THE MAKE IN INDIA PARADIGM – ROADMAP FOR A FUTURE READY NAVAL FORCE

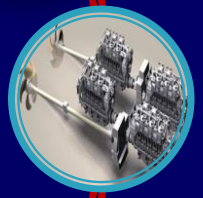
Marine Propulsion & Power Generation : Challenges & Opportunities

IHQ MoD(N)

Content

Propulsion & Power Generation : The Present

Volumes & Value



Challenges & Emerging Technologies

Future induction requirements

Indian Navy expectations & requirements

Propulsion & Power Generation : The Present

Propulsion Systems Evolution

1970 - 80

Leander & Godavari Class Frigates (P-16 & P-16A)

- Steam Propulsion

1980 - 90

Khukri & Kora Class Corvettes (P-25 & P-25A)

- Diesel Propulsion

1980 - 90

Delhi Class Destroyers (P-15)

- Combination of Gas Turbines (COGAG)

1995 - 2012

Shivalik Class Frigates (P-17)

- Combination of Diesels & Gas Turbines (CODOG)

2000 - 2015

ASW Corvettes (P-28)

- Combination of Diesels & Diesels (CODAD)

2000 - 2018

Indigenous Aircraft Carrier (P-71)

- Combination of Gas Turbines (COGAG)

Propulsion & Power Generation : Types

Propulsion Plants

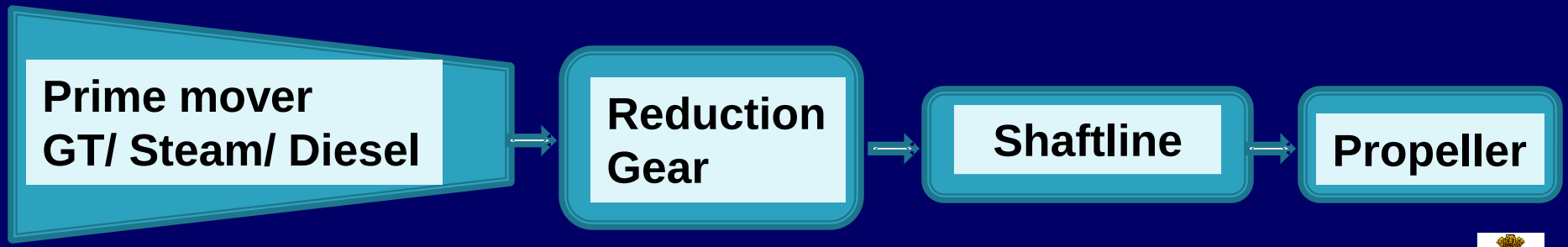
- **Steam Turbines (11 – 33 MW)**
- **Diesel Engines (1.7 – 11 MW)**
- **Gas Turbines (3–22 MW)**

Power Generation

- **Diesel Engines (8KW – 3000KW)**
- **Steam Turbines 500KW – 1000KW**
- **Gas Turbines 1000KW**

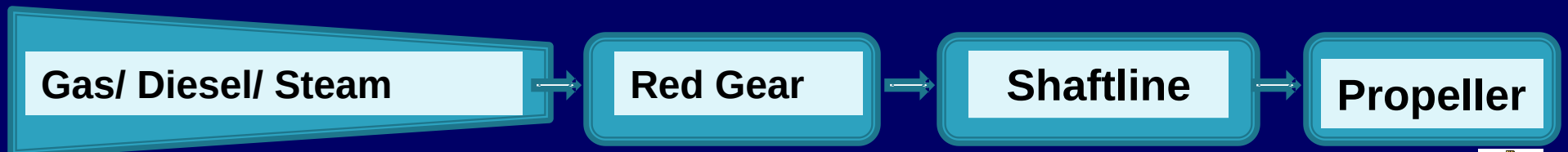
Present : Propulsion Volumes

Prime mover	Ships	Power	Approx Units
Steam	Aircraft Carriers, Frigates, LPD	11 MW to 33 MW	24 Boilers, 18 Turbines
Gas Turbines	Destroyers, Frigates, Missile Boats	3 MW to 22 MW	154
Diesel	Tankers, Corvettes, OPVs, Survey, LST, LCU,FACs,Yardcrafts	1.7 MW to 11 MW	200 +



Propulsion - Approx Cost

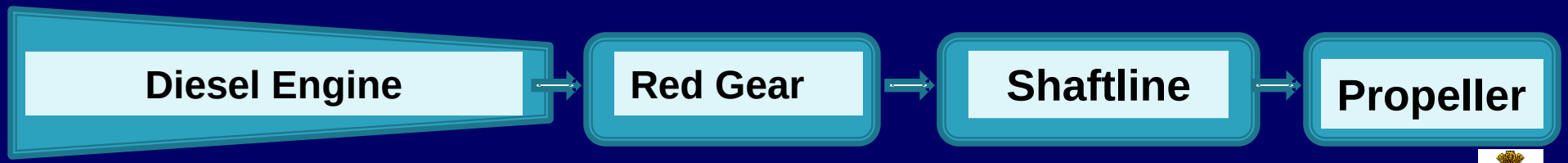
Propulsion	Power	Approx Cost
Gas Turbine	3 MW to 22 MW	INR 12 - 80 Cr/ Unit
Diesel Engine	1.8 MW to 11 MW	INR 5 - 20 Cr/ Unit
Steam (Turbine + Boiler)	11.5 MW to 34 MW	INR 40 – 125 Cr/ Unit
Reduction Gear	Matched with Engine power	INR 1.5 - 40 Cr/ Unit
Shafting &Propellers		INR 1.25 – 30 Cr/ Unit



Approx Cost (INR) : OPV

Ship	Propulsion Fit	Cost @ Unit	Total Cost	Acquisition Cost @ ship	Life cycle Cost (LCC) @ ship
OPV	2 MDEs (Approx 8 MW each)	15 Cr	2X15 = 30 Cr	30 + 10 + 10 = 50 Cr	5 * 30+ 10*2+ 10*2 = 190 Cr
	2 Reduction Gears	5 Cr	2X5 = 10 Cr		
	2 Sets of Shafting & Propellers	5 Cr	2X5 = 10 Cr		

For 1 OPV : Main propulsion : Acq Cost (50 Cr) + LCC (190 Cr) = 240 Cr~
4 DG Sets : Acquisition Cost (4 Cr) + LCC (20 Cr) = 24 Cr ~



Approx Cost (INR) – Propulsion

Ship	Propulsion Fit	Approx Cost per Unit	Approx Total Cost	Approx Acquisition Cost per ship	Approx Life cycle Cost (LCC) per ship
Frigate	2 GTs (Approx 22 MW each)	80 Cr	2X80 = 160 Cr	160 + 30 + 24 + 40 = **254 Cr**	**160*2+ 30*5+ 24*2+ 40*2= 598 Cr**
	2 MDEs (Approx 6 MW each)	15 Cr	2X15 = 30 Cr		
	2 Reduction Gears	12 Cr	2X12 = 24 Cr		
	2 Sets of Shafting & Propellers	20 Cr	2X20 = 40 Cr		

For 1 Frigate Main prop : Acquisition Cost + LCC = 852 Cr Approx

Present : Power Generation Volumes

Power Generator	Ships	Power Range	Approx Units
Gas Turbine Generators	Destroyers	1 MW	60
Diesel Alternators	Carrier, Frigates, Corvettes	8 KW to 3 MW	400 +
Steam TA	Carrier, Steam Frigates	750 KW to 1.5 MW	12

Prime mover
GT/ Steam/ Diesel

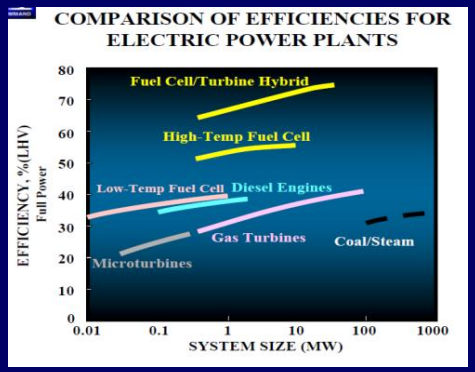
→

Alternator : O/P Voltage & Freq to meet Platform requirements

Challenges & Emerging Technologies

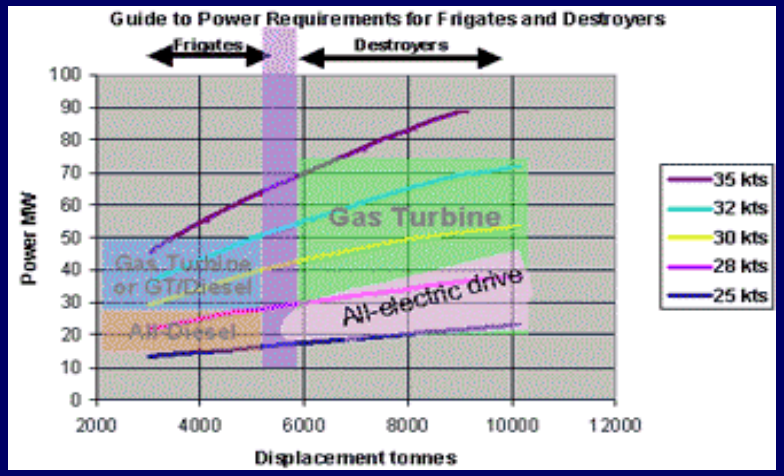
Challenges

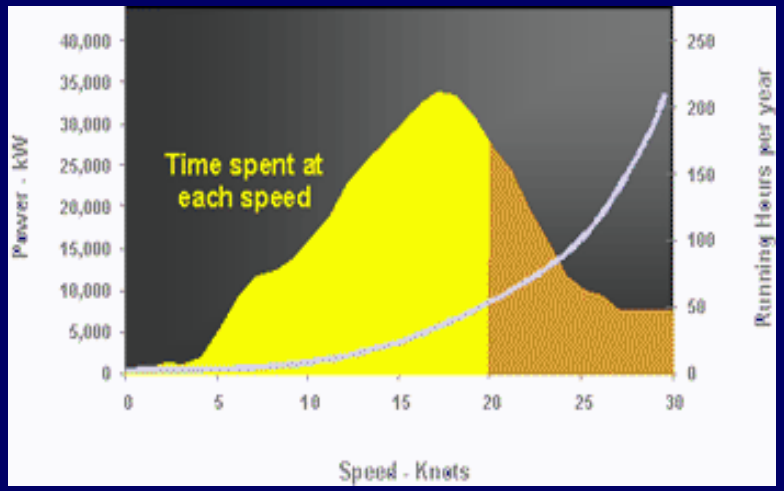
- Components
  - Matching Global Technology
  - MIL Standards compliance
  - Reliability
  - Stringent Emission Norms
  - Lower SFCs / Greater η
  - Stealth requirements
  - Restricted Production Volumes
- Propulsion System Integration (PSI)
  - Multidisciplinary & complex
  - Overall propulsive η is a function of PSI



Emerging Technology Drivers : Internal Factors

- High ‘Power Density’ requirements
  - Relieve space
  - Smaller but ‘loaded’ ships
- More flexibility in operation: Higher efficiency over large operating envelopes
- Stealth requirements





Emerging Technology Drivers : External Factors

- Low ‘Life Cycle Cost’
- Depleting fuel reserves
- Emission norms
- New Technologies

Table 1. MARPOL Annex VI NOx Emission Limits

Tier	Date	NOx Limit, g/kWh		
		n < 130	130 ≤ n < 2000	n ≥ 2000
Tier I	2000	17.0	$45 \cdot n^{-0.2}$	9.8
Tier II	2011	14.4	$44 \cdot n^{-0.23}$	7.7
Tier III	2016†	3.4	$9 \cdot n^{-0.2}$	1.96

† In NOx Emission Control Areas (Tier II standards apply outside ECAs).

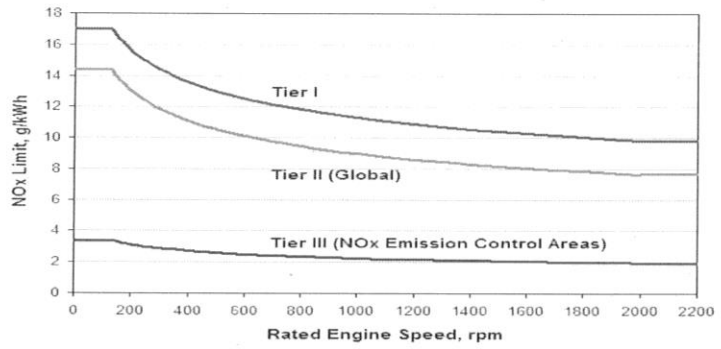
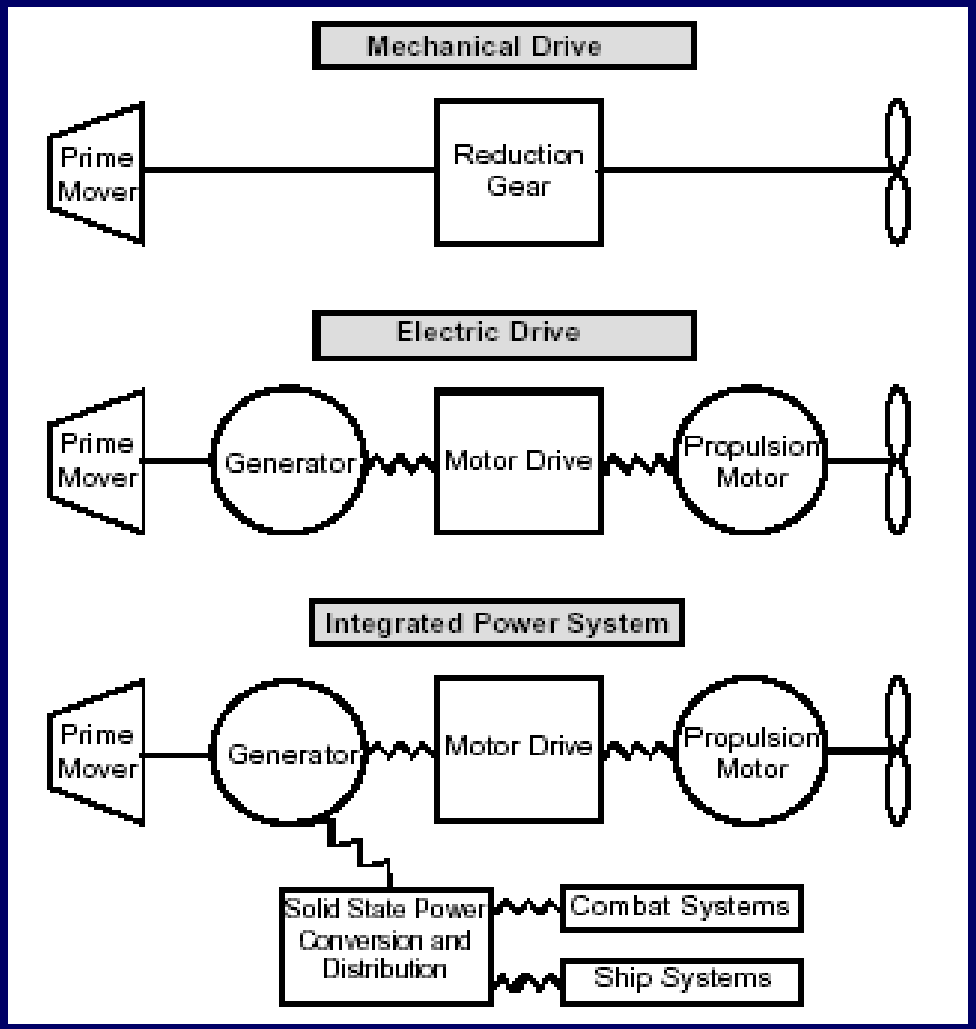


Figure 1. MARPOL Annex VI NOx Emission Limits

by combustion process optimization. The parameters examined by engine manufactu

Emerging Technologies : Propulsion

- **Integrated Full Electric Propulsion (IFEP)**



Future induction requirements

Future Induction : Volumes

Ships	Propulsion/ Power Generation	Power range	Expected Units
Fleet Support Ships, Shallow Water Crafts, MCMVs, LPD, Large Survey Vessel, Diving Support Vessel, Multipurpose Vessel, Barges, Yardcrafts etc.	**Propulsion**		
	Diesel Propulsion	1.2 to 18 MW	160
	Associated Reduction Gears		
	Associated Shafting, Propellers		
	Power Generation		
	Diesel Generators	50 kW to 1 MW	190+

Future Induction Propulsion : Value

Propulsion Type	Power range	Expected Units	Approx Acquisition Cost / Unit	Total Approx Acquisition Cost
Diesel	1.1 to 18 MW	160	2.6 – 25 Cr	1327 Cr
Gearbox & Shafting	Matched with Propulsion	155	2 .0– 10 Cr	1221 Cr
			Acquisition Cost Approx	2547 Cr
* Life Cycle Cost ~ 2 to 5 times the Acquisition Cost				

Acquisition Cost (2547 Cr)
+ Life Cycle Cost (9076 Cr)
~ 11623 Cr

Future Induction Power Gen : Value

Power Gen Type	Power range	Expected Units	Approx Acquisition Cost / Unit	Total Approx Acquisition Cost
Diesel	50 kW- 1MW	190+	0.25 – 5 Cr	307 Cr
* Life Cycle Cost ~ 5 times the Acquisition Cost				

Acquisition Cost (307 Cr)
+ Life Cycle Cost (1536 Cr)
~ 1843 Cr

Future Induction : Value

Equipment	Expected Units	Approx Acquisition Cost	Approx Life Cycle Cost	Approx Total Cost
Main Propulsion	160	2547 Cr	9076 Cr	11623 Cr
Power Gen	190+	307 Cr	1536 Cr	1843 Cr
			Total	13466 Cr

Total Approx Cost ~ 13,466 Cr

Indian Navy : Expectations & Requirements

Indian Navy Expectations & Requirements

- Indian Naval Indigenisation Plan (INIP) 2015-2030
  - Indigenous development
  - *IN*-Industry synergy
- End to End Propulsion solutions
- New & efficient Technologies
- Development of equipment meeting stringent standards
- Modularity with a standard as well as well-defined minimum interfaces

Indian Navy Expectations & Requirements

- Reliability
- Efficient life cycle performance
- Environmental effects
- Efficient Life Cycle Support

Recent initiatives – Make in India

- Diesel Engines for propulsion (6 to 12 MW) and Boats being imported
- No indigenous option presently
- Indigenous manufacture of medium power Diesel engines and small engines for boats under ‘Make’ category
- Preliminary talks with Industry

Recent initiatives – Make in India

- Broad timelines for the project
  - Advanced Planning & Consultation – In progress. Mid May 16.
  - Feasibility study – 31 Aug 16
  - PSQR preparation – 31 Oct 16
  - AON for prototype & final product – 31 Mar 17
  - Prototype development - 2020

Recent initiatives – Make in India

- Govt funding of 90% of prototype development cost under ‘Make-I’ category
- Volumes envisaged between 2019 to 2025
  - 36 Nos Diesel Engines (6 to 12 MW) (AON accorded projects)
  - 221 Nos Boat Engines

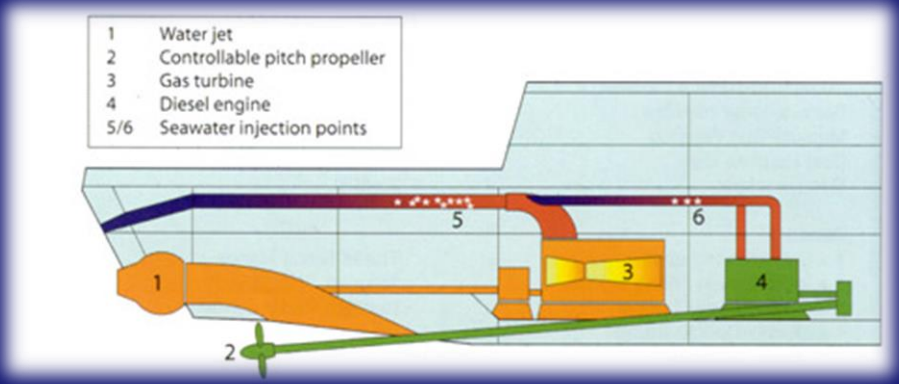

MAKE IN INDIA

Hidden Slides

New Technologies in Propulsion Configurations

- Energy efficient
- Flexible
- Hybrid
- Silent

CODAD	Combined Diesel & Diesel
CODOG	Combined Diesel or Gas Turbine
CODAG	Combined Diesel & Gas Turbine
CODAG-WARP	Combined Diesel & Gas Turbine Waterjet & Refined Propeller
CODLAG	Combined Diesel-Electric & Gas Turbine



MIL / DEF STANs

MIL / Def Stan	Description
Def Stan 02-313	Diesel Engine for Marine Propulsion and auxiliary machinery
NES 1004	Requirement for design and testing of equipment to meet environmental condition
MIL-STD-1472G	Design criteria standard Human engineering
Defence Standard 02-703	Thermal and acoustic insulation of hull and machinery
MIL-STD-740-2 (SH)	Structure-borne vibratory acceleration measurements and acceptance criteria for ship board equipment
MIL-STD-1474 D	Air borne sound measurements and acceptance criteria of shipboard equipment
NES 309	Requirement of Gas Turbines

MIL / DEF STANs

MIL / Def Stan	Description
MIL-S-901D	Shock tests, high impact shipboard machinery and systems.
IN Shock Grade 'A' as per BR 3021	Requirement of High Impact Shock Grading
MIL-STD-167-1(A)	Mechanical vibrations of Shipboard equipment.
NES 305	Requirement of Main Propulsion Gearing
EED-Q-071	Specifications for Motors and Starters for Naval ships (Indian Navy specifications)
MIL-STD-461E/F	Requirements for control of EMI / EMC characteristics of equipment / subsystem

Indian Naval Indigenisation Plan 2015-30

1.12 **Main Areas Where *IN* is Facing Capability Gaps**. As brought out above, *IN* has been able to achieve about 90% indigenisation in the 'FLOAT' category, followed by about 50-60% in 'MOVE, category depending upon the type of propulsion. However, in the 'FIGHT' category we have achieved only about 30% indigenisation. Some of the major equipment where there has not been satisfactory progress are the weapons & sensors, propulsion systems (especially Gas Turbines), Marine Diesel Engines for main propulsion and Gear Boxes under 'MOVE' category, which are imported presently and holds much scope for indigenisation.

Indian Naval Indigenisation Plan 2015-30

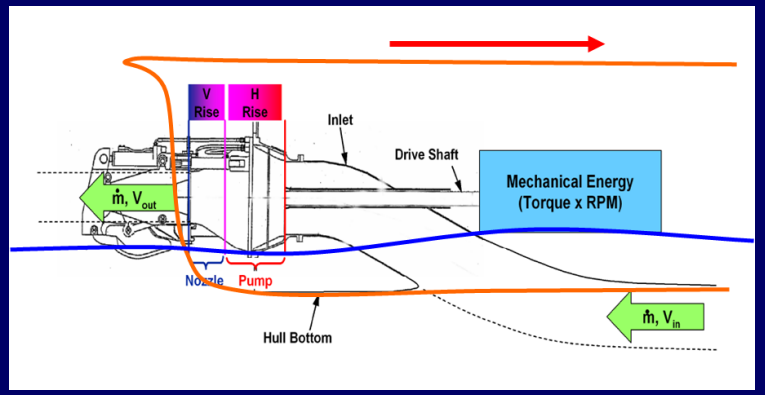
Appendix-A

FORECAST REQUIREMENT OF EQUIPMENT AND SYSTEMS
MARINE ENGINEERING EQUIPMENT

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

Emerging Technologies : Propulsors

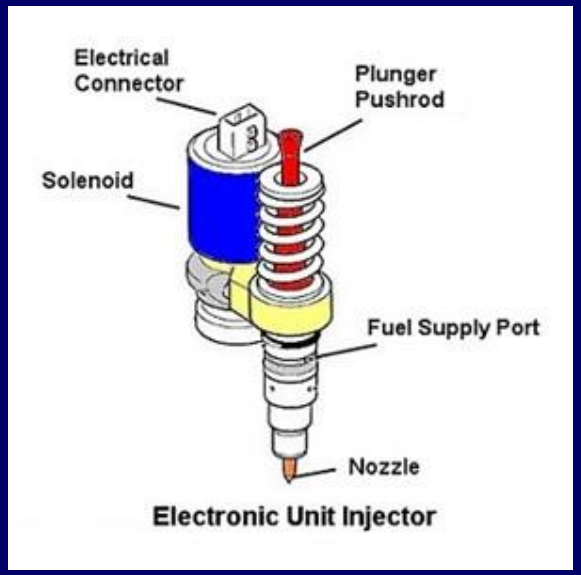
- Water Jets
  - Sustain high speeds
  - Rapid acceleration
  - Extremely maneuverable
  - Shallow draught system
  - More efficient at higher speeds



- Propulsion Pods
  - Free space inside ship
  - Efficiency & maneuverability
  - Field wound synchronous or induction motors
  - Shock grading mandatory

Emerging Technologies : Power Generation

- Electronic Injectors
  - Micro processor based
  - Increased Part Load Efficiency
  - Low Emissions
  - Low SFC



- Fuel Cell
  - High efficiency
  - Low Emissions
  - High Power Density
  - Reduced intake/ Exhaust Ducting