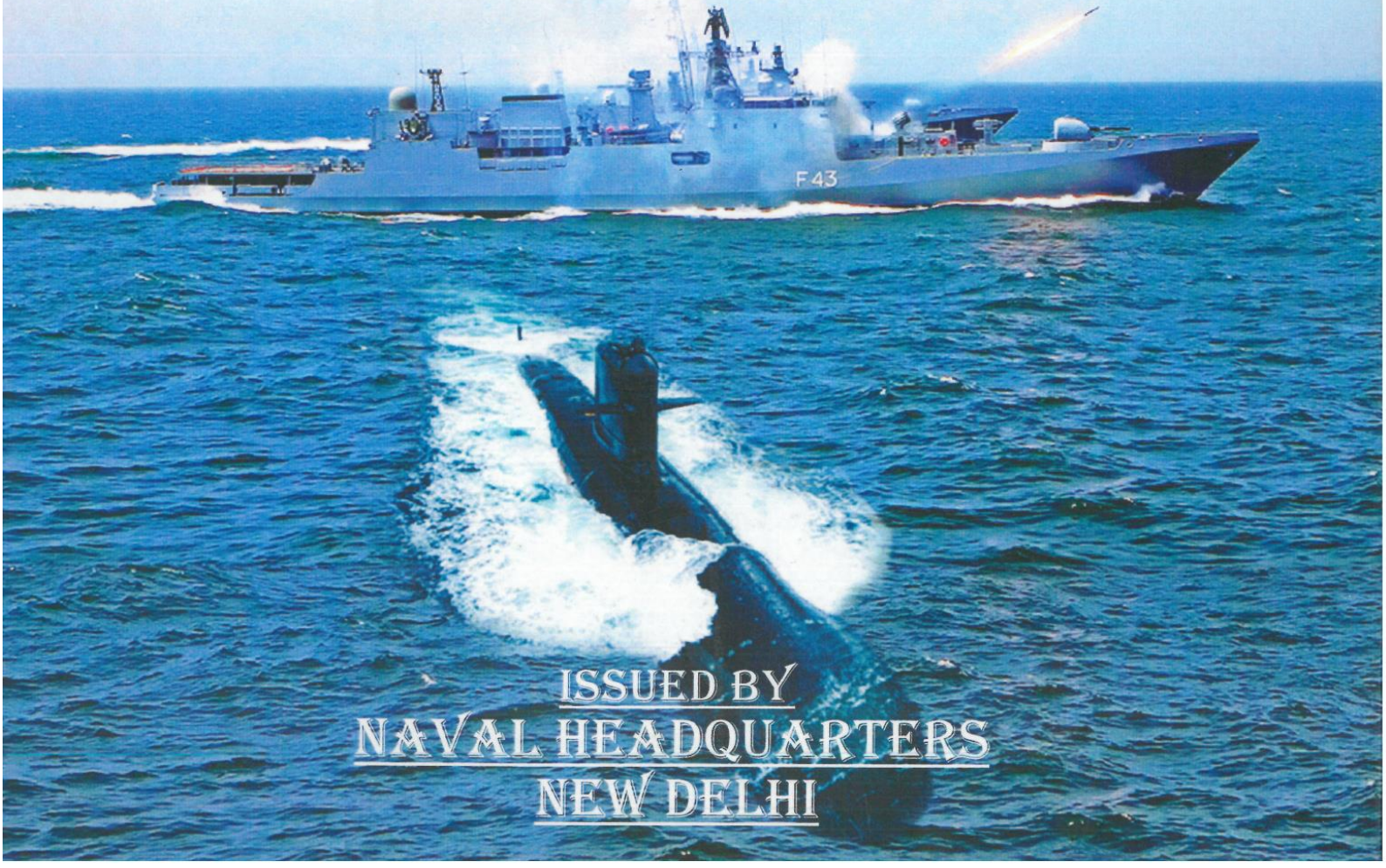
HAR KAAM DESH KE NAAM

INDIAN NAVY

SWAVLAMBAN

SHIP'S SYSTEM, WEAPONS, AVIATION AND ELECTRONICS ATMANIRBHARTA ABHIYAN



ISSUED BY
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MESSAGE

The Indian Navy has been a strong proponent of indigenisation and considerable ground has been covered in the 'Float' and 'Move' categories of Naval platforms. Concurrent impetus is also being accorded to self-reliance in the 'Fight' component. Towards this, existing GoI policies and initiatives are being harnessed to utilise the full potential of Indian industry and academia.

The maiden 'SWAVLAMBAN' is one such additional endeavour, to enable and encourage the Indian industry and academia to participate in *INs* indigenisation efforts. The document provides a roadmap for developing indigenous capabilities, and enables industry to better appreciate Navy's requirements and priorities.

The release of the 'SWAVLAMBAN' would provide a platform for R&D hubs, designers, manufacturers and academia to understand and align their capacities and know-how in meeting the user's requirements. The Indian Navy looks forward to strengthening this partnership to mutual benefit, and provide further fillip to self-reliance efforts in naval systems and weapons.

(Karambir Singh)
Admiral
Chief of the Naval Staff

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MESSAGE

The current geopolitical scenario demands a strong Navy for the nation, necessitating focused acquisition of enabling technologies that will pervade futuristic warfare. It is, thus, imperative to develop a blueprint for indigenous development programs, whilst minimising expenditure on high imports and consequent dependence on other nations for sustainability. The **'MAKE IN INDIA'** initiative of GoI coupled with simplified procurement procedures and offset clauses have paved way for greater participation of private industry and MSMEs.

Over the last few years, the Indian defence Industry has matured in state of the art manufacturing prowess. The progress made in acquiring capabilities in design and precision manufacturing, using niche technology of international standards, are indicative of their willingness and ability in partnering the Indian Navy in its developmental efforts. We are convinced that the domestic industry is all fired up to go the extra mile in providing the armed forces with indigenous design and development of Naval Systems and Weapons through collaborative approach and joint ventures.

The first edition of the **'SWAVLAMBAN'** is yet another reassertion for our commitment to make India emerge as the state-of-the-art manufacturing hub for naval systems and weapons. I am sure that the 'SWAVLAMBAN' would achieve its objectives in providing a technological road map and enable synergising of capabilities of DPSUs, OFB, Private Industry, DRDO and Academia. The Indian Navy looks forward to longlasting partnership and expansion of the industry base in manufacturing of naval systems and weapons.

Jai Hind, Shano Varuna

(G Ashok Kumar)
Vice Admiral
Vice Chief of the Naval Staff

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PART – I

INTRODUCTION

CHAPTER 1

INTRODUCTION TO INDIAN NAVAL INDIGENISATION PLAN

1. Indian Navy's role extends across the entire spectrum of security of the nation ranging from activities benign, to those of constabulary and military. Thus, from peace keeping, low intensity maritime operations to high-intensity hostilities, both conventional and nuclear, Indian Naval platforms are required to be equipped with systems that can face retribution yet perform as desired across all these roles in a multi threat scenario. The Indian Navy (***IN)*** needs to perform these varied tasks in the ever expanding domain cohabitated by 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. The Indian Navy, therefore, needs to acquire adequate deterrent war fighting capabilities.

2. In the past, the ***IN*** sourced military technology through import. This option had to be exercised since our own research organisations and industry had not developed any major military systems to reach technological relevance in the domain of warfare. The lack of credible R&D in military technology, inadequate amalgamation between R&D and manufacturing sector, near absence of an integrated approach amongst users, designers and manufacturers were some of the 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., were also major factors those impeded development and manufacturing of home grown military technology and equipment.

3. Conscious of these constraints, Indian Navy embarked upon development of ship borne 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, weapons and advanced manufacturing processes.

4. The ***IN*** 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 Propulsion Diesel Engines) and related auxiliaries, support services like air conditioning, refrigeration, etc., production capabilities are available in the country. We are also reasonably self-sufficient in power generation and distribution systems, communication systems, Combat Management Systems, Sonars and Electronic Warfare Systems.

5. Indigenous development in weapons and their control elements, sensors, Radars, Fire Control Systems, etc, however, fall much below par and need to be pursued with vigour. Although we possess design capabilities and to some extent the production base, considerable performance enhancements are required in the field of underwater weapons and sensors, Multi-function Radars, IT based systems, etc., as their critical subsystems and components are still being imported.

6. The role of the indigenous industry in defence manufacturing sector cannot be over emphasised. The entire industrial might of the country, whether it is the OFB, Public Sector Units (PSUs), Defence Public Sector Units (DPSUs), large private industries or Medium, Small and Micro Enterprises (MSMEs), need to partner to achieve the goal of self-reliance of the ***IN***. They should become the stakeholders of the plan and provide not only the much 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 ***IN***.

7. **Categorisation of Ship's Equipment**. The ship-building materials, equipment and systems onboard an ***IN*** warship 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 including deck machinery.

(b) **Move**. Equipment under this category encompasses propulsion system, power generation diesel/ gas/ steam turbine engines, alternators, associated control systems (Integrated Platform Management System/ Automatic Power Management System), Auxiliary Equipment/ systems viz. Pumps, AC &

Refrigeration plants, Compressors, Switchboards, Communication equipment, Firefighting Systems etc.

(c) **Fight**. Equipment under this category encompasses all types of ship borne weapons & sensors, armament that directly contributes to the combat capability of the platform.

8. **Indigenisation Strategy**. Indigenisation is undertaken at three distinct levels of complexity viz., systems, subsystems and spares level. These are elaborated below:-

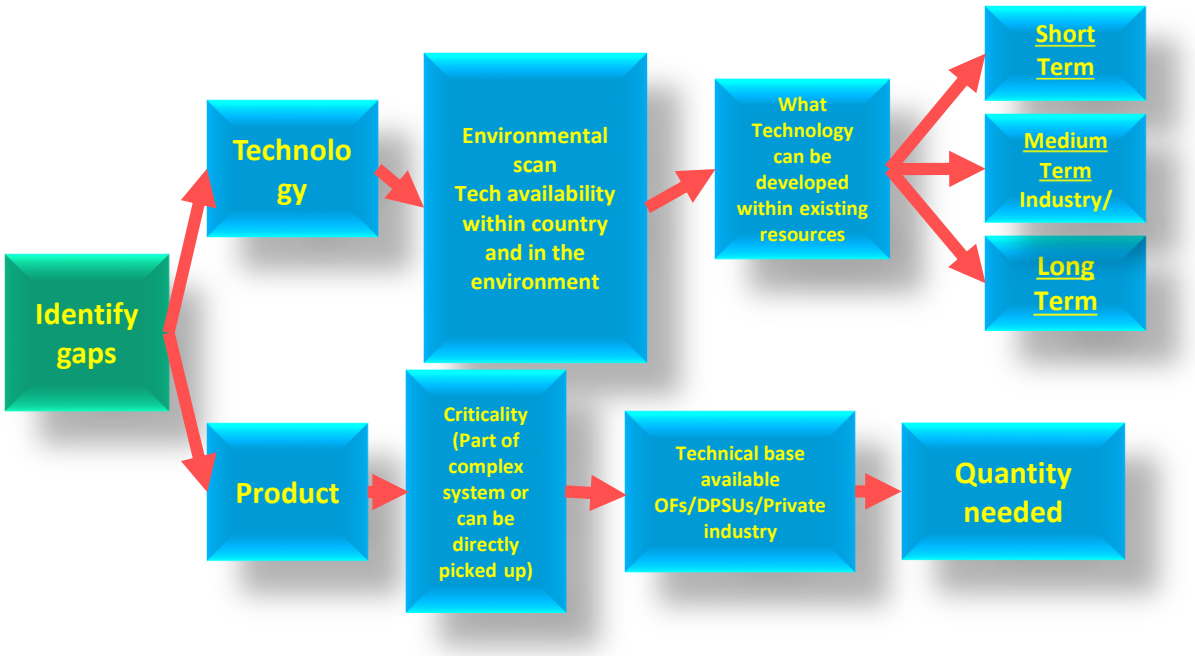
(a) **System Level**. This level includes system as a whole and is primarily based on Naval Staff Qualitative Requirements (NSQR). Due to requirement of ab-initio development and inherent complexity, systems are typically developed by DRDO.

(b) **Subsystem Level**. At the second level are the subsystems which form part of individual systems. Subsystems are indigenised based on specifications generated by ***IN***. Indigenisation at this level can be undertaken through a combination of DRDO and industry, depending on the complexity of the technology involved.

(c) **Spares Level**. The third and very important aspect of indigenisation is sustenance of inventory through regular replenishment of spares. These are the low technology, fast moving items which can be indigenised directly by the industry.

9. An indigenisation strategy has been formulated accordingly to bridge the gap between the desired capability and that existing.

10. Till the recent past, indigenisation was focused on import substitution through reverse engineering and was limited to components/ subsystem. This method, though helpful in management of existing inventories, the IN remained saddled with decades old technology. Indigenisation strategy is, therefore, primarily focused on technology development in gap areas rather than requirement based indigenization.



11. Technology development focusses on the knowledge areas. For each technology area, environmental scan is conducted and technology base available within the country is identified. In order to optimize the developmental timeline, technologies for which feasibility exists are classified into three categories depending upon level of

technology and timeframes for indigenisation. Technologies for which sufficient order quantity are available and technology easily accessible are reserved for industry. Where higher level of technology is required, help of academia is sought and technologies which are futuristic in nature or not feasible for development due to cost considerations vis-à-vis numbers involved, are reserved for DRDO.

12. Product development is aimed at indigenisation of a specific product. Development of products is the preferred mode of indigenisation in situations where urgent import substitution is required.

13. **Agencies Involved in Indigenisation**. Indigenisation in the ***IN*** is undertaken primarily by three agencies :-

(a) Directorate of Indigenisation : Ship systems.

(b) Directorate of Air Projects and Plans : Aviation systems.

(c) Directorate of Armament Production and Indigenisation : Armament systems.

14. **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)	Composite Foldable Aircraft Hangar Door

(b) **Move Category**.

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

(c) **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)	Mine Hunting and Diver Detection Sonars
(x)	Light and Heavy Weight Torpedoes
(xi)	Towed Array Sonars
(xii)	Unmanned Aerial Vehicles/ Autonomous Underwater Vehicles
(xiii)	Global Positioning Systems, Inertial Navigation Systems
(xiv)	Super Rapid Gun Mounts (SRGMs)

15. **Potential of Partnership in Overcoming Constraints**. The Indian private sector Industry has a scope for greater involvement in the Defence Sector and possesses the requisite skills and infrastructure for undertaking defence production. Industries willing to invest/ share the cost of setting up of infrastructure could approach ***IN*** in this regard. The progressing of development contracts could be based on a collaborative approach between the ***IN*** and the Industry

with the understanding that both are equal partners aiming at optimum results.

16. The preference to '*Buy (Indian IDDM)'* in DPP 2016 is a major step by the MoD to promote indigenous design and development of complex systems for the defence services. 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.

17. The Navy as a customer, and the industry as a supplier need to have a clear understanding of the requirements and the plan for induction and indigenisation. Keeping this aspect in focus, the Indigenisation requirements of the ***IN*** have been collated under one head based on current requirements with respect to new induction ships and submarines and life cycle support imperatives of the existing ***IN*** inventory.

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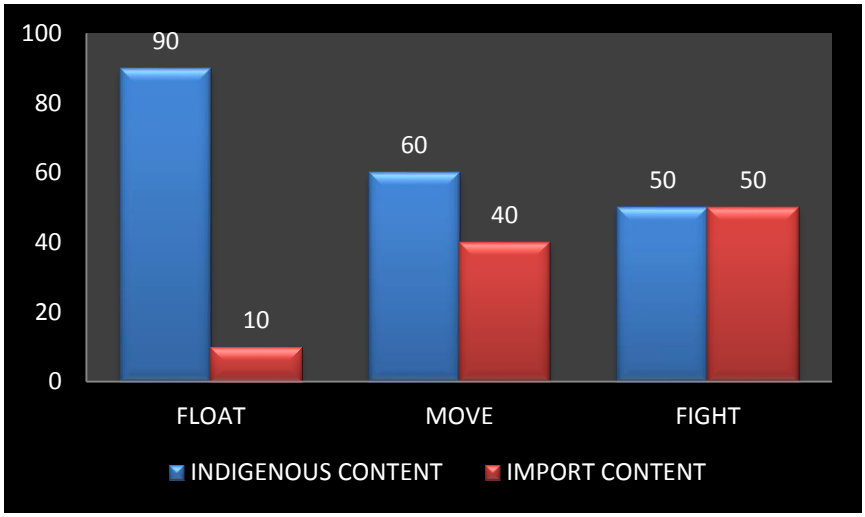
CHAPTER 2

INDIGENISATION ACHIEVED

Background

1. The equipment and machinery fitted onboard ships in the three categories of Float, Move and Fight has been indigenised to the extent of 90%, 60% and 50% 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.



Major Systems Indigenised

2. 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/ Industry
(ii)	Hangar Doors and Shutters	Industry

Ser	Equipment/ Material	Indigenising Organisation
(iii)	Anchor Capstans / Windlass	Shipyards/ Industry
(iv)	Davits and Boats/ Rigid Inflatable Boats (RIBs)	Industry
(v)	General Service Life Jackets/ Hazardous Duty Life Jackets	Industry (M/s Arnaf Futuristic and M/s Galvanisers India)
(vi)	Foldable Hangar Door	Industry (M/s L&T)
(vii)	Silicon Rubber Seals	IRMRA

(b) **Move**.

Ser	Equipment/ Material	Indigenising Organisation
(i)	Steam Turbine	M/s BHEL
(ii)	Boilers	Naval Dockyard, Mumbai, M/s Thermax
(iii)	RO Plants	Industry
(iv)	Pumps	Industry
(v)	HP Air and AC Compressors	Industry
(vi)	AC and Ref Plants	Industry
(vii)	Stabiliser System	Industry
(viii)	Gas Turbine Generator (GTG) Control System	M/s BEL
(ix)	Gas Turbine (GT) /GTG Starting Rectifier	Industry
(x)	Steering Gear	Industry
(xi)	Motors and Power Generation & Distribution Equipment	Industry
(xii)	Submarine Batteries	Industry
(xiii)	Inertial Navigation System	DRDO/ RCI

(c) **Fight**.

Ser	Equipment/ Material	Indigenising Organisation
(i)	Electro Optical Director for GMs - SOP	BEL (Chennai)

Ser	Equipment/ Material	Indigenising Organisation
(ii)	Electronic Warfare Systems	BEL
(iii)	Electro Optical Director for GMs - EON	BEL (Bangalore)
(iv)	Gun Fire Control System – Lynx U2	BEL (Bangalore)
(v)	Anti-Submarine Warfare Fire Control System (ASW FCS)	BEL
(vi)	Supersonic Missile System	M/s BAPL
(vii)	AK630 and Super Rapid Gun Mount	OFBs/ BHEL
(viii)	Torpedo Tube Launchers	Pvt Industry (M/s L&T/ MDS)
(ix)	Combat Management System	WESEE/ BEL(Gad)
(x)	Data Link & Net Centric Operation (NCO) Equipment	BEL
(xi)	Weapon Systems Integration	WESEE/ Pvt Industry
(xii)	Composite Sonar Dome	DRDO [R&DE(E), Pune]
(xiii)	Helo Traversing System	Industry (M/s L&T, M/s GRSE)
(xiv)	Chaff Launchers	OFB/ MTPF
(xv)	CCS/ VCS	BEL
(xvi)	HF/ VLF Receivers	BEL
(xvii)	HF Transmitters	BEL/ HAL
(xviii)	V/UHF sets	BEL & M/s ECIL
(xix)	Main Broadcast/ Sound Reproduction Equipment	M/s Phi Audicom, M/s Linea Engg
(xx)	Rocket Launcher	M/s L&T
(xxi)	Torpedoes	NSTL and M/s BDL
(xxii)	Mines	NSTL, ARPPL

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

(a) Retractable Stabiliser Systems

(b) Digital GTG Control System

(c) Gas Turbine (GT)/ Gas Turbine Generator (GTG) Starting Rectifier

(d) Deck Hydraulic Systems.

(e) Steering Gear Systems

(f) Anchor Capstan

(g) Windlass

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

(j) Extraction Trolley and cross piece for Missiles

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

PART – II

SHIP SYSTEMS

CHAPTER 3

MARINE ENGINEERING

1. Over past few years there has been considerable success in Indigenising major systems like steering gear, stabiliser systems, Reduction Gear (lower power range), deck machinery etc. as replacement for imported ship fits, as well as for major ship/ submarine building programme for Navy. It has infused confidence and will lead to further boost the IN-Industry partnership in 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.

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 Failure (MTBF).

(j) Minimum maintenance requirements with high Mean Time Between Overhauls (MTBO).

3. Marine 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, AC & Refrigeration Plants, Steering Gear and Stabilisers, HP & LP Air Compressors, Hydraulics & other ship systems).

(d) Machinery Control Systems/ Equipment.

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

Main Propulsion Equipment

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.

5. ***IN*** currently employs the three conventional propulsion plants i.e. Steam Boilers & Turbines, Diesel Engines and Gas Turbines. Sufficient developments have been made in respect to steam propulsion plants and smaller diesel engines. Indigenously manufactured steam turbines of M/s BHEL and main propulsion diesels of Kirloskar Oil Engines Limited and Cummins India Ltd. are already in use onboard ships. Nuclear propulsion and Integrated Electric Propulsion are also envisaged for future ships & submarines.

6. **Gas Turbines**. Presently all gas turbines, fitted in IN platforms are of foreign origin. Therefore there is an urgent need to develop indigenous gas turbines. Indigenisation initiatives taken in this regard include induction of General Electric LM 2500 gas turbine on the basis of its licensed Assembly, Inspection & Testing 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.

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 will greatly reduce our dependence on imports. In addition, 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 with high Mean Time Between Overhaul/ Failure (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 engines onboard these ships are to be with non-magnetic characteristics. Presently, no indigenous is manufacturing non-magnetic engines.

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.

(e) High MTBO and MTBF.

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 venture with M/s Renk, Germany and M/s Walchand Industries in collaboration with DCNS/ Naval Group, France. There is a requirement of gearboxes with greater indigenous content in the range of 1-50 MW for the newer platforms.

10. **Shafting/ Controllable Pitch Propellers (CPP)**. Some headway has been made in indigenous development of Fixed Pitch Propeller (FPP) shafting systems with foreign collaboration, wherein, 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 Controllable Pitch Propeller (CPP) based shafting systems is much higher. There is need to indigenously develop CPP shafting systems with greater indigenous content for future projects.

11. **Propulsion System Integration**. The propulsion system comprises of power plant (Diesel Engine/ Gas Turbine/ Steam Turbine or combination of these), Reduction Gear, Shafting, Propulsion system auxiliaries and Control System. These major elements are to be sized and suitably coupled/ integrated to ensure optimum performance of the entire system under various operating profiles of the ship. Presently, expertise for this critical task of system

integration is not available within the country and therefore, IN is dependent on foreign sources. 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.

12. **Air Independent Propulsion (AIP) Solutions for Submarines**. ***IN*** 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 still lacking or is at a very nascent stage and is required to be built up to the range of 225 to 250 KW for retro-fitment on the existing submarines/ incorporation in the new designs.

Prime Movers for Generators

13. 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) and Steam Turbines (500KW - 1000KW) are used for power generation.

14. 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 Controls & Instrumentation

15. **Machinery Control Systems**. To ensure substantial indigenisation design of all machinery control systems and to ensure standardisation, these systems have been evolved around open architecture standards. This has enabled indigenous availability of core hardware as well as software of machinery controls on all new construction ships. 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.

16. 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).

17. 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 indigenised in the past.

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

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

<u>Indigenisation Envisaged</u>

19. The list of critical 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 Fresh water/Feed water Heat exchangers which are fitted in various equipment/systems.

(e) Fuel Pumps

(i) Fuel Transfer Pumps

(ii) Stripping pumps

(iii) Manual Pumps for Aviation Fuel (AVCAT)

(f) Lub oil pumps

(i) Transfer Pumps

(ii) Hand Pumps

(g) Sea water pumps

(i) AC Condenser Sea Water Cooling Pumps

(ii) Seawater Circulating Pumps

(iii) Fire Pumps

(h) Fresh water pumps

(i) AC Chilled Water Pumps

(ii) Fresh Water Pumps

(iii) Pumps for de-mineralised water system

(iv) Pump for technical fresh water

(j) Desalination plant pumps

(k) Bilge system Pumps

(i) Main Drainage Pumps

(ii) Portable Pumps

(l) Hydraulic Pumps

(i) Transfer Pumps

(ii) Manual Pump

(iii) Variable Discharge Pumps

(iv) Hydraulic Pumps for Aircraft Arresting Gear and Lifts

(m) Shafting components viz. Plummer Bearings, Thrust pads etc.

(n) Lub oil coolers, condensers and evaporators of Motor Driven AC Plants, Turbo Driven AC Plant and Refrigeration plants.

(p) Valves of Freshwater, Feed water, Sea water and other Auxiliary systems.

(q) Components of Boiler and Turbine Aggregates control systems.

(r) Filters of lube oil system.

20. The following equipment/ system required to be indigenised:-

(a) Boiler Mounting for K(B)(G)-3(D) boilers and 1500KW Turbo Generator.

(b) Waterjet Propulsion System (being progressed as part of TDF scheme).

(c) Composite material air bottles (being progressed as part of TDF scheme).

(d) Composite material sea water pump (being progressed as part of iDEX scheme)

(e) Specialised SV mount.

21. 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.

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

23. **Hull Equipment**. Considering the extensive operating 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

24. The above ship's boats would be replaced as a part of the periodic review and same would have to be integrated with the davits thereafter.

NBCD Equipment

25. Development of fixed FF system for machinery compartments is being progressed by DRDO/ 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.

Forecast Requirements

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

CHAPTER 4

SUBMARINE EQUIPMENT AND SYSTEMS

1. Private industry has partnered with the IN towards indigenous development of equipment, systems and components for submarines including the strategic platforms. Successful development of many such equipment/ systems for the critical platforms has given the Navy adequate confidence in the Indian Industry for development of technologically complex systems. 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

2. Some examples of indigenisation which have been progressed in the recent past include:-

(a) Hydraulic oil accumulators

(b) Fuel flow meters

(c) System filters

(d) Pumps

(e) Cables

(f) Batteries

(g) Heat Exchangers

(h) Instrumentation components viz. Transducers and Parameter Indication devices

(j) Diesel Engine Monitoring System

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.

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 system.

(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

5. The construction of submarines under the Scorpene project is progressing at Mazagon Dock Limited (MDL) under ToT from DCNS/Naval Group, France. Further, P 75(I) submarine project is being planned through the 'Startegic Partnership' route. This offers an excellent opportunity for indigenous development of equipment and systems as per the provisions of the contracts. Few of the equipment and systems proposed to be indigenised are as follows:-

(a) Steering Gear

(b) Shafting

(c) Reduction Gear

(d) AC Plants.

(e) Ref Plant

(f) Compressors

(g) Pumps

(h) De-Mineralised Water (DM) Plant

(j) Accumulators

(k) Various types of filters

(l) System Valves

(m) Electrical Equipment viz. Motors, Power distribution centers etc.

Forecast Requirements

6. List of forecast requirement of equipment/ systems for submarines is placed at **Appendix `B**.

CHAPTER 5

AIRCRAFT HANDLING EQUIPMENT

1. With the induction of 2nd Aircraft carrier, industry support is being sought for the development and maintenance of various handling and support equipment onboard this ship. Large number of equipment for handling aircrafts/ arms/ ammunition onboard ships is required by Navy. Some of the equipment used onboard and being imported presently which need to be indigenised 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

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

CHAPTER 6

DIVING & SPECIAL OPS. EQUIPMENT

1. Special Operations and Diving equipment, by virtue of the unique requirement, inherently need to be based on high end technology. However, these equipment are required in limited numbers and also have a fixed shelf life. Considering these aspects, the following equipment have been identified for indigenous development and 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.

PART – III

WEAPONS AND SENSORS

CHAPTER 7

WEAPONS AND SENSORS

1. **Background**. At independence, India's defence-industrial production was mainly coming from the existing Ordnance Factories. The IN in the early 80s embarked on indigenisation of fast moving components. Of late, NA stores are being indigenised through ab-initio design and reverse engineering using in-house expertise.

2. **Categorisation of Naval Armament Stores**. Naval Armament stores can broadly be categorised into the following:-

(a) Missiles (Air-to-Air, Air to Surface, Surface to Air, Surface to Surface and Shoulder launched).

(b) Torpedoes (Air, Ship and Submarine launched).

(c) Mines.

(d) Bombs and Mortars.

(e) Depth Charges.

(f) Underwater Rockets and Launchers.

(g) Guns and Ammunitions.

(h) Small Arms and Ammunitions.

(j) Countermeasures (Decoys and Deceivers) and launchers.

(k) Pyrotechnics stores.

(l) Demolition Charges.

(m) Special Arms and Ammunition for MARCOS.

(n) Power cartridges.

3. India has one of the largest defence industrial complexes in the developing world. It consists of 41 Ordnance Factories (OFs), nine Defence Public Sector Undertakings (DPSUs), and an emerging and vibrant private sector. Vital value addition to the effort of this conglomerate is provided by 52 Defence Research and Development (R&D) laboratories under the umbrella Defence Research and Development Organisation (DRDO).

4. State of the art ships and submarines are under construction at Indian shipyards, both public and private. Indigenisation of armament will not only propel the IN to be self-reliant but also cut down costs and reduce dependence on foreign vendors.

5. **Indigenisation in IN**. Indigenisation of ship borne weapons/ armament is very challenging and complex in nature. The indigenisation efforts of IN in the field of Armament Technology is spearheaded by DGNAI. The seamless synergy amongst various stake holders has culminated in successful indigenisation of a variety of critical NA Stores paved way for meeting the operational requirements of seagoing platforms through indigenous means.

6. Indigenisation of armament for Kavach chaff system (launcher & rockets), AK 100 ammunition, AK 630 ammunition, 40/60 modified ammunition, 76/62 SRGM ammunition sub-assemblies, 140mm rocket, RGB-12 and RGB-60 rockets has been undertaken in association with OFB. In addition, a number of explosives for RZ-61 & P-series missiles, propellant for Torpedo Impulse Ctge, re-filling of warheads of missile, torpedo, depth charge, bomb, etc. have been developed. However, despite all this, we have achieved only about 30% indigenisation in the 'Fight Category'.

7. A multipronged approach for development of shipborne weapons/ armaments is being taken; one to harness the R&D potential at DRDO and the other through expertise of Private Industry. Thus there is much scope for improvement in this areas, and a 'Blue Ocean' awaits all these who would want to explore this.

Underwater Systems

8. Underwater systems mainly consist of torpedoes, decoys, rockets and underwater mines. Over the years there has been considerable amount of indigenisation in terms of primary and secondary batteries of torpedoes, torpedo launchers and ASW rockets launchers, explosive filling of depth charges etc.

9. Presently ***IN*** holds a large number of torpedoes imported from western origin countries and of eastern origin. There is a huge opportunity for the private industries to contribute in indigenous development of the following sub-systems of torpedoes:-

(a) **Homing System**. It is a vital component of the torpedo. The homing system mainly consists of a transmission & receiving circuit, transducer, amplifier for the amplification of incoming signals, logic unit for data processing. Presently the entire homing systems of the torpedoes are of foreign origin. There is an urgent need to indigenously develop the homing systems.

(b) **Warhead and Exploders.** Though sufficient expertise for refurbishment of warheads has been achieved through OFBs for some torpedoes, there exists a larger opportunity with private industries for indigenous development of warheads and exploders torpedoes. There is a need to indigenously develop the payload, casing, fuze and safety & arming device(SAD)/ exploders.

(c) **Exercise Head.** The purpose of the exercise head is to record various signals within the torpedo during practice firings. It comprises various sub units viz: recording, surfacing, locating and recovery aids. Sufficient expertise has been achieved in development of surfacing aids such as rubber floats from private industries. However, there exists a need for indigenous development of recorders, actuators, compressed air bottles, electro explosive devices, smoke markers, noise makers etc.

(d) **Propulsion System**. Batteries are used to propel the torpedo. The propulsion batteries are either primary or secondary type. Primary batteries are single shot battery

whereas secondary batteries are of rechargeable in nature. The batteries which are used in the IN are usually of AgO-Zn or sea water activated batteries (Mg-AgCl). In light of recent advancement of Lithium Ion battery technology worldwide, there is a requirement to indigenously develop long lasting and higher endurance batteries in order to achieve better endurance of the torpedo. Indigenous manufacture / development of high power batteries to naval specifications in the higher power rating will greatly reduce our dependence on imports.

(e) **Control System.** The control system of the torpedo caters for regulating the course, depth and roll of the torpedo. Currently, the entire control system of the torpedo are of foreign origin. Indigenous development of course gyro mechanisms, servo actuators for rudders etc is required.

(f) **After Body and Tail Unit.** The after body of the torpedo mainly consists of propeller shaft, propellers, sealing mechanism rubber 'O' rings etc. Sufficient scope exists for the large variety of these sealing mechanisms and 'O' rings could be taken up for development by Indian manufacturers.

10. ***IN*** has indigenised underwater rockets, Depth charges, limpet mines, Processor based ground mines, which are primarily used for combat role against submerged submarines and incoming torpedoes.

11. Other underwater NA stores like anti torpedo countermeasure system are being imported. Indigenous development / licensed production of anti-torpedo countermeasures will enable import substitution and also provide prompt and reliable product support for the Navy.

12. **Indigenisation Envisaged**. The list of equipment for which spare parts/ components could be taken up for indigenisation are as follows:-

(a) Homing heads of torpedoes of eastern and western origin countries.

(b) Warheads and exploders.

(c) Exercise heads and its components.

(d) Rubber floats and recovery aids of torpedoes.

(e) Elastomers used as sealants in propulsion systems and propellers.

(f) Anti Torpedo Countermeasures.

Ordnance/ Gun Systems

13. The ordnance/ gun systems held in the ***IN*** inventory are predominantly of eastern origin, inducted and procured from Original Equipment Manufacturers (OEMs). The Private industry has partnered with the ***IN*** in indigenisation of sub-assemblies of these vital gun systems. A large number of firms have been associated with the development of various gun systems and sub systems for ***IN***. Successful development of these systems 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.

14. There has been requirement of fast moving consumables of gun systems in the past and the requirement is envisaged to grow significantly in the upcoming years with the induction of a large number of ships. The platforms need to be equipped with safe, reliable and ready to combat gun systems.

15. **Indigenisation Envisaged**. The list of equipment for which spare parts/ components could be taken up for indigenisation are as follows:-

(a) Barrels and Liners for various guns.

(b) Proximity Cut-off devices for gun systems.

(c) Bore Gauges for checking condition of barrels.

(d) Various elastomers for gun systems.

(e) Mechanical components such as springs, levers and screws of various gun systems.

(f) Hydraulic Buffers and recuperators of various gun systems.

Missile Systems

16. The missile systems held in the ***IN*** inventory and those which are being inducted are procured from Original Equipment Manufacturers (OEMs) or Indian DPSUs. The requirement of missile systems is envisaged to grow significantly in the upcoming years with the induction of a large number of ships, submarines and aircrafts. The missile technology is ever changing and platforms would need to be equipped with state-of-art missiles with better capabilities at all times.

17. ***IN*** has achieved success in indigenisation of various missile explosives viz. booster powder charges and ignitors, sustainer powder charges and ignitors, various pyros and missile batteries. Though the other missile components are being catered through the OEM, there exists a greater need to indigenise fast moving missile consumables.

18. **Indigenisation Envisaged**. The list of equipment for which spare parts/ components could be taken up for indigenisation are as follows:-

(a) Homing heads of missiles.

(b) Warheads, rocket motors and exploders.

(c) Airframes, control surfaces and actuators of Missiles.

(d) Sealants.

(e) Enamels and Paints.

(f) Various elastomers and rubber components.

(g) Weapon Health Monitoring System.

Electrical/ Electronic System

19. The electrical/ electronic systems in NA stores play a very important role be it within the NA store or the test equipment being used. Most of the electrical/ electronic systems held in the IN inventory are predominantly procured from Original Equipment Manufacturers (OEMs). The electrical/ electronic systems primarily include:-

(a) Test equipment for missile and torpedo preparation.

(b) Simulators.

(c) PCBs of various missiles sections and torpedoes.

20. Optimum self-reliance in these systems is of vital importance for both strategic and economic reasons. There is a requirement to enhance the participation of Private industry in indigenisation of various electronic/ electrical sub-assemblies of NA stores.

21. **Indigenisation Envisaged**. The list of electrical/ electronic systems which could be taken up for indigenisation are as follows:-

(a) Muzzle Velocity and Discharge Pressure Measuring device.

(b) Torpedo Simulators.

(c) Invertors, converters and Frequency stabilisers for torpedoes.

(d) PCBs of various missiles and torpedoes.

(e) Motors, actuators, power amplifiers and sensors of torpedoes and missiles.

(f) Portable and ship borne presetters.

Indigenisation Through Make – II Procedure

22. The 'Make in India' initiative of the Government of India, aims to promote the manufacturing sector and increase the contribution of manufacturing output to 25% of GDP. Defence sector is prominent among the 25 sectors of industry covered under the 'Make in India' initiative. The provision of 'Make' category of capital acquisition is a vital pillar for realising the vision behind the 'Make in India' initiative. Hence it is imperative that the 'Make' procedure should be structured to provide the necessary leverage to make adequate investments, build the required capabilities and match up to the contemporary and futuristic requirements of the Indian Armed Forces.

23. The 'Make' procedure, addresses the multiple objectives of self-reliance, wider participation of Indian industry, impetus for MSME sector, sound implementation, transparent execution and timely induction of equipment into ***IN***. Acquisitions covered under the 'Make' category refer to equipment/system/sub-system/assembly/sub-assembly, major components, or upgrades thereof, to be designed, developed and manufactured by an Indian vendor, as per procedure and norms detailed in Chapter III-A of DPP-2016.

24. Only Indian vendors including Association of Persons (AoP), are eligible for participation under 'Make' program of acquisition. Successful development under this scheme would result in acquisition, from successful Development Agency/Agencies (DA/DAs), through the 'Buy (Indian-IDDM)' category with indigenous design and development and a minimum of 40% IC, by inviting commercial bid and thereafter following the procedures detailed in Chapter II of DPP.

25. The sub-category under 'Make' category are further sub-divided into the following:-

(a) **Make-I (Government Funded)**. Projects under 'Make-I' sub-category will involve Government funding of 90%, released in a phased manner and based on the progress of the scheme, as per terms agreed between MoD and the vendor.

(b) **Make-II (Industry Funded)**. Projects under Make-Il category will involve prototype development of

equipment/system/platform or their upgrades or their sub-systems/ sub assembly/ assemblies/ components/ materials, primarily for import substitution/innovative solutions, for which no Government funding will be provided for prototype development purposes. Cases where innovative solutions have been offered, shall be accepted and progressed, even if there is only a single individual or a firm involved. Projects under the Make-II sub-category, with estimated cost of prototype development phase not exceeding Rs. 3 Crore and cost of subsequent procurement not exceeding Rs. 50 Crore/year based on delivery schedule at the time of seeking AoN, will be earmarked for MSMEs. If no MSME expresses interest for a Make-II program earmarked for them, the same may be opened up for all.

26. **Development and Procurement Process under 'Make-II' Category.** The development & procurement process under Make-II sub-category would involve the following functions:-

(a) Advance Planning & Consultations, and Feasibility Study.

(b) Formulation of Preliminary Staff Qualitative Requirements (PSQR).

(c) Constitution of Project Facilitation Team (PFT).

(d) Categorisation and Accord of Acceptance of Necessity (AoN).

(e) Issue of Expression of Interest (EoI).

(f) Evaluation of EoI responses.

(g) Award of Project Sanction Order.

(h) Design and Development of Prototype.

(j) Conversion of PSQRs into SQRs.

(k) Solicitation of Commercial Offer.

(l) User Trials by SHQ.

(m) Staff Evaluation.

(n) Commercial negotiations by Contract Negotiation Committee (CNC).

(p) Award of Contract.

27. Naval Armament Stores being Indigenised under MAKE – II are as follows:-

Ser	**Naval Armament Store**
(a)	Universal Proximity and DA fuze for 76/62 SRGM with electronic adaptable to 76-127mm ammunition
(b)	5" Mobile Target Emulators for C303/S countermeasure system
(c)	Limpet Mines Mk 414(7kg) and Mk 430(15Kg)
(d)	Signal Flares and Anti Sonar Decoys submarines

28. Naval Armament Stores proposed for Indigenisation under MAKE – II are as follows:-

Missiles	
(a)	Missile Balwanka
(b)	Missile Mockup
(c)	Lightweight Supersonic Target
Torpedoes	
(d)	Exploders for torpedoes
(e)	Consumables for torpedo and decoy
(f)	Torpedo Simulator
Ammunition	
(g)	Signal Flares
(j)	Flare Launchers
(k)	SSE Ejector
(l)	Insensitive Energetics
(m)	Homing system for underwater rockets
Decoys	
(p)	Passive off-board decoys including inflatable decoys
(q)	Active off-board decoys
(r)	Ship launched IR and Smoke decoys
(s)	A/c launched IR flares and Chaff
Test and Handling Equipment	
(t)	Torpedo and Missile loading gears
(u)	Decoy loading gears

Indigenisation Through Academia

29. Naval Armament Stores proposed for Indigenisation through Academia are as follows:-

Ser	NA store	Institute
(a)	Advanced Artillery Smart Shell Design – SUDARSHAN.	IIT Kanpur
(b)	Finite Element Analysis of SRGM barrel	IIT Kanpur
(c)	Design and Development of Polymer/ Composite based driving band for gun ammunition.	IIT Delhi
(d)	Identification of molecules for making insensitive explosives	IIT Chennai

30. The assemblies/ subassemblies which can be taken up for indigenisation besides systems that can be offered to the Navy have been classified under Short, Medium and Long Term Requirements and placed at **Appendix 'D', 'E' and 'F'** respectively.

31. **Major Stores still being imported**. The list of major stores still being imported as tabulated below:-

Ser	Naval Armament Store
(a)	Light Weight and Heavy Weight Torpedoes
(b)	Light Weight and Heavy Weight Torpedo Test Equipment
(c)	Torpedo Countermeasure Systems
(d)	Surface to Air Missiles and Surface to Surface Missiles
(e)	Missile Test Equipment
(f)	Small Calibre Ammunition for Negev, Tavor, Galil, Dragonov Rifles
(g)	Proximity and Direct Action Fuzes
(h)	Chaff Payloads
(j)	Flare Countermeasures

32. As in the case of any onboard equipment, the optimum self-reliance of weapon systems 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 cost 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, the option for indigenous production through ToT, could be leveraged by utilising the 'Buy & Make' route.

33. Private industry has been involved in manufacture of various missiles, rockets, torpedoes, mines and launcher for rockets and torpedoes. A number of missile handling equipment have also been manufactured by industry and are being used onboard ships. However, the number of vendors is limited and larger participation would be desirable. Some of the firms viz. 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.

PART – IV

NAVAL AVIATION

CHAPTER 8

NAVAL AVIATION EQUIPMENT

1. The indigenisation activities in the Naval Aviation commenced in the year 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 under Buy (Indian-IDDM), Buy and Make (Indian).

2. In order 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 promulgated in 2009 covering all aspects in the indigenisation process of air stores including DPM-09 provisions. In the year 2017, the Naval Aviation Indigenisation Roadmap comprising the indigenisation requirements of components of aircrafts (Five year requirements) was published. 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, items of Ground Support Equipment, tools, test equipment etc. The airworthiness certification for the said items is accorded by Naval Aeronautical Quality Assurance Services, Kochi (NAQAS).

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 aerospace, particularly defence aerospace sector 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.

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 Strategic Partnership model, Buy (Indian-IDDM), 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.

Forecast Requirements

5. List of naval aviation systems which are envisaged for indigenisation is placed at **Appendix 'G'**.

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CHAPTER 9

PROJECTS COMPLETED/ PROPOSED WITH DRDO/ PRIVATE INDUSTRY

1. ***IN*** is in the process of developing certain technology intensive projects through DRDO, towards which synergy meetings/ interactions with DRDO clusters are held periodically. 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' category of Chapter III and IIIA of DPP – 2016.

2. Proposals for projects envisaged to be taken up under 'MAKE' category and products to be taken up for development is placed at **Appendix 'H' & 'J'** respectively.

3. Similarly, a number of equipment for new construction ships have been developed through DRDO/ Pvt. Industry. These indigenous equipment are being installed onboard all new construction ships, indigenously constructed Indigenous Aircraft Carrier (IAC)/ Anti Submarine Warfare (ASW) Corvettes and other ships. List of these equipment is placed at **Appendix 'K'** respectively.

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PART –V

ELECTRONICS AND ELECTRICAL SYSTEMS

CHAPTER 10

ELECTRICAL/ ELECTRONIC SYSTEMS

1. A large number of electrical/ electronic equipment for IN ships 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.

2. Greater participation of the industry for development and production of the under mentioned Electrical/ Electronic equipment, merits consideration.

Navigational Aid Equipment

3. **Gyros**. Indigenous Ring Laser / Fibre Optic Gyro.

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

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

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

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

8. **INMARSAT**. SATCOM terminals in UHF and S bands have been developed indigenously by M/s Avantel and efforts are being made to develop C and Ku band equipment to enhance and create sufficient redundancy for continued exploitation in future. The C and Ku band systems for ships are being developed under Innovation for Defence Excellence (iDEX) scheme.

9. **Electronic Warfare**. Indigenisation of EW systems had been progressed with the induction of EW systems for IN platforms.

10. **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 and ECIL etc.

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

Power Generation & Distribution (PGD) Equipment

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

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

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

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

16. **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.

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

18. **GT Starting Rectifier**. The systems have been indigenously developed by M/s Precision Power Products and M/s Static Transformers, Indore.

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

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

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

Sensors/ C3 Equipment and their Integration

22. **Integration of Surveillance/ Weapon Delivery Systems**. Induction of these systems 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).

23. **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 items by multiple Indian vendors.

24. **Command & Control System**. Command, Control and Communication (C3) system is an information system which incorporates strategic and tactical systems viz. 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 C3 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. C3 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

25. **High Speed Data Link**. 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.

26. 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 could be considered by Indian Industry.

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

Ser	**Item/ Eqpt**	**Potential Vendors**
(a)	Auto Change Over Switch (ACOS)	M/s Precision Power Products, Aurangabad
		M/s L&T, Mumbai
		M/s Marine Electricals, Mumbai
		M/s GEII, Mumbai
(b)	Main Switchboards and Weapon Switchboard	M/s L&T, Mumbai
		M/s Siemens Ltd., New Delhi
		M/s Maine Electricals, Mumbai
(c)	Cables	M/s Radiant Cables Ltd, Hyderabad
		M/s NICCO Corporation Ltd, Kolkata
		M/s Universal Cables Ltd, New Delhi
		M/s Thermo Cables, Hyderabad
		M/s Apar Industries Pvt. Ltd., Mumbai
		M/s Siechem Technologies Ltd, Pondicherry
(d)	Lanterns/ LED Based Lighting	M/s Ray Enterprises, Ambala
		M/s Mcgeoth Marine, Mumbai
(e)	Light Fittings/ Navigational Lights	M/s Manish Industries, Kolkata
		M/s Issac Engg Works, Kolkata
		M/s Arvin Industries, Mumbai
		M/s Ray Enterprises, Ambala Cantt
		M/s Fabricon, Mumbai
(f)	Auto Transfer Switch (ATS)	M/s Precision Power Products, Aurangabad
		M/s L&T, Mumbai
		M/s Marine Electricals, Mumbai
(g)	Ruggedised UPS	M/s Precision Power Products, Aurangabad
		M/s L&T, Mumbai
		M/s Marine Electricals, Mumbai
(h)	Automated Power Management System (APMS)	M/s L&T, Mumbai
		M/s Marine Electricals, Mumbai

Ser	Item/ Eqpt	Potential Vendors
(j)	Gas Turbine Rectifier (GTSR)	M/s Precision Power Products, Aurangabad
		M/s Static Transformers, Indore
(k)	Helo Starting Rectifier (HSR)	M/s Precision Power Products, Aurangabad
		M/s Static Transformers, Indore
		M/s L&T, Mumbai
(l)	Sound Power Telephone (SPT)	M/s Marine Electricals, Mumbai
		M/s Linea Engineering, Mumbai
		M/s Elcome Integrated System, Mumbai
(m)	Submarine Battery	M/s Exide
(n)		M/s HBL
(p)	Battery Monitoring System	M/s Precision Power Products, Aurangabad
(q)	Auto Plotter	M/s Elcome Marine
(r)	GPON (Gigabit Passive Optical Network)	M/s BEL
(s)	MCT Glands	M/s MDL
(t)	Electrical Junctions	M/s MDL
(u)	Electrical Boards & Cabinets	M/s MDL
(v)	Spares for Type IV Submarine Battery cells fitting and connections	M/s MDL
(w)	Spares for Main Switchboards (MU 14A) and Secondary Switchboards (MU14-C1, C2 & C3)	M/s MDL
(x)	Battery Loading Trolley	M/s MDL
(y)	Honeycomb filters	M/s MDL

Forecast Requirements

28. The annual forecast list of Electrical/ Electronic equipment and systems anticipated for fitment onboard is placed at **Appendix 'L'**.

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PART – VI

FUTURE TECHNOLOGIES

CHAPTER 11

FUTURE TECHNOLOGIES

1. Rapid and profound technological change is one of the most potent factors shaping the modern world. It creates significant opportunities, but drives increasingly complex, ambiguous and destabilising global threats, and catalyses profound societal, economic and political shifts. Technology is a strategic force; the nations that are best able to anticipate and exploit technological opportunities may have a decisive edge in future conflicts. In a resource constrained environment and given the breadth and relentless pace of technological change, focusing of effort is essential. The ***IN*** needs access to the right capability base (people, knowledge, facilities, industrial capacity etc.) to understand and develop technologies that offer the most promising cross-cutting applications so that it can exploit these technologies at a speed of relevance for transformative real-world impact.

2. Future wars will be characterized 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. Advancement in critical technologies, sensors, robotics, communication and electronics are shaping the future battle space. The technologies that would have defence related applications are:-

(a) Advanced Electronics and Computation.

(b) Sensors (Photonics, Laser, MEMS).

(c) Advanced Weapons.

(d) C^4ISR and Network Centric Operations.

(e) Advanced Propulsion, Energy Storage and Power Systems.

(f) Warship Design.

(g) Stealth.

(h) Advanced Materials.

(j) Autonomous Systems and Robotics.

(k) Artificial Intelligence.

3. Fundamental technology developments will largely take place outside the government sector, and effective defence modernisation must be a partnership with DRDO, industry and academia. ***IN*** intends to engage with them in pursuit of better and quicker capability outcomes. The technologies outlined in the succeeding paragraphs would be the backbone of future ***IN***.

Advanced Electronics and Computation

4. Advanced electronics and computing are concerned with information processing, systems that are programmable, and the technologies that support them. It includes silicon-based digital information processing technologies like traditional microprocessors; specialist chips such as Graphical Processing Units (GPUs); Field Programmable Gate Arrays (FPGAs); Application- Specific Integrated Circuits (ASICs); and system-on-chip computing boards. It includes supporting elements like memory and associated software development environments. It also includes emerging information technologies like neuromorphic processors, and non-silicon-based quantum and DNA computing.

5. Rather than supporting a range of specific defence applications, advanced electronics and computing are of critical importance to defence as a foundational technology supporting other systems. Almost all platforms, systems and services contain a programmable element, and in many cases, this is critical to delivering the capability. Examples include the targeting systems for weapons, the processing of sensor data, and the flight control systems for aircraft. In addition, since programming is comparatively easy to change, this technology family contributes towards the agility necessary to counter today's rapidly-changing threats.

6. High-performance and fast computation capabilities have already emerged as essential ingredients for almost every conceivable application viz. management, networking, decision making, equipment performance enhancement, design and training & simulation studies. Advances in related technologies are continuously driving towards more and more miniaturization, 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.

7. Automated systems have already found their way on board naval platforms for management of machinery, power and battle damage assessment systems. 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.

8. 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.

9. **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.

10. **Integrated Platform Management Systems**. A possible example of Automation 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.

Sensor Technologies

11. A sensor detects a physical phenomenon such as an electrical field, vibration or particle, and generates a response, such as the transmission of digital information or a change in colour to represent a detected chemical. Data from sensors, appropriately stored and analysed, builds our understanding of the operating environment, identifies items within it, and combines to provide situational awareness. Sensing therefore informs decisions at all levels.

12. Sensing technologies are diverse and include: electromagnetic sensing (e.g. electro-optic, infra-red, radar and electronic surveillance); gravity sensing; acoustic sensing; position navigation and timing (PTN); chemical, biological, radiological and nuclear (CBRN); explosive sensing; quantum sensing; and sensor fusion. Sensors are deployed on a range of platforms operating in a variety of environments – and need to overcome congestion and clutter, detect difficult (including fast or stealthy) targets, continue to function despite adversary jamming attempts and counter-surveillance techniques, and conform to stringent size and weight requirements.

13. 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. Considerable commonality of technologies exist in various types of sensors and therefore R&D efforts in various associated technology areas could be shared among different projects.

14. **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. Important areas for sustained indigenous R&D effort are broadly outlined in the succeeding paragraphs.

15. **Radars**. With their all-weather and long-range capabilities for detection and tracking, radars will remain the primary electromagnetic sensors for 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 digitisation for returning radar signals, smarter algorithms for improving signal processing, reducing clutter and false alarms, Track While Scan (TWS) capabilities, capability to track much larger number of targets simultaneously, identifying targets and providing motion analysis.

16. Future radars will utilise 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 digitised 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.

17. 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).

18. **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.

19. **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, 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.

20. **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.

21. **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.

22. **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.

23. **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.

Weapons

24. Emerging threats and increasingly complex and congested environments present a new threat and there is a need to improve existing weapons, further enhancing precision in addition to new capabilities which deliver non-conventional effects.

25. Conventional weapons such as bombs and missiles are designed to cause kinetic damage to a target – physically destroying it or degrading it. Although kinetic damage is an appropriate response to some threats, modern threats and scenarios may require non-kinetic engagement. The presence of civilians or civilian infrastructure may preclude the use of current conventional weapons. As such, enhanced precision guidance and 'smart' munitions are the need of the hour, the latter being able to distinguish its target from its surroundings and providing directional lethality. Other targets may not be suitable for conventional engagement due to their dispersed nature, imprecise or hidden location information, or resilience to conventional attack. In this situation, alternative weapons including offensive cyber and non-lethal weapons provide additional options for the commander and may allow the target to be engaged. In addition, next-generation weapons can deliver scalable or temporary effects, in situations where military action is required but lethal force is not desirable. Hypersonic and high-speed weapons could provide a rapid response to emerging threats and time-sensitive targets.

26. There are a range of technologies that could be weaponised, including Radio Frequency and Laser Directed Energy Weapons(DEW), and offensive cyber. Radio Frequency-DEW allows the engagement of targets containing electronics-rich systems or subsystems, potentially including mobile threats, targets within infrastructure, hostile sensors, and command and control. Laser-DEWs can counter a broad target set from improvised unmanned aerial vehicles to complex missiles. Offensive cyber weapons can deny or even destroy adversaries' capabilities affecting their ability to

understand the world. Even when not used, these effects can act as a deterrent.

27. Next generation guidance and navigation systems utilising miniaturised multimodal sensors and advanced algorithms will enable precise delivery of effects onto a target in a GPS denied environment. Exploiting technologies and manufacturing processes from the commercial sector enables a range of new opportunities for defence. This is being demonstrated in DEW systems which are developed from RF and laser technologies first used in the civil market.

28. 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).

29. 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.

30. **Anti-Ship Missile Defence**. Technological advances will result in the development of highly manoeuvrable, stealthy, sub-sonic, 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 need to comprise 'quick–reaction high-performance Surface-to-Air Missile (SAM) systems', 'high rate of fire Close-in Weapon System (CIWS) guns' and in future, the 'Directed Energy Weapons (DEW)'.

31. **SAM Systems**. 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.

32. **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.

33. **Attack and Fire Support Missions**. In order to prosecute threats and provide Naval Gun Fire Support (NGFS), precision anti-ship missiles, land-attack missiles and large caliber 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.

34. **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.

35. 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.

36. **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.

37. 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. Similarly, shells with Course Correction Fuzes(CCF) provide accurate targeting and could be used in NGFS role. This will significantly enhance shore bombardment and NGFS capabilities of warships and need to be indigenously developed.

38. **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.

39. **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.

40. **Underwater Weapons**. 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

41. 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.

42. **Command & Control Systems**. 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.

43. **Communication**. 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.

44. 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.

45. **Technology Status and Trends**. Advances in C4ISR 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 Communication System (PCS) for global service for hand held telephone with capability to exchange voice, video and high speed data links worldwide need to be realised which will require a constellation of satellites and would be developed/ launched by coordinated efforts of ISRO, Defence Space Agency.

(b) **Security Overlay and Interoperability**. As part of development of Joint Services Interoperable Waveforms for tri-service interoperability, DRDO has been nominated as the development agency for the waveforms which will be ported over SDRs.

(c) **Electronic Warfare**. The design and development model has augured well for IN and has resulted in strengthening of the development of EW system and support infrastructure in the country. Since sufficient expertise remains with the developmental agency DLRL and production partner BEL(Hyd), most capable EW system available worldwide. An Advanced Integrated EW system incorporating future technologies need to be progressed to meet the current and future challenges.

46. **Intelligence, Surveillance and Reconnaissance**. 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.

47. **Network Centric Warfare**. A C4ISR 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.

48. **Co-operative Engagement Capability (CEC)**. 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 utilize 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.

49. **Common Information Grid**. Since the C4 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.

50. **Weapon Grid**. The weapon grid can enable increase of the combat power by exploiting high levels of awareness through utilization 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.

51. **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.

52. **Network Security**. Protection of C4ISR 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.

53. **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

54. **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 (SFC) curve over entire operating range, when compared to contemporary Gas Turbines. These GTs combine the best of diesel and gas turbines, i.e., low SFC at part loads and high power density and fulfills 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. 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.

55. **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.

56. **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.

57. **Fuel Cells**. Fuel cell technology is receiving considerable attention worldwide as it provides a viable AIP solution. The fuel cell power packs could 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, NafionTM, 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.

58. **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.

59. 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.

60. **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 inducted electric propulsion in their platforms and in the not too distant future, this is expected to become the standard technology for naval propulsion packages.

61. Most of the elements required for adoption of this technology in warship applications are already available in the international 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-conductivity technology will make the electrical propulsion option more attractive.

62. **Marine Engineering Systems**.

(a) **Optimal Pipe and Duct Design**. Computational Fluid Dynamics studies for aerodynamic (low-noise) fluid flow in ducts and pipes needs to be taken up. 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) **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.

63. **Production and Design Technology**.

(a) It is essential to develop technology for use of air-lubricated bearings for use in high-speed turbines, rotating machinery etc. Air lubricated bearings would offer advantages of reduced friction levels, operating temperatures, longer life due to lower wear rate and reduced Specific Fuel Consumption of turbines.

(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

64. **Introduction**. The ***IN*** has an ambitious 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. for of such capabilities. Indigenous development & early realisation assumes urgency keeping in view the large gestation period of these and resultant ship building efforts.

65. **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. Certain important newer hull forms are broadly outlined in the succeeding paragraphs.

66. **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.

67. **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.

68. **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.

69. **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.

70. **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

71. 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. Important aspects that need to be covered for realizing stealthy warships are broadly outlined in the succeeding paragraphs.

72. **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.

73. **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 emphasized during ship design and construction. Measures incorporated include design of machinery foundations, 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.

74. **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 emmissivity 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.

75. **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

76. 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.

77. **Ship Building Steel**. DMR 249A steel has been recently developed successfully for indigenous ship building programme. Production is adequate to meet all future requirements of new construction and repair. Steel for Submarine construction is still being imported and efforts are in hand to indigenise the same for which industry support would be required.

78. **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.

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

(d) 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.

80. **Titanium**. 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.

81. **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.

82. **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.

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

84. **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.

85. **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.

86. **Coating Materials**. The issue of life extension will be a critical one for the ***IN*** 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.

87. **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.

88. **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.

89. 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.

90. **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.

91. **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.

92. **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.

93. **Insensitive Energetics**. Insensitive explosives are much safer than conventional explosives in handling, storage and operational exploitation. Research into insensitive energetics is

focused on converting the whole explosive chain, from primary initiators to warheads into insensitive compositions. ***IN*** plans to induct armament with insensitive energetics in the future. Therefore, there is a need for enhanced focus on development of insensitive energetics.

94. **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.

95. **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.

96. **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.

97. 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.

98. **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.

99. **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.

100. **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. Research into development of polymer driving bands for ammunition is underway at IIT, Delhi. Development of novel polymers for more defence applications is needed, especially in lighter, fire resistant ammunition packaging.

101. **Coating Technology**. Coating of materials provides thermal protection and increased abrasion resistance. There is an urgent need for development of high temperature coatings especially in gun barrel and cartridge case applications.

102. **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.

Autonomous Systems and Robotics

103. Autonomous systems exploit sensors and other data sources to gather information on their environment, use advanced algorithms and Artificial Intelligence to process and understand it, and make decisions about how to respond, and perform tasks – whether physical or virtual – to achieve assigned goals. Robotic systems are automated machines that carry out complicated actions independently of, or in conjunction with, humans.

104. Some of the illustrative applications are :-

(a) Replacing human operators with machines in high-risk environments, such as logistics resupply or explosive ordinance disposal.

(b) Maximising the effectiveness by allowing personnel to focus on complex tasks while the simple and low- value tasks are delegated to machines.

(c) Exceeding the performance of a human operator by taking actions autonomously, such as in response against anti-ship missile threat.

(d) Generating physical mass in the battlespace through resilient swarms of low-cost systems.

(e) Integrated human- machine teams which use the respective strengths of both humans and autonomous systems.

(f) Supporting an active military presence in areas where it would not traditionally be possible.

105. **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, C2, 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.

106. **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 US Navy 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 already being progressed to include artificial, remote-controlled 'fish', equipped with explosive loads that can be activated through acoustic means.

Artificial Intelligence

107. Technological advancements in Artificial Intelligence (AI) and fuzzy logic will help in making advanced decision-making and decision

support systems available. The new generation platforms that the ***IN*** operates are equipped with cutting edge technology systems. This puts it in an advantageous position to develop and absorb new Artificial Intelligence/ Machine Learning (AI/ML) based technologies that are becoming increasingly popular with the military and industry. Some of the areas where AI/ML technologies can be implemented are as follows :-

(a) Automated computer-network defence – real time anomaly detection and patching of vulnerabilities.

(b) Logistics – improved and automated stock management and resupply.

(c) Performance optimisation – real-time monitoring of data about equipment to predict problems and target appropriate interventions such as repairs.

(d) Intelligence analysis – new kinds of advanced analytics to identify patterns and anomalies in large, diverse datasets, freeing up human analytical capacity and supporting more complex assessments.

(e) Autonomous platforms – systems that sense and understand their environment, decide how to respond, and then perform tasks to achieve goals, overseen by humans.

(f) Streamlining administrative back office functions such as HR and finance.

Appendix 'A'

(Refers to Para 26 Chap 3)

FORECAST REQUIREMENT OF EQUIPMENT AND SYSTEMS
MARINE ENGINEERING EQUIPMENT

Ser	Equipment	2021-25	2026-30	Total
1.	Lub oil and sea water coolers fitted on various machinery	20 sets each	30 sets each	60 sets each
2.	Shafting components like bearings, thrust pads etc	08 sets	16 sets	28 sets
3.	Valves fitted in freshwater, feed water, sea water and other auxiliary system.	150	300	500
4.	Components level items of Boiler and Turbine Aggregates control system.	04 sets each	04 sets each	10 sets each
5.	Feed Condensate Booster Turbo-Driven Pumps	02	01	05
6.	Turbo-driven Main Circulating Pumps	02	02	06
7.	Turbo-driven Oil Pumps	02	02	06
8.	Turbo-drive of AC Plants	02	02	06
9.	Automatic Working Water Pumps	12	02	16
10.	Pumps for boiler chemical treatment	02	02	06
11.	Hand Pumps for boiler dosing	04	02	08
12.	Proportioning Pumps for boiler dosing	04	02	08

Ser	Equipment	2021-25	2026-30	Total
13.	Fuel Transfer Pumps	05	05	15
14.	Stripping Pumps	05	05	15
15.	Manual Pumps for AVCAT	09	02	13
16.	Motor Driven Fuel Pumps	08	04	16
17.	Motor-driven Oil Pump	04	04	10
18.	AC Condenser Cooling Water Pumps	08	04	14
19.	Seawater Circulating Pumps for TA	06	04	12
20.	Auxiliary Cooling Water Pumps	10	10	30
21.	Chilled Water Pumps	08	08	20
22.	Fresh Water Pumps	02	02	06
23.	Main Drainage Pumps	16	08	28
24.	Pumps (Variable discharge type)	06	06	15
25.	Hydraulic Pumps for Arresting Gear	02	02	06
26.	Pumps for Aircraft lifts	04	04	10
27.	Boiler Mounting for КБГ-3Д boilers	01 Set (22Nos)	-	01 Set (22Nos)
28.	1500 KW Turbo Generator	01	-	01

Appendix 'B'
(Refers to Para 6 Chap 4)

FORECAST REQUIREMENT OF EQUIPMENT AND SYSTEMS SUBMARINES

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

Ser	Equipment	2021-25	2026-30	Total
16.	Diesel Engine Fresh Water Pumps	4	4	12
17.	Combined Exhaust Silencers	2	2	6
18.	Non Return Valves	12	12	36
19.	Diesel Exhaust Pneumatic Drain Valves	8	8	24
20.	Combined Board Stop & Non-Return Valves	4	4	12
21.	Diesel Exhaust Shut Off Flaps	6	6	18
22.	V Belts	20	20	60
23.	Diesel Thermocouples	48	48	144
24.	Batteries (Varying capacities/ specifications)	10	10	30
25.	Globe Valves	3	3	9
26.	Life Raft Three-Way-Cocks	9	9	27
27.	OC Angle Valves	8	8	24
28.	Diesel Monitoring Equipment	4	4	12
29.	Diesel Engine Pressure Monitors	4	4	12
30.	Coolant Expansion Tanks	4	4	12
31.	Electric Bilge Drying Pumps	12	12	36
32.	Refrigerating Plants	2	1	6
33.	Hydraulic Manipulators	35	30	105
34.	Electromagnetic Drain Valves	14	8	36
35.	Sea Water Valves	50	45	155
36.	Tacho Generators	2	4	10
37.	Diesel Engine Starting Air Valves	48	24	120

Ser	Equipment	2021-25	2026-30	Total
38.	Diesel Engine Water Pumps	6	4	16
39.	Diesel Engine Fuel Pump Glands	6	4	16
40.	Diesel Engine Lube Oil Coolers	6	4	16
41.	Diesel Engine Fresh Water Coolers	6	4	16
42.	Diesel Engine Air Distributors	6	4	16
43.	Diesel Engine 8wmc Coupling Control Valves	6	4	16
44.	Hyd Accumulator Micro Switches	30	20	90
45.	Main Thrust Block Upper Shells	6	4	16
46.	Main Thrust Block Lower Shells	6	4	16
47.	Pump Safety Valves	6	4	16
48.	Pump Diaphragm Membranes	5	3	13
49.	Hydraulic Pump Spring Stuffing Boxes	6	4	16
50.	Periscope Lower Cup Seals	6	4	16
51.	Periscope Upper Cup Seals	6	4	16
52.	Gem Block Manipulators	100	50	250
53.	Hydraulic System Non Return Valves	8	4	20
54.	Reel Drum With Foundations	40	20	100
55.	Air Induction Flap Sealing Rings	8	4	20
56.	Fuel Loading Hull Valves	5	2	12
57.	Speed Governor Block Locking Mechanisms	6	3	15
58.	Block Drying Unit Coolers	10	6	26
59.	Block Drying Unit Shut Off Valves	10	6	26
60.	Block Drying Unit NR Elements	10	6	26

Ser	Equipment	2021-25	2026-30	Total
61.	8WMC Needle Valves	9	5	23
62.	Grouper Exhaust Flap Grouper Rings (Plates)	9	5	23
63.	Exhaust Link Piece pressure Rings	48	24	120
64.	Operating Handles (various types)	45	25	115

REQUIREMENT OF SUB-SYSTEMS/ COMPONENTS SUBMARINES

Ser	Equipment	Item Description
1.	HP AIR COMPRESSOR	OIL FILTER NNO 4330142387253
2.	HP AIR COMPRESSOR	AIR FILTER
3.	HOISTABLE MAST	CPU 317 2DP
4.	HOISTABLE MAST	16 ON/OFF INPUT MODULE 24V
5.	HOISTABLE MAST	OUTPUT MODULE SM322
6.	HOISTABLE MAST	8 ANALOG MODUEL
7.	HOISTABLE MAST	16 OUT MODULE 24/48V
8.	HOISTABLE MAST	8 INPUT ANALOG MODULE
9.	HOISTABLE MAST	PLC CARD CP341 RS422/485
10.	HOISTABLE MAST	MEMORY CARD 512 KO
11.	FAPMO PUMP	SET OF GASKETS FOR EM PUMPS

Ser	Equipment	Item Description
12.	FAPMO PUMP	SET OF LOCK WASHERS FOR EM PUMPS
13.	FAPMO PUMP	MECHANICAL SEAL FOR EM PUMPS
14.	FAPMO PUMP	SET OF PUMP BEARINGS FOR EM PUMPS
15.	FAPMO PUMP	SET OF MOTOR BEARINGS FOR EM PUMPS
16.	FAPMO PUMP	SET OF GASKETS FOR EN PUMPS
17.	VOLUMETRIC PUMP	FILTER SOFRANCE P8898
18.	FILTERS : HYDRAULIC FILTERS	FILTER ELEMENT
19.	FILTERS : HYDRAULIC FILTERS	FILTER ELEMENT
20.	FILTERS : HYDRAULIC FILTERS	FILTER ELEMENT
21.	FILTERS : HYDRAULIC FILTERS	FILTER ELEMENT
22.	FILTERS : HYDRAULIC FILTERS	FILTER ELEMENT
23.	FILTERS : HYDRAULIC FILTERS	FILTER ELEMENT
24.	FILTERS : HYDRAULIC FILTERS	FILTER ELEMENT

Ser	Equipment	Item Description
25.	FILTERS : AIR + WATER FILTERS	FILTER CARTRIDGE
26.	FILTERS : AIR + WATER FILTERS	FILTER CARTRIDGE
27.	STEERING CONSOLE	HERMETICALLY SEALED RELAY WITH PROTECTION DIODE 2I10B1 P 28VCC
28.	STEERING CONSOLE	HERMETICALLY SEALED RELAY WITH PROTECTION DIODE TYPE 326-401 4RT 4PDT 28VCC
29.	STEERING CONSOLE	HERMETICALLY SEALED RELAY WITH PROTECTION DIODE TYPE 328-25A 3RT 3PDT 28VCC
30.	STEERING CONSOLE	HERMETICALLY SEALED RELAY 2I10B1 P115V50/60HZ GAM T1 NNO 5945 14 4260815
31.	STEERING CONSOLE	DELAY MODUL5- 100S TPR3 28VCC GAM T1 NNO5945 14 360 1513
32.	STEERING CONSOLE	CONFIGURED NORMAL MONITORING CPU BOARD
33.	STEERING CONSOLE	2/3 LOGIC BOARD (PPDT)
34.	STEERING CONSOLE	LOGIC INPUTS MODULE (ETC)
35.	STEERING CONSOLE	4XCHANNEL RS485 MODULE (PBSIO4 A)

Ser	Equipment	Item Description
36.	STEERING CONSOLE	CURRENT OUTPUT 0-20MA MODULE (SIR)
37.	STEERING CONSOLE	ANALOG OUTPUT 0-1OV OR +/- 10V MODULE (SVR)
38.	STEERING CONSOLE	SERVOVALVE AMPLIFIER BOARD (SERV-AA)
39.	STEERING CONSOLE	CONFIGURED HYDROPLANE SERVO-CONTROL CPU BOARD
40.	IPMS	ET200S TÊTE DE STATION
41.	IPMS	DP ASI CONVERTER
42.	IPMS	QUINT-PS/1AC/24DC/3.5
43.	IPMS	ANALOGIC INPUT BOARD
44.	IPMS	DIGITAL INPUT BOARD
45.	IPMS	ANALOGIC OUTPUT BOARD
46.	IPMS	DIGITAL OUTPUT BOARD
47.	IPMS	BATTERY
48.	IPMS	REMOTE CONTROL FOR SCREEN
49.	IPMS	RELAY 2I10 B1 115 V 50/60HZ

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Appendix 'C'
(Refers to Para 2 Chap 5)

FORECAST OF INDIGENISATION REQUIREMENT
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

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Appendix 'D'
(Refers to Para 30 Chap 7)

SHORT TERM REQUIREMENTS – 5 YEARS

Ser	Store	End Use	Type
1.	Plasticiser Sealant	Utilised for sealing Plasticiser leakage from Surface to Surface Missile	Non explosive
2.	Sealant and Hardener	State changing material for Surface to Air missile	Non explosive
3.	Glue 88НП	Gluing rubber on container and fixing of end ring during replacement of section of missile	Non explosive
4.	Rubber O Rings various sizes	Missile Systems	Rubber
5.	Rubber seal (26 types)	Under the hatches and section joints	Rubber
6.	Diaphgram Sealing Rings, Gaskets and O Rings of various types	Used in Warhead section of Surface to Air missile	Rubber
7.	Cross gauge for submarines	Series Inspection of torpedo tubes	Non Explosive
8.	Smoke Markers and Float smoke	Markers used in maritime operations	Explosive
9.	Shear Bolt and Washer	Used for Warhead section of missile	Explosive
10.	Main Fuelling Gun and Vent Gun	Used for fuelling of Liquid fuel Missiles	Mechanical
11.	Leak-Tec, leak detection liquid (Type 16 OX)	Leak detection of canister	Non Explosive
12.	Anti-seizure paste	Canister repair	Non Explosive

Ser	Store	End Use	Type
13.	Grease of Various Types	Used in various sections of Missiles	Non Explosive
14.	Sealants	State changing material	Non Explosive
15.	O-rings (Set of 37 Nos)	Missile	Rubber
16.	Accumulator Diaphragm for SSM missile	Missile	Rubber
17.	Door Plug 'O'-rings	TLC Door	Rubber
18.	Missile TLC junction Box 'O'-ring	Junction Box of TLC	Rubber
19.	Rubber Comp. (16 Types)	MCMV	Rubber
20.	Cocking Lever, Springs, Extractor of various types	Gun	Mechanical
21.	Gauge testing blow of striker & striker-eccentricity equipment	Gun	Mechanical
22.	Gauge measuring bore	Gun	Mechanical
23.	Plug bore gauge	Gun	Mechanical
24.	Screws, Levers, Springs of various types	Gun	Mechanical
25.	Pinion	Gun	Mechanical
26.	Sector gear	Gun	Mechanical
27.	Seal Packing	Gun	Mechanical
28.	Support	Gun	Mechanical
29.	O Ring of various types	Gun	Rubber
30.	SSE (Green & Red)	Submarines for signalling purpose	Explosive
31.	Cassette Flares	Submarines	Explosive

Ser	Store	End Use	Type
32.	Over flow Valve along with squib	GCS	Explosive
33.	RPM pickup	Practice torpedo	Explosive
34.	Fibre optic Bobbin	MCMV	Non Explosive
35.	Fasteners (10 types)	MCMV	Non Explosive
36.	Warhead Refilling	Torpedo	Explosive
37.	Oil 4LF	MR of torpedo	Non explosive
38.	3ঙ Grease	Lubricant for oxygen application	Non Explosive
39.	Foldable Butt LMG with swivel mounting and Kevlar shield	Countermeasure for submarines	Non Explosive
40.	192P - 44 - 10	Booster Case washer	Mechanical
41.	0501-8	Locking washer	Mechanical
42.	17473-72	Screw secure clamp	Mechanical
43.	300 3A - 1030-4-2-30 KP	Bolt 131103 -80	Mechanical
44.	2-12-48KP-OST	Bolt 1310013-80	Mechanical
45.	12-KP-OST	Nut 133048-80	Mechanical
46.	Rubber seal (26)	Under the hatches and section joints	Mechanical
47.	TG Stub	Critical component of missile.	Non explosive
48.	End Ring	Used in Missile	Non explosive
49.	Enamels, Solvents, Hardners and Primers of various types	Reconditioning of missile surface paint.	Non explosive
50.	Nefras C4-155/200	Used in combination to wipe out grease and to clean missile surface/ fasteners	Non explosive

Ser	Store	End Use	Type
51.	Nefras C2-80/120	Used in combination to wipe out grease and to clean missile surface/ fasteners	Non explosive
52.	Antistatic additive SIGBOL	Used in combination to wipe out grease and to clean missile surface/ fasteners	Non explosive
53.	Sealing Paste Y-30Э-5	Used to prepare sealing compound Y-30МЭС-5М, which is used to seal the missile post repairs.	Non explosive
54.	Vulcanising Paste No.9	Used to prepare sealing compound Y-30МЭС-5М, which is used to seal the missile post repairs.	Non explosive
55.	Product АГМ-9	Used to prepare sealing compound Y-30МЭС-5М, which is used to seal the missile post repairs.	Non explosive
56.	Nitrocellulose Glue AK-20	Coating of cable bundle at binding points.	Non explosive
57.	Varnish AK-113	Missile surface.	Non explosive
58.	Underpaint Putty ЭП-0080	Reconditioning of missile surface.	Non explosive
59.	Sealing Compound Виксинт	Bare surfaces of component parts.	Non explosive
60.	Putty XB-004 ГОСТ 10277-90	Reconditioning of paint coating and application of seals to missile hatches.	Non explosive
61.	Enamel XB-5169	Reconditioning of container outer surface paint.	Non explosive
62.	Molykote medium 33 silicon low temperature grease	Used in elastomers	Non Explosive
63.	High vacuum silicon grease	Used in elastomers	Non Explosive
64.	Silicone Rubber sealant (RTV-162)	Power supply assembly replacement	Rubber
65.	Silicone Rubber sealant (RTV-560)	Power supply assembly replacement	Rubber
66.	NIL4	Split pin for slotted nut	Rubber

Ser	Store	End Use	Type
67.	Screws, Lock, Push Rod, Pin and Springs of various types	Rocket launcher	Mechanical
68.	Ball Bearings of various Types	Heavy Weight Torpedoes	Mechanical
69.	Air Pressure Switch	Heavy Weight Torpedoes	Mechanical
70.	Cut Off Valve	Heavy Weight Torpedoes	Mechanical
71.	Poppet Valve	Heavy Weight Torpedoes	Mechanical
72.	Khladon/Mafron 113	De-greasing agent	Non Explosive
73.	Arcanol Grease for Torpedo	Torpedo	Non explosive
74.	Mobil XHP 221 Grease for Torpedo	Torpedo	Non explosive
75.	Release Wire for Torpedo	Torpedo FIAM	Non explosive
76.	Scoop Arming Wire for Torpedo	Torpedo FIAM	Non explosive
77.	Coupling Ring for Torpedo	Torpedo	Non explosive
78.	CRU Battery	Afterbody of torpedo	Electrical
79.	Molykote HP-870 grease	Missile	Non Explosive
80.	Molykote 55 silicon grease	Warhead, Power supply unit replacement of Missile	Non Explosive
81.	Air charging gun	Leak check of missile	Mechanical
82.	Section 4 charging rig & adaptor	leak check	Mechanical
83.	O tank charging gun	Leak check	Mechanical
84.	G tank charging gun	Leak check	Mechanical
85.	Silica Indicator	BCMs	Non Explosive
86.	Silica Bags	BCMs	Non Explosive

Ser	Store	End Use	Type
87.	Loctite 222, 495, 241, 242, 648 adhesive	Canister	Non Explosive
88.	Poly sulphide sealing compound MIL –S-81733, MIL-S-8802, PR-1750-A2	Canister	Non Explosive
89.	Nefras C4-155/200	Used in combination to wipe out grease and to clean missile surface/ fasteners	Non Explosive
90.	Nefras C2-80/120	Used in combination to wipe out grease and to clean missile surface/ fasteners	Non Explosive
91.	Antistatic additive SIGBOL		Non Explosive
92.	Sealing Paste Y-30Э-5	Used to prepare sealing compound Y-30МЭС-5М, which is used to seal the missile post repairs.	Non Explosive
93.	Vulcanising Paste No.9		Non Explosive
94.	Product АГМ-9		Non Explosive
95.	Varnish АК-113	Missile surface.	Non Explosive
96.	Underpaint Putty ЭП-0080	Reconditioning of missile surface.	Non Explosive
97.	Putty ХВ-004 ГОСТ 10277-90	Reconditioning of paint coating and application of seals to missile hatches.	Non Explosive
98.	Enamel ХВ-5169	Reconditioning of container outer surface paint.	Non Explosive
99.	Washer	Hyd charging point	Rubber
100.	Sealing Compound Виксинт	Bare surfaces of component parts.	Non Explosive
101.	Explosive bolts for Missiles	TLC	Explosives
102.	Rubber Comp. (03 Types)	MCMV	Rubber
103.	Electrical Squib Connector	Various Squib holders and connectors	Electrical

Appendix 'E'
(Refers to Para 30 Chap 7)

MEDIUM TERM REQUIREMENT – 10 YEARS

Ser	Store	End Use	Type
1.	Torpedo and Missile Loading Gear with accessories	Torpedo and Missile Loading Gear with accessories	Mechanical
2.	Shoulder launched missiles	Shoulder launched missiles	Explosive
3.	Gas Generator	Component of missile.	Explosive
4.	Bore erosion checking tool	Checking bore erosion of gun barrel	Electrical
5.	Bore erosion measuring tool	Checking bore erosion of gun barrel	Electrical
6.	Cartridge case section	Checking Clearance between round case rim and anti-rebound lever	Mechanical
7.	Dynafor	Measuring overlap of loading tray releasing transmission lever	Electrical
8.	Detonator Electric for Torpedo	Torpedo Exploder	Explosive

Ser	Store	End Use	Type
9.	Transmitting Load for Torpedo	Torpedo Exploder	Explosive
10.	Electric Squib for Torpedo	Motor Dis-connector	Explosive
11.	EED Squib for Torpedo	Recovery Aid	Explosive
12.	Float	Torpedo	Explosive
13.	Long Storage Bottle (LSB)/ Air Bottle	GCS	Mechanical
14.	Float along with accessories	Exercise head of torpedoes	Mechanical
15.	Practice Head along with components	Practice Head of Torpedoes	Mechanical
16.	Fuel Flask	Old Practice torpedo	Mechanical
17.	Starting Gear	Torpedo	Mechanical
18.	Tail Section	Torpedo	Mechanical
19.	Towed Reel	Torpedo	Mechanical
20.	Torpedo Reel	Torpedo	Mechanical
21.	Air Flask	Flask section	Non explosive
22.	Nozzle Box	Turbine compartment	Non explosive
23.	Rotor	Turbine compartment	Non explosive
24.	Water Pump	Turbine compartment	Non explosive
25.	Retarder	After body	Non explosive
26.	Tube Safety Device	After body	Non explosive

Ser	Store	End Use	Type
27.	Labyrinth Packing Pressurizing Valve	After body	Non explosive
28.	Torpedo Reel	Torpedo	Electrical
29.	Towed Reel	Torpedo	Electrical
30.	Self-contained Noise Maker (SCNM) along with Battery	Ex-Head	Electrical
31.	Warhead for Missile	Payload meant to be delivered on the target	Explosive
32.	Warhead for missile	Payload meant to be delivered on the target	Explosive
33.	Input Device assembly (IDA) along with squibs and accessories	Tail unit	Explosive
34.	Input Device assembly along with squibs and accessories	Tail unit	Explosive
35.	Over flow Valve along with squib	GCS	Explosive
36.	Pusher along with squib	Practice Insert	Explosive
37.	Coil along with squib	Transport Module	Explosive
38.	Kerosene Cut off valve	Torpedo	Mechanical
39.	Load unit (40 kg)	Lead weight for CG	Mechanical
40.	Bypass Mechanism	Mod torpedo	Mechanical

Ser	Store	End Use	Type
41.	Fwd & Aft Propeller for Torpedo	Torpedo	Non Explosive
42.	LSB/Air bottle	GCS	Non Explosive
43.	Helium Bottle	Mockup missile	Electrical
44.	Chamber	Warhead sections of torpedoes	Explosive
45.	A Spool	Torpedo	Electrical
46.	B Spool	Torpedo	Electrical
47.	Converter and Frequency Stabilizer	Torpedo	Electrical

Appendix 'F'
(Refers to Para 30 Chap 7)

LONG TERM REQUIREMENT – 15 YEARS

Ser	Store	End Use	Type
1.	Missile Balwanka	Series Inspection	Non Explosive
2.	Missile Mock-up	Series Inspection	Non Explosive
3.	Turbo Generator	Component of missile.	Electrical
4.	Imitator-R	Missile Balwanka and Missile Mockup firing.	Electrical
5.	Proximity fuze cut out device checking tool	Inspection of proximity fuze cut out device	Electrical
6.	Proximity fuze cut out device test bench with dummy fuze and three test diode bases	Inspection of proximity fuze cut out device	Electrical
7.	Proximity fuze cut out device test bench technical manual	Inspection of proximity fuze cut out device	Electrical

Ser	Store	End Use	Type
8.	Velocity recording equipment	Measurement of recoil length	Electrical
9.	Torpedo Simulators	Simulating Torpedo inside torpedo tubes during Series Inspection of submarines.	Electrical
10.	MVDP Equipment	Muzzle Velocity Discharge Pressure measurement for Balwanka firings in submarines	Electrical
11.	Ballast Compartment	Old PH	Mechanical
12.	Oxygen Flask	Old Practice torpedo	Mechanical
13.	Scoop Bulkhead	Torpedo	Non Explosive
14.	Water Discharge Governor	Hydrostatic compartment	Non explosive
15.	K1C Kit	Mockup missile	Electrical
16.	PCBs of Exercise Head for Torpedo	Torpedo	Electrical
17.	One Shot Battery Compartment (OSBC) along with Battery, squibs and accessories	Integrated Battery Compartment	Electrical
18.	Start Battery		Electrical
19.	Filling sensor Battery (FSB)		Electrical

Ser	Store	End Use	Type
20.	Battery along with electrolyte		Electrical
21.	Start battery		Electrical
22.	Battery	MCMV	Electrical
23.	Arming Device for Torpedo	Exploder	Explosive/Electrical
24.	Signals Flares for submarines	Flare launching system for Kalvari Class boats	Explosives
25.	Hose with coupling for Torpedo	Torpedo	Non explosive
26.	Battery Section Shell for Torpedo	Torpedo	Non explosive
27.	Flare Launcher for signal flares	Flare launching system for Submarines	Non explosive
28.	A-B Connector for Torpedo	Torpedo	Electrical
29.	Inverter	Torpedo	Electrical
30.	Device И-346	Contact Explosive Device	Explosive
31.	Fwd & Aft Propeller for Torpedoes	Various Torpedoes	Non explosive
32.	Towed Array Sonars	Navigation	Non explosive
33.	Autonomous Underwater Vehicles	Search	Non explosive

Ser	Store	End Use	Type
34.	Expendable Aerial Target	Practice firing	Non explosive
35.	PCBs for MRP Mines	Instrument compartment of mines	Electrical

Appendix 'G'
(Refers to Para 4 Chap 8)

LIST OF NAVAL AVIATION STORES/ EQUIPMENT TO BE INDIGENISED

Ser	Description	Part Number
	MIG-29K/ KUB – SPARES	
1.	Active Fuel Filter	8D2.966.134-01
2.	Canopy Control Cock	83.0253-410A
3.	Engine Main Fuel Filter (Low Pressure)	8D2.966.664
4.	Engine Oil Filter	38.07.00560
5.	Ring	098-105-46-1-052-A OST 100980-80
6.	Hydraulic Return Line Filter	8D2.966.022-6
7.	Interlock Valve	83.0254-50
8.	Lena Filter (Radar Liquid Cooling System)	8D2.966.756-01
9.	Blanks (Cap lugs Make) Of Electrical Connectors On Bark-42	EC-24(NAS831-24MS90376-24MSAA813-24)
10.	Blanks (Cap lugs Make) Of Electrical Connectors On Bark-42	EC-22(NAS831-22MS90376-22MAS813-22)
11.	Blanks (Cap lugs Make) Of Electrical Connectors On Bark-42	EC-16(NAS831-16MS90376-16RMAS813-16)
12.	Blanks Of Electrical Connectors Of Different Diameters	-
13.	Bolt	5.41.0100.0033.05
14.	Bolt	6-16-KD-OST 1 31149-80
15.	Bolt	6-20-KD-OST 1 31149-80
16.	Bolt	6-26-KHIM.PAS-OST 1 31128-80
17.	Bolt	5.41.3431.8005.98
18.	Bolt	6-64-KD-OST131124-80
19.	Cotter Pin	2X18.2.11 GOST 397-79
20.	Preservation Adapter	Not Available
21.	PTT 3 Position Selector Switch	5.41.6501.0080.00

Ser	Description	Part Number
22.	Washer	6.4-1.5-20-KD-OST 1 11494-74
23.	Gasket	7846.304
24.	Non-Magnetic Screw Of ISIS	Not Available
25.	PTT 3 Position Selector Switch	5.47.6501.0470.00
26.	Filter Section	380700560
27.	Rubber Coupling	2.24.7603.1780.00
28.	Sealing Ring	642801
29.	Support Bonding Strip	5.41.2000.1017.48
30.	TPG (Tyre Pressure Gauge)	MA-60K
31.	Rubber Cap On Trim Button	Not Available
32.	Static Discharger	5.01.7110.0130.00
33.	Control Unit	6635-29
34.	Fluro plastic Sleeve	8D4.470.197
35.	Heat Resistance Pressure Gauge	NTM-240
MIG 29K/ KUB – GSE		
36.	Cradle Support For Engine Cowls	5.41.9915.2400.00
37.	Wing Drop Tank Cradle	5.12.9920.8790.00
38.	Installation Trolley, Suspended Fuel Tank	A-1325M-0000
39.	A1320 Cradles For Engine On A1320 Trolley	A1505-0000
40.	Air Intake Blank	5.15.9927.0070.92
41.	Cradle Support For Cone	5.41.9915.2500.00
42.	Ejection Seat Sling	3AB-9925-1050-01
43.	Engine Cradles And Accessory Gear Box	5.12.9900.3660.00
44.	Maintenance Stand	A3819-0000
45.	Support For Zhuk-Me	5.41.9915.2600.00
46.	Support For A 1505 Cradles	5.31.9915.0460.00
47.	Unit-01 Support / Scanner Stand	5.41.9915.1400.00
48.	Appliance For Draining Fuel Residue	5.12.9920.1950.00
49.	Bracket For Replacement Of Main Landing Gear Wheels	5.31.9915.0810.00
50.	Bracket for Replacement Of Main LG Wheels	5.41.9915.1010.00
51.	Engine Inserter And Remover	A1801-0000
52.	Grounding Cable	OST1 10661-831-2

Ser	Description	Part Number
53.	Hoist Sling For RD-33 MK Engine Lifting, Lid Of RD-33 Mk Container And KSA In Container	5.41.9915.3850.00
54.	Zhuk-Me Mono block Lifting Sling	5.17.9915.1300.00
55.	Cross Arm Sling	5.41.9915.2200.00
56.	Device for Fixing Arrestor Hook	5.41.9920.0320.00
57.	Dorsal Tank Removal Tool	725.41.644.0451.00.00.00
58.	Hydraulic Jack	A43-0200-0
59.	Floor Mat For Work On Cockpit	8.21.9920.5000.00
60.	Hoist Sling RD-33MK Lifting In Container	5.41.9915.4850.00
61.	Hoist Sling For PAZ-MK with Beam	5.41.9915.6000.00
62.	Hoisting Device	5.41.9943.0550.00
63.	Hydraulic Operated Hoist	A1029-0000
64.	Mooring Facilities	A3202-0000
65.	Mounting for Wings	5.41.9915.7500.00
66.	Radar Exciter Container	FGM29-22
67.	Radar Transmission Container	FGM129-02
68.	Slings for Units 01 And 13S	5.41.9915.0200.00
69.	T-Joint for Connection of Two UPATS	5.41.9920.1850.00
70.	Tow Bar	A3125-0000
71.	Manual Tow Bar	A3126-0000
72.	Wheel Remover	A1326-0000
73.	Sling for Built In Tank	5.41.9915.2250.00
74.	Sling for Wing Mounting And Canting	5.41.9850.1400.00
75.	Stabilizer Cover (Left)	5.47.9926.0510.92
76.	Stabilizer Cover (Right)	5.47.9926.0510.91
77.	Towing Cable	A3301-0000-0-5
78.	Trolley	905-9225-00-01
79.	Safety Device for Air Brake	Not Available
80.	Fin Cover (Right)	5.12.9926.0500.91
81.	Electrical Circuit Test Indicator	5.12.8120.0180.00
82.	Fin Cover (Left)	5.12.9926.0500.92
83.	Device for Ramp Air Intake Measurement	5.31.9920.0000.00
84.	Device for Canopy Hoisting Strut	5.15.9915.0700.00
85.	Compressor Washing Rig	Not Available

Ser	Description	Part Number
86.	Cover for Fuel Drop Tank	5.12.9926.0120.00
87.	Cover On Adaptor For SPJAT	5.41.9926.1300.00
88.	Cowling Installation Device	5.15.9920.0450.00
89.	Adaptor For Engine Blowing With Nitrogen	Not Available
90.	Engine Divergent Nozzle Blank / Exhaust Cover	5.12.9927.4000.00
91.	KSA-33M Support	5.41.9915.3500.00
92.	Fixture for Installation Of Main LG Strut	5.31.9915.2500.00
93.	Aircraft To Bore Sighting Target Tie-In-Device	5.41.9941.1100.00
MIG 29K/ KUB – MANDATORY SPARES		
94.	Bolt	5.41.0100.0033.03
95.	Bolt	5.41.0106.0003.05
96.	Bolt	5.41.0106.0003.07
97.	Bolt	5.41.2210.1007.09
98.	Blank	EP-27 GYEO.364.241 TU
99.	Blank	EP-33 GYEO.364.241 TU
100.	Blank	EP-36 GYEO.364.241 TU
101.	Bolt	5.12.7010.1015.98
102.	Bolt	5.41.2100.1044.98
103.	Bolt	5-28D-AN.OKS-OST 1 10574
104.	Washer	5.12.7010.1014.98
105.	Filter	5.01.6113.0130.00
106.	Filter Disk	8D6.270.001-5
107.	Filter- Pneumatic Air Filter	11VF20A
108.	Valve Body	KN35.007
109.	Valve Core	V5-33 GOST 8107-75
110.	Cable	5.41.0220.0014.98
111.	Filter	8D5.886.059
112.	Installation Valve Cap	KN25.020
113.	Interlock Valve	83.0254-50
114.	Plug	5.41.8700.2857.98
115.	Ring Controlling Fuel Filter	57.25A-82
116.	Rubber Beading	5.47.7701.0503.98

Ser	Description	Part Number
117.	Trim Button	4KNR-M2
118.	Wire	5.41.0410.0000.15
119.	HUD Alignment Tool	FAZ.811.001
120.	Blank	EP-39 GYEO.364.241 TU
121.	Pitot Static Tube	PVD 7
122.	Borne Sight Fixture Adaptor	5.12.9941.0080.00
123.	Flexible Lena Hose	6-12-1-700-OST113814-81
124.	Hoist Sling for Special Load Lifting	5.12.9943.4000.00
125.	Filter Packet	8D2.99.034-10
126.	PAZ MK Connector Metallic Cap	5.41.6100.1263.98

KV-28 MANDATORY SPARES LIST

Ser	Description	Part Number
1.	Washer	AH082396
2.	Washer	3405A-3-14-28KD
3.	Sealing Cord	7857.072
4.	Cotter/Split Pin	1X12.2.05
5.	Rivet	3549A-3.5-9
6.	Cap	5.00.7217.0060.004
7.	Rivet	3560A-3.5-9
8.	Rail Lower	500.0210.5120.000
9.	Washer	3452A-24KD
10.	Annunciator	TS-2K
11.	Annunciator With Lamp	TS-2V
12.	Circuit Breaker	AZZK-15
13.	Bolt	500.6460.0004.000
14.	Funnel With Filter	220-STI-10892-73
15.	Bracket	5.02.6915.0015.000
16.	Rail	500.0210.5630.000
17.	Circuit Breaker	AZZK-50
18.	Shutter	1254C56-5-30-720
19.	Cable (Left)	5.00.6915.0020.004
20.	Flexible Hose	500.6300.0020.000
21.	Relay	TKE24PIGB
22.	Pick Up	MV-03
23.	Hose	6-6-2-390-OST1-13818-81

Ser	Description	Part Number
24.	Master Warning Lamp	SHSO
25.	Shutter	500.6915.5140.002
26.	Shutter	1254C56-6.7-30-630
27.	Oil Dram Hose	9-2OSTI-11219-83
28.	Nose Shock Strut Safety Upright	500.9908.0900.000
29.	Socket, Wrench, S=12mm	25.19.01.045
30.	Head Phone	012.00IV.17118474
31.	Selector Switch	PNG-15A
32.	Compass Liquid Filled	KI-13-SB
33.	Rod	8126008
34.	Hose	6-8-2-600OCT110853-72
35.	Hose	6-6-2-390-OSTI-13818-81
36.	Hose	6-6-2-390-OSTI-13818-81
37.	Hose	6-4-2-515 OST113814-81
38.	Hose	6-4-2-1000 OST 113814-81
39.	Hose	6-16-530 OST1 10848-72
40.	Pipe Line	519.5390.0000.000-12.061
41.	Profile	500.6911.0000.114
42.	Profile	500.6911.0000.113
43.	Pipe Line	500.6522.0000.105
44.	Pipe Line	500.6522.0000.101
45.	Inclined Strut	500.6460.5100.000
46.	Threaded Sleeve	2808A-8-43
47.	Bracket	500.6460.0020.002
48.	Spring Mech.	500.5112.0040.005
49.	Axle	500.0100.5341.000
50.	Carriage Retainer Control Mechanism	5.00.7500.3430.000
51.	Feel Spring Mechanism	5.00.5930.0350.000
52.	Hose	341350
53.	Nut	3355A-8 KD
54.	Button With Normally Open Contacts	2KNR
55.	Hose	1-10-2-450-OST1 10853-72
56.	Hose	6-4-1-550 OST1 13818-81
57.	Rivet	3560A.3.5-15
58.	Hose	6-16-530 OCT1 10848-72
59.	Rivet	3560A-4-15

KM-31

Ser	Description	Part Number
KM-31 SPARES		
1.	Tyre	480X200M 14A
2.	Tyre	620X180M 3A
3.	Navigation Lights	PSSO-45A
4.	Extender Tube For Brake Unit	160X60 MODEL V2
5.	Pipe	PTS58X80D6VR
6.	Anti Collision Light	MSL-3M
7.	Hand Fire Extinguisher	OP1-1.0-20-30
8.	Chain	1-2-01-OCT 110806-72
9.	Hose	500.6562.5011.000
10.	Hose	500.6562.5010.000
11.	Casing Lower	OST1 10524-72
12.	Casing Upper	1-OCT 1 10503-72
13.	Trim Button	2KR
KM-31 – GSE LIST		
14.	Engine Lifting Sling	500.9985.0000.000
15.	Deck Mooring Set	503.9908.0500.000
16.	Summer Cover (Nose Section)	503.9905.0080.000
17.	Rudder Locking Screw Clamp	500.9906.0090.000
KM -31 MANDATORY SPARES LIST		
18.	Cotter /Split Pin	2X20.0.029 GOST 397-79
19.	Cotter Pin	1.6X32.2.11 GOST 397-79
20.	Cotter Pin	3.2x36-2.11 GOST 397-79
21.	Cotter/Split Pin	1.6X1.4.0.019TOCT397-79
22.	Cotter/Split Pin	2X22.02.9 GOST 397-79
23.	Cotter/Split Pin	5X80.0.029 GOST 39779
24.	Cotter/Split Pin	3,2X63.2.11 GOST 39779
25.	Deck Mooring Set	503.9908.0500.000
26.	Cotter/Split Pin	1X12.0.019TOCT397-79
27.	Cotter/Split Pin	2.5X25-2.05
28.	Cotter/Split Pin	3.2X60-2.16
29.	Ring	30-1.5OST110291-71
30.	Clamp	11-OST1 13449-78
31.	Cotter Pin	3.2X36-2.11 GOST 397-79
32.	Ring IPC Bk	024-027-19-2-061
33.	Screw	3-6-KD-OST 1 31543-80
34.	Screw	4-10 TS OST1 31514-80

Ser	Description	Part Number
35.	Sealing Ring	Y-58-3.5-51-1668HTA
36.	Sealing Ring	Y-42-3-51-1668HTA
37.	Washer	0.5-8-10KD OST134505-80
38.	Lubricator Fitting	1.1.SH6 GOST 19853-74
39.	Cotter/ Split Pin	2.5X28.0.02.9 (GOST397-79)
40.	Non Return Valve	N5810-270
41.	V/V Charging (v)	800.600-1
42.	Locking Wire	KO-0.8
43.	Wire Locking	KO 1.6
44.	Wire Locking	KO 0.6
45.	Cable	500.5101.0040.000
46.	Clutch	500.6300.0070.000
47.	Filter, Dehydrator	500.5320.0700.000
48.	Hose Flexible	500.6300.0020.011
49.	Sealing Ring	0250050297
50.	Sealing Ring	2262A-14-2
51.	Sealing Ring	2262A-16-2
52.	Sealing Ring	058-062-25-2-061-A OST 100980-80
53.	Sealing Ring	0800980081
54.	Sealing Ring	0800980063
55.	Sealing Ring	2262A-179-2
56.	Sealing Ring	2262A-177-2
57.	Sealing Ring	2262A-7-2
58.	Sealing Ring	2262A-13-2
59.	Sealing Ring	34M51-12-8,2-1 KD9-13
60.	Sealing Ring	0250050297
61.	Gasket	7846.0036
62.	Gasket	7831.0518
63.	Gasket	7846.303
64.	Gasket	7846.304
65.	Screw	5-14KD OST 131502-80
66.	Sealing Ring	2267A-95-2
67.	Gasket	7846.0036
68.	Gasket	7831.0518
69.	Bushing 12 Mm	78029906402
70.	Washer 6-Chem Pas	OST 1 34523-80
71.	Gasket	7846.303
72.	Gasket	7846.304
73.	Shim	780290167
74.	Shim	0780290167-02
75.	SPRING	Kt 44-70
76.	BRAKE PAD	Kt 44-100
77.	KEY	19zh-1028

Ser	Description	Part Number
78.	WIRE	0.8-T-12x1bh9t Gost 18143-72
79.	BRAKE INNER TUBE	160x60
80.	RUBBER PACKING	Od27-29
81.	Cup1	Kt44-53
82.	LOCK NUT	Kt38-24
83.	CUP2	Kt44-54
84.	CAP	25n10-14x1-01
85.	CAP	Od38-11
86.	BOLT	(3)-6-30-Kd Ost 1.31103-80
87.	LEAD	Ost1.10067-71
88.	RING	Kt44-52
89.	CLAMP	500.6200.5020.005
90.	RING	021-025-25-2-043-A OST 100980-80
91.	SHIM	0780290167-01
92.	FLANGED CONNECTION	KT 44-40

HAWK SPARES LIST

Ser	Description	Part Number
1.	Washer	AH082396
2.	Rivet	CR4174-4-02
3.	Seal	100-210-8815
4.	Screw, Machine	A204D14
5.	Gasket	R13314
6.	Screw, Machine	A260-5010
7.	Seal	MBEU15868
8.	Seal O Ring	100-160-8810
9.	Gasket	C11604-20B
10.	Seal	R13308
11.	Bolt, Machine	A173-4D
12.	Nut	S111-05
13.	Washer	KB571L2921-004
14.	Ring Seal Toroidal	KB21076
15.	Ring, Sealing	AS43013-161
16.	Rivet	AS460-406
17.	O-Ring	MBEU61510
18.	Washer, Tab	AIR129930
19.	Pin, Cotter	LN94-20020
20.	Ring, Sealing, Toroidal	BS1806-012DTD5543F

Ser	Description	Part Number
21.	Pin, Split 1.8mmx40lg	EN2028-18040
22.	Pin, Cotter	LN94-20025
23.	O Ring	P34284
24.	Pin, Split	EN2028-10014
25.	Washer, Sealing	KB280K0065-000
26.	Pin Spring	D5E9318-161
27.	Washer	AJJ6193-177A
28.	Bolt Assy	SL4507-82
29.	Seal	100-021-1109
30.	Pin, Split	LN94-20015
31.	Pin, Split	LN94-10015
32.	Nut, Plain, Hexagon	A103DT
33.	Seal	100-131-0073
34.	Seal, Ring	100-218-0073
35.	Washer	SP41C
36.	Flat Washer	KB1081
37.	Pin, Split	LN94-10020
38.	Sealing Washer	AGS1186-2
39.	Pin Split	NA274000-1430
40.	Washer, Sealing	AH04861
41.	Seal	KB571L2921-000
42.	Spring Washer	K11403
43.	Pin, Cotter	LN94-15015
44.	Washer Tab	MBEU67042
45.	Lamp Sealed Beam	GE4587
46.	Filter	ACO9350
47.	O-Ring	MBEU61517
48.	Nut	AC09109
49.	Valve, N.R.V. Oxygen	OP4510
50.	Screw, Cheese Head	MBEU37369
51.	Ring, Sealing	MBEU61530
52.	Seal O Ring	53-34X5-33S7I02
53.	Rivet CSK 90 Degree	AS2229-405
54.	Lamp Incandescent	8GS003329-28
55.	Screw	AJJ6193-367A
56.	Set Screw	MBEU12070
57.	Washer Tab	MBEU90586
58.	Screw, Machine	A113-3E
59.	Screw, Machine	MBEU60873
60.	Lamp Incandescent (Flood Light)	CRD7386-028-02
61.	Screw	A261-4022
62.	Gasket	F249330
63.	Nut, Self-Locking, Hexagon	A126G66
64.	Sleeve, Anti Abrasive	1930-4AA

Ser	Description	Part Number
65.	Seal O-Ring	100-244-1109
66.	Seal, O Ring Cap	100-229-1109
67.	Seal, Ring	KB16208
68.	Bolt	SL4192-06-02
69.	Nut, Stiff Metallic	A125D66
70.	Spring	7R-9659003
71.	Seal	KB538L1144-001
72.	Bolt Plate Attachment	D5E10475-161
73.	Bolt	DSR53502-1506
74.	Ring	AC043341
75.	Gasket	F315743
76.	Valve, Aux Cooling	HTE250090
77.	Seal	KB536K0499-000
78.	Seal O-Ring	100-236-1109
79.	Screw, Bleed	DAS2431-01
80.	Connector, Pipe	MBEU61344
81.	Valve	AC66886
82.	Pipe Assy, Brake	AIR121905
83.	O-Ring	HDS1171-1-19
84.	Pin, Split	LN94-20050
85.	Seal Metal Wedge	171-905-0300
86.	Pin, Assy	MBEU36041
87.	Split Pin	SP90-C5
88.	Plug, Fusible	AH090575
89.	Pin Special	MBEU23502
90.	Sleeve Threaded	AH083987-18
91.	Bush	MBEU6508
92.	Ring Sealing	A0H023073-18
93.	Desicator	40-356-112
94.	Coalescer Assy	4217C120
95.	Relay, Mag Latch	M302D4N-C
96.	Relay	M210D4C-C
97.	Relay	M220E4N-C
98.	Switch	1EN61-6
99.	Pin, Shear	KB321L0026-000
100.	INGPS Battery Module	21310340A02
101.	Collar	AS44408-05
102.	Cap, Blanking	KB132K0418-000
103.	Relay	T412-DN-1203-J-UUW
104.	Stop Assy	KB276L0088-009
105.	Element, Disposable	51147H1
106.	Pin Cotter	DDE32880-161
107.	Hose Assy	MBEU77311
108.	Brush Barrel Cleaning	7R-9641469
109.	Actuator Assembly, Seat Pan	MBEU98918

Ser	Description	Part Number
110.	Piston	7R-9647206
111.	Nipple Lubricating	AS44402
112.	Lens, Red LH	9EL408903-01
113.	Handle	MBEU62452
114.	Assembly - Release Mechanism	KB959K0139-026
115.	Mat Main plane(25mm)	501D120876D
116.	Pin Assembly	KB132K0517-000
117.	Lens, Green RH	9EL408903-02
118.	Tyre Main	DR24620T
119.	ACP Filament 28V	SV410955
	GSE	
120.	Mobile Maintenance Crane	DG5601
121.	Adaptor Main Wheel Jacking	KB132L1204-000
122.	Jack Pillar 5 Ton	SSL(M)5-22-26
123.	Engine Installation Trolley	S3S23038000
124.	Engine Inhibition Rig	C13104
125.	Sling Canopy Servicing	KB132L0015-006
126.	Fuel Dip Test Kit	KB132K0898-010
127.	Oxygen Test Kit	KB132K0623-000
128.	Sling Seat Lifting	MBEU59042-1
129.	Compressor Washing Rig	S3S20243000
130.	Tool Alignment, Brake	A15045
131.	Tool Kit Engine Change	BAE8
132.	Rigging Set Flying Controls	KB132L1497-004
133.	Fuel Transfer Kit Adapter	KB132K0410-002
134.	Engine Change Kit	KB132K0492-006
135.	Flap Wheel	KB321L0126-001
136.	5 Ton Tripod Jack	SSL(M)5-66-87
137.	Relay	M210D4N-C
138.	Seal O Ring	100-159-8810
139.	Ring Sealing	A0N023073-18

SEA KING SPARES LIST

Ser	Description	Part Number
1.	Retainer Nut	2752-054RET
2.	Screw	AN52510R6
3.	Screw	AN525-10R8
4.	Washer	AN960C10L

Ser	Description	Part Number
5.	Connector	D660
6.	Packing 'O' Ring	MS28775-225
7.	Ring, Back Up	MS28777-4
8.	Packing, O Ring	MS28778-16
9.	Packing 'O' Ring	MS28778-4
10.	Pin Cotter	AN381-3-20
11.	Packing, O Ring	MS28778-6
12.	Packing, O Ring	MS28778-8
13.	Nut, Locking	N6595
14.	Element Filter	QA04056
15.	Element Assy Filter	QA06542
16.	Cord, Lacing	R88W
17.	Washer	SP11E
18.	Washer	SP127C
19.	Washer	SP127D
20.	Pin Split	SP90C5
21.	Pin Cotter	SP90C6
22.	Seal	WRS2400
23.	Ring	MS28777-16
24.	Packing 'O' Ring	100-156-2129
25.	Pin Cotter	MS24665-152
26.	Pin Cotter	MS24665-300
27.	Pin Cotter	MS24665-377
28.	Screw	NAS509-8
29.	Gasket	SS4421-1
30.	Spiral Wrapping Swp-3	EFWRAP 0.3
31.	Wrapping Spiral	EFWRAP3-0MM
32.	Wrapping Spiral	EFWRAP7-5
33.	Tie Cable	LK2
34.	Tie Cable	LK2C
35.	Bolt	NAS625H4
36.	Packing 'O' Ring	100-012-2129
37.	Ring Sealing	38054-408
38.	Nut	1802-048
39.	Filler	2837-003E
40.	Lining Brake	9521592-1
41.	Pin Cotter	AN381-25-10
42.	Screw Machine	AN500A4-16
43.	Screw	AN525-10R11
44.	Screw	AN525-10R9
45.	Screw	MS27039DD4-27
46.	Washer	AN960PD10L
47.	Bolt	S6135-20711-1

Ser	Description	Part Number
48.	Ring Sealing Union	UP40017
49.	Fastener	X5-49348
50.	Pin Cotter	MS24665-153
51.	Pin, Cotter	MS24665-304
52.	Pin Cotter	MS24665-372
53.	Pin Cotter	MS24666-374
54.	Clamp	MS21920-26
55.	Washer	MS172275
56.	Nut	S6130-80110
57.	Seal	SS4021-5-16B
58.	Packing 'O' Ring	100-014-2129
59.	Packing 'O' Ring	100-908-2129
60.	Seal	S6120-63164-7
61.	Screw	AN525-10R7
62.	Seal Bearing Outboard	9533361
63.	Bolt	NAS630-36
64.	Cable Tie	LK0B
65.	Decal, Yellow Bar	SS9032-19
66.	Tie Cable	LK3
67.	Ring, Backup	MS28777-12
68.	Bush	S10-10-3389-1
69.	Boot, Protective Yellow	MS25171-4SYELL0W
70.	Clip	9510375
71.	Packing 'O' Ring	100-131-2129
72.	Bush Assy	S6135-20842-1
73.	Seal	2837-002E
74.	Clip	AS46783-08
75.	Bolt	NAS630-58

P8I Spares

Ser	Description	Part Number
1.	Portable Water Cart	CPW100-2
2.	Lifting Tray Base Assembly	MC96003-5
3.	Radome Assembly Nose	4D5336-103
4.	Rudder Hinge Inspection Ladder	Not Available
5.	Fly Away Wheel Stowage Equipment	Not Available

6.	Long Bar	G5D35578-7F (NOT IN- CATED)
7.	Radome Nose Cover	142425OCD72B019003 - 1001(NOT INCATED)

ALH SPARES

Ser	Description	Part Number
1.	Upper Eye End Assy	201P 640H 2100 001
2.	Lower Eye End Assy	201P 640H 2200 001
3.	PU Tape	3M 8671
4.	Vinyl Tape (Self Adhesive)	3M-471(2")
5.	CAMLOC Stud Assy	CAMLOC 4002 13
6.	Split Pin	EN 2367-14014
7.	Sky Flex Seals (Shell Assy.)	GO.AS-0017
8.	Bonding Braid	MS 25083 2BB 10
9.	Parmacell Tape	P-601
10.	Filter Element	QA 08954
11.	Sleeve	RAYCHEM 3/8 DR-25
12.	Fire Detector Compound	RHODOSIL CAF 730
13.	Screw Blade Fork (Small)	201P 620H 1000 230
14.	Split Pin	2X18 IS:549 AISI 304
15.	Aluminum Tape	40 AL
16.	EFG Cover Bush	FT25723
17.	Thread Sealant	222E

DORNIER SPARE LIST

Ser	Description	Part Number
1.	Damper Vibration	93469-12
2.	Armature Assy	300SG1064

3.	Ball Bearing	300SG1052-1
4.	Bearing Ball	03-6010-18
5.	Bearing For Starter Gen	03-6010-08
6.	Drive Shaft	300SG1103
7.	Insulator	250SG1046
8.	Retainer	MS16628-1078
9.	Screw Mounting	MS35276-264
10.	Cold Air Unit	1431D000

RPA SPARES LIST

Ser	Description	Part Number
1.	Oil Radiator Assy	Mct1233269-501

NASDO

Ser	Description
1.	Latex Coated Safety Gloves
2.	Maintainer Ultraviolet Protector
3.	Aircraft Fastener Pouches
4.	Aircraft Fastener Pouches
5.	Protective Sleeve
6.	Self-Fusing Silicone Aviation Tape
7.	Air Bubble Film Roll
8.	Protective Tape
9.	Anti-Static Gloves With Polyurethane Palms
10.	Rodenator (Electronic)
11.	Storage Rack
12.	Tool Waist Pouch
13.	Aircraft Window Cleaner
14.	Low Lint Wiper Tissue (Roll)
15.	Aircraft Washing Compound
16.	Safety Mask With Valve
17.	Safety Mask With Dual Valve
18.	Evaporative Cooler
19.	Aircraft Dry Wash & Polish

Ser	Description
20.	Portable Ready-Use Storage Box
21.	Sealant Tape
22.	Storage Rack
23.	Waterless Aircraft Cleaning Kit
24.	Rechargeable Led Headlamp
25.	Corrosion Inhibitor Compound
26.	Automatic Floor Scrubber Drier
27.	Tool Carrying Bag
28.	Digital Wireless Boroscope
29.	Tool Carry Bag
30.	Anti-Contamination Pol
31.	Corrosion Inhibiting Compound
32.	Interactive Ear Defender
33.	Paint Remover
34.	Heavy Duty Creeper
35.	Heavy Duty Creeper
36.	Ef Poly Urethane Sealant
37.	Portable Film Making Equipment
38.	Paint Coating & Polish
39.	Oil Absorbent Products
40.	Tyre Charging Kit
41.	U-Safe Lifesaver (Self Propelled & Remote Controlled)
42.	Automatic Floor Scrubber Drier
43.	CPC Remover
44.	Corrosion Inhibition Compound (CIC)
45.	Foam-In-Place System
46.	Oil Transfer Pump
47.	IOD Pick-Up Tool Kit

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Appendix 'H'

(Refers to Para 2 Chap 9)

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

Ser	Project
1.	Mini UAVs
2.	Long range Electro Optic IR Sensors for Aircrafts
3.	Marine Version Doppler Radars
4.	Advance Arrestor Gears
5.	Composite Foldable Hanger Doors
6.	Diesel Engines
7.	Propellers
8.	SAMS
9.	Mine Hunting Sonars
10.	Shock & Vibration Mounts
11.	Submarine Generator
12.	Ship Installed Radiation Monitoring System (SIRS)
13.	Fire / Flood Alarm Sanctions
14.	Flight Safety Equipment
15.	Flight Simulators
16.	Gear Boxes
17.	Gas Turbines
18.	Stern Gear (Shafting / Propeller / Stern glands & Seals
19.	Water Mist Fire Fighting System
20.	Gas Turbine Generators (GTG)
21.	High Pressure (HP) Air Fittings
22.	Tactical Mission System for Aircrafts and Helicopters
23.	Personnel Rescue Beacons (PRBs)
24.	Motor Boat Engines
25.	5MW Electric Propulsion Equipment (warship grade)

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Appendix 'J'
(Refers to Para 2 Chap 9)

PRODUCTS TO BE TAKEN UP FOR DEVELOPMENT

Ser	Projects	
1.	Active Mounts	Traffic Analysis to filter Data and VoIP traffic based on keywords and IP address over Naval Networks.
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.

Ser	Projects	
11.	Integrated Mast	Develop an I-Mast and integration of systems (MFSTAR, SDR, ACCS, EW 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.	Fuses	-

Ser	Projects	
25.	Ship Installed Chemical System (SICS)	System capable of detecting Chemical Agents to be installed onboard IN Ships.
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.
27.	Specialised SV mount	Cradle mounts of Talwar Class ships and Raft mounts of P-28 class ships
28.	Motor Boat Engines	-
29.	5MW Electric Propulsion Equipment	Development of indigenous warship grade electric propulsion equipment
30.	Non-Magnetic Engines	-

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Appendix 'K'
(Refers to Para 3 Chap 9)

PROJECTS COMPLETED/ PROPOSED THROUGH DRDO/ PRIVATE INDUSTRY

Ser	Product Description	Development Agency/ Firm
1.	Echo Sounder (Multi Frequency Type)	M/s KELTRON
2.	Log EM (Type EML 40)	M/s KELTRON
3.	Main Switchboard/ EDC/ EDPs	M/s L&T M/s GE Ltd, Bangalore
4.	Converters, 400 Hz	M/s ELMOT Alternators
5.	VCS System (VOIP Based)	M/s BEL Bangalore
6.	C&C Switchboard	M/s L&T, M/s Marine Electricals
7.	Main Broadcast & SRE System	M/s Phi AudioCom
8.	SIRS	M/s ECIL Hyderabad
9.	Sound Power Telephones (SPT)	M/s ELCOME Marine M/s Linea M/s Marine Electricals
10.	LED Light Fittings	M/s McGeoach Marine Electricals M/s Ray Enterprises
11.	Power Panel for Heavy Loads	M/s L&T, Mumbai M/s Marine Electricals
12.	Degaussing Cable	M/s Universal Cables Bangalore
13.	Emergency Supply System	M/s Ray Enterprises
14.	Rectifiers	M/s Precision Power Ltd
15.	Ship Data Network (SDN)	M/s BEL, Bangalore
16.	Integrated Bridge System (IBS)	M/s Navicom
17.	CMS	M/s TPSED Mumbai
18.	Conventional Light Fittings	M/s Ray Enterprises
19.	AELs	M/s Ray Internationals

Ser	Product Description	Development Agency/ Firm
20.	Power Cables for Main Switchboard	M/s Nicco Corporation & Radiant Cables
21.	Lighting Cables	M/s Radiant Cables
22.	Cable Ways	M/s Shakti Engg Works
23.	Air Cooled Transformers (20 KVA)	M/s Marine Electricals
24.	Power Panel for Engine and DA Room	M/s L&T, Mumbai
25.	Lighting Panel	M/s Marine Electrical
26.	Control and Monitoring Cable	M/s Radiant cables M/s Siechem Technology, Chennai M/s Nicco Corporation, Bangalore
27.	COS for Heavy and Machinery LOADS	M/s L&T, Mumbai
28.	VLF system	DRDO/ Industry
29.	INCIS (*IN* Communication Interoperability system)	WESEE
30.	AVLF Modulator/ Demodulators	DEAL/ BEL
Additional Shipborne Systems		
31.	GSHRB	M/S ECIL Hyderabad
32.	C & C SW BD	M/S L & T LTD Mumbai
33.	Emergency DA SWBD	M/S Marine Electricals
34.	20 KVA Convertor	M/S ELMOT LTD
35.	ACOS	M/S Marine Electrical
36.	SIRS	M/S ECIL
37.	ICCP System	M/S Cathodic Control Ltd
38.	Transformer	M/S Static Transformer
39.	Lighting System	M/S ISAAC Engg M/S Manish Industries M/S Arvin Industries M/S Ray Enterprises
40.	Emergency Supply System	M/S AIM Engg M/S ISAAC Engg
41.	30 KVA Helo Convertor	M/S Kirloskar Ltd
42.	Helo Starting Rectifier	M/S Static Transformer

Ser	Product Description	Development Agency/ Firm
43.	CCS MK-III	M/S BEL (Bangalore)
44.	VCS-28	M/S BEL (Bangalore)
45.	SDN-28	M/S BEL (Bangalore)
46.	LINK-II MOD-III	M/S BEL (Bangalore)
47.	LUP-329	M/S BEL (Bangalore)
48.	100 W MF Transmitter	M/S BEL (Bangalore)
49.	EW SANKET	M/S BEL(Hyderabad)
50.	V/UHF COMNIT/ DF System ELK-7036-WB DF	M/S BEL(Hyderabad)
51.	MB/SRE	M/S Phi AudioCom
52.	Intercom System	M/s Phi AudioCom (Pune)
53.	SATCOM	ISRO
54.	SATCOM, PCS	DEAL/ DRDO/ BEL
55.	Network Security Encryptors	ECIL/BEL
56.	EW Ellora/ Ellora Mk II	DLRL/ BEL(Hyd)
57.	EW Varuna	DLRL/ BEL(Hyd)
58.	CMS-28	M/s BEL (Ghaziabad)
59.	ATM Switch for CMS	M/s BEL (Bangalore)
60.	DDU for RLG	M/s Data Patterns Ltd (Chennai)
61.	Kavach Mod –II	M/s Machine Tool Prototype Factory Completed
62.	50 KVA Converter	M/s PCL Ltd (New Delhi)
63.	Radar Revathi	M/s BEL Bangalore Completed
64.	UWT	Completed
65.	Echo Sounder V-2	M/s Keltron (Trivandrum) Completed
66.	AK 630	Completed
67.	SOP for AK 630	Completed
68.	ITTL	Completed
69.	FCS LYNX U1	Completed
70.	IAC MOD 'C'	Completed
71.	SONAR HUMSA NG	Completed
72.	IRL	Completed
73.	Anchor Capstans	Completed
74.	Foldable Hangar Door	Completed

Ser	Product Description	Development Agency/ Firm
75.	Railed Helo Traversing System	Completed
76.	Boat Davit	Completed
Indigenisation Process in Progress		
77.	HDVLF Rx	DEAL/ BEL
78.	IBA (Integraged Broadcast Application)	M/s Data byte
79.	HEMP, 1000 Amps Filter	DRDO/ M/s Zeonics
80.	Indigenous Secure Router	M/s Nivetty Systems
81.	MDA-DSS (Maritime Domain Awareness – Decision Support Software	CRL/ BEL
82.	Software Driven Radio (SDR)	DRDO/ BEL

Appendix 'L'
(Refers to Para 28 Chap 10)

ANNUAL FORECAST REQUIREMENT OF ELECTRICAL/ ELECTRONIC EQUIPMENT AND SYSTEMS

Ser	Equipment Description	Total
1.	Power supply boards for Gallies	120
2.	Power Boards (Distributive, Group, Area, Power Supply etc)	1100
3.	Boards with Contactors	550
4.	Automatic Change Over Switch cum Starters	220
5.	Automatic Change Over Switches	550
6.	Hand change over switches	1500
7.	Connection Boxes(Junction Boxes)	2900
8.	Junction Boxes	1200
9.	Plugs and Sockets/ Sockets for portable Electric Devices (various ratings)	12000
10.	Electrical Water Heaters	90
11.	Electrical instrumentation (ammeters, voltmeters, watt-meters, high-resistance ohmmeters, phase-meters, frequency meters)	1600
12.	Shore Supply Cables	11000
13.	Emergency Power Supply Cables	6000
14.	Set of lighting and signalling equipment	180
15.	Flood and Navigation projectors	18
16.	HF Transceiver with advanced features	110
17.	Motors of various ratings	500
18.	SFC	100
19.	Cable(various rating)	1500 km
20.	Switchboard with APMS	10
21.	ATS (Auto Transfer Switch)	150
22.	SPT (Sound Power Telephone)	200
23.	IBS (Integrated Bridge System)	5
24.	HSR (Helo Starting Rectifier)	7
25.	MCT glands (various size on a refit ship)	200
26.	LED Light fitting including magazine light fitting	5000

Ser	Equipment Description	Total
27.	Rubber mats	10000
28.	HVLAS	10
29.	Submarine Battery	5 sets
30.	AVRs (for DA and convertors of various ratings)	100
31.	Type IV Battery	1 set
32.	VFD (for starters of various ratings)	100

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