Application Center Governmental Naval

Propulsion System Choices for modern Naval Vessels

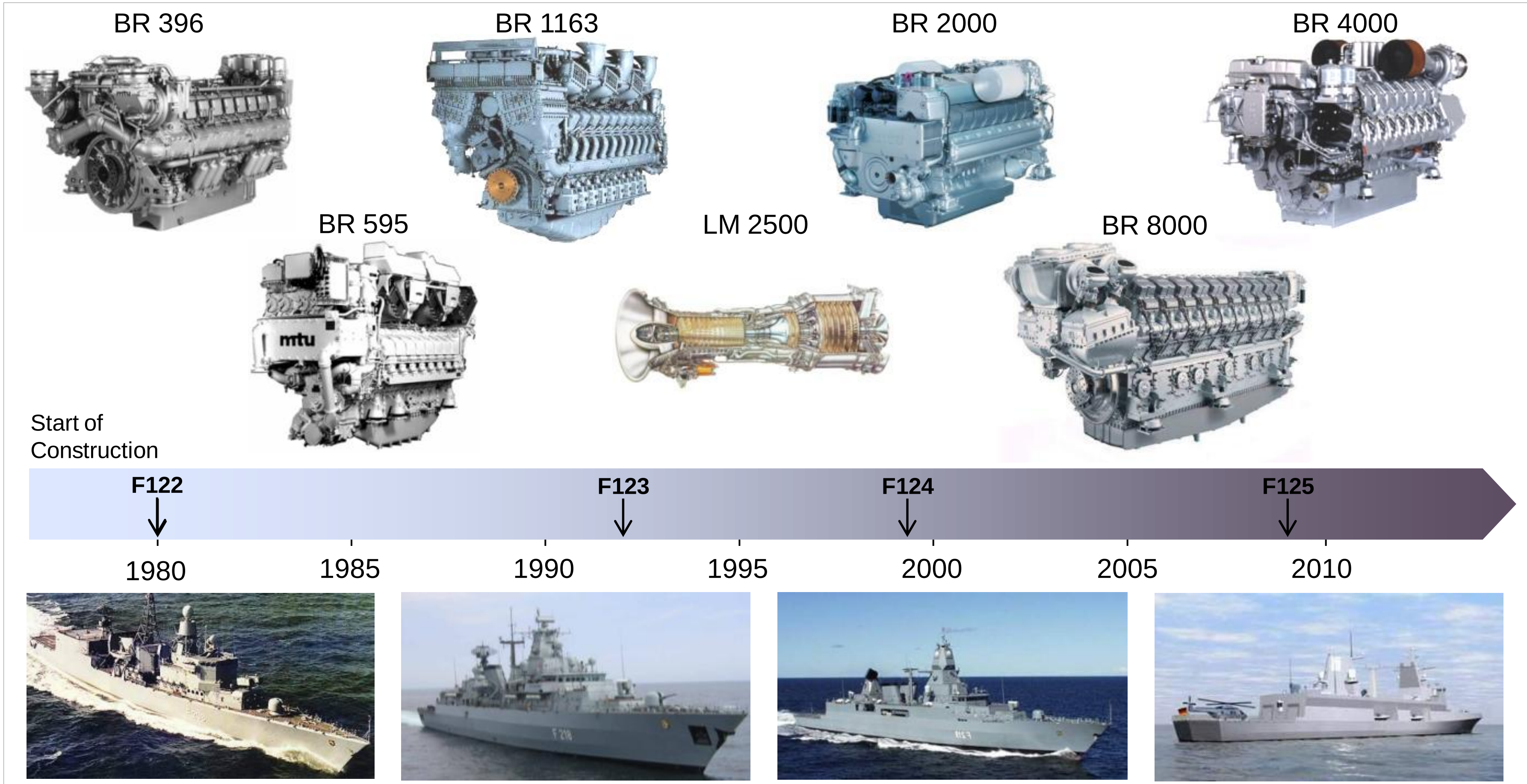
Washington, November 8, 2012 Hubert F. Ohmayer

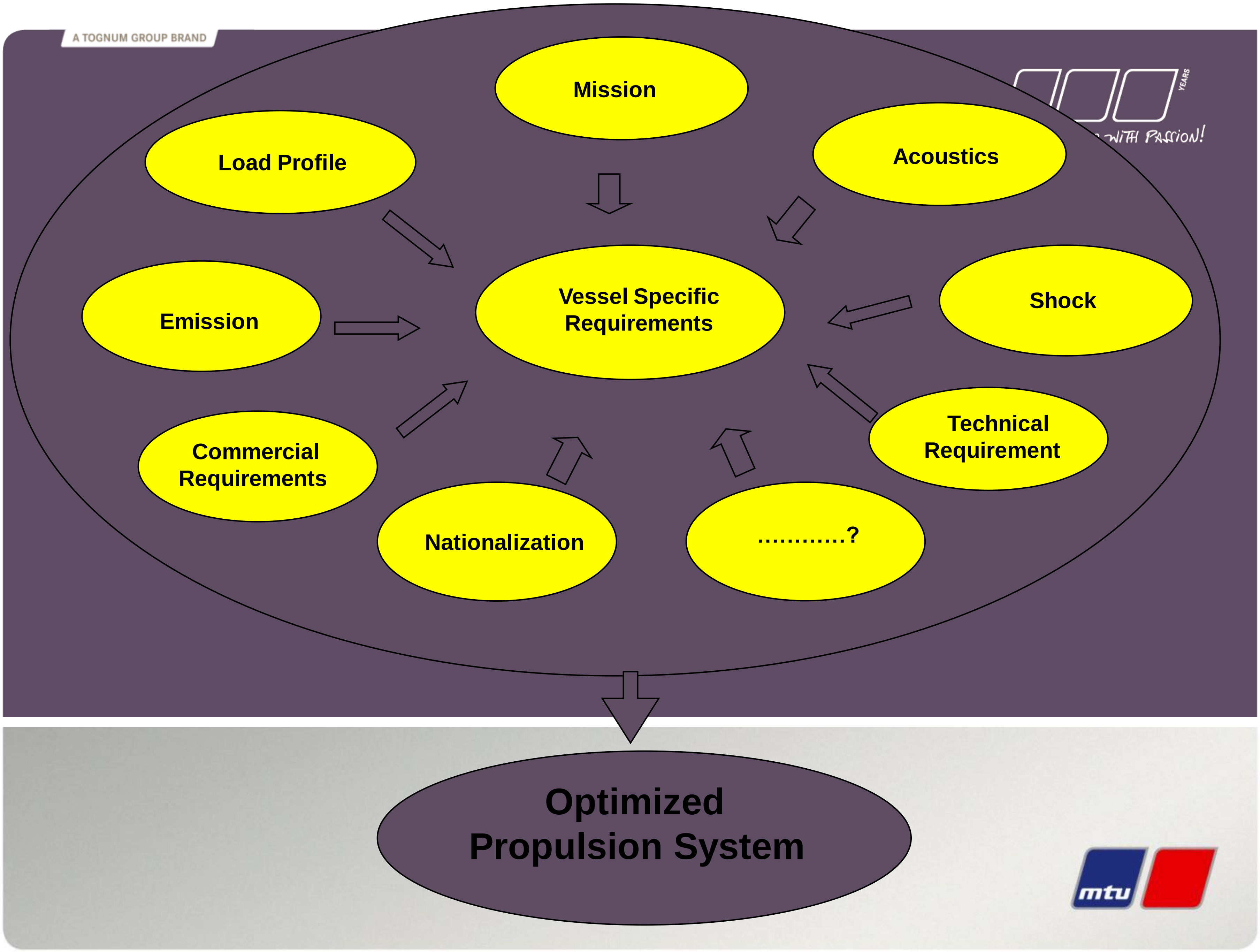
Major Brands Under One Umbrella

Tognum
HOME OF POWER BRANDS

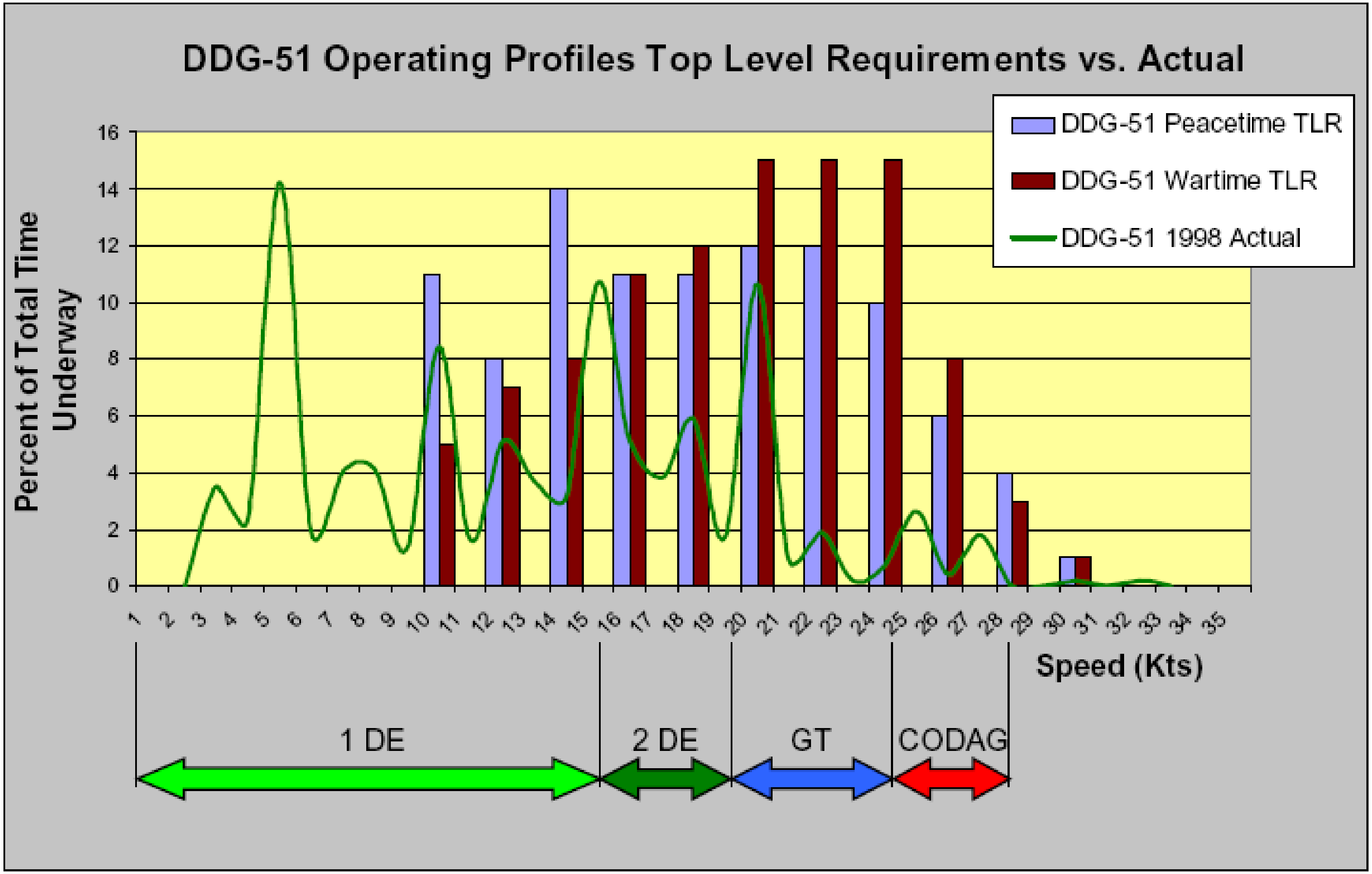
Business Units	Engines	Onsite Energy			Components
Brands	mtu, DETROIT DIESEL	mtu onsite energy			L'orange
Products	   Complete Drive and Propulsion Systems	 Gas Engine Systems	 Diesel Engine Systems	 Fuel Cells Systems	 Injection systems

Propulsion System Choices for modern Naval Vessels
MTU: Partner of Navies (Example German Navy)




A TOGNUM GROUP BRAND
Mission
Load Profile
Acoustics
Vessel Specific Requirements
Emission
Shock
Technical Requirement
Commercial Requirements
Nationalization
…………?
Optimized Propulsion System
mtu

Speed Profile Comparison



Propulsion System Choices for modern Naval Vessels Changes in selection criteria

Traditional criteria

- ship speed requirements
- shock capability
- noise reduction
- infrared signature

Additonal criteria

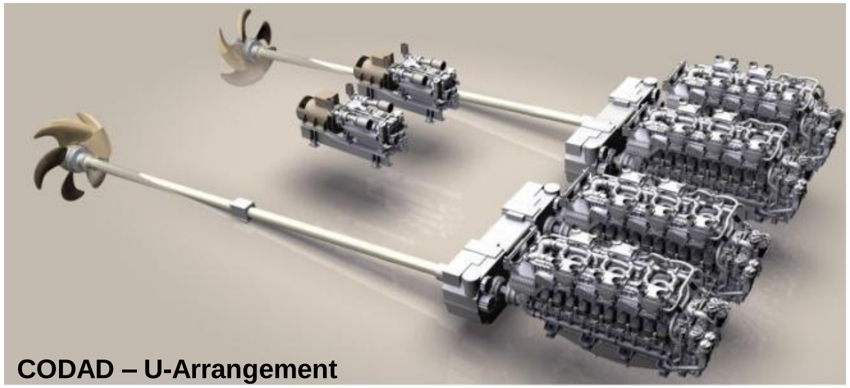
- change in operation requirements
- greater range of speed
- added mission flexibility
- longer periods away from base with smaller crews
- cleaner emissions

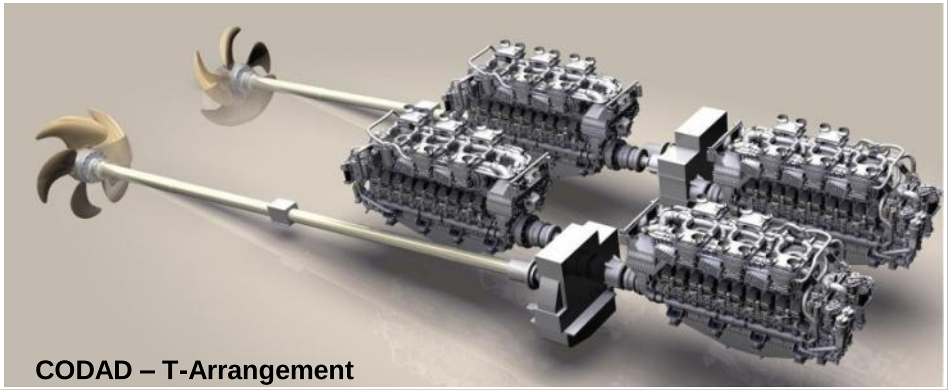
CODAD Propulsion System


DELTA Frigates – DCNS – Singapore Navy

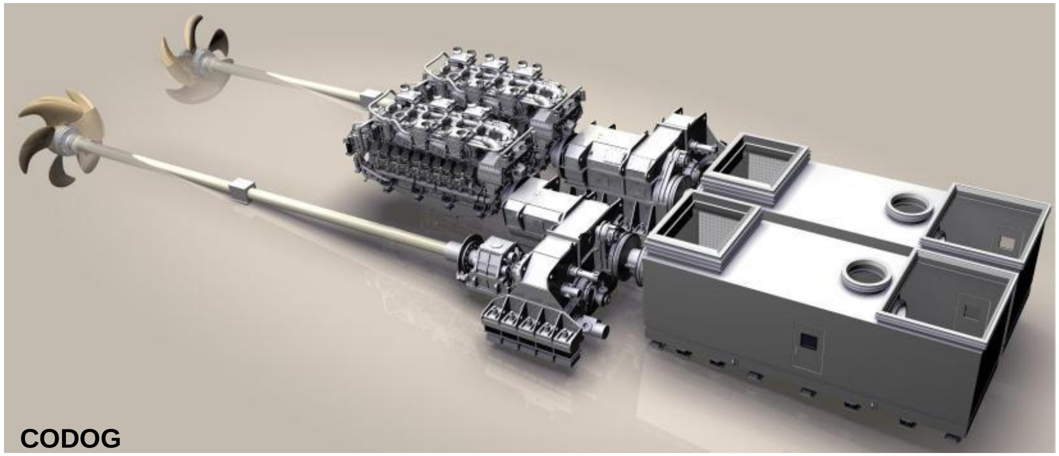

LEKIU Class Frigates – BAE – Malaysia Navy


Padilla Class Frigates – HDW – Colombian Navy


CODAD – U-Arrangement


CODAD – T-Arrangement

CODOG Propulsion System

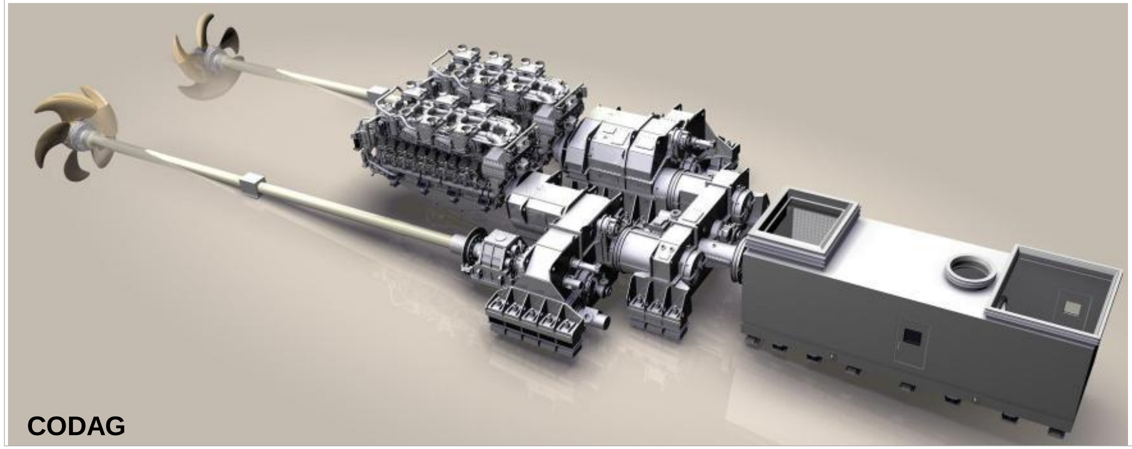


CODAG Propulsion System

F124 – German Navy

MILGEM Corvette – Turkish Navy

NSC Deepwater – US Coast Guard



CODAG

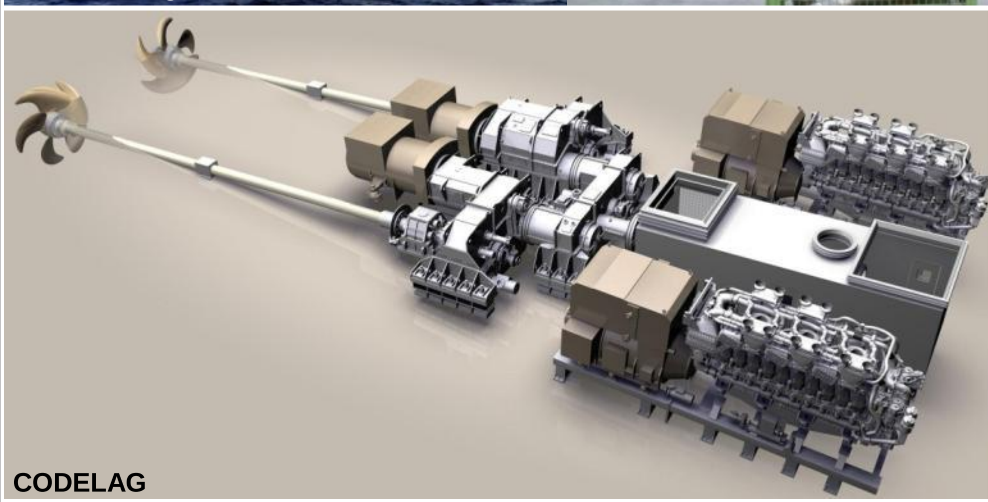
mtu

CODELAG Propulsion System

FREMM Frigate

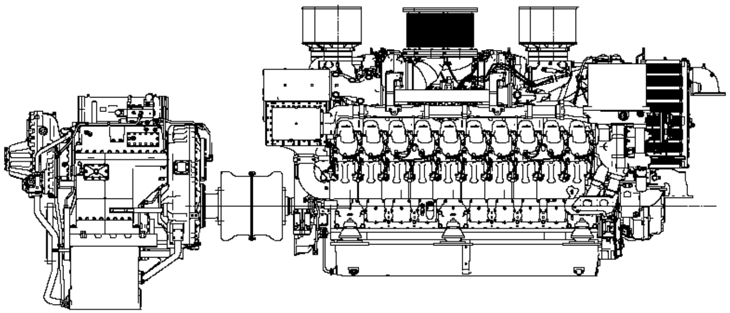

FREMM 16V4000N43 Genset


F125 – German Navy

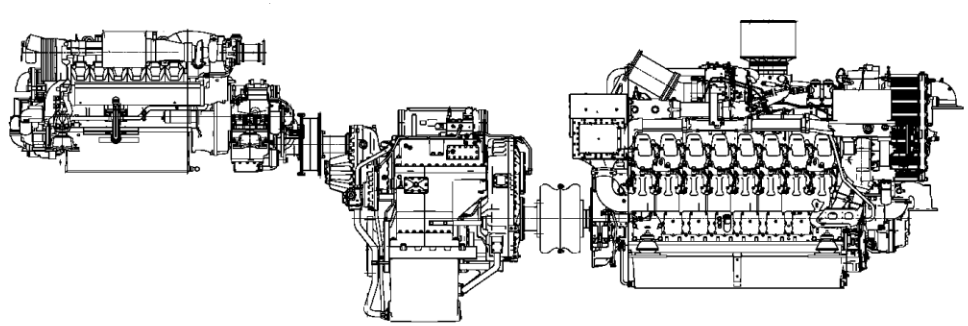

CODELAG

Propulsion Systems
Overview examples

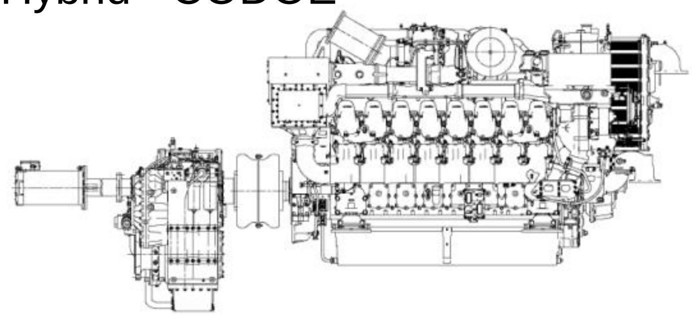
2 engines – direct drive



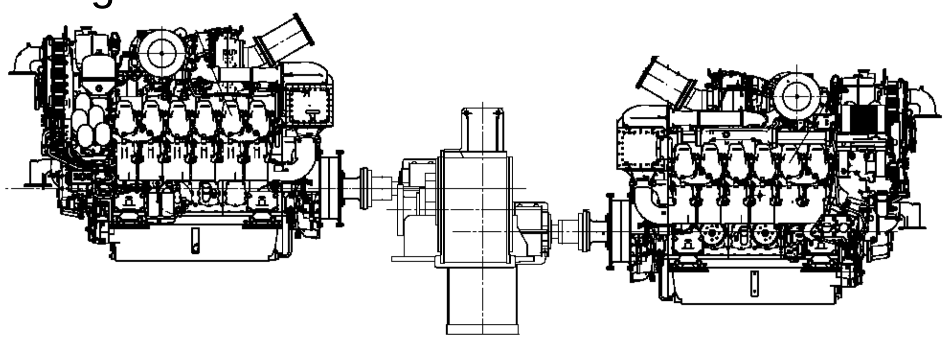
father-son - CODOD



Hybrid - CODOE



4-engines - CODAD



Propulsion Systems for smaller Vessels
Engines in operation according to speed profile of ship

V (kn)	Time (%)	Power (kW)	Direct drive (2-engines)	CODOE (Hybrid)	CODOD (Father- Son)	CODAD (4-engines)
5	25	350	1 x 20V4000M73L	1 x 12V2000M51B	2 x 12V2000M61	2 x 16V4000M53
12	50	1000	1 x 20V4000M73L	2 x 12V2000M51B	2 x 12V2000M61	2 x 16V4000M53
15	20	2000	2 x 20V4000M73L	2 x 20V4000M73L	2 x 20V4000M73L	2 x 16V4000M53
20	5	7200	2 x 20V4000M73L	2 x 20V4000M73L	2 x 20V4000M73L	4 x 16V4000M53

Task	Speed	Time	Power
Transit, Interception, SAR	15 - 20 kn	5 %	30 - 100% of MCR*
Patrolling in operational zone	12 - 15 kn	20 %	15 - 30 % of MCR*
Loitering in operational zone	0 - 12 kn	75 %	<15 % of MCR*

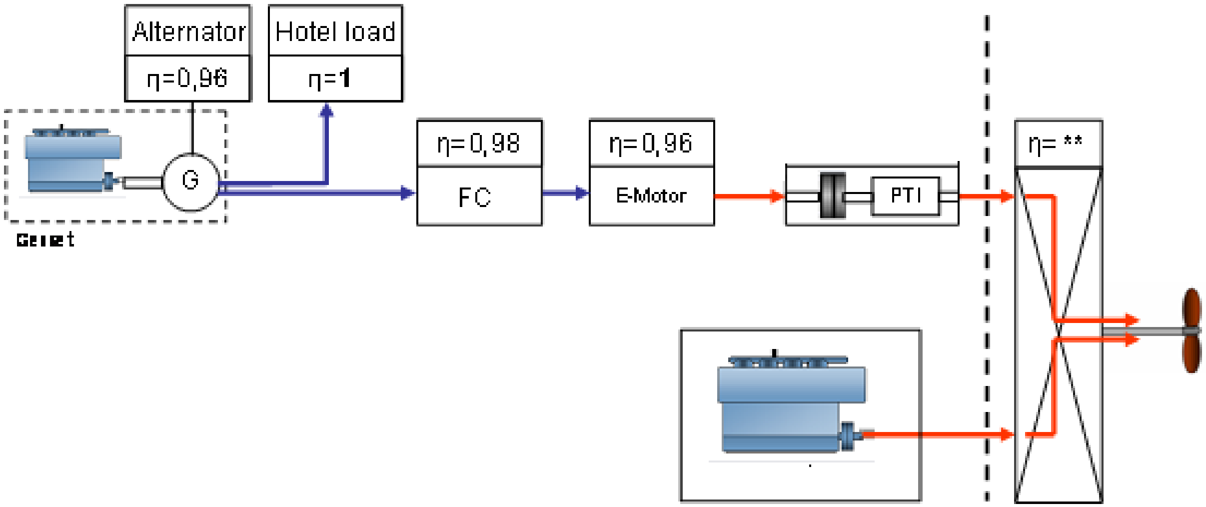
* MCR – Maximum Continuous Rating

Propulsion Systems
Hybrid-Plant - CODOE

Electrical Systems have

losses:

- Generator
- Frequency converter
- E-motor



$$\eta_{CODOE} = \eta_{Generator} \cdot \eta_{Freq.} \cdot \eta_{E-Motor} \approx 90\%$$

Electrical propulsion systems need more power to achieve same ship speed compared to mechanical systems

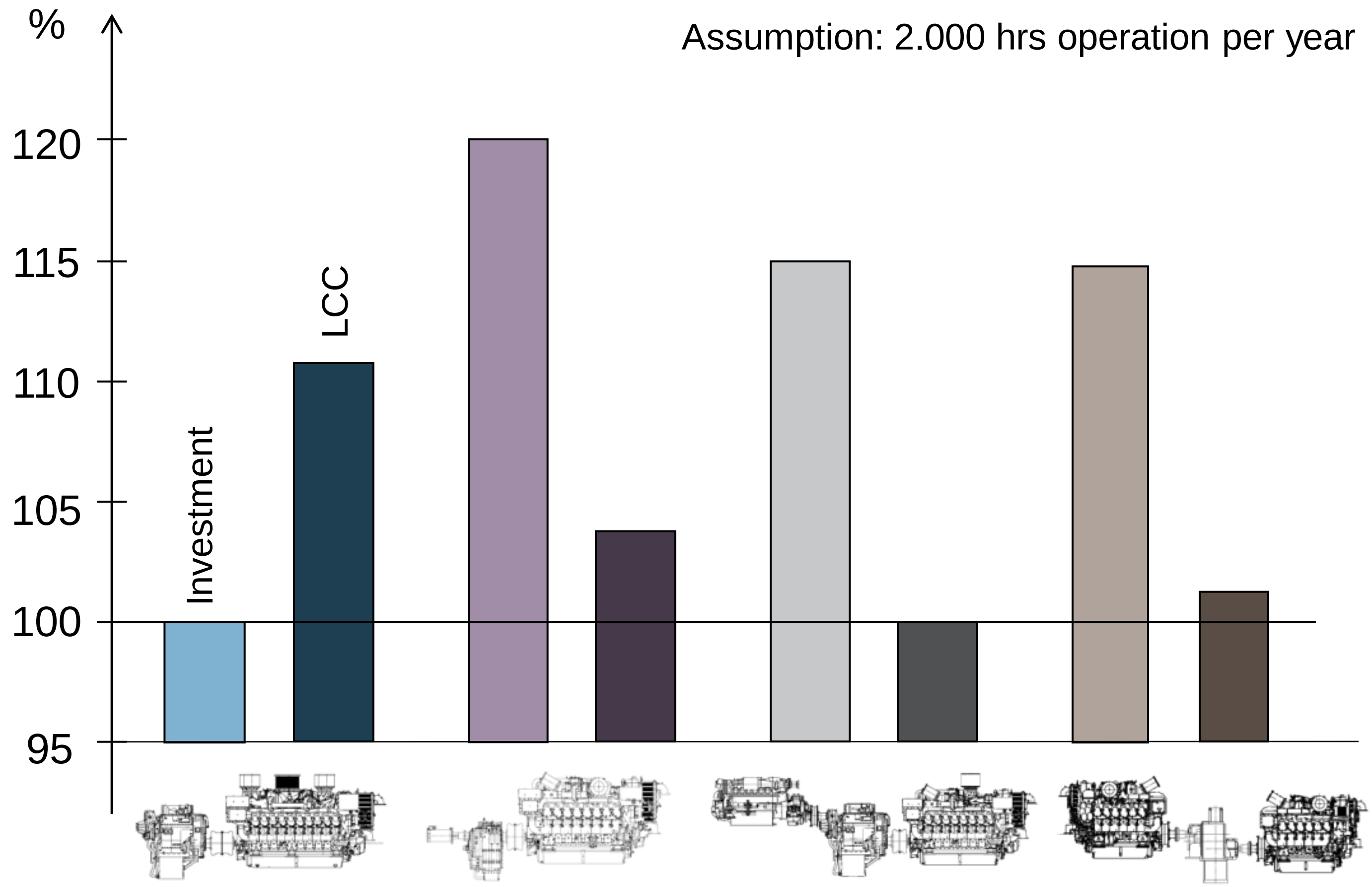
Propulsion Systems
Comparison Investment and LCC

LCC include:

- Fuel consumption
- LO consumption

Investment cost include:

- engines
- Gearboxes
- Shafts
- Propellers
- Gensets
- Electrical motors
- Frequency conv.



Comparison CODAG / CODELAG
6000 ton ship

	Volume (m^3)		Weight (t)	
	CODAG	**CODELAG**	**CODAG**	**CODELAG**
Main Switch-Board 6,6 kV	0	240	0	18
Xfrmr & Converter 6,6 kV	0	675	0	52
Gearbox	630	630	160	173
Shaft + Propeller			165	175
Main Diesel Engines	378	0	122	0
Electrical Motors	0	540	0	140
Gas Turbine	300	300	37	43
Generator Sets	648	1200	96	225
Summary	**1956**	**3585**	**580**	**826**

German Frigate F125
7000 tons

- „Stabilization frigate“ for operation of about 2 years abroad
- 21 days of endurance
- About 5.000 operating hours per year
- Built acc. to actual naval design rules
- No. of sailors reduced by 50%
- ships speed electrical mode >20 kts
- 4 vessels under contract

Fregatte F125 CODELAG Concept
max. 20 kts in electrical mode

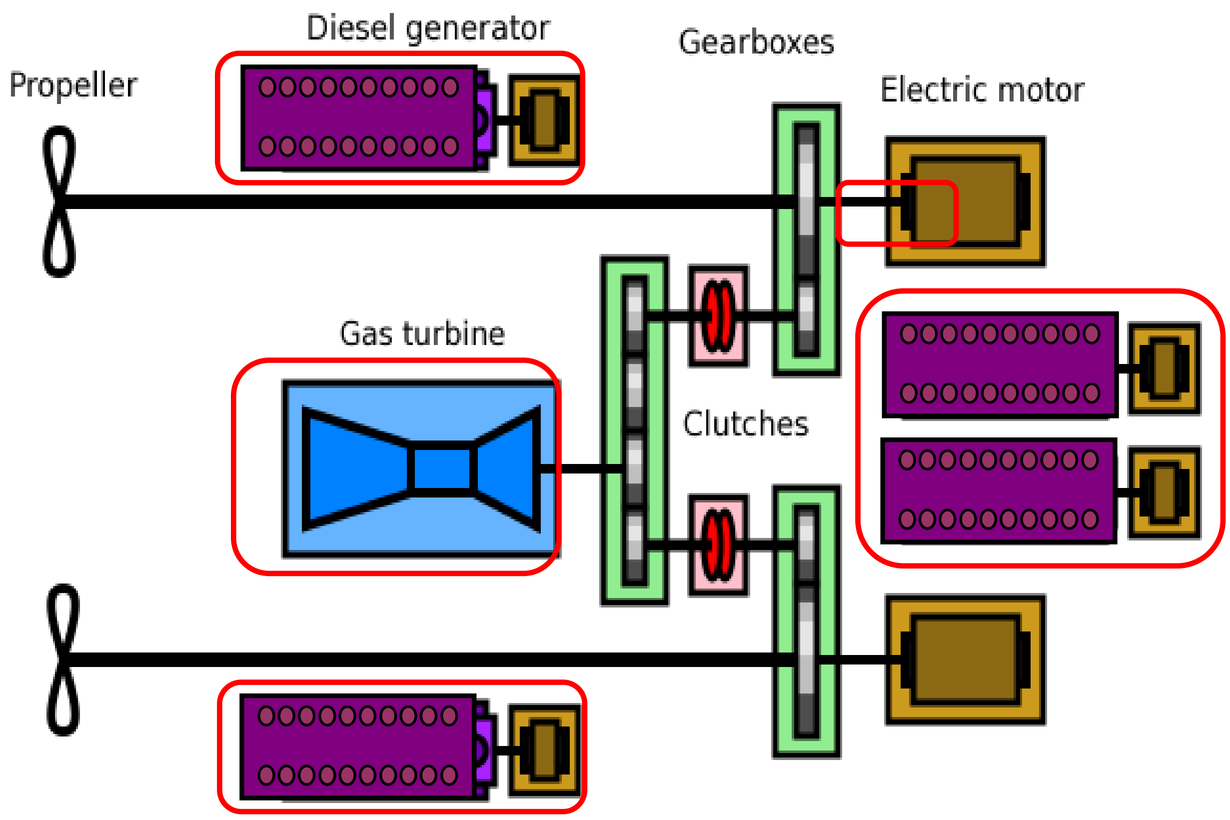
Gensets:

4 Gensets with Diesel engine 20V 4000 M53B, each 3.015 kW @ 1.800 rpm

Gas Turbine:

1 Package MTU LM2500, 20.000 kW @ 3.600 rpm

→ full military qualification: shock, acoustics, ABC, Load acceptance



schematische Darstellung

FREMM Frigates
CODELAG Propulsion System

L = 142 m

Displacement approx. 6000 tons

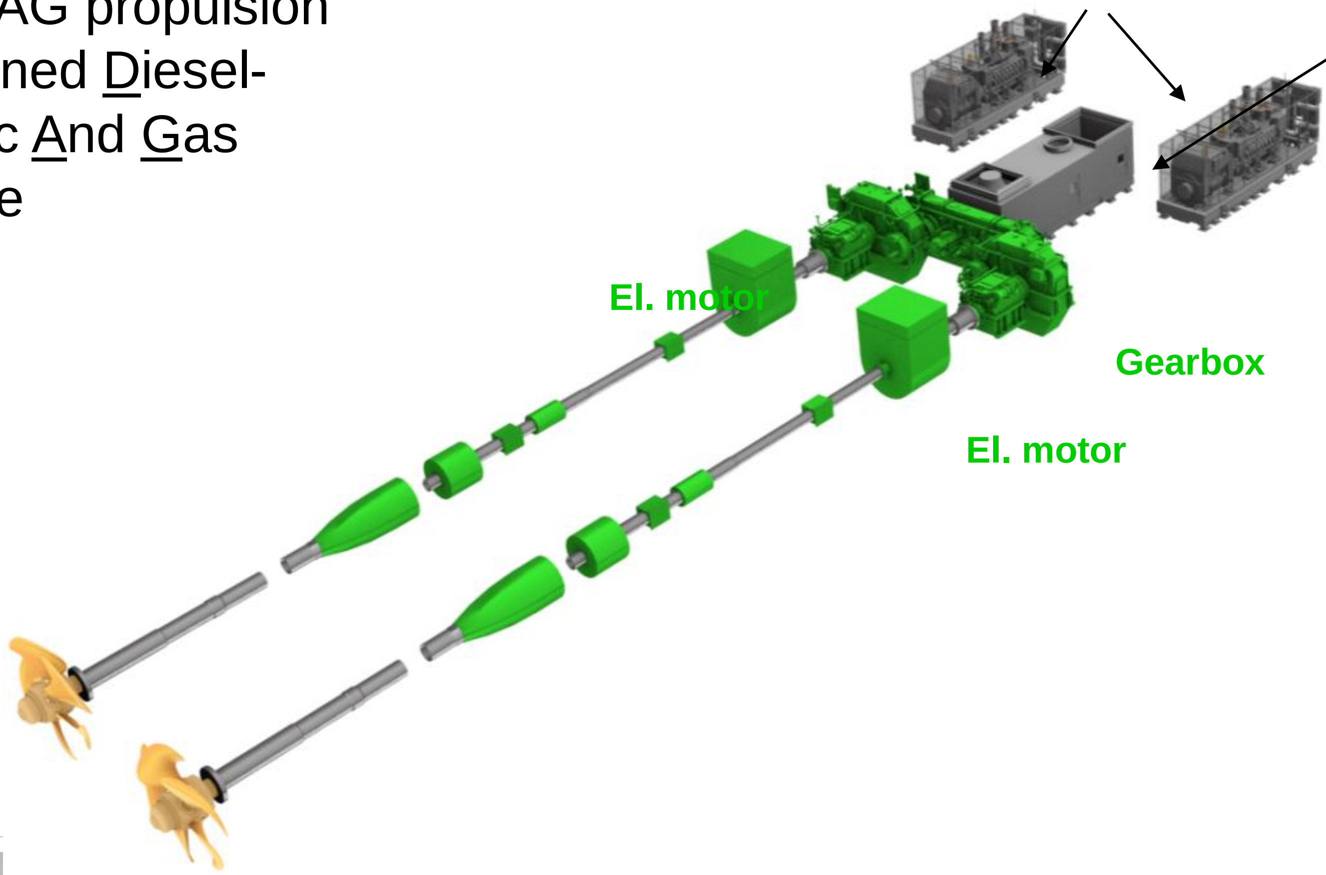
ASW Capability

27 kts max speed

15 kts max. electr. mode

FREMM
Propulsion plant max. 15 kts in electrical mode

CODLAG propulsion
Combined Diesel-
Electric And Gas
Turbine



FREMM
Gensets

4 x 16V 4000 Genset

2240 kW

- base frame filled with Polymeric concrete
- Sound enclosure
- Sliding door access

Turkish Corvette MILGEM
ASW

MILGEM Corvette
Scope of Supply

<u>Scope per Shipset:</u>

2 x MTU 16V 595 TE 90, Enclosed Module

1 x Gasturbine LM2500

1 x Renk „CODAG/CC“ Gearbox

2 x Escher Wyss Props and Shafts

1 x Propulsion System Automation

<u>Service Support:</u>

System Integration

Support for Installation, STW and

TrialsProject Management

Extensive Integrated Logistic Support (ILS)-Package

USCG Projects
National Security Cutter (NSC)

MTU was awarded the contract to act as the Propulsion Plant Single Source Vendor (PPSSV) for the NSC.

USCG Projects
NSC Design Basis

SAN Corvette

WARP Drive

Waterjet And Refined Propeller

Total Power: 31,840 kW

F124 Frigate

CODAG Drive

Combination Of Diesel And Gas

Total Power: 37,000 kW

USCG Projects
NSC Design Basis

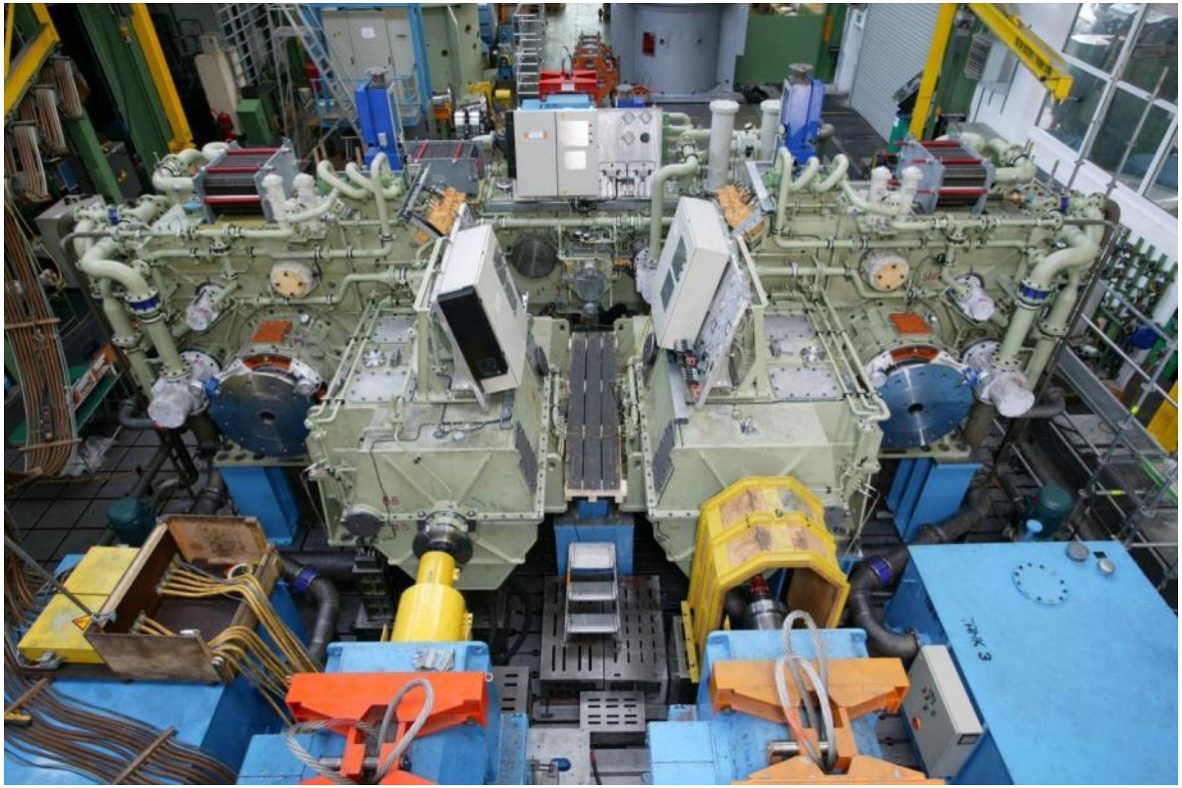
Diesel Engine
20V 1163 TB93

7,400 kW

Mounting Systems

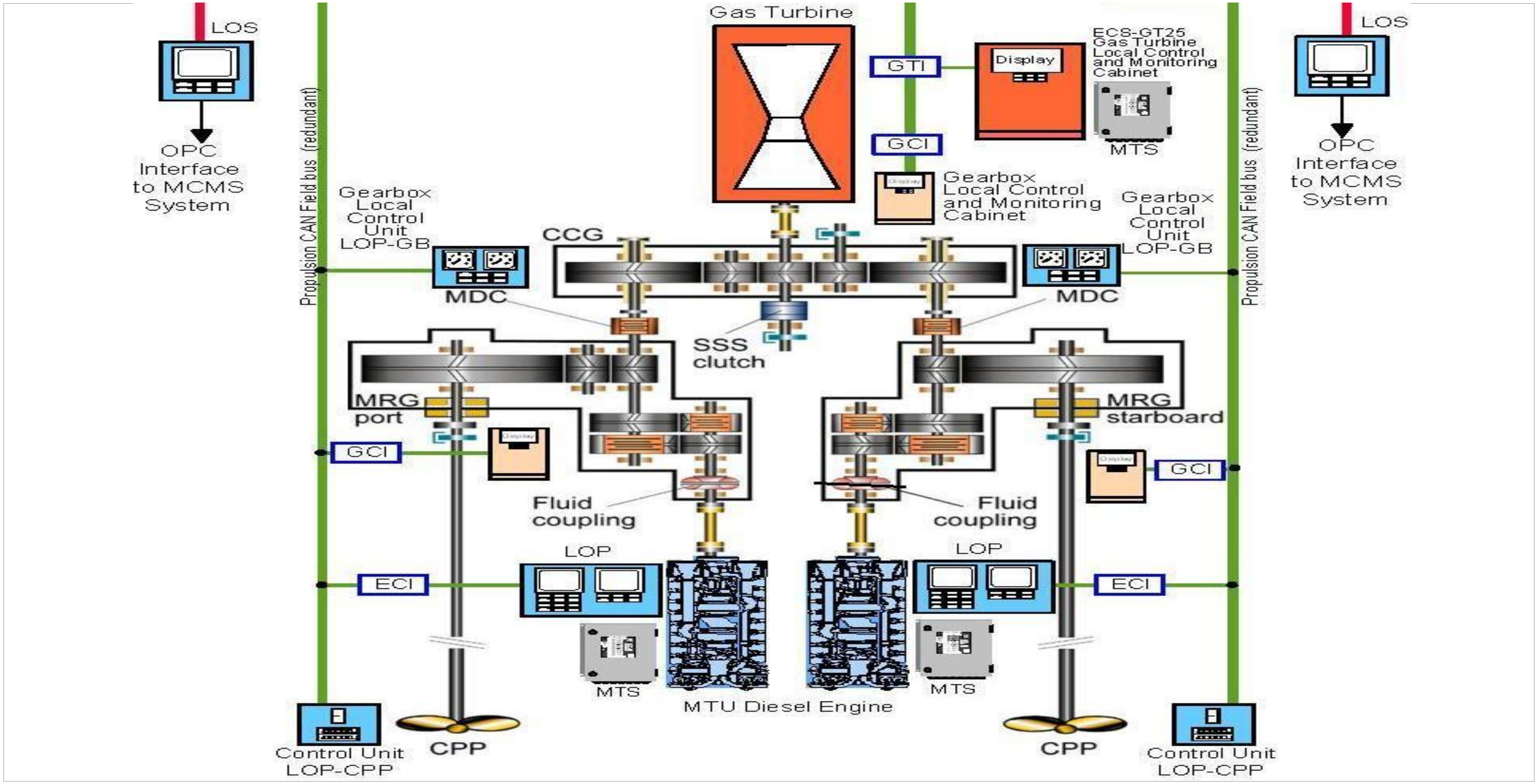
according to application

USCG Projects
NSC - Equipment



1 each Ờ RENK AS 2/250-AS 198F Cross Connect / Reduction Gear

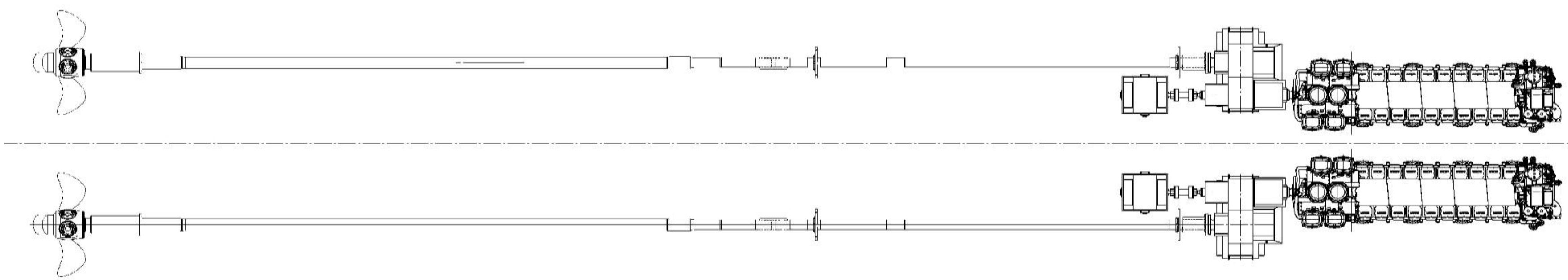
USCG NSC – Equipment Monitoring and Control System



Large Vessels
Propulsion System Combination

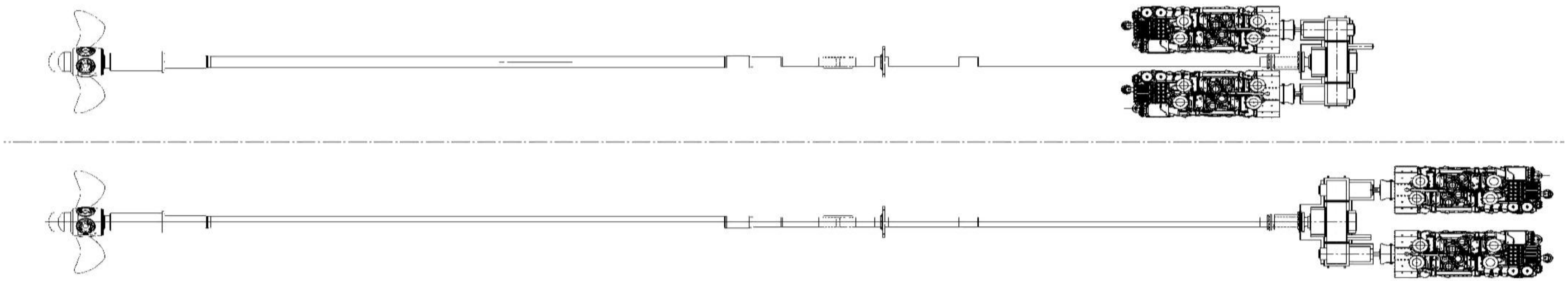
SISO (Single in / Single out) Direct Drive

SISO + E-PTI (Single in / Single out + Electrical PTI)

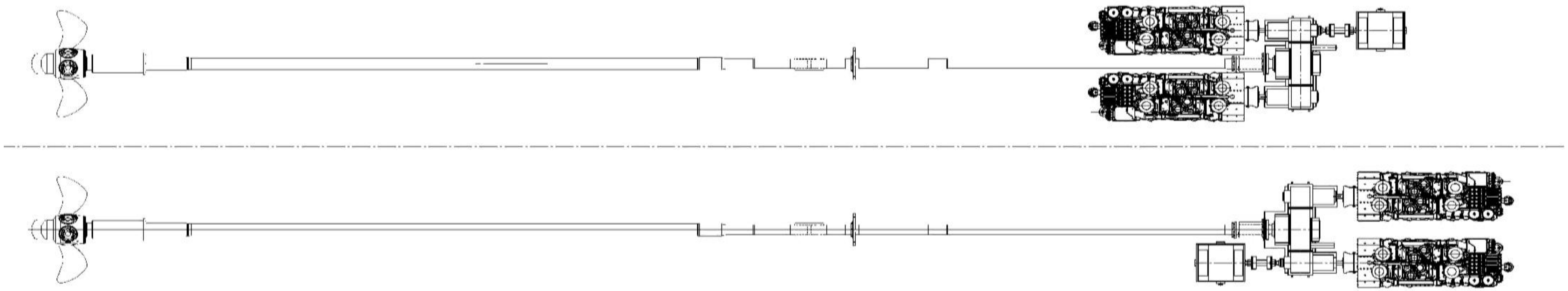


Large Vessels
Propulsion System Combination

CODAD (Combined Diesel and Diesel)

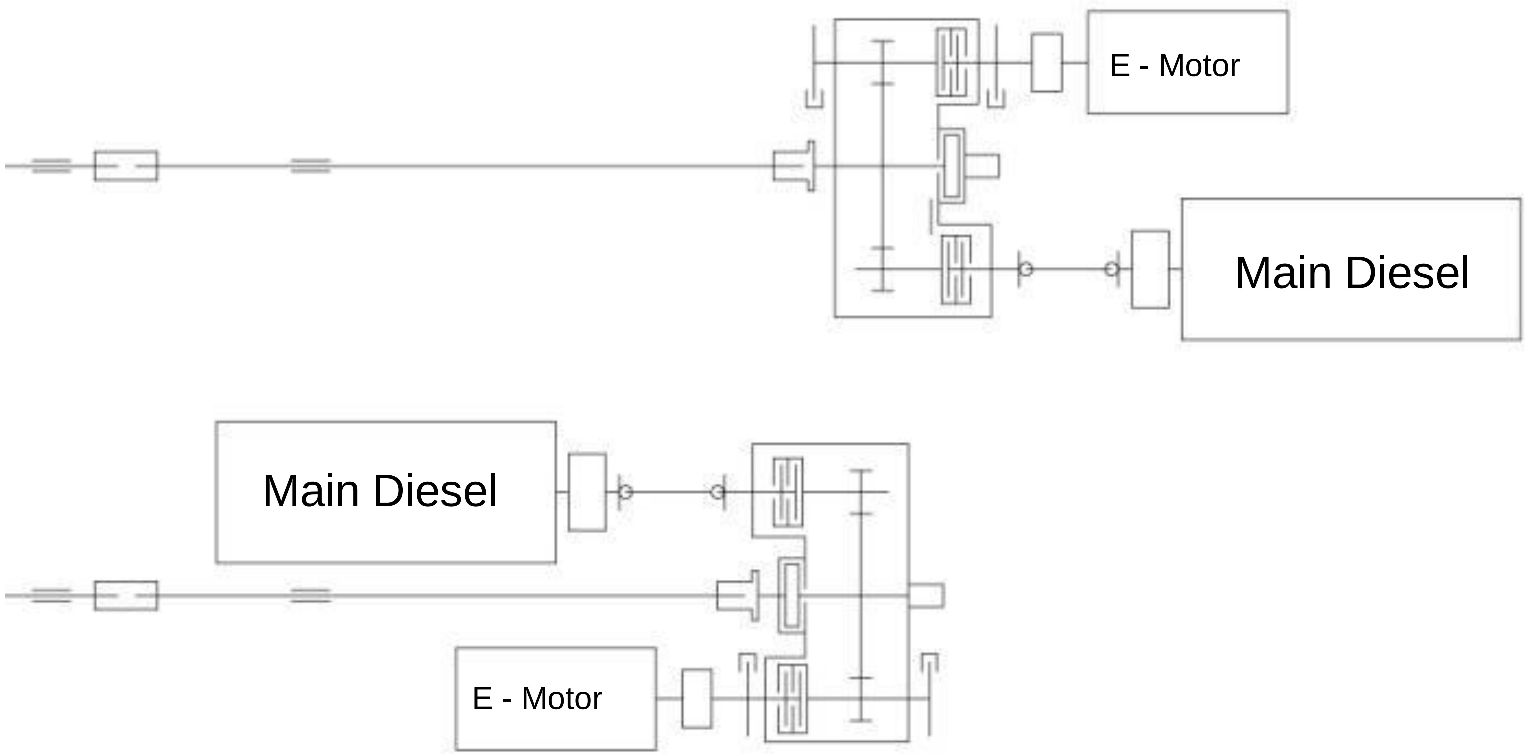


CODAD + EPTI (Combined Diesel and Diesel and EPTI)



Large Patrol Vessel **Hybrid Propulsion CODOE**
Reference: Royal Navy of Oman

Oman Patrol Vessel **Hybrid Propulsion CODOE Propulsion Arrangement**



General Project Data/Description

MTU Flexible Propulsion

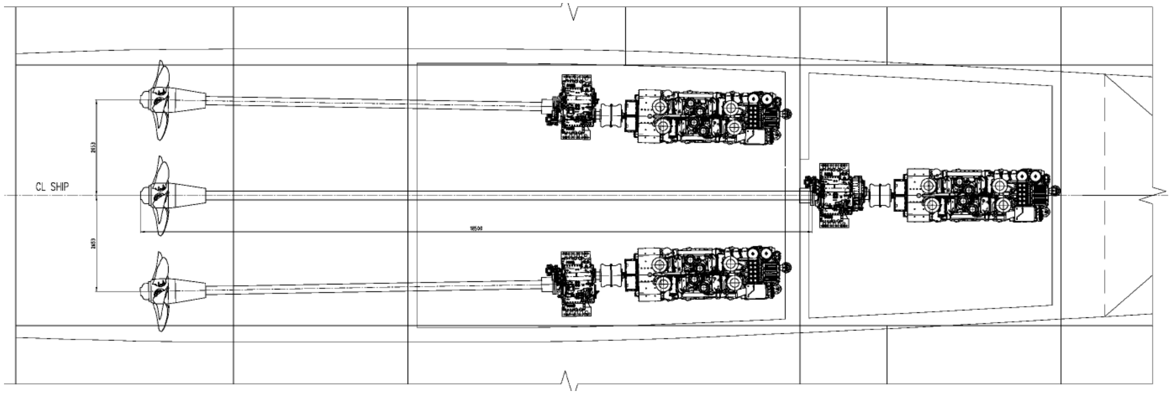
Direct drive propulsion plant with loiter drives or conventional diesel arrangement

3 x 20V4000M73L
- 3600 kW; 2050 rpm

Loiter Drives
- Power up to 800kw

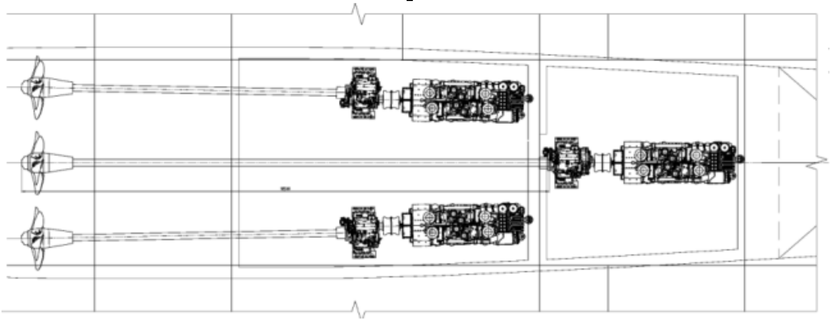
AUSTAL MRV 80

L = 80 m
Displacement 400 tons
max speed 25 kts

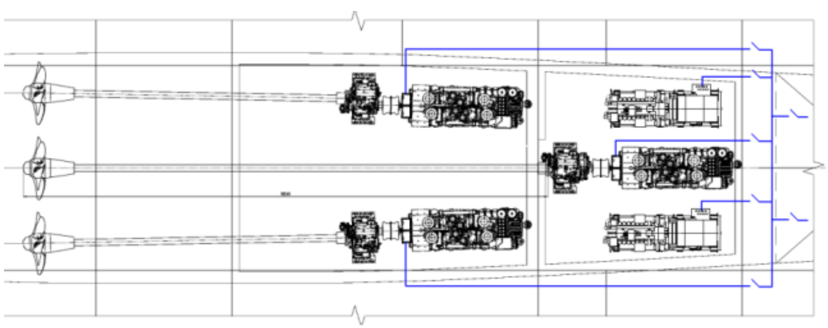


MTU Flexible Propulsion Concepts

Conventional Propulsion



Hybrid or Diesel Electric Propulsion



Conventional

- 3 x 20V4000M73L (3600kW)
- Diesel engine with low load operation capability

Hybrid Loitering, up to 10kn on e-mode

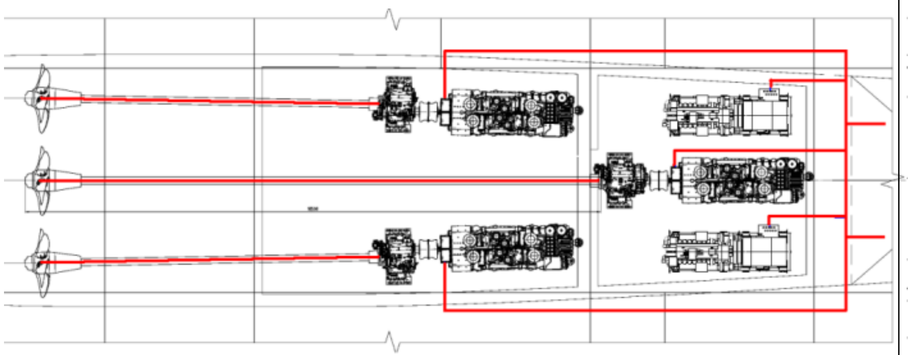
- Main diesels: 20V4000M73L
- Gensets: 2 x 12V2000M41A (541 kW)
- Integrated Electric Motors

Hybrid Patrolling, up to 17kn on e-mode

- Main diesels: 20V4000M73L
- Gensets: 3 x 16V2000M41A (725 kW)
- Integrated Electric Motors

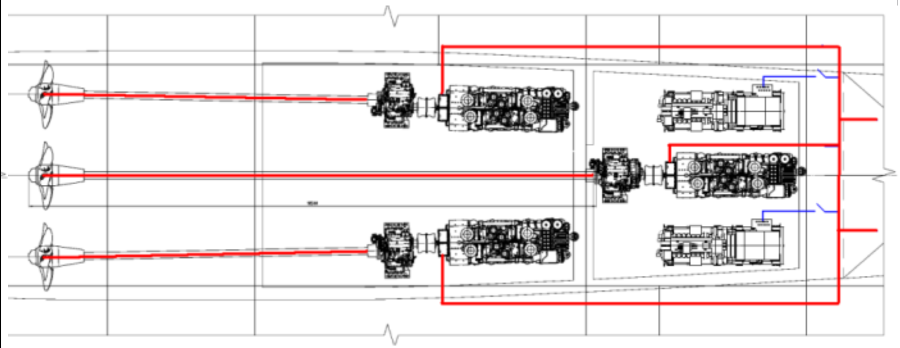
Advantage 1 - Flexibility

Hybrid Propulsion at lower speed



- E-Motors power the vessel at loitering or patrolling speeds (10 or 17kts) depending on gensets installed
- E-Power for Hotel Load generated by Gensets
- Plant acceleration improved, since electric motors produce higher torque at lower speed

Hybrid Propulsion at higher speed



- Vessel powered by main diesel engines
- E-Power for Hotel Load generated by main diesel engines (E-Propulsion motor switched to alternator mode)
- Gensets disconnected from ship electric power distribution net

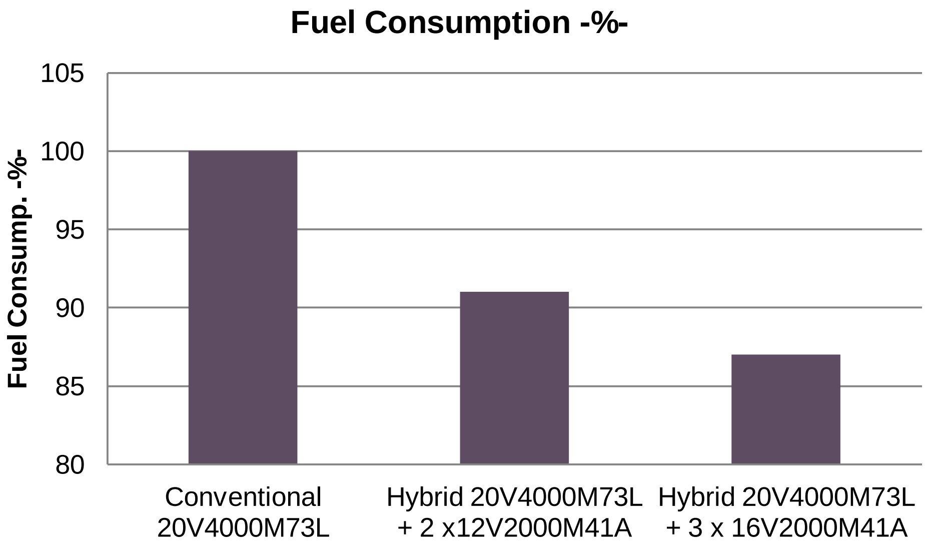
Advantage 2 - Fuel Oil Consumption

Reduction of Fuel Oil Consumption

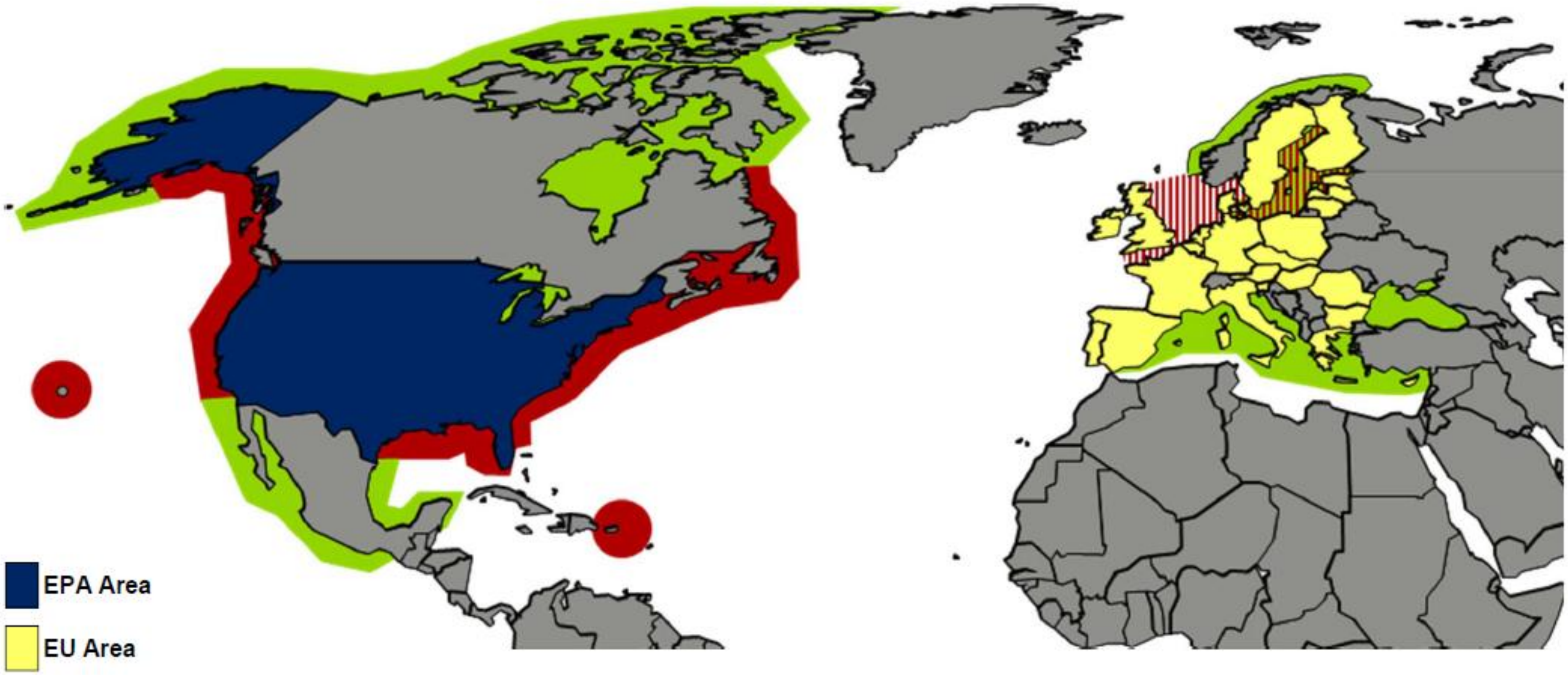
Diesel engines running at low load have higher specific fuel oil consumption compared with higher loads. Hybrid propulsion avoids main engines running at very low load by using gensets for vessel propulsion and hotel load power generation

Hybrid Plant for Loitering (up to 10kn)
9% Reduction of fuel consumption compared with conventional plant

Hybrid Plant for Patroling (up to 17kn)
13% Reduction of fuel consumption compared with conventional plant



Emission Legislation Marine EPA, EU & North American ECA[1] for IMO Tier III



ECA:
Coasts of Canada, USA & Hawaii *(effective 08/2012)*.
Puerto Rico, the US Virgin Islands *(effective 01/2014)*.
Range 200 nm, NO_x, SO_x & PM[2] emission control.

Existing SECAs:
North Sea (SO_x[2] only),
Baltic Sea (SO_x[2], and also proposed for NO_x[2])

Discussed ECAs:
Coasts of Mexico, Alaska and Great Lakes, Australia, Singapore, Hong Kong, Tokyo Bay, Norway, Northern Mediterranean Sea, Black Sea.

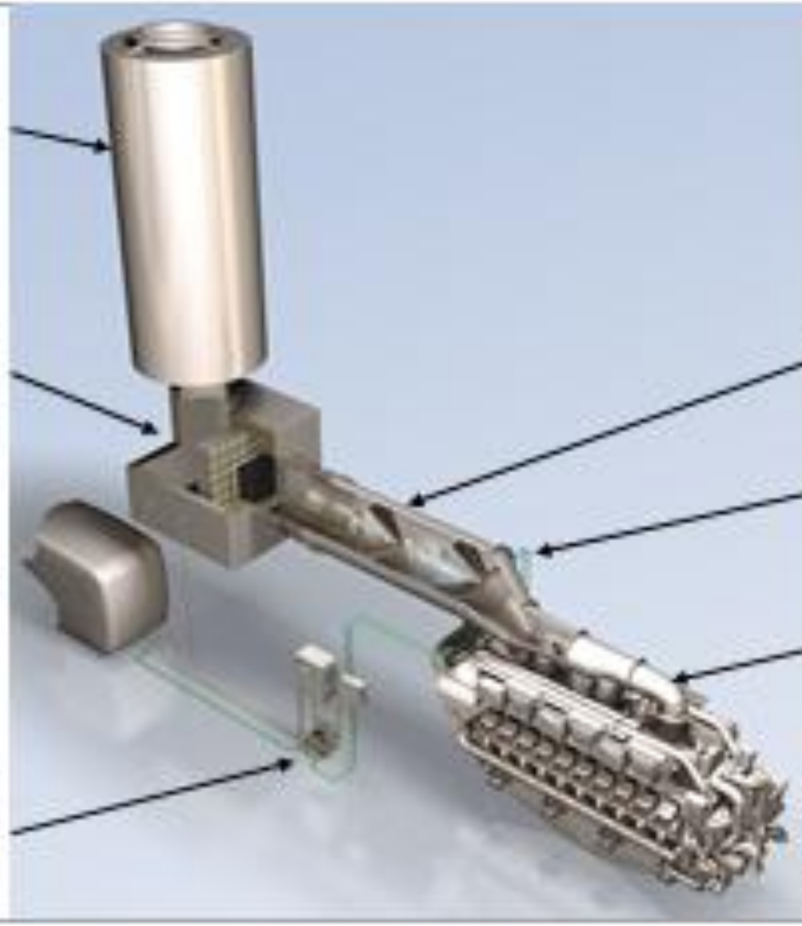
[1] IMO III applies only within ECAs (elswhere IMO II); IMO III does not apply to a marine diesel engine installed on a ship with a length less than 24 metres when it has been specifically designed, and is used solely, for recreational purposes. [2] NO_x=Nitrogen Oxides; SO_x=Sulfur Oxides; PM=Particulate Matter

Emission Reduction Technologies - Overview

- Emission reduction technologies
  - Engine internal
    - Conventional
      - Turbocharging
      - Injection
      - Combustion
    - Advanced
      - Miller Cycle
      - Exhaust gas recirculation
      - Fuel water combustion
      - Alternative fuel: natural gas
  - Engine external
    - CO, HC: Oxi Cat
    - NOx: SCR
    - PM (Soot): DPF

➔ Advanced technologies are required to meet future emission legislation.

SCR for IMO 3
Study for a big vessel



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100 YEARS

Moving with Passion!

Thank You.