motor Pumps	02-100TR	02-100TR	02-100TR	06-100TR
46.	Sonar Domes	15	10	15	40
47.	Sewage Treatment Plants and Vacuum Toilet Systems	30	20	30	80
48.	NATO Standard RAS / FAS System for Receiving Ships	15	10	15	40
49.	Composite Pipes	10 Kms	10 kms	10 kms	30kms

Appendix-B

FORECAST REQUIREMENT OF EQUIPMENT AND SYSTEMS
ELECTRICAL/ ELECTRONIC SYSTEMS

Ser	Equipment	2015-20	2021-25	2026-30	Total
1.	Power supply boards for Galleys (Ship's Kitchen)	30	40	50	120
2.	Power Boards (Distributive, Group, Area, Power Supply etc)	200	400	500	1100
3.	Boards with Contactors	150	200	200	550
4.	Automatic Change Over Switch cum Starters	40	80	100	220
5.	Automatic Change Over Switches	150	200	200	550
6.	Push Button control stations	300	500	500	1300
7.	Hand change over switches	300	600	600	1500
8.	Connection Boxes(Junction Boxes)	700	1000	1200	2900
9.	Junction Boxes	300	400	500	1200
10.	Plugs and Sockets/ Sockets for portable Electric Devices	200	400	600	1200
11.	Electrical Water Heaters	20	30	40	90
12.	Electrical instrumentation (ammeters, voltmeters, watt-meters, high-resistance ohmmeters, phase-meters, frequency	300	500	800	1600

Ser	Equipment	2015-20	2021-25	2026-30	Total
	meters)				
13.	Shore Supply Cables	3000	4000	4000	11000
14.	Emergency Power Supply Cables	1500	2000	2500	6000
15.	Set of lighting and signalling equipment	40	60	80	180
16.	Floodlight and navigation projectors	40	60	80	180
17.	Lanterns	35	70	120	225
18.	Projectors for illumination for landing spots	20	30	40	90
19.	Bulbs	5000	8000	12000	25000
20.	HF Transceiver with advanced features	30	30	50	110

Appendix-C

FORECAST REQUIREMENT OF WEAPON SYSTEMS & ARMAMENT

Ser	Equipment		2015-20	2021-25	2026-30	Total
1.	RF Module & Power Supply Module (Varying specifications)		10	10	10	30
2.	Missile Radio Homing System & Power Supply Modules (Varying specifications)		5	5	5	15
3.	Microwave Power Amplifier Modules (Varying specifications)		15	15	15	45
4.	Missile	Front Safety Mechanisms	05	05	05	15
		Dummy Missiles	02	02	01	05
		Communication Units	03	04	03	10
		Safety and arming devices	05	05	05	15
		Auto pilots	05	05	05	15
		Radio Altimeter	05	05	05	15
		Power supply units	05	05	05	15
		Proximately fuses	03	04	03	10
		Display units	02	01	01	04
		Attenuator	02	02	01	05

Ser	**Equipment**		**2015-20**	**2021-25**	**2026-30**	**Total**
		Antenna assemblies	02	02	01	05
		Delay lines	02	02	01	05
		Torsion bars	05	05	05	15
5.	Guns	Spare parts of varying Specification	100 types	100 types	100 types	100 types

Appendix-D

FORECAST REQUIREMENT OF EQUIPMENT AND SYSTEMS
SSK/ EKM SUBMARINE EQUIPMENT AND SYSTEMS

Ser	Equipment	2015-20	2021-25	2026-30	Total
1.	AC Chilled Water Pump With Motors	4	4	2	10
2.	Piston Bilge Pumps	2	2	1	5
3.	Cockpit Mast Snorkel	1	1	1	3
4.	Pneumatic Ejecting Device	2	2	2	6
5.	Piston Rods	2	1	1	4
6.	Pressure Cylinders	2	2	2	6
7.	Non-Return Valves	4	4	4	12
8.	Screwing Valves	4	4	4	12
9.	Ring Type Strainer Inserts	24	24	24	72
10.	OC-Globe Valves	4	4	4	12
11.	Reducing Stations	4	4	4	12
12.	Pressure Controllers	2	2	2	6
13.	Balanced Slide Valves	6	6	6	18
14.	Diesel Engine Coolant Circulating Pumps	4	4	4	12
15.	Diesel Engine Oil Priming Pumps	4	4	4	12

Ser	Equipment	2015-20	2021-25	2026-30	Total
16.	Diesel Engine Fresh Water Pumps	4	4	4	12
17.	Combined Exhaust Silencers	2	2	2	6
18.	Non Return Valves	12	12	12	36
19.	Diesel Exhaust Pneumatic Drain Valves	8	8	8	24
20.	Combined Board Stop & Non-Return Valves	4	4	4	12
21.	Diesel Exhaust Shut Off Flaps	6	6	6	18
22.	V Belts	20	20	20	60
23.	Diesel Thermocouples	48	48	48	144
24.	Batteries (Varying capacities/ specifications)	10	10	10	30
25.	Globe Valves	3	3	3	9
26.	Life Raft Three-Way-Cocks	9	9	9	27
27.	Diesel Engine Resistance Thermometers	8	8	8	24
28.	OC Angle Valves	8	8	8	24
29.	Diesel Monitoring Equipment	4	4	4	12
30.	Diesel Engine Pressure Monitors	4	4	4	12
31.	Coolant Expansion Tanks	4	4	4	12
32.	Battery Breakers	2	2	2	6
33.	Armature Breakers	2	2	2	6
34.	Electric Bilge Drying Pumps	12	12	12	36
35.	DC Network Insulation Measuring Units	3	2	2	7
36.	AC Network Insulation Measuring Units	3	2	2	7
37.	Coupling Indication Systems	4	4	4	12

Ser	Equipment	2015-20	2021-25	2026-30	Total
38.	Refrigerating Plants	3	2	1	6
39.	Hydraulic Manipulators	40	35	30	105
40.	Electromagnetic Drain Valves	14	14	8	36
41.	Sea Water Valves	60	50	45	155
42.	Tacho Generators	4	2	4	10
43.	DC Motor Generator Blowers /Hyd Pumps	4	2	4	10
44.	DC Motor Main Motor Blowers	4	2	4	10
45.	DC Motors	4	2	4	10
46.	Diesel Engine Starting Air Valves	48	48	24	120
47.	Diesel Engine Water Pumps	6	6	4	16
48.	Diesel Engine Fuel Pump Glands	6	6	4	16
49.	Diesel Engine Lube Oil Coolers	6	6	4	16
50.	Diesel Engine Fresh Water Coolers	6	6	4	16
51.	Diesel Engine Air Distributors	6	6	4	16
52.	Diesel Engine 8wmc Coupling Control Valves	6	6	4	16
53.	WC Filters	6	6	4	16
54.	Hyd Accumulator Micro Switches	40	30	20	90
55.	Hydraulic System Air Bottles	6	4	2	12
56.	Main Thrust Block Upper Shells	6	6	4	16
57.	Main Thrust Block Lower Shells	6	6	4	16
58.	Pump Safety Valves	6	6	4	16

Ser	Equipment	2015-20	2021-25	2026-30	Total
59.	Pump Diaphragm Membranes	5	5	3	13
60.	Hydraulic Pump Spring Stuffing Boxes	6	6	4	16
61.	Periscope Lower Cup Seals	6	6	4	16
62.	Periscope Upper Cup Seals	6	6	4	16
63.	Gem Block Manipulators	100	100	50	250
64.	Hydraulic System Non Return Valves	8	8	4	20
65.	Reel Drum With Foundations	40	40	20	100
66.	Air Induction Flap Sealing Rings	8	8	4	20
67.	Fuel Loading Hull Valves	5	5	2	12
68.	Speed Governor Block Locking Mechanisms	6	6	3	15
69.	Block Drying Unit Coolers	10	10	6	26
70.	Block Drying Unit Shut Off Valves	10	10	6	26
71.	Block Drying Unit NR Elements	10	10	6	26
72.	8WMC Needle Valves	9	9	5	23
73.	Grouper Exhaust Flap Grouper Rings (Plates)	9	9	5	23
74.	Exhaust Link Piece pressure Rings	48	48	24	120
75.	Operating Handles (various types)	45	45	25	115
76.	Very Low Frequency (VLF) Loop Aerials (Ferite Antenna)	15	4	4	23
77.	VLF Towed Wired Arrays	15	4	4	23

Appendix-E

FORECAST REQUIREMENT OF AIRCRAFT HANDLING EQUIPMENT

Ser	Equipment
1	Ship Based Hoisting and Lifting Equipment (Aircraft / Vehicle Lifts and Cranes)
2	Automatic Aircraft Landing System (Microwave/ Electronic ACLS) for indigenous fixed wing Aircraft
3	Carrier Based Fixed Wing Aircraft Arrester Wire Recovery System
4	Aircraft Catapult Launch System
5	Flight Deck & Hangar Fixed Fire Fighting System
6	Rail-less and Wireless Aircraft Traversing System
7	Telescopic Hangars & Foldable Hangar doors

Appendix 'F'

PROPOSALS FOR PROJECTS ENVISAGED TO BE TAKEN UP UNDER THE CATEGORY OF 'MAKE'

Ser	Project
1	Mini UAVs
2.	Long range Electro Optic IR Sensors for Aircrafts
3.	Marine Version Doppler Radars
4.	Air Route Surveillance Radars (ARSRs)
5.	Control System for Submarines viz. Pirit/ Palladi
6.	Airfield Security System
7.	Advance Arrestor Gears
8.	Composite Foldable Hanger Doors
9.	Diesel Engines
10.	Propellers
11.	SAMS
12.	AEW Radars
13.	Mine Hunting Sonars
14.	Air Field Surveillance Radar
15.	Shock & Vibration Mounts
16.	Submarine Generator
17.	HF (Transmitter/Receiver)
18.	Ship Installed Radiation Monitoring System (SIRS)
19.	Fire/Flood Alarm Sanctions
20.	Flight Safety Equipment
21.	Flight Simulators
22.	Gear Boxes
23.	Gas Turbines
24.	Stern Gear (Shafting / Propeller / Stern glands & Seals
25.	Water Mist Fire Fighting System
26.	Gas Turbine Generators (GTG)
27.	Diesel Alternator (DA)
28.	High Pressure (HP) Air Fittings
29.	Man Overboard Markers
30	Electronic Chart Display (ECDIS)
31.	Gun Systems / Close-in Weapon Systems (CIWS)
32.	Sonar Domes

Ser	**Project**
33.	Sound Power Telephone (SPT)
34.	Under Water Telephone (UWT)
35.	TAS Winches
36.	Rocket Launchers
37.	Tactical Mission System for Aircrafts and Helicopters
38.	Personnel Rescue Beacons (PRBs)

Appendix 'G'

PRODUCTS TO BE TAKEN UP FOR DEVELOPMENT

Ser	Projects	
1.	Active Mounts	Active mounting systems for main and auxiliary machinery.
2.	Advanced Hull Coatings	Advanced anechoic hull coatings to reduce low frequency radiated noise as well as absorb incident acoustic energy.
3.	Radar Absorption Paints	Radar absorbent materials/ coatings which are also resistant to immersion in sea water
4.	Low Acoustic Signature Machinery	Manufacture of low acoustic signature mechanical machinery such as hydraulic pumps etc.
5.	Hull Material	Development of high tensile density, high yield, corrosion resistant low magnetic signature steel for pressure hull of submarines
6.	Hull Paints	Long life solvent less epoxy coating for internal as well as external submarine applications
7.	Electric Drive Propulsion for Submarines	Development of main drive technology for motors.
8.	Solid State Power Electronics Control for Submarines	Sophisticated, solid state power control devices for control of motors (for electric drive and other motors) with an aim to reduce the total power consumption during operations.
9.	Improved Battery Power Systems for Submarines	Integrated with all sensors of the submarines
10.	Tethered submarine Buoy	To enable submarine communications at depth as well as intelligence collection.
11.	Integrated Mast	Develop an I-Mast and integration of systems (MFSTAR, SDR, ACCS, EW

Ser	Projects	
		Systems)
12.	Fuel Cells	To enhance performance of existing fuel cell as well as R&D of alternate fuel cell technologies like PEM, AFC etc.
13.	Carrier borne fixed wing UCAVs with satellite link	-
14.	Sonobuoys	DIFAR / DICASS / Bathy
15.	Long range Electro Optical sensors	For helicopters, UAVs and MR aircraft
16.	Fresnel Lens based Optical Landing System	For aircraft carriers and airfields
17.	UW LED Lights	Tool for diver to provide lighting underwater. To be miniaturised to fit diving helmet/ mask.
18.	Supersonic Aerial Targets, Remote Controlled Target Boat (RCTB) with DPS	Supersonic targets for practice firing of missiles/ guns and remote controlled unmanned boats as surface targets for practice firings.
19.	Active off board decoys	Decoys to be fired from ship capable of seducing missiles at standoff ranges from the firing platform.
20.	Close-in-Weapon System	Small calibre multi barrel guns with high rate of fire > 4000 rd/ min
21.	Infra-Red/ Thermal Imaging Search and Tracking System (IRST)	A passive detection system (range > 30km) based on IR/ night vision capability for fitment on ships.
22.	Next Gen NVDs (IR/ Thermal Imaging)	State of art 3rd generation Night Vision Devices.
23.	Helmet mounted NVBs	Night Vision Binoculars (NVB) helmet mounted, to provide hands free capability.
24.	Fuse for 76mm and 100mm guns	-
25.	Ship Installed Chemical System (SICS)	System capable of detecting Chemical Agents to be installed onboard IN Ships.

Ser	Projects	
26.	Magazine Fire Fighting Systems for ships	Fire Detection and associated Fire Fighting System (containing different propellant and explosives) for installation in various weapon magazines on board IN ships.

Appendix 'H'

PROJECTS COMPLETED/ PROPOSED THROUGH DRDO/ PRIVATE INDUSTRY

Ser	Product Description	Development Agency/ Firm	Status
1	Degaussing System	M/s Pvt Ltd, Bangalore	
2	Under Water Telephone (UWT)	M/s KELTRON	
3	Echo Sounder (Multi Frequency Type)	M/s KELTRON	
4	Log EM (Type EML 40)	M/s KELTRON	
5	Main Switchboard/ EDC/EDPs	M/s L & T	
6	Converters, 400 Hz	M/s ELMOT Alternators	
7	VCS System (VOIP Based)	M/s BEL Bangalore	
8	C&C Switchboard	M/s GE India	
9	DF V / UHF Search Receiver	M/s BEL Hyderabad	
10	Main Broadcast & SRE System	M/s Phi AudioCom	
11	SIRS	M/s ECIL Hyderabad	
12	Sound Power Telephones (SPT)	M/s ELCOME Marine	
13	LED Light Fittings	M/s McGeoach Marine Electricals	
14	Ship's Scale Model	M/s Achrekar & Associates	
15	Power Panel for Heavy Loads	M/s L & T, Mumbai	
16	Degaussing Cable	M/s Universal Cables Bangalore	
17	Emergency Supply System	M/s Ray Enterprises, Ambala C	
18	Anchor Capstan	M/s Geeta	

Ser	Product Description	Development Agency/ Firm	Status
		Engineering Works	
19	Rectifiers, 24 V DC	M/s Precision Power Ltd	In Progress
20	Ship Data Network (SDN)	M/s BEL Bangalore,	
21	Wind Instrument & Direction Finder	M/s Hi Point Pvt Ltd., Mumbai	
22	Integrated Bridge System (IBS)	M/s Navicom	
23	CMS	M/s TPSED Mumbai	
24	Conventional Light Fittings	M/s Ray Enterprises	
25	AELs	M/s Ray Internationals	
26	Power Cables for Main Switchboard	M/s Nicco Corporation & Radiant Cables	
27	Lighting Cables	M/s Radiant Cables	
28	Cable Ways	M/s Shakti Engg Works	
29	Air Cooled Transformers 20 KVA	M/s Marine Electricals	
30	Anti Missile Chaff System (Kavach Mod-II)	M/s MTPF, Ambernath	
31	AK-630	M/s GSF, Cossipor	
32	SOP for AK-630	M/s BEL, Chennai	
33	Power Panel for Engine and DA Room	M/s L & T, Mumbai	
34	Lighting Panel	M/s Marine Electrical, Mumbai	
35	Control and Monitoring Cable	M/s Radiant cables	
36	Control and Monitoring Cable	M/s Siechem Technology, Chennai	
37	Control and Monitoring Cable	M/s Nicco Corporation, Bangalore	
38	COS for Heavy and Machinery LOADS	M/s L & T , Mumbai	

Additional Shipborne Systems

Ser	Product Description	Manufacturing Firm	Status
1	Main Switchboard & Electrical Distribution Centres	M/S GE LTD. Bangalore	
2	Gyro Stabilised Horizontal Roll Bar	M/S ECIL Hyderabad	
3	Control & Communication Switchboard	M/S L & T LTD Mumbai	
4	Emergency DA Switchboard	M/S Marine Electricals	
5	20 KVA Convertor	M/S ELMOT LTD	
6	Auto Change Over Switch	M/S Marine Electrical	
7	Ships Installed Radiac System	M/S ECIL	
8	Impressed Current Cathodic Protection System	M/S Cathodic Control Ltd	
9	Transformer	M/S Static Transformer	
10	Lighting System	M/S ISAAC Engg M/S Manish Industries M/S Arvin Industries M/S Ray Enterprises	
11	Emergency Supply System	M/S AIM Engg & M/S ISAAC Engg	
12	30 KVA Helo Convertor	M/S Kirloskar Ltd	
13	Helo Starting Rectifier	M/S Static Transformer	
14	CCS MK-III	M/S BEL (Bangalore)	
15	VCS-28	M/S BEL (Bangalore)	
16	SDN-28	M/S BEL (Bangalore)	
17	LINK-II MOD-III	M/S BEL (Bangalore)	
18	LUP-329	M/S BEL (Bangalore)	
19	100 W MF Transmitter	M/S BEL (Bangalore)	
20	EW SANKET	M/S BEL (Hyderabad)	
21	V/UHF COMINT/ DF System ELK- 7036-WB	M/S BEL (Hyderabad)	

Ser	Product Description	Manufacturing Firm	Status
	DF		
22	Main Broadcast/ Sound Reproduction System	M/S Phi AudioCom	
23	Intercom System	M/s Phi AudioCom (Pune)	
24	Combat Management System-28	M/s BEL (Ghaziabad)	
25	ATM Switch for CMS	M/s BEL (Bangalore)	
26	Data Distribution Unit for RL Gyro	M/s Data Patterns Ltd (Chennai)	
27	AK-630 M	M/s Gun & Shell Factory (Cossipore)	
28	ITTL	M/s Larsen & Tourbo	
29	SWISS-28	M/s BAeHAL Software Ltd (Bangalore)	
30	Tri-Axial Degaussing system	M/s Larsen & Tourbo Ltd	
31	Kavach Mod –II	M/s Machine Tool Prototype Factory	
32	Fire Control System LYNX-U1	M/s BEL Bangalore	
33	50 KVA Converter	M/s PCL Ltd (New Delhi)	
34	IAC MOD ’C’	M/s BEL Bangalore	
35	SONAR HUMSA – NG	M/s BEL Bangalore	
36	IRL	M/s Larsen L&T Tourbo Ltd	
37	Radar Revathi	M/s BEL Bangalore	
38	Echo Sounder V-2	M/s Keltron (Trivandrum)	

Appendix 'J'

PROJECTS COMPLETED/ PROPOSED THROUGH DRDO/ PRIVATE INDUSTRY

Ser	Product Description	Manufacturing Firm	Status
Communication/ Weapons/ Sensors & Spares/ Sub Assemblies			
1	IBA (Integrated Broadcast Application)	M/s Data byte	**Completed**
2	EW System	BEL (Hyd)	**In Progress**
3	Software Driven Radio (SDR)	DRDO/ M/s BEL,	**In Progress**
4	INCIS (*IN* Communication Interoperability system)	WESEE	**In Progress**
5	Lynx U2 Fire Control System	BEL, Bangalore	**Completed**
6	Sonars	DRDO (NPOL)/ BEL, Bangalore	
7	Indigenous Rocket Launcher (IRL)	L&T	
8	Indigenous Torpedo Tube Launcher (ITTL)	L&T	
9	AK 630	GSF, Cossipore & BEL Chennai	
10	Wind Speed & Direction System	M/s Oriole Technical Solutions	
11	Aparna Power Supply	M/s Hindustan Electronics Engg Co.	
12	Power supplies for Fire Control Systems	M/s Hindustan Electronics Engg Co.	
13	Power supplies for Radar Systems	M/s Grow Controls, Hyderabad	
14	SPST Switch	M/s Kavveri Telecommns	
15	Low Noise Amplifiers (LNA) For Radars	M/s I-Futura Technology	
16	Frequency Shift Devices	M/s I-Futura Technology	
17	RF cables	M/s Hindustan	

Ser	Product Description	Manufacturing Firm	Status
		Electronics Engg Co.	
18	Power Supply Modules	M/s Hindustan Electronics Engg Co.	
19	RF Mixer Modules	M/s Astra Microwave	
20	Ground Support Equipment for Missiles	M/s Aeromarine Services, Mumbai	

Directorate of Indigenisation,
Integrated Headquarters of Ministry of Defence (Navy)
5th floor, Chanakya Bhawan,
Chanakyapuri, New Delhi 110021
Tel: 011-24108377 • Fax: 011-24122689
Email: doi-navy@nic.in