हर काम देश के नाम

स्वावलंबन 2.0
SWAVLAMBAN 2.0
स्वदेशीकरण योजना
INDIGENISATION PLAN

MAKE IN INDIA

Directorate of Indigenisation
Integrated Headquarters
Ministry of Defence (Navy)

PREFACE

1. The first 'Swavlamban' document was released by the Hon'ble Raksha Mantri in Aug 2020 as guideline document enunciating the needs of the Indian Navy towards developing various equipment/systems/subsystems for various platforms indigenously.

2. In a bid to showcase the growing strength of indigenous defence manufacturing and progress towards the goal of 'Atmanirbharta' (Self-Reliance), the Indian Navy felt the need for a roadmap to enhance R&D in military technology, ensure amalgamation between R&D and manufacturing sector and serve as a guide to integrated approach to users, designers and manufacturers.

3. The document has now been revised to make it more 'industry friendly' and also to act as a comprehensive reference document of all indigenisation requirements of the Navy. The revised edition of the document 'Swavlamban 2.0' attempts to formulate the requirements of Indian Navy and lists out the equipment/systems/sub systems which can be taken up for indigenisation in the coming years by PSUs, DRDO and private industry.

4. The release of 'Swavlamban 2.0' document would further synergise Indian Navy's relationship with the industry and encourage all sectors of industry to come forward and participate in indigenous development of all Naval Systems, with an ultimate aim towards making the nation self-reliant in this vital domain of defence technology. In accordance with the Hon'ble RM's directives, this document aims to assist in the 'Joint Exercise' for self-reliance with participation of every stakeholder viz Indian Navy, Industry, MSMEs, Academia, DRDO, PSUs and MoD.

Admiral R Hari Kumar
PVSM, AVSM, VSM, ADC
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MESSAGE

'Swavlamban 2.0'

1. As India charts its course towards becoming a fully developed nation, *Aatmanirbharta* in defence is not merely an economic imperative, but a strategic necessity. Recognising this, the Indian Navy has made an unequivocal commitment of transforming itself into a 'fully *Aatmanirbhar* force' by 2047, and I am sanguine that the Navy will get there.

2. This confidence draws from numerous achievements of the recent past which have been a result of collective team-work of multiple stakeholders, including the Indian Defence Industry. Be it ship-building, development of niche systems such as electronic warfare suites and SONARs, weapons, sensors, machinery systems, or the commissioning of the first indigenous aircraft carrier INS Vikrant last year, a lot of ground has been covered.

3. However, a lot more needs to be done and with greater speed, scale, and scope to attain self-reliance in letter and spirit. In this regard, clear and coherent communication of Indian Navy's indigenisation requirements becomes a crucial enabler.

4. This document flows from the Navy's ethos of treating the Indian Defence Industry as a partner and a team member, going beyond the transactional 'buyers-seller' relationship. I am convinced that *Swavlamban* 2.0 will aid in aligning the Industry's innovation and indegenisation efforts with the Navy's requirements, and strengthen our partnership in the collective pursuit of *Aatmanirbharta*.

Harikumar

(R Hari Kumar)
Admiral

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MESSAGE FROM VCNS

1. It is heartening to note that the second edition of 'Swavlamban 2.0' has been reinvigorated towards making it an 'industry friendly' document, evidently outlining the proposed indigenisation plan of the Indian Navy.

2. The prevalent geopolitical situation, and the impetus given by the Government of India towards 'Atmanirbhar Bharat', implores upon the Indian Armed Forces to intensify indigenisation efforts. The Indian Navy, having taken an early lead towards pursuit of indigenisation, has further ramped up its indigenisation efforts to evolve into a technologically advanced and combat ready force.

3. As *IN* progresses through indigenous development of high-end technology, its translation into defence hardware, subsequent induction, and standardisation, we are likely to face challenges. Towards this, our Industry partners would have to play a bigger role and work hand-in-hand with the Navy in converting these challenges into opportunities by leveraging various schemes of 'Make in India' initiative.

4. I am confident that this document would provide an excellent opportunity for our Industry partners to understand and fulfill the Indigenisation requirements of the Indian Navy.

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MESSAGE

1. Considering the current geo-political situation, rapid technological development and impetus on government of India's vision of 'Make in India' and 'Aatmanirbhar Bharat', it is imperative that all out efforts are made to achieve maximum Self Reliance through support of the Indian industry, which has a vast but yet untapped capability for supporting and sustaining ***IN***'s requirements.

2. I am pleased to note that 'Swavlamban 2.0' is a step in the right direction. The primary objective of this Document is to enunciate the needs of the Indian Navy for Innovation/ Indigenisation. Also, this endeavour aims to fill the gaps in communication to the defence industry partners for undertaking indigenous design, development and manufacturing of Naval equipment and system components.

3. With the launch of this Document, ***IN***'s commitment and resolve to make India 'Aatmanirbhar' in Defence Production is reiterated. I am confident that the 'Swavlamban 2.0' will emerge as a 'single point' reference for Indian industries in the Defence Sector.

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PART – I

INTRODUCTION

CHAPTER 1

INTRODUCTION TO INDIAN NAVAL INDIGENISATION PLAN

1. The first Swavlamban document was released in Aug 2020 by the Hon'ble Raksha Mantri as a guideline document for all stakeholders, enunciating the Indigenisation requirements of Indian Navy *(IN)*.

2. With the renewed thrust towards 'Atmanirbharta' and increased interest of Industry, MSMEs and Academia in the indigenisation program of *IN*, a need was felt to revise the document and make it more 'industry friendly'. Accordingly, 'Swavlamban 2.0' aims to be a comprehensive reference document for all indigenisation requirements of the *IN* by listing out all the equipment/systems/ subsystems which can be taken up for indigenisation in the coming years.

3. 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

4. Indigenous development in weapons and their control elements, sensors, Radars, Fire Control Systems, Unmanned Systems, etc, however, fall much below par and need to be pursued with vigor. 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.

5. 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 erstwhile Ordnance Factories, 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 fruition in the form of world class defence hardware that would serve the needs of the *IN*.

6. Part I of the document briefly elucidates the Indigenisation Strategy of *IN,* various methodologies and schemes available for indigenisation under GoI/MoD and broad requirements of indigenisation in Shipbuilding and Indigenisation achieved so far. Part II-V of the document highlight the indigenisation requirements of *IN* under various categories whereas Part VI deals with the future technologies with Defence Applications relevant to *IN* where industry participation is solicited. In the appendices where the exact indigenisation requirements in various categories are listed out, the Point of Contact for further discussion/information are also clearly listed.

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 and Special Operation Missions by MARCOs.

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 have been typically developed by DRDO till date.

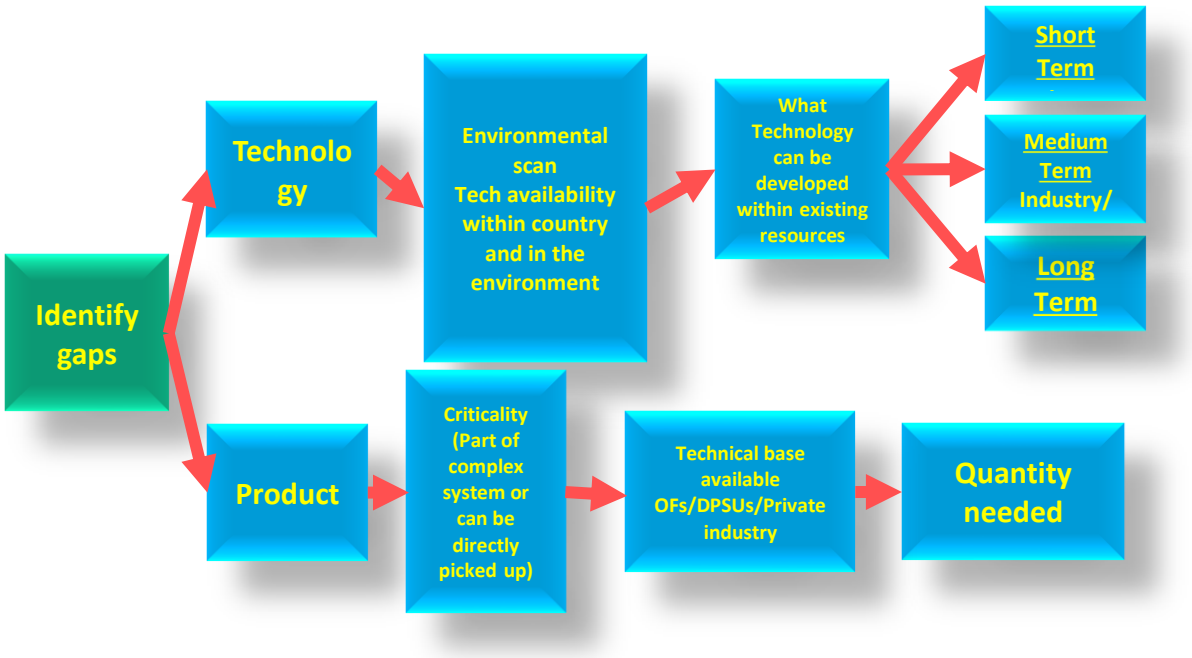
(b) **Subsystem Level**. At the second level are the subsystems which form part of individual systems. Subsystems are indigenised based on specifications generated by *IN*. Indigenisation at this level can be undertaken either through a combination of DRDO and industry or by industry alone, depending 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, ensured that the *IN* remained saddled with

decades old technology. The revised indigenisation strategy is, therefore, focused on technology development in gap areas in addition to requirement based indigenisation.



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 optimise 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**. Though all professional directorates are involved in indigenisation of equipment/systems/spares to certain extent, the 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 and need to be indigenised 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
(vi)	Marine Grade Aluminium Plates > 6mm

(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
(vii)	Marine Grade Sewage Treatment Plant (STP)

(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]
(iv)	Satellite Communication System (SATCOM)
(v)	Aviation Control Suites
(vi)	Fire Control Systems
(vii)	Integrated Mast & Control System for Submarines
(viii)	Mine Hunting and Diver Detection Sonars
(ix)	Light and Heavy Weight Torpedoes
(x)	Towed Array Sonars
(xi)	Unmanned Aerial Vehicles for Surveillance and Delivery of Ordnance/ Autonomous Underwater Vehicles
(xii)	Global Positioning Systems, Inertial Navigation Systems
(xiii)	Super Rapid Gun Mounts (SRGMs)
(xiv)	Next Generation Helo Harnessing and Traversing System (NGHHTS)

Methodology/ Indigenisation Routes

15. The procedure followed for indigenisation of stores/systems is as per Chapter 15 of DPM-2009 (through Indian industries) or Chapter IV of DAP-20 (through DRDO). Funds are expended from Minor Heads 110(P), 110(Q) or 110(F) based on extent of production/ R&D activities involved. Additionally, projects are also taken up with Indian Industry through 'Make' category, culminating in procurement under Capital route. Indigenisation projects are progressed under following routes:-

(a) **Revenue Scheme**. This route is exercised through funds allotted to IHQ-MoD(N) under Minor Heads 110(p) – Indigenous Development and 110(q) – Research & Development.

(b) **Make Schemes**. Make Schemes are sub-divided into three categories; Make-I, Make-II & Make III and are elaborated in succeeding para 17.

(c) **Technology Development Fund (TDF) Scheme**. The Technology Development Fund (TDF) operated by DRDO was setup in union budget 2014-15. This scheme aims at funding the development of Defence & Dual use technologies. The funding is for public/ private industry especially MSMEs and only Indian vendors including Association of Person are eligible for this scheme. Each project is capped at 50 Crore with a development period of two to four years (https://tdf.drdo.gov.in).

(d) **iDEX**. The iDEX (Innovations for Defence Excellence) initiative was launched by the Hon'ble PM in Apr 18 with the aim to achieve self-reliance and foster innovation and technology development in Defence and Aerospace by engaging industries including MSMEs, Start-ups, individual innovators, R&D institutes and academia. Defence India Start-up Challenge (DISC) is being launched since then with Problem Statements (PS) from Armed Forces and DPSUs. iDEX has provision of providing funding to shortlisted vendors upto 10 Cr under various schemes (https://idex.gov.in).

(e) **DRDO Projects**. The indigenisation of Naval Armament stores is also progressed through DRDO. DGNAI is the Co-Chairman for the IN-DRDO Synergy - Armament Combat & Engineering (ACE) Cluster.

Indigenisation Methodology at Indigenisation Units

16. Following methodology would be followed for indigenisation:-

(a) **Development Procedures**. The procedure followed for indigenisation of stores are as per Chapter 15 of DPM-2009 (through Indian industries) or Chapter IV of DAP-20.

(b) **No Cost-No Commitment (NCNC) Basis**. The Production Agencies (PAs) are at times engaged for development of stores on NCNC basis. In such cases, the Indigenisation Cells will generate Paper Particulars (PPs) in association with the Production Agencies (PAs). The store will be declared developed and bulk production may be initiated based on satisfactory trials and approval of IHQ-MoD(N).

(c) **Indigenisation through DRDO/ Academia**. Stores shall be taken up for indigenisation through DRDO/ Academia wherever feasible, post discussion with respective development agencies in Development cum Production Partner (DcPP) mode.

(d) **Sample Based Indigenisation**. In view of large number of stores required to be indigenised and constraints on resources for generation of drawings/ paper particulars, samples will be issued to development agencies (DAs) for indigenisation. The DAs shall be responsible for generation of drawings and identification of material, etc. based on the sample provided under the supervision of concerned Indigenisation Units. The RFP would be formulated accordingly.

Indigenisation Through 'Make' Procedure

17. 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 (https://www.makeinindiadefence.gov.in).

18. 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 of DAP-2020.

19. Only Indian vendors as defined in Chapter-III of DAP 2020, 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 50% IC or under 'Buy (Indian)' category with minimum of 60% IC by inviting commercial bid and thereafter following the procedures detailed in Chapter II of DAP 2020 (https://www.ddpmod.gov.in/defence-acquisition-procedure-2020).

20. 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 upto 70%, of prototype development cost or maximum 250 crores per Development Agency released in a phased manner and based on the progress of the scheme, as per terms agreed between MoD and the vendor (iaw Chapter-III of DAP 2020).

(b) **Projects under Make II and Make III**. Projects under Make II and Make III would encompass equipment/ system/ platform or their upgrades or their sub-systems/ sub-assembly/ assemblies/ components/ materials/ ammunition/ software, primarily for import substitution. Under Make II and Make III, no government funding is envisaged for prototype development but there is an **assurance of orders** on successful development and trials of the prototype. Projects under the Make categories, with procurement not exceeding Rs 100 Cr/year based on delivery schedule at the time of seeking AoN will be earmarked for MSMEs. However, if at least two MSMEs do not express interest for a Make programme earmarked for them, the same shall be opened up for all.

(i) **Make-II (Industry Funded)**. This category essentially pertain to products involving indigenous design, development and manufacturing. To enable Indian industry to leap frog to higher or complex technology, cases where Indian companies either hold the IPR, including where it has been acquired from the foreign companies, or have the ownership of the design of the main system/equipment, will be deemed to be indigenously designed and developed. Successful development under Make I and Make II would result in

acquisition, from successful Development Agency(ies) (DA/DAs), through the 'Buy (Indian-IDDM)' category with indigenous Design & Development and a minimum of 50% IC on cost basis of base contract price.

(ii) **Make-III (Industry Funded)**. The procedure is applicable to ammunition/ equipment/ system/ assemblies, etc which although would not be designed/ developed indigenously, but can be manufactured in India as import substitution for product support of weapon systems/equipment held in the inventory of the Services. Indian firms may manufacture these either in collaboration or with ToT from foreign OEMs. In this category, an Indian vendor can enter into a JV with OEM. Schemes under Make III will be procured under the Buy 'Indian' category with a minimum of 60% IC on cost basis of base contract price. However, vendors eligible in Buy (Indian-IDDM) are also permitted to participate under Buy (Indian) category with indigenous design and min. of 50% IC on cost basis of base contract price.

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

(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) Single Stage Composite Trials/ User Trials by SHQ.

(m) Staff Evaluation.

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

(p) Award of Contract.

22. Defence Acquisition Procedure (DAP) 2020 aims to further '**Self Reliance'** of the country in the defence sector and implement **'Ease of Doing Business'** with emphasis on **Simplification**, **Delegation**, **Reduced Timelines** and making the process as **Industry friendly** as possible. Make in India initiative of the Government of India focuses on increasing participation of Indian vendors including MSMEs, and therefore "Make" procedure has been further refined in DAP 2020 to make it more objective and time bound with focus on Indian Industry specially MSMEs. The visionary FDI policy statement of enhancing FDI through automatic route from 49% to 74% in defence will enable in making 'Manufacture in India' a lucrative option for foreign equipment manufacturers.

23. **Srijan Defence Portal**. Pursuant to Atmanirbhar announcement, MoD/DDP launched an Indigenisation Portal on 14 Aug 20, named 'srijandefence.gov.in' as an opportunity for Make in India for Defence to give information on items that can be taken up for indigenisation by the Indian industry. On this portal, DPSUs and SHQs display details of their items which have been imported or being imported, which the Indian industry can design, develop and manufacture as per their capability or through joint venture with OEMs. Presently, more than 400 items of *IN* have been uploaded in the portal. Major items uploaded on the portal which are still pending for indigenisation are included in this document.

24. The Navy as a customer, and the industry as a supplier need to have a clear understanding of the requirements and the plan for

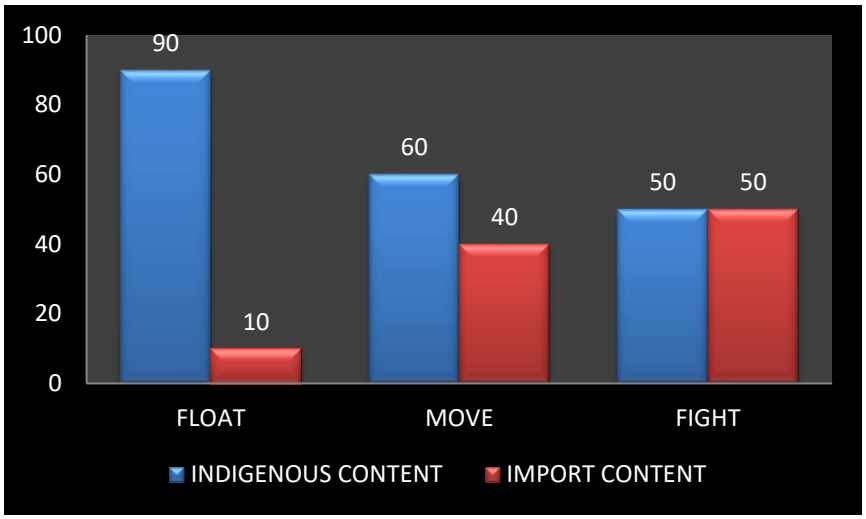
induction and indigenisation. Keeping this aspect in focus, the Indigenisation requirements of the *IN* have been collated under one head based on current requirements with respect to new induction ships and submarines and life cycle support imperatives of the existing *IN* inventory.

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	M/s L&T
(iii)	Anchor Capstans / Windlass	Shipyards/ Industry

Ser	Equipment/ Material	Indigenising Organisation
(iv)	Davits and Boats/ Rigid Inflatable Boats (RIBs)	M/s HH Group, M/s Fibroplast, M/s SHM Ship Care, M/s Hemant Engg
(v)	General Service Life Jackets/ Hazardous Duty Life Jackets	M/s Arnaf Futuristic, M/s Galvanisers India)
(vi)	Foldable Hangar Door	M/s L&T
(vii)	Silicon Rubber Seals	M/s 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	M/s Rochem, M/s Technoprocess
(iv)	Pumps	M/s Best & Crompton, M/s Alekton, M/s BE Pumps
(v)	HP Air and AC Compressors	M/s ELGI Compressors, M/s ACCEL
(vi)	AC and Ref Plants	M/s Voltas, M/s KPCL, M/s ACCEL
(vii)	Stabiliser System	M/s Veljan Hydrair, M/s L&T
(viii)	Gas Turbine Generator (GTG) Control System	M/s BEL
(ix)	Gas Turbine (GT) /GTG Starting Rectifier	M/s Precision Power
(x)	Steering Gear	M/s Veljan Hydrair
(xi)	Motors and Power Generation & Distribution Equipment	M/s Narhari Motors, M/s Marine Electricals
(xii)	Submarine Batteries	M/s Exide, M/s HBL
(xiii)	Inertial Navigation System	DRDO/ RCI

Ser	Equipment/ Material	Indigenising Organisation
(xiv)	Switchboard and APMS	M/s GE Ltd
(xv)	ATS (Auto Transfer Switch)	M/s Marine Electricals
(xvi)	HSR (Helo Starting Rectifier)	M/s Static Transformer
(xvii)	Echo sounder for Submarines	M/s Keltron

(c) **Fight**.

Ser	Equipment/ Material	Indigenising Organisation
(i)	Electro Optical Director for GMs - SOP	M/s BEL
(ii)	Electronic Warfare Systems	M/s BEL
(iii)	Electro Optical Director for GMs - EON	M/s BEL
(iv)	Gun Fire Control System – Lynx U2	M/s BEL
(v)	Anti-Submarine Warfare Fire Control System (ASW FCS)	M/s BEL
(vi)	Supersonic Missile System	M/s BAPL
(vii)	AK630 and Super Rapid Gun Mount	M/s OFBs/ BHEL
(viii)	Torpedo Tube Launchers	M/s L&T, M/s MDS
(ix)	Combat Management System	M/s WESEE, M/s BEL
(x)	Data Link & Net Centric Operation (NCO) Equipment	M/s BEL
(xi)	Weapon Systems Integration	M/s WESEE
(xii)	Composite Sonar Dome	DRDO
(xiii)	Helo Traversing System	M/s L&T, M/s GRSE
(xiv)	Chaff Launchers	M/s OFB/ MTPF
(xv)	CCS/ VCS	M/s BEL
(xvi)	HF/ VLF Receivers	M/s BEL
(xvii)	HF Transmitters	M/s BEL, M/s HAL
(xviii)	V/UHF sets	M/s BEL & M/s ECIL

Ser	Equipment/ Material	Indigenising Organisation
(xix)	Main Broadcast/ Sound Reproduction Equipment	M/s Phi Audicom, M/s Linea Engg
(xx)	Rocket Launcher	M/s L&T
(xxi)	Torpedoes	M/s BDL/NSTL
(xxii)	Mines	M/s ARPPL/ NSTL
(xxiii)	ILMEN-GUVK (system for transfer alignment of Ship borne Gyro parameters to Kamov helicopters) for 1135.6 Ships).	M/s Whirlybird
(xxiv)	Helo Deck Communication System (HDCS).	M/s L&T
(xxv)	Integrated SATCOM Multifunction Antenna (ISMS) for SSK Submarines.	M/s Navstar

3. **Other Equipment & Systems Developed**.

(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. have been completed.

4**.** **Oceanology & Meteorology**. With an endeavor to contribute towards strengthening the spirit of Aatmanirbharta, Directorate of Naval Oceanology & Meteorology (DNOM) has steered the 'Panorama' and 'MAUSM' Projects which will provide Met & Oceanology support to aid the decision makers in planning and understanding evolutions. The details of the projects are mentioned below:-

(a) **Marine Weather Forecast Visualisation System 'Panorama'**

(i) Panorama is a 3D Marine Forecast Visualisation System indigenously developed by CDAC, Pune in collaboration with DNOM.

(ii) Panorama System has successfully replaced the foreign origin weather routing software that were used by *IN* units. The system comprises three modules, of which two modules (Data Deck and Forecast Dashboard) are installed and administered from Indian Naval meteorological Analysis Centre (INMAC), Kochi and the third, client module called 'SeaView' is installed onboard ships, submarines and establishments across *IN*.

(iii) The system is capable of providing visualisation of marine weather parameters for desired location, with a forecast duration of five days at an interval of six hours.

(b) **Development of 'METOC' advanced Users Simulcast Module (MAUSM)**

(i) MAUSM application is an in house effort undertaken by DNOM to bridge the gaps on collation, storage and sharing of meteorological sensor data from point of observation across the *IN* in near-real-time.

(ii) The software is deployed at DIT servers, New Delhi for providing real time access/visualisation of graphical & textual representation of latest weather warning, weather forecast, meteorological codes/ reports and observational Met data recorded (hourly/half hourly intervals) at various *IN* Met offices across *IN*. MAUSM uses NUD as the backbone for communicating between the clients (*IN* users) and central server.

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 built 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) including for Special Operations, 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 built with non-magnetic characteristics. Presently, no indigenous industry 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 a need to indigenously develop CPP shafting systems with greater indigenous content for future projects.

11. **Propulsion System Integration**. The propulsion system comprises 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 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 in the 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, Talwar class, etc. 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 has 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) and 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) 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

(b) 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

(c) Lub Oil and Fresh Water/Feed Water Heat Exchangers which are fitted in various equipment/systems.

(d) Fuel Pumps

(i) Fuel Transfer Pumps

(ii) Stripping Pumps

(iii) Manual Pumps for Aviation Fuel (AVCAT)

(e) Lub Oil Pumps

(i) Transfer Pumps

(ii) Hand Pumps

(f) Sea Water Pumps

(i) AC Condenser Sea Water Cooling Pumps

(ii) Seawater Circulating Pumps

(iii) Fire Pumps

(g) Fresh Water Pumps

(i) Pumps for De-Mineralised water system

(ii) Pump for Technical Fresh water

(h) Desalination Plant Pumps

(j) Bilge system Pumps

(i) Main Drainage Pumps

(ii) Portable Pumps

(k) Hydraulic Pumps

(i) Transfer Pumps

(ii) Manual Pump

(iii) Variable Discharge Pumps

(iv) Hydraulic Pumps for Aircraft Arresting Gear and Lifts

(l) Shafting Components viz. Plummer Bearings, Thrust Pads etc.

(m) Lub Oil Coolers, Condensers and Evaporators of Motor Driven AC Plants and Turbo Driven AC Plant.

(n) Components of Boiler and Turbine Aggregates Control Systems.

(p) Filters of Lube Oil System.

20. The following equipment/ system are also 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 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.

Indigenisation Requirements

26. A list of requirement for indigenisation of Marine Engineering equipment and systems 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

(k) Anechoic Tiles, Submarine Acoustic Coating and other types of Submarine Acoustic Coatings such as Vibro-damping Coatings and Silencers.

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.

(k) Wet Deck Shelters for Special Operations Missions.

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) Tuned Mass Dampers & Pneumatic Shock Mounts for < 200 kgs Equipment.

(iii) 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 'Strategic 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.

Indigenisation Requirements

6. List of requirement for indigenisation 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 & Composite Foldable Hangar doors

Indigenisation Requirements

2. A list of requirement for indigenisation of 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 limited shelf life. Considering these aspects, the following equipment have been identified for indigenous development and production:-

(a) Thermal Night Vision devices with advanced optics and user defined sizes based on application ie worn by human, weapon mounted sight etc.

(b) **Communication Systems**. Communication is the backbone of any Special Operation and every team should have a reliable and rugged communication system. Following to be developed indigenously:-

(i) Software Defined Radios

(ii) Satellite Communication Sets

(iii) Remotely Deployable Command and Control System

(c) **Specialised Crafts for Special Operations and Diving Operations**. Discreet induction of Special Forces in Area of Operations is paramount for a successful mission. Specialised crafts are, therefore, an indispensable part of the planning process. Indigenisation in this field would be a great capability enhancer for special operations in the *IN*.

(d) Air Diving Sets and Closed Circuits Oxygen diving sets with Full Face Masks/Mouth piece for diving operations up to various depth and capable of stand-alone as well as Surface Demand Modes.

(e) Man-Portable Unmanned Aerial Vehicle with following capabilities:-

(i) Ordnance delivery

(ii) Day/night aerial surveillance of enemy targets

(iii) Relay of information between deployed teams and commend post

(iv) Capability of being launched and recovered from a mobile platform eg RHIB, rubber dinghy and surface vehicle

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

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PART – III

NAVAL ARMAMENT, WEAPONS AND SENSORS

CHAPTER 7

ARMAMENT, 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 sixteen Defence Public Sector Undertakings (DPSUs), and an emerging 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 (erstwhile) 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.

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 OFs 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 Systems

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.

Framework and Organisation

22. DAPI was established at IHQ-MoD(Navy) in Apr 2017. The role and responsibility of indigenisation of NA stores has been entrusted to DAPI since its inception. Subsequently, following Indigenisation Cells (ICs) were created at:-

(a) Controllerate of Naval Armament Inspection(West), Mumbai/ CNAI(W)

(b) Controllerate of Naval Armament Inspection(East), Vishakhapatnam/ CNAI(E)

(c) Controllerate of Naval Armament Inspection(South), Alwaye/ CNAI(S)

(d) Controllerate of Naval Armament (Ordnance Factories), Pune/ CNA(OF)

(e) Controllerate of Naval Armament (Defence Production), Hyderabad/ CNA(DP)

23. In addition, following NAI cells at DRDO labs have been mandated to associate during the R&D activities being undertaken for NA stores:-

(a) NAI Cell at HEMRL, Pune

(b) NAI Cell at ARDE, Pune

(c) NAI Cell at NSTL, Vishakhapatnam

24. 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)

25. Some of the Naval Armament Stores proposed for Indigenisation under various indigenisation routes 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
(h)	Flare Launchers
(j)	SSE Ejector
(k)	Insensitive Energetics
(l)	Homing System for Underwater Rockets
Decoys	
(m)	Passive Off-Board Decoys including Inflatable Decoys
(n)	Active Off-Board Decoys
(p)	Ship Launched IR and Smoke Decoys
(q)	A/c Launched IR Flares and Chaff
(r)	Anti-Sonar Decoys (Submarines)
Test and Handling Equipment	
(s)	Torpedo and Missile Loading Gears
(t)	Decoy Loading Gears

Indigenisation Through Academia

26. 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

27. **Major Stores still being imported**. The list of major stores still being imported is 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

Ser	Naval Armament Store
(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

28. 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.

29. 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.

30. The entire industrial might of the country, whether it is the Public Sector Undertakings, Defence Public Sector Units, Large private industries or Medium, Small and Micro Enterprises (MSMEs), need to partner to achieve the goal of self-reliance of the Indian Navy.

Indigenisation Requirements

31. A list of requirement for indigenisation of stores integral to missiles, torpedoes and other underwater stores, guns, gun ammunition, etc. is placed at **Appendix 'D'**.

32. Through this, it is evident that there are enormous opportunities available for Indian industries in various domains to participate in the Navy's indigenisation plan towards sustaining existing imported armaments and eventually replacing them with Indian armaments.

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 to establish a streamlined procedure towards indigenisation of air stores, a document titled "PINAS" Procedure for Indigenisation of Air Stores" was initially promulgated. Subsequently, Manual for Indigenisation of Air Stores (MINAS) was 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, 2017-2022) was published. Subsequently, on culmination of the first 05 years period, a revised Naval Aviation Indigenisation Roadmap for the period 2022-2027 was published on 30 Mar 22. 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 IL38SD and KV 28 ASW helos of Russian origin and western origin platforms such as Seaking ASW helo. 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.

Indigenisation Requirements

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

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PART –V

ELECTRONICS AND ELECTRICAL SYSTEMS

CHAPTER 9

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. New technology in Log systems (eg. Doppler Velocity Log etc.) may be explored by the industry.

5. **Echo Sounder**. Indigenised through M/s Keltron. Indigenisation of Transducer for the Keltron Log is being progressed as import substitution of high value items.

6. **Indigenous ILMEN-GUVK**. Successful development of an indigenous ILMEN-GUVK system (utilised for transfer alignment of Ship borne Gyro parameters to Kamov helicopters) for Talwar & Teg Class ships has been undertaken through the industry and the contract for six systems for Talwar & Teg Class ships has also been concluded. Indigenisation of similar systems installed onboard other platforms is envisaged through private industry.

7. **GPS**. Development of Indigenous Satellite Based Navigation systems with compatibility for GPS/ GLONASS/ IRNSS/ GAGAN, with jamming resistant and anti-spoofing technology.

8. **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, however the present vendor base is limited and can be expanded with participation of the private industry.

9. **Auto-Plotter**. The function of an auto-plotter is to plot and record the position and track of own ship and be used as Action Information Organisation (AIO) for providing integrated track management for targets using ships sensors for tactical operations. At present the vendor base for the Auto plotter in the *IN* is limited and can be expanded with participation of capable private industry partners.

10. **HVLAS**. VLAS is a visual landing aid system installed onboard *IN* ships for providing visual indications to the pilot of a Helicopter, who is coming onboard a ship for recovery. The present equipment fit in the *IN* is of foreign origin which is being supplied by the firm's Indian rep. Design and development of an indigenous Visual Landing aid system by participation of the industry, is considered essential to achieve self-reliance in the domain.

Communication Equipment

11. **Rukmani**. A case for indigenous development of Rukmani (C and Ku Band) has been initiated by the *IN* for both *Above and Below deck* equipment. AIP for the case has been accorded in Apr 22 and the project is presently at feasibility study stage. Participation of the private industry in the indigenous development of the system is solicited.

12. **SATCOM terminals for Submarines**. A proposal for development of SATCOM terminals (Ku Band) for Submarine application is also being deliberated, as the present equipment fit is supplied by foreign OEMs. Participation of the private industry in the project is recommended as it envisages development of in-board equipment, outboard Antenna head units, and necessary ancillaries.

13. **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. 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.

14. **Digital Beam-Forming Based Satellite TV (DB2ST)**. View frequent failure of servo drives of Satellite TV antenna terminal onboard ships at sea, development of 'Digital Beam Forming Based Satellite TV (DB2ST)' is being progressed under Make II category. The technology requirement of DB2ST entails development of an antenna with no movable part and electronic beam steering. The EOI was hosted on MoD website post accord of AoN by SCAPCC on 06 Dec 18. Post receipt of budgetary offers, the Project Sanction Order was issued. However, limited success has been achieved till date. Participation of more firms in the project is recommended for materialising the project.

15. **Integrated Mast (IM)**. The development of UNICORN antenna is being progressed with M/s ATLA, Japan with BEL (Bg) as production partner which aims at integrating V/UHF Communication, EW, IFF, TACAN, Wi-Fi, Link-16, in a single Radome structure. However, the lead time for realisation of UNICORN antenna, customised for *IN* requirements is likely to be 2-3 years view technological challenges and finalisation of terms and conditions for technology transfer. Therefore, as an interim solution, a parallel project for in-house development of an Indigenous Integrated Mast (IIM) (in limited scope) for *IN* Ships on fast track basis is being undertaken through BEL(Bg). *IN* requirements for the proposed IIM envisages integration of ELINT, COMINT, CAW and Data Link antenna on a single mast without Radome. Private industry may propose suitable solutions in the domain, especially development of frequency selectable radome for consideration by *IN*.

16. **Development of Integrated Communication and Surveillance System (ICSS) for Submarines**. One of the most crucial aspects of submarine operations is the RCS when the submarine is at periscope depth. With the advancements in

technology, there is requirement to minimise the number of masts which are protruding above the sea surface. In order to lower the probability of interception, there is a requirement to downsize and integrate sensor payloads so as to fit them on a single mast. The solution is expected to integrate optical surveillance R-ESM, C-ESM, SATCOM and communication antenna payloads. With integration of these payloads, one mast can integrate surveillance, communication and NCO requirements of an underwater platforms. Once developed and inducted on conventional submarines, these solutions can also be suitably adopted for AUVs/ UUVs which have an inherent restriction of available space.

17. **Advanced Multifunction Antenna Systems (Submarine Application)**. Existing multifunction antenna systems onboard submarines support VHF, UHF, S-Band, GPS, IFF and AIS functionalities. However, there are separate antenna systems for VLF, HF and Satellite communication. In order to optimise the available space onboard submarines and obviate the requirement of towed wire antennas for VLF communication, advanced multifunction antenna systems can be developed which support communication from VLF to K bands. Once designed and developed, these antenna systems can be configured to meet the requirements of submarines and well as AUVs/ UUVs. The development will require integration of multiple antennae in a pressure proof radome connected to the inboard equipment of the submarine through hybrid pressure tight cables. Further, these multifunction antenna systems can be installed on all classes of present and future submarine platforms in order to achieve standardisation of antenna systems.

18. **Software Defined Radios (SDR)**. Secure and reliable communication is the backbone of any military operation. Great advancements have been made in the field of military communication around the world. The SDRs are not only compact but also provide multiple modes of communication from a single set. It is felt that efforts should be invested in the indigenous fructification of this technology.

Electronic Warfare

19. **Ship and Air Borne EW Systems**. Development of new generation indigenous Electronic Warfare (EW) systems is being steered through DLRL (Hyd) under programme 'Samudrika'. The programme was sanctioned on 06 Jul 12 for development of seven types of EW systems (03-Ship Borne and 04 Air Borne) and are at various stages of implementation. As a sequel to the Programme Samudrika, development of next generation Advanced integrated EW and COMINT systems is being targeted for which the industry may also consider to undertake Design and Development efforts in collaboration with DRDO.

20. **TR Modules**. *IN* is progressing a case for development of 'T/R module based EW systems, using Active Aperture Electronically Scanned Phased Array' for incorporation in indigenous EW projects. Involvement of Private industry is also solicited in the design and development efforts which is being progressed by DRDO. These modules are envisaged to be a game changer technology in the domain.

21. **Drone Based ELINT System**. As part of the future inductions in the field of EW systems, development of Drone based ELINT system (2-18 GHz) is being undertaken through BEL(Hyd). While system specifications have been finalised and procurement of hardware for the ELINT payload has been completed, there is an enormous scope of R&D in the domain as the present system is targeted in the frequency range of 2-18 GHz only. Participation of the private sector in development of Drone based ELINT systems in the entire spectrum of 0.175 to 40 GHz is envisaged.

22. **Modular ESM Receivers**. Modular design and BLI technology based ESM receiver for 18-40GHz frequency range is a likely field of interest to the IN as it aims to reduce the size of the antennae and provide the flexibility akin to a plug in module. Further, development of Base Line Interferometry (BLI) based low band antenna for ESM coverage for 175-500 MHz frequency band is also envisaged in the future. Participation of the private industry in development of such modular and technologically advanced systems is recommended.

Power Generation & Distribution (PGD) Equipment

23. **Induction of Lithium Ion Batteries**. Case for Li-Ion batteries for submarine and ship application is being progressed by the *IN*. Further, towards inducting Lithium Ion Batteries for ship borne applications, development in potential application areas such as AELs, LED based lamps and UPS is being progressed. Involvement of private industry in development of Li-Ion batteries for these already identified applications, and future applications (as and when finalised by the *IN*) is deemed to be essential.

24. **Vendor Base Expansion**. Vendor base expansion in respect of the following systems is being progressed and capable industry partners are requested to engage with *IN* for offering products for trials as per promulgated specifications:-

(a) Automated Power Management System (APMS) and Main Switchboard.

(b) Alternators.

(c) Motors.

(d) Helo Starting Rectifiers.

(e) LED Luminaries.

(f) Ruggedised UPS and ATS.

25. **Axial Flux Motors**. Conventional Induction motors used onboard ships are Radial Flux Machines where in the magnetising flux is generated in a direction perpendicular to the shaft axis. Axial Flux Motors generate the magnetising flux in a direction parallel to the shaft axis. This design makes the motor power dense and compact. The technologies required for realisation of these machines, which needs to be taken up by the private industry are as under:-

(a) **Electrical Machine Design**. Design of stator and rotor based on available sources of magnetizing current and core properties.

(b) **Permanent Magnet Material**. Use of permanent magnets would yield the performance results from Axial Flux machines.

(c) **Power Conversion Electronics**. The motor control (speed and torque) will be achieved using voltage and current control by a power electronic converter.

26. **Inertial Energy Storage System**. Inertial Energy Storage System (IESS) is an ancient technology. However with the advancements in power electronics this technology is being increasingly used as a replacement of batteries for energy storage devices. IESS comprises a high speed dual feed electrical machine coupled with a flywheel. IESS can be utilised for high power transitional power supply applications for safety critical equipment like Steering Gear Motors. The technologies required for realization of these systems, which needs to be taken up by the private industry are as under:-

(a) **Electrical Machine Design**. Design of a suitable electrical machine with very high speed of rotation (1,00,000 RPM).

(b) **Material Science**. Use of carbon fiber reinforced materials which can withstand the centrifugal forces at high RPM.

(c) **Magnetic Bearings**. The high speed rotating assembly is required to be suspended using magnetic bearings in a vacuum chamber to nullify the effect of drag and maximum utilization of Flywheel energy.

Sensors/ C3 Equipment and their Integration

27. **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.

28. **<u>Air Surveillance Radars</u>**. Early Warning radars have traditionally been sourced from M/s Bharat Electronics in the past. Even though these radars include some foreign content, the maximum constituents of these are sourced by the DPSU from indigenous vendors and MSME. Further, the private sector is also participating in the development of radars with M/s TASL supplying the 3D ASR for the new construction platforms. As part of the future requirements, development of an indigenous 3D-AMDR is being progressed by DRDO. Involvement of the private sector is being further encouraged as replacement of foreign origin ASRs is also likely to be undertaken with suitable indigenous substitutes in the future.

29. **<u>Command Control & Communication System</u>**. 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) Strategic and Tactical Weapons Deployment

30. **C2 System with Integrated Data Link**. *IN* is conceptualising development of a C2 system comprising CMS, SDN and Data link. The technology required for the same is the principal man-machine interface for realisation of combat capability in a networked environment. It should have latest processing capabilities and hardware adaptable as per *IN* requirements for fitment on Naval platforms. The system is also envisaged to be integrated with SDN and a data link for networking with other platforms.

31. **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.

32. 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.

Indigenisation Requirements

33. The list of requirement for indigenisation of Electrical/ Electronic equipment and systems anticipated for fitment onboard is placed at **Appendix 'F'**.

CHAPTER 10

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 of DAP – 2020.

2. Proposals for projects envisaged to be taken up under 'MAKE' category, Projects under Innovations for Defence Excellence (iDEX) scheme and miscellaneous products to be taken up for development are placed at **Appendices 'G', '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'**.

4. Notwithstanding, any private industry/MSME/Startup interested in any of these projects may approach *IN* through the POC listed at the appendices to discuss their proposal and take it forward, keeping the co-ordinating directorate informed. The list of co-ordinating directorates is placed at **Appendix 'L'.**

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.

(l) Software Defined Radio.

(m) Remotely Deployable Command and Control System.

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. **Remotely Deployable Command and Control System (RDCCS)**. A robust and secure Command and Control system is

paramount for a successful Special Operation. Ability to relay and receive time information between the deployed teams and Command post greatly enhance effective decision making. This would require development of high speed modems and a reliable high bandwidth communication backbone.

44. **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.

45. 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.

46. **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.

47. **Intelligence, Surveillance and Reconnaissance**. Intelligence must be able to provide timely, usable, detailed intelligence to allow naval forces including Special Forces teams 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.

48. **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.

49. **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.

50. **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.

51. **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.

52. **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.

53. **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.

54. **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

55. **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.

56. **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.

57. **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.

58. **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.

59. **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.

60. 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.

61. **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 including electric OBMs for smaller boats.

62. 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.

63. **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.

64. **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

65. **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. Indigenous development & early realisation assumes urgency keeping in view the large gestation period of these and resultant ship building efforts.

66. **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.

67. **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.

68. **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.

69. **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.

70. **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.

71. **Specialised Crafts for Discreet Usage**. The warship design program should include research in design and fabrication of Specialised Crafts for clandestine operations by Special Forces. These include fully submersible and semi-submersible manned crafts with the ability to traverse both on surface and under-water.

72. **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

73. 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.

74. **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. Radar Absorbent Paints (RAP) in the frequency range of 8-12 GHz has been developed by NMRL and inducted for application onboard snort and periscope mast of submarines. Development of higher frequency range upto 40 GHz needs to be further explored.

75. **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. Mastic coating for reduction of underwater radiated noise ranging from 200-2500 Hz resulting in vibration damping of the order of 10-15 dB has been developed by NMRL and inducted for onboard application on as required basis. Development of similar coatings for vibration damping in lower frequencies < 200Hz need to be further explored.

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

77. **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

78. 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.

79. **Ship Building Steel**. DMR 249A steel for ship building and DMR 301 & 249B certified steel for submarine application has been

developed successfully for indigenous ship and submarine building programmes. Development of further high strength steels with yield strength of 1000 MPa for submarine constructions is in hand for which industry support would be required.

80. **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.

81. **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.

82. **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.

83. **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.

84. **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.

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

86. **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.

87. **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.

88. **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.

89. **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.

90. **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.

91. 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.

92. **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.

93. **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.

94. **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.

95. **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.

96. **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.

97. **Smart Materials and Sensors**. Smart materials technology consists 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.

98. **Nano-Phase Materials**. A new emphasis in material science centres on the nanometer (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 nanometer 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.

99. 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.

100. **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.

101. **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.

102. **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.

103. **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.

104. **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

105. 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.

106. 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.

107. **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.

108. **Unmanned Surface Vehicle**. Unmanned and Autonomous surface vehicles have a diverse employability for the *IN.* These range from benign missions eg collection of MET data, Tsunami warning to

an offensive role eg swarm attack, *Kamikaze* attacks on opportune afloat/ashore targets, ISR etc.

109. **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

110. 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.

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Appendix 'A'
(Refers to Para 26 Chap 3)

INDIGENISATION REQUIREMENT OF EQUIPMENT AND SYSTEMS MARINE ENGINEERING

Ser	Description
Main Propulsion Equipment	
1.	Marine Diesel Engine (Capacity: 3-10 MW)
2.	Gas Turbine Engines (Capacity: 20-30 MW)
3.	Electric Propulsion System (Capacity: 6-10 MW)
4.	Shafting System-Plummer Blocks and Shaft (with capability to design and integrate)
5.	Fixed Pitch and Controllable Pitch Propeller for Frigate and Destroyer Class of Ships
6.	Waterjet Propulsion System
7.	Optical Torsion Meter
8.	Boiler Control System-INS Vikramaditya
9.	Hydrogen Based Engine (1-3 MW)
10.	Marine Diesel Engine with Stern Drive (330 HP)
11.	Reduction Gears (1-50 MW)
12.	Main Propulsion Control System for Gas Turbine
Power Generators	
13.	Gas Turbine Generators (Capacity: 1-4 MW)
14.	Steam Turbo Generators (Capacity: 1-2 MW)
Auxiliary Equipment	
15.	Magnetic Bearing Compressor for AC Plant
16.	Fuel/Lub Oil Centrifuge
17.	Bilge Oily Water Separator
18.	Variable Stroke Gear (VSG) Pump for Steering and Stabiliser System
19.	Magnetic Bearing Pumps
20.	Fuel Transfer Pump with Motor (400 TPH)
21.	AVCAT Transfer Pump
22.	Advanced Motion Control Systems/Motion Interceptors for Roll and Pitch Stabilisation
23.	Turbo Blower Unit-INS Vikramaditya
24.	Turbo Driven Forced Lubrication Pump-INS Vikramaditya

Ser	Description
25.	Turbo Driven Circulator Pump-INS Vikramaditya
26.	Composite Material Sea Water Pump 125 TPH
27.	Composite Material HP Air Bottles
Miscellaneous Item	
28.	Bow Thrusters

Point of Contact:-

Directorate of Marine Engineering
IHQ MoD (Navy), 129/A, Sena Bhawan,
New Delhi 110 011
Telephone: 011-23010802, 23010622
Email: dme@navy.gov.in

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

INDIGENISATION REQUIREMENT OF EQUIPMENT AND SYSTEMS OF SUBMARINES

Ser	Description
1.	Telescopic Hangers
2.	Integrated Platform Management System (IPMS)
3.	Hoistable Mast
4.	De-Mineralised Water (DM) Plant
5.	System Valves (Hull and Doubler)
6.	HP Air Compressor
7.	MU12 Volumetric Pump
8.	MU12 B Hydraulic Pump
9.	MU12 D1 De-Mineralised Pump
10.	MU12 D2 Self Priming Pump
11.	MU12 D3 Centrifugal Pump
12.	Diesel Exhaust Valves
13.	Turbo Charger-1.1 MW Diesel Engine
14.	Emergency De-Ballasting System
15.	Rosa 42 System for EKM Submarines
16.	Diesel Governor for EKM Diesel Engine
17.	Steering Console
18.	LoX Tank for Air Independent Propulsion

Point of Contact:-

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

INDIGENISATION REQUIREMENT OF AIRCRAFT HANDLING EQUIPMENT

Ser	Description	Point of Contact
1.	Ship Based Hoisting and Lifting Equipment (Aircraft / Vehicle Lifts and Cranes)	Directorate of Naval Architecture '200' Talkatora Stadium Annexe, New Delhi-110001 Telephone: 011-21410495 Email:dna.ihqmod@navy.gov.in
2.	Next Generation Helo Harnessing and Traversing Systems (NGHHTS) with minimal human intervention while operation.	
3.	Telescopic Hangars	
4.	Arresting and Restraining Gear	Directorate of Marine Engineering IHQ MoD (Navy), 129/A, Sena Bhawan, New Delhi 110 011 Telephone: 011-23010802 Email: dme@navy.gov.in
5.	Carrier Based Fixed Wing Aircraft Arrester Wire Recovery System	
6.	Aircraft Catapult Launch System	
7.	Flight Deck & Hangar Fixed Fire Fighting System	
8.	Rail-less and Wireless Aircraft Traversing System	

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Appendix 'D'
(Refers to Para 31 Chapter 7)

INDIGENISATION REQUIREMENT OF NAVAL ARMAMENT STORES

Ser	Item Description	End Use	Point of Contact
1.	Universal Proximity and DA Fuze for 76/62 SRGM with Electronic Adaptable to 76-127mm Ammunition	76/62 Super Rapid Gun Mount (SRGM)	Directorate of Armament Production & Indigenisation, IHQ MOD (Navy), West Block -V, Wing No. 1 (FF) RK Puram, New Delhi – 110 066 Tele: 01126194691 Email: dapi.ihq@navy.gov.in
2.	5" Mobile Target Emulators for C303/S Countermeasure System		
3.	Limpet Mines Mk 414 (7kg) and Mk 430 (15Kg)		
4.	Development of 76/62 SRGM ammunition (HE and HEPFF variants)	76/62 Super Rapid Gun Mount (SRGM)	
5.	IR Decoy	Kavach LRCR, MRCR & SRCR (Chaff Rockets)	
6.	Advanced Artillery Smart Shell Design – SUDARSHAN	--	
7.	Finite Element Analysis of SRGM barrel	--	
8.	Design and Development of Polymer/ Composite Based Driving Band for Gun Ammunition.	--	
9.	Identification of Molecules for making insensitive Explosives	--	

Ser	Item Description	End Use	Point of Contact
10.	Kavach Chaff Rockets	Kavach LRCR, MRCR & SRCR	Directorate of Armament Production & Indigenisation, IHQ MOD (Navy), West Block -V, Wing No. 1 (FF) RK Puram, New Delhi – 110 066 Tele: 01126194691 Email: dapi.ihq@navy.gov.in
11.	Electromechanical Fuze	Mini Depth Charge(MDC)	
12.	Primer for SRGM Ammunition	Super Rapid Gun Mount	
13.	Electric Detonator DM-12	SUT (Torpedo)	
14.	Contact Exploder N-239	CET 65E, TEST 71ME Torpedo	
15.	SRGM Ordnance Sub Components	Super Rapid Gun Mount	
16.	Barrels and Liners for Various Guns	Naval Guns	
17.	PP3CP	Fire Extinguisher	
18.	Contact Explosive Device	TE2-02 Article (Torpedo)	
19.	53-65KE Torpedo Preparation Items	53-65KE Heavy Weight Torpedo	Controllerate of Naval Armament Inspection(East) PO : Naval Armament Depot, Vishakhapatnam 530009 Tele: 0891-2571143 Email: enccnaiv@navy.gov.in
20.	55 Types Spares	53-65KE Torpedo MR Items	
21.	Molykote Grease and Loctite	Barak Missile	
22.	Springs, O-Rings Seals etc	SRGM Gun	
23.	Spring and Cocking lever	AK 176 (Gun), 40/60 Gun	
24.	Missile Head 3M-14 E.9210.0	Club Missile	
25.	Radar Homing Head У554-5		

Ser	Item Description	End Use	Point of Contact
26.	On Board Computer Complex (OBCC) БЦВМ3АРЯ-43		Controllerate of Naval Armament Inspection(East) PO : Naval Armament Depot, Vishakhapatnam 530009 Tele: 0891-2571143 Email: enccnaiv@navy.gov.in
27.	'O' Rings (12 types)		
28.	Inert Warhead for Club 3M-54E	3M54E Missile	
29.	Auto Pilot Control Unit ДВ2.564.012	P-Series Missile	
30.	Altitude Prediction Gyro ДВ2.562.096		
31.	Rate Gyro		
32.	Radio altimeter ГУ1.000.040.-05		
33.	Self-Contained Noise Maker Battery	TE2-02/ MG-74 Torpedo/ Decoy	
34.	One Shot Battery Compartment with squib and accessories		
35.	Long Storage Battery		
36.	Float along with accessories (Article 2600/ MG 74)		
37.	Warhead		
38.	Contact Fuze		
39.	Ejection Charge		
40.	Squibs		
41.	Start Battery		
42.	Long Storage Bottle		
43.	Rubber Components		
44.	Towed Reel		
45.	Torpedo Reel		
46.	Vertrel XF	53-65KE Torpedo	
47.	Oil 4LF		
48.	Missile Head 3M-54 E.9240.0	Club Missile	

Ser	Item Description	End Use	Point of Contact
49.	Monoblock 3M-14 E.9230.0		Controllerate of Naval Armament Inspection(East) PO : Naval Armament Depot, Vishakhapatnam 530009 Tele: 0891-2571143 Email: enccnaiv@navy.gov.in
50.	Control Unit (CU) БУ-40		
51.	Radio Altimeter РВэ-12 ГУ2.000.106-07		
52.	Gyro Inertial Unit ГИБ-123-1		
53.	Plasticiser Sealant ПАСТА Тф-1		
54.	Timer Missile bIK2.320.083	P-Series Missile	
55.	Timer Radar bIK2.320.094		
56.	Amplifiers		
57.	Power Supply Unit лИ2.087.747		
58.	Communication Unit лИ3.622.557		
59.	RF portion of Receiver bIK2.026.010-1СП		
60.	Current Control Unit (bIK)2.032.188		
61.	Synchroniser unit bIK2.075.035-1СП		
62.	Auto Tracking Unit bIK2.076.272-1СП		
63.	Rectifier Unit		
64.	Steering Engine КЯ2-503-026	53-65 KE Torpedo	
65.	Accumulator Battery 743.19.007-1		
66.	Steering Engine 243.08.000-01Э		
67.	Converter 253.58.000-I МЭ		
68.	Linear Acceleration Pickup 243.64.000. МЭ		
69.	Retarder 243.13.000		

Ser	Item Description	End Use	Point of Contact
70.	Water Discharge Governor 243.06.027		
71.	Nozzle Box 243.40.000 МЭ		
72.	Valves (243.06.031, 243.06.032)		
73.	Steering Engine 810.10.11-01		
74.	Spares for 53-65 KE Torpedo	53-65 KE Torpedo	
75.	Receiving Coil 243.91.002 МЭ and улр гилш 468332.084		
76.	Depth and Roll Recorder ЕП001-04-020-II		
77.	26 Types of Cables & Conductors	TEST 71ME Torpedo	Controllerate of Naval Armament Inspection(West) Naval Dockyard, Gun Gate, Mumbai 400023 Tele: 022-22751977 Email: wnccnaimb@navy.gov.in
78.	Consumables for Torpedoes and Decoys		
79.	Electronic Pack 2517.040.0050		
80.	52 Types of Pipes & Hose Pipes		
81.	Headlight 2517.034.0000		
82.	Depth Sensor 1563.039.0500		
83.	Poppet Valve 002.84.030		
84.	Bollard 2526.003.009		
85.	Battery Hose Pipe for TEST 71ME		
86.	Torpedo Reel End Connector		
87.	14 types of springs		
88.	10 Types of Valves		
89.	02 Types of Piston		
90.	07 Types of Bearings		
91.	N239 contact exploder		
92.	Electronic Pack 2517-040-0300	CET-65E Torpedo	

Ser	Item Description	End Use	Point of Contact
93.	Air Flask / Long Life Balloon (LLB) 260.030.122		Controllerate of Naval Armament Inspection(West) Naval Dockyard, Gun Gate, Mumbai 400023 Tele: 022-22751977 Email: wnccnaimb@navy.gov.in
94.	Bulk Head Terminals		
95.	10 types of Bus Bar		
96.	06 Types of Cables (Loose), 14 Types of Cable, 06 Types of Cable(inbuilt)		
97.	21 Types of Pipes		
98.	Bollard- 02 Nos.		
99.	Sensor		
100.	18 Types of Rubber Embedded Valves and Collars		
101.	03 Types of Connector		
102.	02 Types of Hose		
103.	Emergency Battery	A244S Torpedo	
104.	Squibs		
105.	Ex Head PCB'S (CR cards)		
106.	Pressure Switches (N 212000100, N 212000101)		
107.	Varnish and Paint		
108.	Inverter of MOD 3		
109.	SBH of MOD 3		
110.	FIAM MOD 0 (Set) with Accessories		
111.	Battery Section of Mod 3		
112.	Electronic Rack of MOD 0 Torpedo		
113.	Acoustic Head MOD 0		
114.	Locking Ring II Complete 279.840 322	SUT Torpedo	
115.	A- Spool and B-Spool		

Ser	Item Description	End Use	Point of Contact
116.	Mechanical and electronic assemblies of SUT Torpedo		Controllerate of Naval Armament Inspection(West) Naval Dockyard, Gun Gate, Mumbai 400023 Tele: 022-22751977 Email: wnccnaimb@navy.gov.in
117.	Propeller		
118.	Gas Generator	Kashmir Missile	
119.	Section No.4 (9M381э.0401.000-01)		
120.	Radar Homing Head (RHH) 9э501э		
121.	Radio Fuse 9э241M1э		
122.	Auto-pilot БУ-10		
123.	Turbo Generator Power Supply unit 9Б256		
124.	Section 1 Assembly 9M317.0100.000-05	SHTIL Missile	
125.	Section 4 Assembly 9M317.0400.000-02		
126.	Plug Fitting (End Ring) 9M38.0000.002		
127.	KH-35 Explosive Bolts	KH-35 Missile	
128.	Flare Launcher Basket for Signal Flares	Flare Launching System (Kalveri Class)	
129.	Scoop Bulk Head (Mod 3)	A244S Torpedo	
130.	Missile Balwanka 3M14eBW	Series Inspection of EKM submarines	
131.	Missile Mockup 3M14ETBM and 3M54ETBM		
132.	Imitator-R	EKM Submarine	
133.	TOSIM	Kalveri Submarine	

Ser	Item Description	End Use	Point of Contact
134.	Cross Gauge for EKM Submarine	EKM Submarine	Controllerate of Naval Armament Inspection(West) Naval Dockyard, Gun Gate, Mumbai 400023 Tele: 022-22751977 Email: wnccnaimb@navy.gov.in
135.	Cross Gauge for Kalveri Class Submarines	Kalveri Class Submarine	
136.	TONA	SSK Submarines	
137.	Caliber Jig	Shishumar Class	
138.	Torpedo Reel	TEST71ME Torpedo	
139.	Hydraulic Pump with Reduction Unit 2517.011.0000-01		
140.	Distance Gear 2526.010.000		
141.	Air Flask and Fluid Flask		
142.	Valves		
143.	Filter 2526.043.000		
144.	Noise Maker 094.033.000-I		
145.	Noise Emitter	CET65E Torpedo	
146.	Pressure Pick up		
147.	Relay МАГ-11		
148.	FIAM Mod 3 (SET) with Accessories WMP 324400405	A244S Torpedo	
149.	Transducer, Pressure N211000200, N211000202		
150.	SRP Electronics W036718 and SRP Electronics Cable		
151.	Sensor Box W003198		
152.	Arming Device of Mod 0 and Mod 3 W002257		
153.	Acoustic Head for Mod 3 Torpedo WMP324400429		

Ser	Item Description	End Use	Point of Contact
154.	Inclinometer (N215000200, N215000100)		Controllerate of Naval Armament Inspection(West) Naval Dockyard, Gun Gate, Mumbai 400023 Tele: 022-22751977 Email: wnccnaimb@navy.gov.in
155.	Pressometer Support WMP324400232		
156.	DAS Recorder WMP324400029		
157.	Muzzle Velocity Discharge Pressure (MVDP) measuring equipment	SSK S/M (Harpoon Missile mock up firing)	
158.	Propellers, Rudders and ailerons	TEST71ME Torpedo	
159.	Towed Reel		
160.	Tail Unit 2517.020.0000		
161.	Converter and Frequency Stabilizer ПТО-1000 & БР42Н		
162.	Propeller	CET65E Torpedo	
163.	Pneumatic Switch (APS) 260.042.006		
164.	Hydraulic Fluid Flask 282.019.030		
165.	Steering Engine (829.25.03), (810.11.10)		
166.	Gyroscope W018940	A244S Torpedo	
167.	Elevators Yoke (Heel Trim Motor With Cable) W001968		
168.	Inverter(EX-HEAD) W036615		
169.	Card (B1 W001673, B2 W001674)		
170.	Sealing Paste, Nitrocellulose Glue etc	SHTIL Missile	

Ser	Item Description	End Use	Point of Contact
171.	SBP for 100mm Ammn	100mm Ammn	Controller of Naval Armament, Controllerate of Naval Armament Inspection (Ordnance Factories) Naval Armament Inspectorate At Ammunition Factory Khadki, Pune 411003 Tele: 020-25810852/ 25823207 Email: naipune@navy.gov.in
172.	Primer for Ammunition	GUV-7 Primer for 100 mm & 76.2 mm	
173.	Refilling and Indigenisation of Warheads	Club 3M 14E TLAM and A244S Mod 0 Torpedo	
174.	30 mm Barrel using alternate material	AK-630 Gun	
175.	Propellant for PK-16 Chaff	PK-16 Chaff Rockets	
176.	Low Smoke EDB Propellant for TIC	Torpedo Impulse Cartridge	
177.	CE pellet of Contact Exploder И-239	CET-65E Torpedo	
178.	PDM 9030A1 Fuze for SRGM	76/62 SRGM Gun	
179.	Steel CC for SRGM	76/62 SRGM Gun	
180.	Fuze for 76.2mm Ammn	76.2mm Ammn	
181.	3M54E and 3M54TE warhead	CLUB Missile	
182.	SAP rounds	76/62 SRGM Ammn	
183.	AO-18 spares using indigenous material	AO-18 Gun	
184.	DM12 Detonator Electric for SUT Torpedo	SUT Torpedo Exploder	Controllerate of Naval Armament (Defence Production) Naval Armament Inspectorate PO – Kanchanbagh
185.	PCBs of Electronic Rack (XA22, XA23, XA24, XA09) for A244S Torpedo	A244S Mod 0 Torpedo	

Ser	Item Description	End Use	Point of Contact
			Hyderabad – 500059 Tele: 040-24340589 Email: naihyderabad@navy.gov.in
186.	Towed Reels	Test 71ME Torpedo	Controllerate of Naval Inspection(South) PO: Naval Armament Depot Alwaye 683563 Tele: 0484-2838384 Email: sncnaia@navy.gov.in
187.	Torpedo Reels		
188.	Battery Section Shell	SUT Torpedo	
189.	A Spool	SUT Torpedo	
190.	B Spool		
191.	P-21/22 Surface to Surface Missile System	P-Series Missile	Directorate of Armament Production & Indigenisation, IHQ MOD (Navy), West Block -V, Wing No. 1 (FF) RK Puram, New Delhi – 110 066 Tele: 01126194691 Email: dapi.ihq@navy.gov.in
192.	Club Surface to Surface Missile System	Club Missile	
193.	MRSAM Surface to Air Missile System	MRSAM	
194.	SRGM	76/62 SRGM Gun	
195.	Kashmir MR surface to air missile system	Kashmir Missile	
196.	Shtil MR Surface to Air Missile System	SHTIL Missile	
197.	Pyrotechnic	Pyrotechnic common to ships/ submarines	
198.	A-176 gun system	A-176 gun	
199.	A244S torpedo	A244S Torpedo	
200.	Limpet mine disposal equipment	Limpet mine disposal	
201.	RVV "Air to Air" Missile	RVV Missile	
202.	KH-35E Missile	KH-35E Missile	

Ser	Item Description	End Use	Point of Contact
203.	A-190E Gun System	A-190E Gun System	Directorate of Armament Production & Indigenisation, IHQ MOD (Navy), West Block -V, Wing No. 1 (FF) RK Puram, New Delhi – 110 066 Tele: 01126194691 Email: dapi.ihq@navy.gov.in
204.	AK-176/ AK 726 Guns	AK-176/ AK 726 Guns	
205.	Uran Surface to Surface Missile System	Uran Surface to Surface Missile System	
206.	AK 100/ AK 190 Guns	AK 100/ AK 190 Guns	
207.	RBU6000, PK2, PK10 & PK16 Rocket Launchers	RBU6000, PK2, PK10 & PK16 Rocket Launchers	
208.	CET65E/ TEST71ME/ 53-65KE Torpedoes	CET65E/ TEST71ME/ 53-65KE Torpedoes	
209.	SM39 Missiles	SM39 Missiles	
210.	SUT Torpedo	SUT Torpedo	
211.	TE-2-O2/ MG-74ME Torpedo	TE-2-O2/ MG-74ME Torpedo	
212.	Anti-Sonar Decoys	Submarines	
213.	Smoke Markers and Float Smoke	Miscellaneous	
214.	Gauge Testing Blow of Striker & Striker-Eccentricity Equipment		
215.	Plug Bore Gauge		
216.	Enamels, Solvents, Hardners and Primers of various types		
217.	Ship-Borne Close-in Weapon Systems		Directorate of Weapons Equipment IHQ/ MoD (Navy),
218.	Anti-Submarine Rocket Launchers		

Ser	Item Description	End Use	Point of Contact
219.	Ship-Borne Medium Range Gun	Miscellaneous	6th Floor, 'D' Block, Defence Offices Complex, Africa Avenue, New Delhi -110023 Tel:011-26771356 Email: dwe@navy.gov.in Directorate of Weapons Equipment
220.	Torpedo Tube Launcher for Light Weight Torpedoes		
221.	Ship-Borne Sonars for Large Ships		
222.	Hull Mounted Submarine Sonar		
223.	Expandable Aerial Targets		
224.	Anti Torpedo Decoy		
225.	Ship-Borne Surface Surveillance Radar		
226.	Portable Diver Detection Sonar		
227.	Composite Sonar Dome for Ships		
228.	Upgraded 76 mm SRGM		
229.	AWS Fire Control System for Ships		
230.	Heavy-weight Torpedo Launcher for Ships		
231.	Multifunction Surveillance & Threat Alert Radar for Ships		
232.	Ship based Medium Range Surface to Air Missile		
233.	Loitering Munitions		
234.	Anti-Submarine Warfare Sonar for shallow water		
235.	Ship Based Vertical Launched Short Range Surface to Air Missile System		
236.	Supersonic Weapon Imitating Flying Target		

Ser	Item Description	End Use	Point of Contact
237.	Mine Counter Measures (Autonomous Surface Vessel)	Miscellaneous	IHQ/ MoD (Navy), 6th Floor, 'D' Block, Defence Offices Complex, Africa Avenue, New Delhi -110023 Tel:011-26771356 Email: dwe@navy.gov.in
238.	Ship-Borne Gun Direction Fire Control Radar		
239.	Ship-Borne Electro Optic System for Weapons		
240.	Ship-Borne Electro System Stabilised Optronic Pedestal (SOP)		
241.	Ship based Expendable Aerial Target		
242.	Expendable Underwater Target for Naval Applications		
243.	Automatic Missile Detection Radar for Ships		

Appendix 'E'
(Refers to Para 5 Chap 8)

INDIGENISATION REQUIREMENT OF NAVAL AVIATION STORES/ EQUIPMENT

Ser	Description	Part Number
1.	Coupling Unit	BS-29K
2.	Data Acquisition and Processing Unit	BSOI-1K
3.	Unit HF Trans receiver	B1-BZ2M
4.	Control and Monitoring Unit	BARK-42
5.	Onboard Oxygen Generation System	BKDU-130
6.	Optical Mechanical Unit	BOM
7.	Aircraft Accessory Gearbox	KSA-33M
8.	Head Up Display	IKSH-1K
9.	Hydraulic Pump of Main Hydraulic System	NP92A
10.	Gear Box Oil Cooler	2404A
11.	Multi-Functional Display	MFI-10-5I
12.	Antenna Coupler Unit	B5A2D-KTSIII
13.	Multifunctional Display	MFI-10-7-01
14.	Short Range Navigation System	RSSRN-85
15.	Air Data Computer	SVS-2TS-2 SER.3
16.	Control Actuator	RPD-17
17.	Control Actuator	RPD-15
18.	Video Data Processor	VDP-29
19.	Specialized Digital Computer	A-380-002
20.	Air to Air Receiver	A-312-010
21.	Trans receiver	UNIT-2
22.	Generator Drive	PGL-21K
23.	Adjuster, Protection and Control Unit	BRZU-1VM
24.	Limiting Signal Computer	VSO-29
25.	Data Exchange Unit	A-380-036
26.	MLS Receiver	2.027.163-02
27.	Mission Computer	BTSVM-486-2K-01
28.	Integral Sensor Unit	IBD-51

Ser	Description	Part Number
29.	Plunge Pump	NP-115M
30.	DC Generator	GSR-12BKM
31.	Navigation and Landing Unit (NLU)	2.000.344-01
32.	Unit (Radar Exciter)	FGM 129-22
33.	Unit (Radar Transmitter)	FGM 29-02
34.	Integral Drive Vane	PGL-21K
35.	Microwave Landing system (MLS) Receiver	2.027.163-02
36.	20.1" Display	K9345740
37.	Lift Transducer	C80507-4
38.	INS-GPS (TNL-16G)	1406.0011.00.00
39.	Speed Control Indicator	C-80505

Point of Contact:-

Directorate of Air Projects and Plans
IHQ/ MoD (Navy), 5th Floor, 'D' Block,
Defence Offices Complex, Africa Avenue,
New Delhi -110023
Telephone: 011-26771521
Email: dapp@navy.gov.in

Appendix 'F'
(Refers to Para 33 Chap 9)

ELECTRICAL/ ELECTRONIC PROJECTS UNDER PROCESS/ INDIGENISATION REQUIREMENT

Ser	Description	Status	OEM/Vendor
1.	Motors of Various Ratings	Completed (Vendor Base Expansion in progress)	M/s Narhari Engg Works M/s Poly Phase Motors M/s Ketaki Engg Pvt. Ltd M/s Laxmi Hydraulics Pvt Ltd, M/s KEC M/s Megha Rototech
2.	Switchboard with APMS	Completed (Vendor Base Expansion in progress)	M/s L&T M/s Marine Electrical M/s Siemens Ltd M/s Precision Power Products M/s Symtronics
3.	ATS (Auto Transfer Switch)	Completed (Vendor Base Expansion in progress)	M/s Precision Power Products M/s Marine Electrical, Mumbai M/s Sipani Defence, Bengaluru
4.	Helo Starting Rectifier (HSR)	Completed (Vendor Base Expansion in progress)	M/s Static Transformers M/s Precision Power Products M/s L&T
5.	LED Light Fitting Including Magazine Light Fitting	Completed (Vendor Base Expansion in progress)	M/s Ray Enterprises M/s Mcgeoch Marine M/s Zeal Tech M/s Sipani Energy Ltd.

Ser	Description	Status	OEM/Vendor
6.	IBS (Integrated Bridge System)	Vendor Base Expansion is envisaged	M/s Marine Electricals (Participation of more vendors is being encouraged).
7.	Auto Plotter	Vendor Base Expansion is envisaged.	M/s Elcome Marine
Indigenisation in Progress/ Planned			
8.	HVLAS	-	M/s AMA M/s Elcome Marine Integrated Systems
9.	EM LOG Transducer	-	M/s CDAC
10.	Development of indigenous Echo Sounder for Submarines	-	M/s Keltron
11.	Development of Integrated SATCOM Multifunction Antenna (ISMS) for SSK Submarines	-	M/s Navstar
12.	Fiber Optic Gyro (FOG) for Ship Application	-	M/s RCI
13.	SSPA for AMDR Radars	-	TDF Route through DRDO (M/s AIDIN Technologies)
14.	Drone Based ELINT System	-	M/s BEL
15.	Indigenous Integrated Mast (IIM)	-	M/s ATLA, Japan & M/s BEL
16.	RF Over Fiber Based CAW with Conformal Antenna	-	M/s BEL & M/s CDAC
17.	Single Chip/ Single Board Radio	-	M/s CDAC
18.	Development of Varuna Lite EW System	-	M/s BEL
19.	Digital Beam-Forming Based Satellite TV (DB2ST)	-	M/s Rangsons

Ser	Description	Status	OEM/Vendor
20.	Helo Deck Communication System (HDCS)	-	M/s L&T
21.	RF Components for EW systems	-	Under TDF scheme through DRDO
22.	Axial Flux Motors	-	Through iDEX route, M/s Tressa Energy
23.	Inertial Energy Storage Systems	-	Through iDEX route, M/s ELMOT
24.	Li-Ion Based AELs and Lead Lamps	-	M/s Zeal Tech
25.	BLI Based 18-40 GHz ESM Sub Unit	-	M/s BEL
26.	SATCOM Terminals for Submarines (Ku Band)	-	M/s ECIL M/s BEL
27.	Rukmani (C and Ku Band) for Ship Application	-	M/s BEL
28.	Integrated Communication and Surveillance System for Submarines	-	DRDO Project. Being steered by NPOL, Kochi.
29.	Modular ESM Receivers	-	M/s BEL
30.	TR Modules for EW Systems	-	M/s BEL
31.	Software Defined Radio	-	M/s BEL
32.	Inertial Navigation System for Ship Applications	-	M/s BEL
33.	EW Systems -Shipborne	-	M/s BEL
34.	Shipborne High Accuracy ELINT System 0.17 to 40MHz	-	M/s BEL
35.	SDR for Combat Ships (SDR NC)	-	M/s BEL
36.	Battery Monitoring System for Submarines	-	M/s Precision Power Products
37.	Alternators for Ships (up to 1.5 MW)	-	M/s Kirloskar Electric Co Ltd

Ser	Description	Status	OEM/Vendor
			M/s Cummings Generator Technology M/s Elmot Alternators Pvt Ltd M/s TDPS M/s BHEL
38.	DC Insulation Measuring Instrument for EKM Submarines	-	M/s Precision Power Products
39.	Shipborne Main Broadcast System	-	M/s Elcome Integrated System, Mumbai M/s Linia Engineering Services M/s Phi Audiocom
40.	Data Network for Ships	-	M/s BEL
41.	Ship Borne 1KW High Frequency Trans-Receiver	-	M/s Avantel
42.	IFF MKXII-S	-	M/s BEL
43.	Intercom System for Ship and Submarines	-	M/s Linia Engineering Services
44.	Link II MOD III for Ships and Submarines	-	M/s BEL
45.	Radar Finger Print System for ELINT Application	-	M/s BEL
46.	Deep Sea Side Towing Winch (DS4TW)	-	M/s L&T
47.	COMINT (Ship Based)	-	M/s BEL
48.	Remote Embedded System Support (Remote Control/ Monitoring Panels for Electrical/Machinery) for Naval Ships	-	M/s Info Allies M/s Yeoman Marine Services Pvt Ltd.
49.	High Data Rate VLF-HF Receivers for Ships	-	M/s BEL(Panchkula)
50.	IU for AWOS-MNS for VKD	-	M/s Keltron

Ser	Description	Status	OEM/Vendor
51.	Li-Ion Battery for Submarine Application	-	-
52.	LCU (AMDR 2D)	-	-
53.	Rotary Joint (AMDR 2D)	-	-
54.	TWT (AMDR 2D)	-	-
55.	BSI Module (RLG Sigma-40)	-	-
56.	SPC (Fregate M2EM)	-	-
57.	Mobile Cable Handling Assembly (MoCHA)	-	-
58.	LED Based Taxy, Landing and Navigation Lights	-	-

Point of Contact:-

Directorate of Electrical Engineering
IHQ MoD (Navy), D II Wing, Sena Bhawan,
New Delhi 110 011
Telephone: 011-21411705, 23010946
Email: dee@navy.gov.in

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Appendix 'G'
(Refers to Para 2 Chap 10)

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.	Tactical Mission System for Aircrafts and Helicopters
22.	Personnel Rescue Beacons (PRBs)
23.	Motor Boat Engines
24.	5MW-12 MW Electric Propulsion Equipment (Warship grade)
25.	Development of Oily Water Seprator-5TPH
26.	127 mm, 76 mm, 30 mm Naval Guns and their Ammunition
27.	Shore Based Guided Rockets
28.	Glide Surface to Surface Missile
29.	Autonomous Surface Vessel for Mine Counter Measures
30.	Semi-Submersible Autonomous Vessel
31.	Autonomous Surface Craft
32.	High Endurance Autonomous Underwater Vehicle

Ser	Project
33.	Lightning Detection System
34.	Electro Optical Infrared Search and Tracking
35.	Auto Take-Off/Landing Recording System
36.	Next Generation Helo Harnessing and Traversing System
37.	Buoyancy Glider

Point of Contact:-

Directorate of Indigenisation
IHQ/ MoD (Navy), 5th Floor, Chanakya Bhawan,
Chanakyapuri,
New Delhi 110021
Telephone: 011-24103984, Fax: 011-24122689
Email ID: doi-navy@nic.in

Appendix 'H'
(Refers to Para 2 Chap 10)

PROJECTS UNDER INNOVATIONS FOR DEFENCE EXCELLENCE (iDEX) SCHEME

Ser	Project
1.	Development of 4G/LTE based Tactical LAN
2.	Unmanned Surface & Underwater Vehicle
3.	AI based Logistics and Supply Chain Management
4.	Development of Advanced Technology Based De-salination Plant and Bilge OWS System
5.	Stabilised C & KU Band Terminal Antennae
6.	Low Cost Autonomous Underwater Swarms
7.	Machinery Health Monitoring System
8.	Enhancing UDA by the Use of AI/ML or Other Novel Techniques
9.	Miniaturisation for Implementation on Mini and Micro Drones and Drone SWARMS
10.	Development of a Private 5G Network for Machine to Machine Communication
11.	Development of Inertial Energy Storage System for Naval Applications (IESS)
12.	Non-Lethal Devices for Stopping Vessels at Sea
13.	Artificial Intelligence and Augmented Reality Based Virtual Assistant
14.	Smart Loitering Munitions
15.	Axial Flux BLDC Motors
16.	Integrated Maritime Domain Awareness Platform for Detecting Anomalies using AI/ML
17.	Minimising Downtime /Outages in Mission Critical Application
18.	Monolithic Telescope-Based Imaging System
19.	Automated Celestial Navigation System
20.	Development of 11mtr 'All Electric' Work Boat
21.	Non-availability of an Indigenous SIEM Solution Developed Based on Open Source Framework for Monitoring the Endpoints which are not Connected to NUD
22.	Non-availability of a Proper Advance Sanitisation Tool for Sanitising Data Transferred between Multiple Air-gapped Networks

Ser	Project
23.	Build Autonomous AI Based Threat Detection and Threat Elimination Engine to Block Ransomeware and Zero-day Attacks
24.	Low Latency Multicast Accelerated File Transfer and Video Streaming over Existing SATCOM Links to Remote Platforms/ Sites.
25.	Below the Noise Floor Modems in S/ C/ Ku Band (1 Kbps to 20 Mbps) to Operate within Existing out/ in Routes on S, C and Ku Band.
26.	Portable (Handheld / Manpack) Ku Band Terminal for *IN* SATCOM Network.
27.	Development of On-board Processing and Beam Switching Payload for 'Ku' and 'Ka' band GEO Satellite for High Throughput Maritime Requirements.
28.	Beam Steering Ku Band SATCOM Antenna over IN SATCOM Network for MR Aircraft.
29.	Compact, Lightweight, Multiband SATCOM (UHF/ S /C/ Ku / Ka) SDR for Ships, Submarines and aircraft
30.	Customised Remote Modem with Ruggedised Field Programmable Gate Array (FPGA) based Platform with Inbuilt Post Quantum Encryption for VSAT Baseband.
31.	Disposal of expired Ammunitions & Bombs into Sea
32.	Heavy Lift Tethered Aerial Vehicles (HLTAV)
33.	Water Mist Fixed Firefighting System
34.	Blast Proof Doors
35.	Compressor Washing Rig
36.	Multi – Sensor Monitoring of Machinery
37.	AI Based Adapted Noise Cancellation for Sonar of Autonomous Underwater Vehicle (AUVs) and Ship Borne SONARS
38.	Axial Flux Motor Based Light Weight Electric OBM with Optional Fuel Cells
39.	Portable Underwater Diver Delivery System (PUDDS)
40.	Submersible Boat
41.	Disposable Light Weight Drone (DLD)
42.	Underwater Remotely Operated Vehicle (UWROV)
43.	Hardware of INS Information System
44.	Submarine Voyage Data Recorder (SM-VDR)
45.	Submerged Submarine Launched Expendable Bathy Thermograph (SSLXBT)

Ser	Project
46.	AI Bsed FOD Detection System for Air Station
47.	Beam forming ASIC Based Radar with Massive MIMO Technology
48.	AI Based Collision Avoidance System
49.	Automatic Floatation Device
50.	Hydroacoustic ASW Vector Sensors
51.	Converting Oxygen Torpedoes to UW Targets
52.	Blue Green Lasers
53.	Reusable Offboard Missile Decoy
54.	Microwave Obscurant Clouds
55.	Portable RCS Measuring Device
56.	Autonomous Weaponised Boat Swarms
57.	AI Based Multi Radar Signals Conversion, Distribution and Multi Target Tracking
58.	Depth Based Positioning System
59.	AI Based Ship Recognition Software
60.	Expandable/Tethered Submarine Communication Buoy
61.	Fire Suppressant
62.	Moisture Wicking Hydrophobic Weapons Cover
63.	Noise Augmentation Unit
64.	Smart Shore Supply and Charging Cable Gangway
65.	Smart Shore Supply and Charging Cable Mobile Units
66.	Non-Hull Penetrating Connectivity to Submarines
67.	Submarine Communication Using Blue- Green Laser
68.	Super Hydrophobic Coating for Torpedoes
69.	30 mm Proximity Fuse
70.	Long Range Communication Technology for Locating Torpedo
71.	AI Based Gun Part Inspection
72.	AI Based Barrel Crawling Bot Inspection System
73.	Personal Locator Band with Fall Detection
74.	Smart Firefighting Breathing Apparatus
75.	Remote controlled NBC Monitoring Bot
76.	Indigenous Morpene Foaming Agent
77.	Axial Motor Based Light Weight Portable Submersible Pump
78.	Firefighting Bot
79.	Caged Drone with TIC for Fire Fighting
80.	Aerogel Based Fire Proximity Suit
81.	Instant Cooling Vests for Fire Fighters
82.	Portable Hydraulic Metal Cutter

Ser	Project
83.	Indigenous Aluminised Fire Proximity Suit
84.	Light Weight Portable Illumination Device
85.	Filtration Based Breathing Apparatus
86.	Long Range Communication in Helicopters
87.	Light Weight Integrated ESM – COMINT System for MSUAS/MULE Tactical RPA Platforms
88.	Multiutility Long Endurance (MULE) NSUAS Class RPA
89.	GNSS Based Helicopter Landing Aid Light Weight Integrated ESM – COMINT System for Ships
90.	Light Weight Integrated ESM – COMINT System for Ships
91.	Next Generation Helo Harnessing and Traversing System
92.	Environmentally Benign Firefighting System for Machinery Spaces
93.	Autonomous Hull Maintenance Crawler
94.	Air Borne Mine Detection System (AMDS) for Helicopters
95.	Underwater Communication System for AUV
96.	Underwater Navigation System for AUV
97.	3D forward Looking SONAR
98.	Underwater Photography Noise Cancellation Using Artificial Intelligence and Deep Learning
99.	Autonomous Beach Survey Device
100.	EO/IR POD
101.	AESA RADAR
102.	EMATT
103.	Light Weight COMINT
104.	ASIC Based Beam Forming Antenna for Space Communication
105.	AD Training and Radar Calibration Using DRFM
106.	AI Based Remote Monitoring System to Access Wear Down of Outboard Shaft Bearing
107.	Lithium Ion Battery Solution for XLUUV
108.	Computational Studies for UUV Dynamics
109.	Autonomous OPR of Diesel Alternator for Battery Charging
110.	Propulsion System for AUVS
111.	Indigenous Development of Unmanned Airborne Combat Attaché
112.	Achieving IR and Ultrasonic Stealth through Advanced Material Insulations
113.	Fast, Reliable and Economic Areal Transport of Armed Forces
114.	Guided Missile with Turbojet Engine

Ser	Project
115.	Anti-Helicopter Missile Fired from Torpedo Tube of Submarine Launched
116.	Gyro-Stabilised Crew Served Weapon Mount
117.	Design and Development of LASER Based Labour Saving Device for Hull Maintenance Onboard Warships
118.	Nonintrusive, Multistep and Multi-Technology Fusion Intrusion Detection Systems to Secure Defence Establishment
119.	Very High-Speed Data Transfer
120.	Encore Video Streaming Solution to Relay UAV Footage in Real Time
121.	Areal Platform-a Low Cost UAV with Very Long Endurance
122.	Underwater Breathing Machines "UJJAYI"
123.	Secure AV Communication
124.	Aviation Operations Management
125.	Emergency Survival Water Filtration Pouches Forward Osmosis
126.	Communication On The Move (COTM) for SATCOM
127.	Tactical Multi Role Combat Airborne Loitering UAS
128.	Automation of Material Movement Between Navy Ship & Jetty
129.	Financial Management Analysis
130.	Aircraft Weapons and Tactics Trainer
131.	Multi-Function Satcom and Tropo-Scatter Communication System for Shipborne Installation
132.	Phased Array Multi-Beam Communication System for Ships and Unmanned Platforms (Surface/Sub-Surface/Aerial)
133.	Development of Autonomous Boat for Oil Field Development Area Security and Surveillance
134.	Heavy Lift Autonomous Flying Robot for Shipborne Operations
135.	Labour Saving Devices for Material Shifting Onboard Submarine
136.	Material Movement Shifting Onboard Ship Over the Hatch Door Coaming
137.	Lightweight Mini UAV Radar Based on Active Beam-Forming Technology
138.	Submarine Detection Technology
139.	Silent Ship Communication
140.	Precise Time & Frequency transfer during GPS/GNSS Satellites Denial.
141.	Free Fat Fryer Gimbaled Frames

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Appendix 'J'
(Refers to Para 2 Chap 10)

MISCELLANEOUS PRODUCTS TO BE TAKEN UP FOR DEVELOPMENT

Ser	Projects	Description
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

Ser	Projects	Description
10.	Tethered submarine Buoy	To enable submarine communications at depth as well as intelligence collection.
11.	Fuel Cells	To enhance performance of existing fuel cell as well as R&D of alternate fuel cell technologies like PEM, AFC etc.
12.	Carrier Borne Fixed Wing UCAVs with Satellite Link	-
13.	Sonobuoys	DIFAR / DICASS / Bathy
14.	Long Range Electro Optical Sensors	For helicopters, UAVs and MR Aircraft
15.	Fresnel Lens Based Optical Landing System	For aircraft carriers and airfields
16.	UW LED Lights	Tool for diver to provide lighting underwater. To be miniaturised to fit diving helmet/ mask.
17.	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.
18.	Active off Board Decoys	Decoys to be fired from ship capable of seducing missiles at standoff ranges from the firing platform.
19.	Close-in-Weapon System	Small calibre multi barrel guns with high rate of fire > 4000 rd/ min
20.	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.
21.	Next Gen NVDs (IR/ Thermal Imaging)	State of art 3rd generation Night Vision Devices.
22.	Helmet Mounted NVBs	Night Vision Binoculars (NVB) helmet mounted, to provide hands free capability.
23.	Fuses	-
24.	Ship Installed Chemical System (SICS)	System capable of detecting Chemical Agents to be installed onboard IN Ships.

Ser	Projects	Description
25.	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.
26.	Specialised SV Mount	Cradle mounts of Talwar Class ships and Raft mounts of P-28 class ships
27.	Motor Boat Engines	-
28.	5MW Electric Propulsion Equipment	Development of indigenous warship grade electric propulsion equipment
29.	Non-Magnetic Engines	-

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Appendix 'K'
(Refers to Para 3 Chap 10)

PROJECTS COMPLETED/IN PROGRESS THROUGH DRDO/ PRIVATE INDUSTRY

Ser.	Project	Description
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
4.	Converters, 400 Hz	M/s ELMOT Alternators
5.	VCS System (VOIP Based)	M/s BEL
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
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
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

Ser.	Project	Description
24.	Power Panel for Engine and DA Room	M/s L&T
25.	Lighting Panel	M/s Marine Electrical
26.	Control and Monitoring Cable	M/s Radiant cables M/s Siechem Technology M/s Nicco Corporation
27.	COS for Heavy and Machinery LOADS	M/s L&T
28.	VLF system	DRDO/ Industry
29.	INCIS (*IN* Communication Interoperability System)	M/s WESEE
30.	AVLF Modulator/ Demodulators	M/s DEAL/ BEL
Additional Shipborne Systems		
31.	GSHRB	M/S ECIL
32.	C & C SW BD	M/S L & T LTD
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
43.	CCS MK-III	M/S BEL
44.	VCS-28	
45.	SDN-28	
46.	LINK-II MOD-III	
47.	LUP-329	
48.	100 W MF Transmitter	
49.	EW SANKET	
50.	V/UHF COMNIT/ DF System ELK-7036-WB DF	
51.	MB/SRE	M/s Phi Audio Com

Ser.	Project	Description
52.	Intercom System	
53.	SATCOM	ISRO
54.	SATCOM, PCS	M/s DEAL/ DRDO/ BEL
55.	Network Security Encryptors	M/s ECIL/BEL
56.	EW Ellora/ Ellora Mk II	M/s DLRL/ BEL
57.	EW Varuna	M/s DLRL/ BEL
58.	CMS-28	M/s BEL
59.	ATM Switch for CMS	
60.	DDU for RLG	M/s Data Patterns Ltd
61.	Kavach Mod –II	M/s Machine Tool
62.	50 KVA Converter	M/s PCL Ltd
63.	Radar Revathi	M/s BEL
64.	UWT	M/s Keltron
65.	Echo Sounder V-2	
66.	AK 630	M/s GSF, M/s Cossipore & M/s BEL
67.	SOP for AK 630	M/s BEL
68.	ITTL	M/s L&T
69.	FCS LYNX U1	M/s BEL
70.	IAC MOD 'C'	
71.	SONAR HUMSA NG	
72.	IRL	M/s L&T
73.	Anchor Capstans	M/s Geeta
74.	Foldable Hangar Door	M/s L&T
75.	Railed Helo Traversing System	
76.	Shore Supply Cables (including light weight SS cables)	M/s Radiant Cables M/s Siechem Technologies Pvt. Ltd M/s Quadrant Cables M/s Apar Cables M/s Thermo Cables M/s Polycab Ltd.
77.	SFC	M/s Precision Power Products M/s Elcome Integrated System M/s Static Transformers
78.	Boat Davit	M/s HH Group, M/s Fibroplast,

Ser.	Project	Description
		M/s SHM Shipcare, M/s Hemant Engg
79.	AC Condenser Cooling Water Pumps	M/s KBL Pumps M/s SPX M/s DESMI
80.	Auxiliary Cooling Water Pumps	
81.	Chilled Water Pumps	
82.	Fresh Water Pumps	
83.	Economiser Elements for Boilers of Vikramaditya	M/s Virtue Engineering M/s BHEL
84.	Valves Fitted in Freshwater, Feed Water, Sea Water and Other Auxiliary System	M/s GDPA, M/s L&T M/s Lender M/s Meason
85.	Feed Condensate Booster Turbo Driven Pump	M/s TOCOL
86.	Proportioning Pumps for Boiler Dosing	
87.	Motor Driven Fuel Pumps	M/s DESMI M/s Alektor M/s Allenetor
88.	Reducing Stations	M/s Hale Hamilton Pvt Ltd M/s Elgi
89.	Globe Valves	M/s GDPA, M/s Meason M/s Lender, M/s L&T
90.	Diesel Monitoring Equipment	M/s Symptronic
91.	Coolant Expansion Tanks	M/s Ship Builder
92.	Electric Bilge Drying Pumps	M/s SPX, M/s MERU M/s DESMI
93.	Refrigerating Plants	M/s Accel, M/s KPCL, M/s JCIPL
94.	HP Air Compressors – Oil Filter (Submarine)	M/s Burckhardt DRDO/ CVRD M/s Elgi
95.	IBA (Integrated Broadcast Application)	M/s Data Byte
96.	HP Air Compressors – Air Filter (Submarine Application)	M/s NUKON Industries DRDO/ CVRD M/s BEKU/ NUCON

Ser.	Project	Description
97.	Hydraulic Filters Filter Element (Submarine Application)	DRDO/ CVRD
98.	Air + Water Filters Cartridge (Submarine Application)	
Indigenisation Process in Progress		
99.	HDVLF Rx	M/s DEAL, M/s BEL
100.	HEMP, 1000 Amps Filter	DRDO, M/s Zeonics
101.	Indigenous Secure Router	M/s Nivetty Systems
102.	MDA-DSS (Maritime Domain Awareness – Decision Support Software	M/s CRL, M/s BEL
103.	SSM Loader	M/s Mahindra Defence Systems Ltd
104.	Fin Stabiliser	M/s L&T
105.	ONEGA Control System	
106.	Development of Portable & Universal Pump Efficiency Monitoring System	M/s CSIR, CSIO
107.	TDFL Pump for VKD	M/s Tocol Machine Tools Pvt. Ltd
108.	Main Circulating Pump for VKD	
109.	85KW DC Motor with starter for HP Air Compressor for Submarines	M/s Elmot Alternator Pvt. Ltd,
110.	Thermal Imaging Camera (TIC)	M/s BEL

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Appendix 'L'
(Refers to Para 4 Chap 10)

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