Conversion of LNGC Tenaga vessels to FSU: Challenges and lesson learnt

MJB Technical Talk 1

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18 Jan 2013

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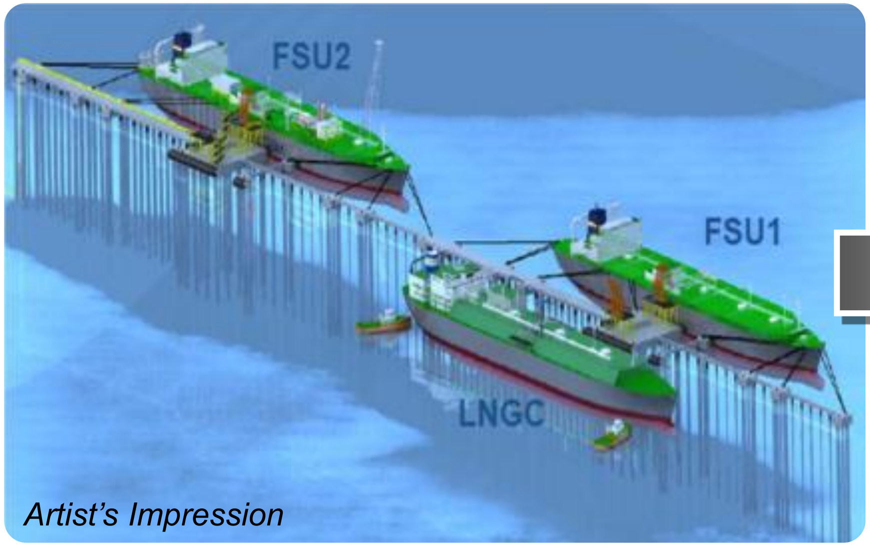
Introduction

Introduction

Regasification Terminal (RGT), Sungai Udang



Artist's Impression

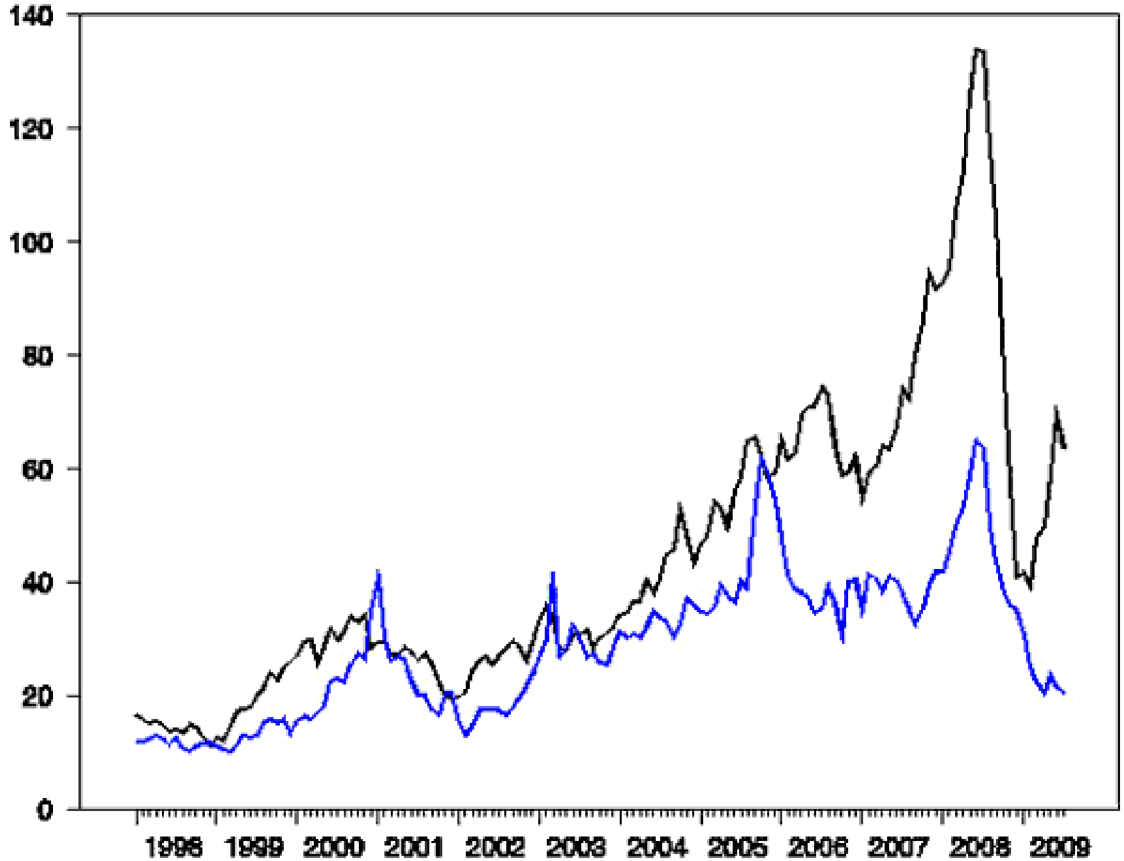
2nd June 2012, Sungai Udang

10th Malaysia Plan

10th June 2010

"Construction of the first liquefied natural gas regasification plant in Melaka"

RATIONALE FOR FSU

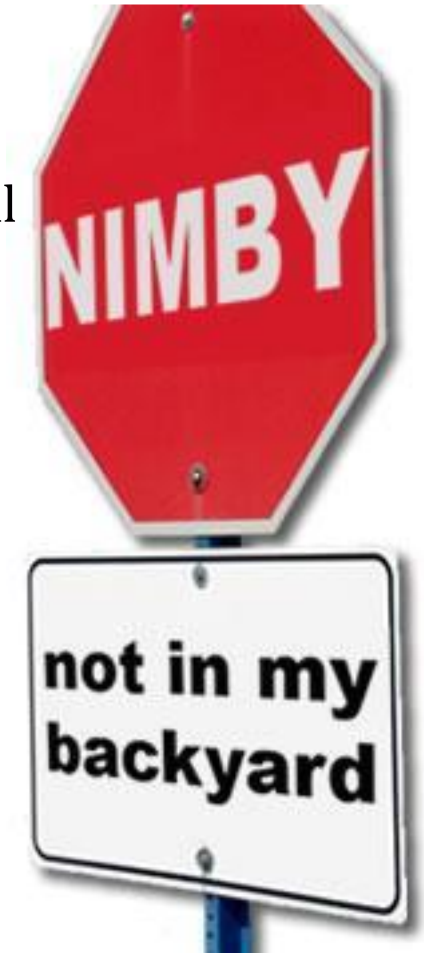


Black line. Jan 1998 to Jun 2009: average price over the month of West Texas Intermediate, in dollars per barrel (from [FRED]). Jul 2009 entry is spot price on July 17 (from [WSJ]). Blue line. Jan 1998 to April 2009: six times the U.S. natural gas wellhead price (from [EIA]). May to Jul 2009: six times estimated Henry Hub spot price (from [WTRG]).

RATIONALE FOR FSU

Why Offshore solution?

- Establishing onshore LNG storage & regasification terminal is difficult
- Risk of LNG production misinterpreted - local opposition
- Economically attractive

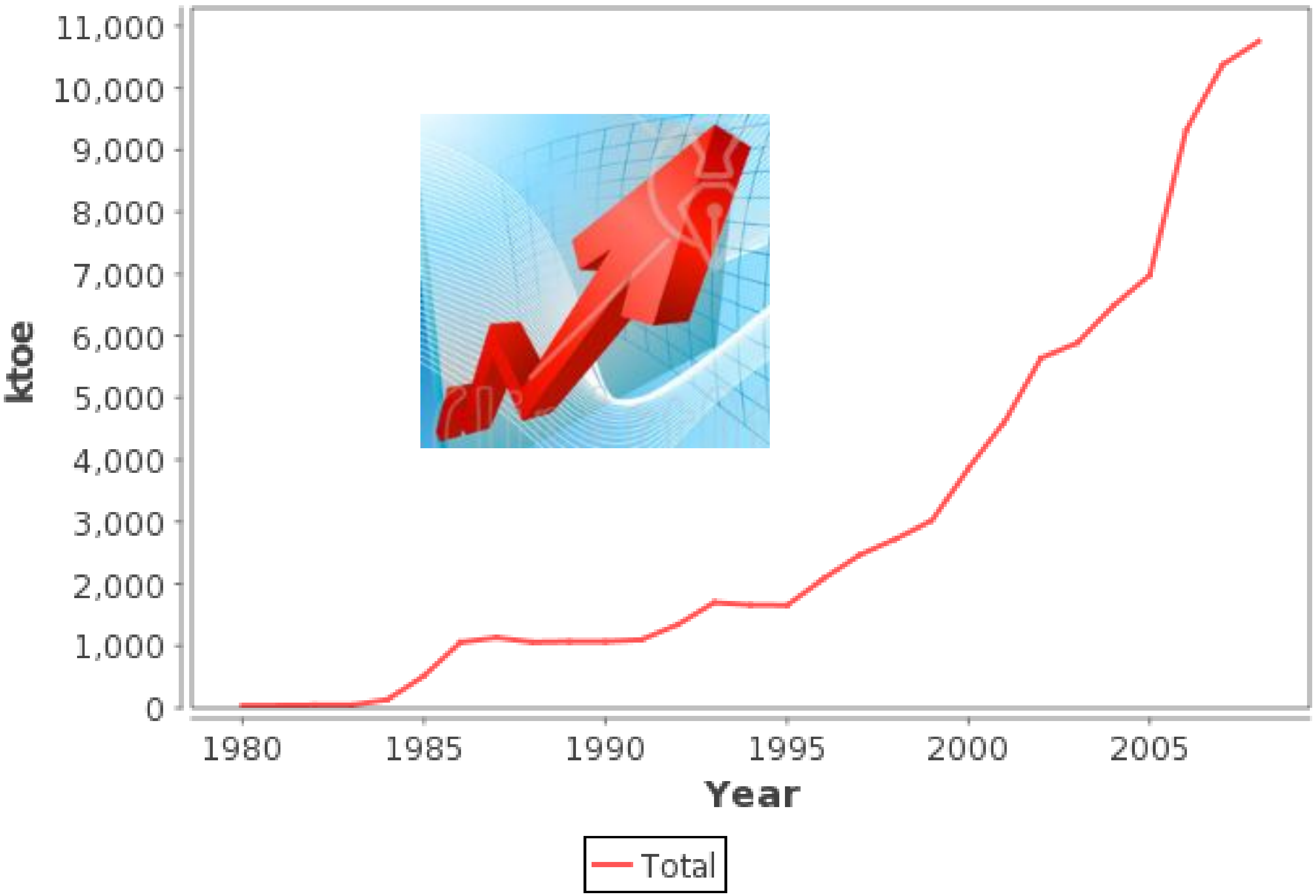


Why Conversion?

- Lower CAPEX
- Enters the market faster
- Minimum modification to cater for floating storage

Total natural gas consumption in Malaysia

Source: Malaysia Energy Commission (Suruhanjaya Tenaga)



Project development

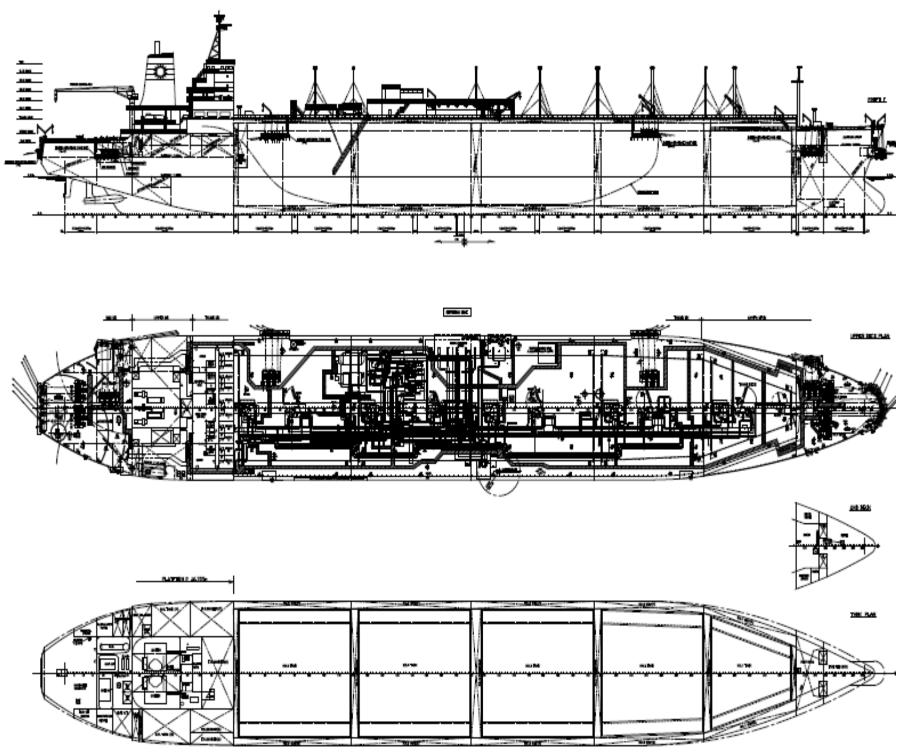
- Repair, life extension and conversion (RLEC) began in August 2011 at shipyards in Malaysia and Singapore.

- Dry docking commenced in February 2012.

- Vessels were redelivered at shipyards and towed to terminal in Melaka at the end of May 2012.

Introduction

An overview of LNGC Tenaga Empat



Principal dimensions

- LBP : 266.00 m
- Beam (mld) : 41.60 m
- Draught (summer) : 11.72 m

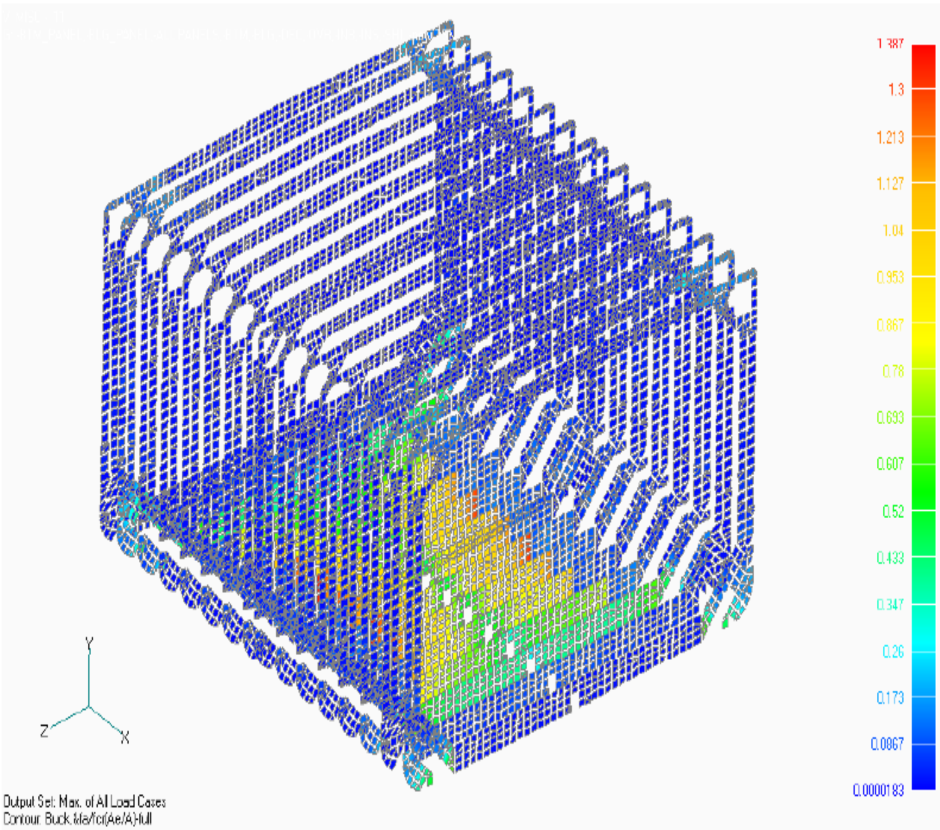
- Cargo capacity : 130,022 m^3
- Cargo containment system: GTT NO88

- Design life (extension) : 20 years
- Year built : 1981

Hull structure, painting and outfitting

Hull structure, painting and outfitting

Structural analysis and reinforcements (ISE and TSA)



Transverse Webs Buckling Check – Max. of all Load Cases

Fatigue analysis and reinforcements

- Following ABS Rules for Floating Production Installations, initial scantling evaluation (ISE) was carried out on all primary and secondary members.
- Total strength analysis (TSA) was also carried out using finite element modelling (FEM).
- TSA reinforcement plan was combined with repair plan after condition assessment.

Hull structure, painting and outfitting

20-year coating

20-year coating

- Full blast for external hull and water ballast tanks
- Up to 875 µm dry film thickness (DFT) for paint system
- Dry docking for about 40 days
- Latest hydrolysis technology in self-polishing copolymer
- A good coating system will enable vessel to operate without dry-docking for 20 years

misc

Hull structure, painting and outfitting

Fairlead support structure

Fairlead support structure

- Fairleads are installed on the external hull, so support structures are required.
- Additional scantlings and railings to allow for safe maintenance of fairlead.
- Distance of fairleads and support structures from trunk deck are determined from in-depth mooring analysis.
- Thorough non-destructive tests (NDT) are part of QA/QC policy.

Hull structure, painting and outfitting

Lifting philosophy

- Port side lifting to quayside no longer required due to permanent mooring.
- To reduce OpEx, portable air-operated davit are used to replace midship cranes.

- Due to no dry-docking for 20 years, davits are installed at cargo tank areas to allow lifting of cargo machineries for maintenance.
- A total of about 20 davits are installed in various areas.

Hull structure, painting and outfitting

Sacrificial anodes

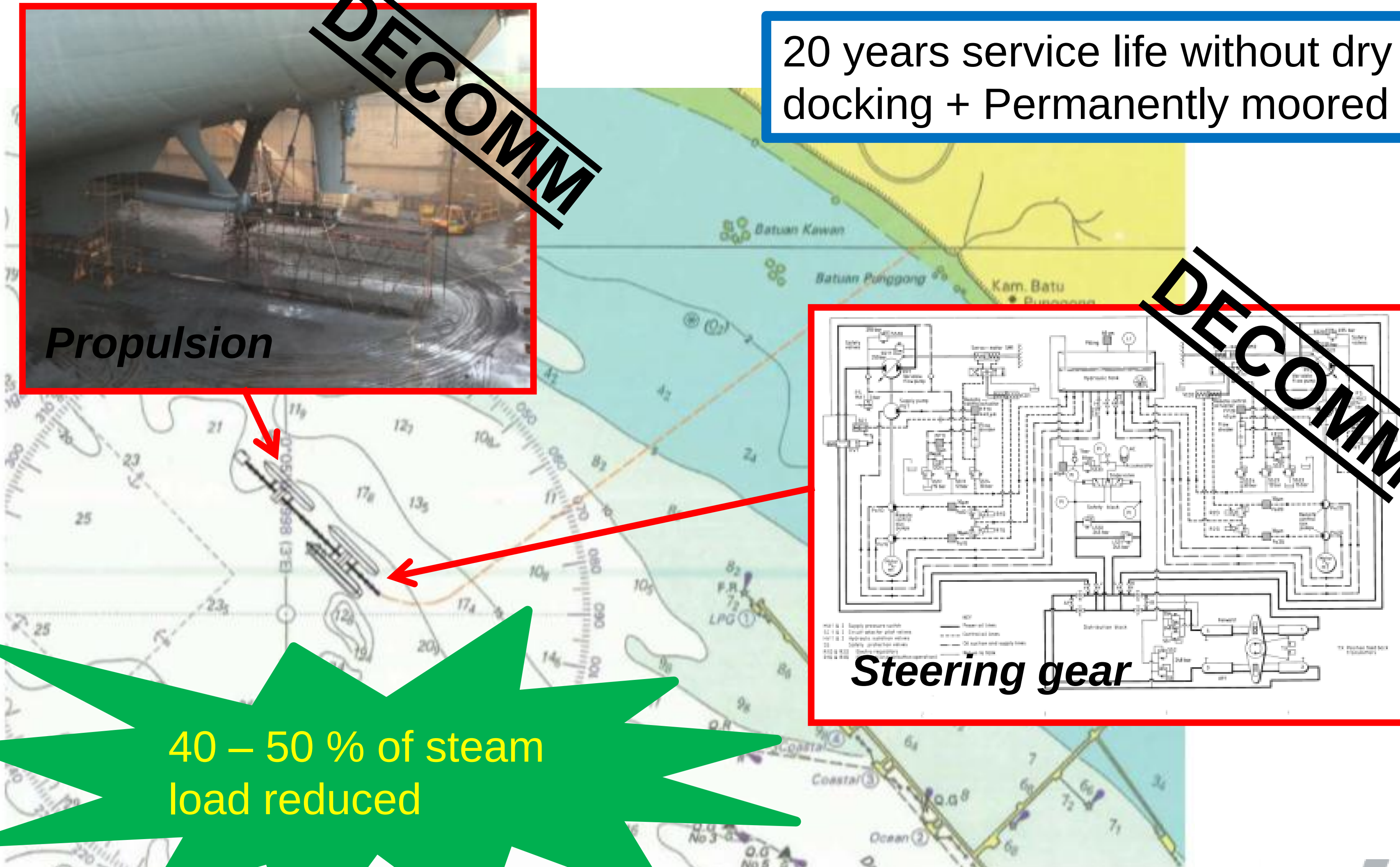
Sacrificial anodes

- Use of ICCP has been discontinued due to potential arcing between jetty and vessel.
- Sacrificial anodes are used instead.
- Calculations are made by consultant based on DNV RP B401.
- OpEx cost savings are significant as compared to use of ICCP in the past.
- Good paint system helps to increase the benefits of sacrificial anodes.

Electrical Developments and Boiler Challenges

Electrical Developments

High Voltage Shore Connection (HVSC)



20 years service life without dry docking + Permanently moored

40 – 50 % of steam load reduced

Electrical Developments

High Voltage Shore Connection (HVSC)

---- ECONOMIC STUDIES ----

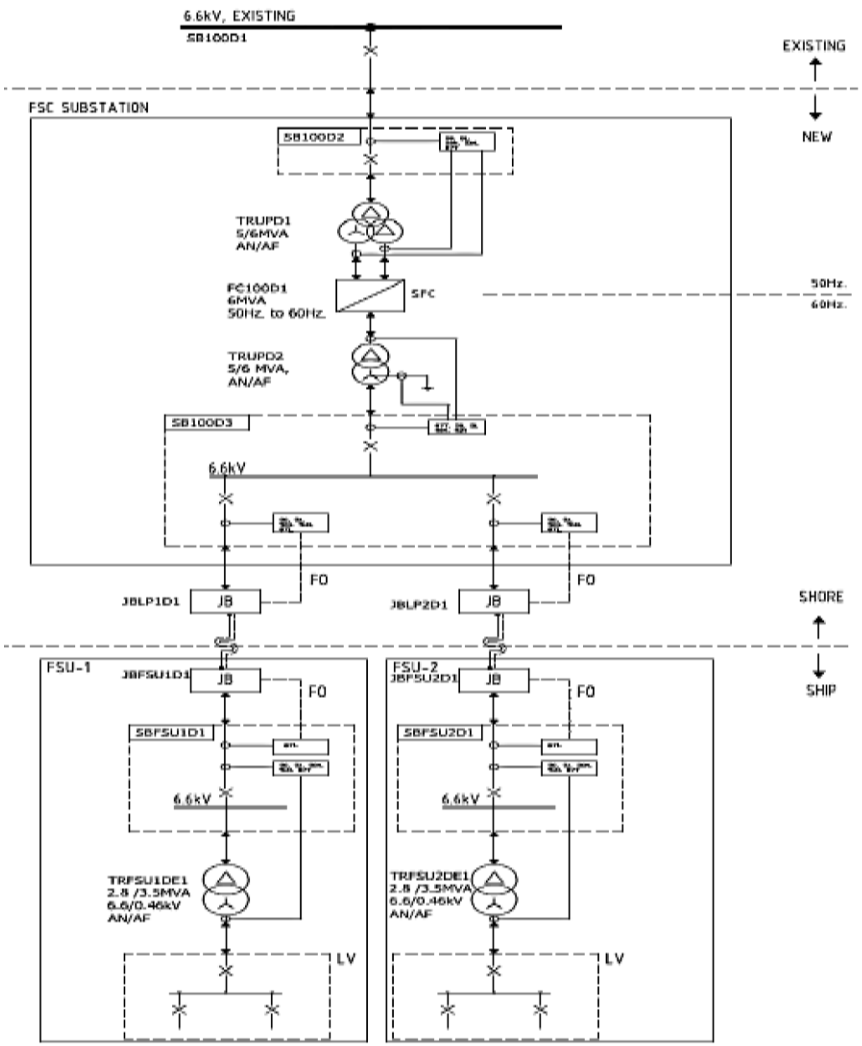
Concept	Option 1: 100% Shore Power	Option 2: 50% Shore – 50% Ship	Option 3: 100% Ship Power
Description	• 2MW supplied from shore power • Boiler running at about 13% load (to run feed pump, LD compressor, boiler gas heater, boiler steam air heater, etc)	• 1MW supplied from shore power • Shore power supply at approx. 50% + STG supply (ship) at approximately 50% of ship power	• FSU STG 100% supplying the load.
Total Energy Cost, %/year	50%	70%	100% (Base)

***** Shore Power Tariff from TNB is much CHEAPER option than the BOG cost**

❖ Due to project schedule, the concept of **50% shore - 50% ship** had been adopted.

Electrical Developments

High Voltage Shore Connection (HVSC)



Ship to Shore Power SLD

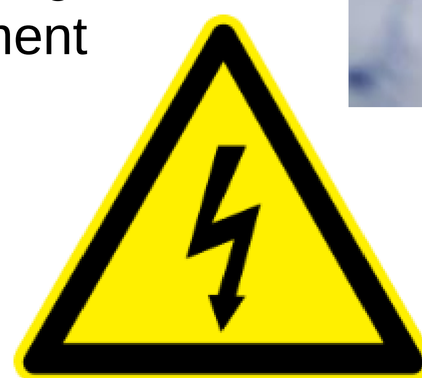
Shore Power JB

Electrical Developments

High Voltage Shore Connection (HVSC) - Challenges

- Integration of new system with existing & keep the related electrical equipment manageable.
- To develop system with primary focus on safety of operating crews & security of the shipboard equipment based on ABS Guide for HVSC.
- Fast-track project - Long lead to develop engineering drawings, acquiring relevant resources, approvals & endorsement

ABS
FOUNDED 1862
AMERICAN BUREAU OF SHIPPING & AFFILIATED COMPANIES



High Voltage

misc

Electrical Developments

High Voltage Shore Connection (HVSC) - Challenges

Additional footprint required for the new HVSC equipment (transformer, switchgears, JB, cable trays).

Solution - Existing electrical workshop converted into new HVSC switchboard room.

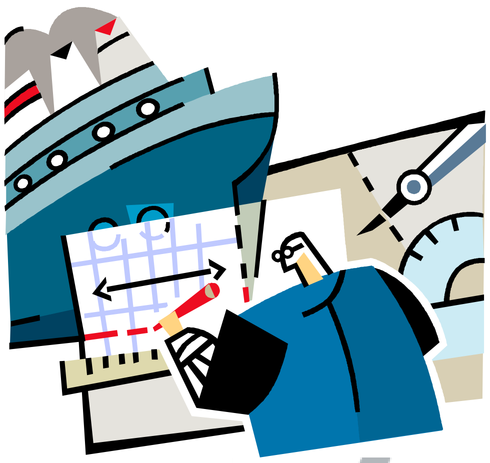
Electrical Developments

Other E & I Challenges

- **Reliability** of the existing equipment and instrument was very subjective.

- Parts found defective were **obsolete** – transmitters, electro-pneumatic solenoids, level sensors, alternators electrical components, relays, PLC based system spare parts & etc.

- Detailed evaluation & fault findings – consume lots of **time** & man power especially in a project where **time** is a major constraint.



- Capability to **coordinate** plant up activities for troubleshooting while other RLEC works for various other departments (e.g structure, piping & hull) concurrently.

Boiler Challenges

HFO → **MDO** *(MARPOL Annex VI Global Sulphur cap reduction)*

Modification on related existing steam & fuel oil system

Existing HFO equipment & fuel heating system removed & decommissioned

MDO Skid

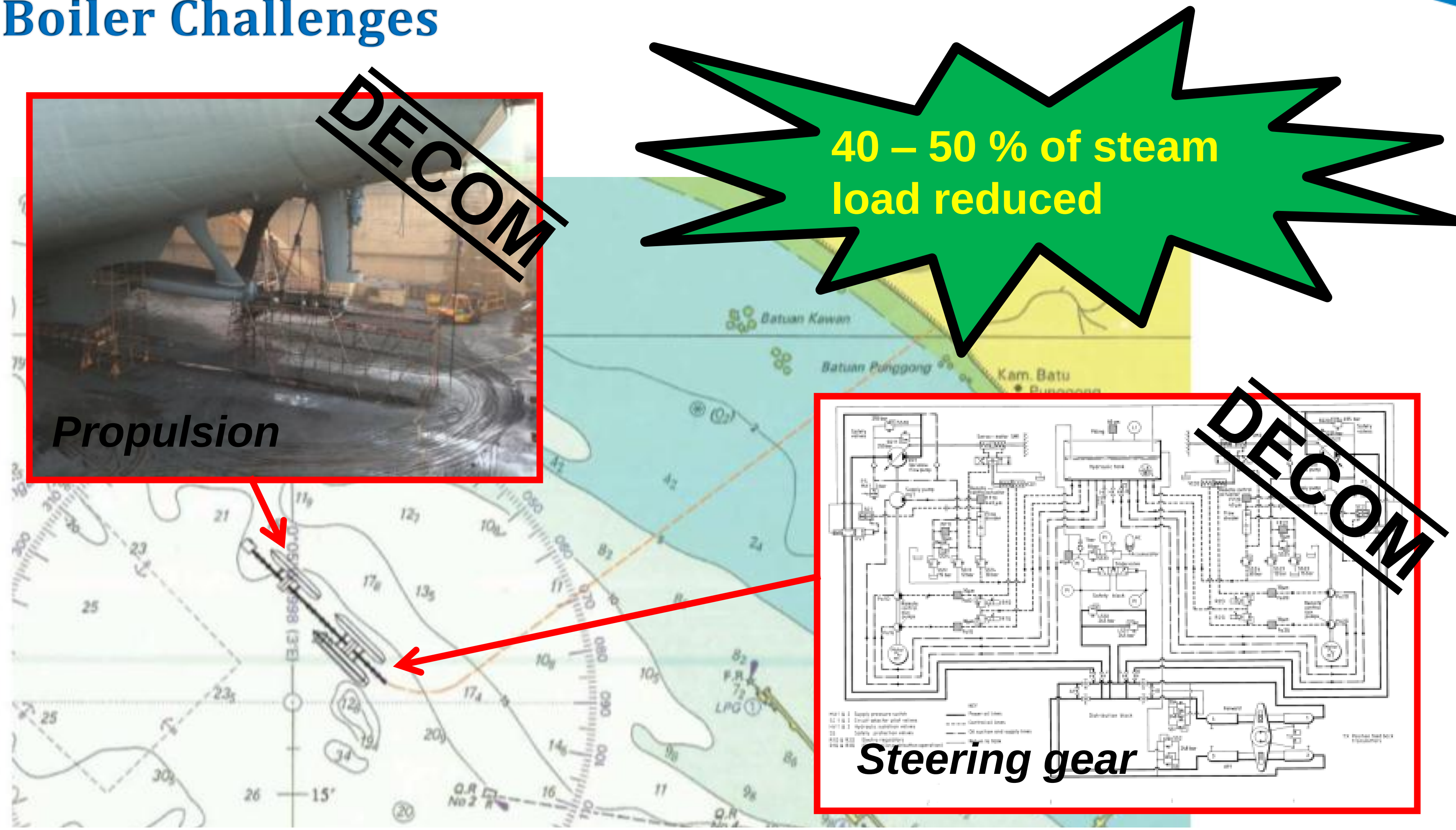
Boiler Challenges

100% gas firing + **Dual firing** + **100% oil firing**

NEW for FSU → Modification of DCS, BMS & ACC

Refitting of new burner assemblies for 100% gas burning

Boiler Challenges



Required - Boiler load adjustment from existing 78 tonnes/hour to ensure related system equipment rating compatible to new boiler rating.

Boiler Challenges

Item	Case 1: Normal Regasification			Case 2: Normal Regas + Loading			Remarks
	Qty in use	Steam (kg/h)	Load (%)	Qty in use	Steam (kg/h)	Load (%)	
STG (2x2.6MW)	1	12,600	63	1	15,400	77	Case 1: 1790 kW Case 2: 2150 kW
Feed Pumps (2x6 ton/h)	1	2,900		1	3,200		170 m^3/h x 847 m (617 kW)
Desuperheater & miscellaneous		12,418			16,422		
Boiler Demand (Total)	1	Approx. 28,000	36	1	Approx. 35,100	45	Steam flow max per unit 78,000 kg/h

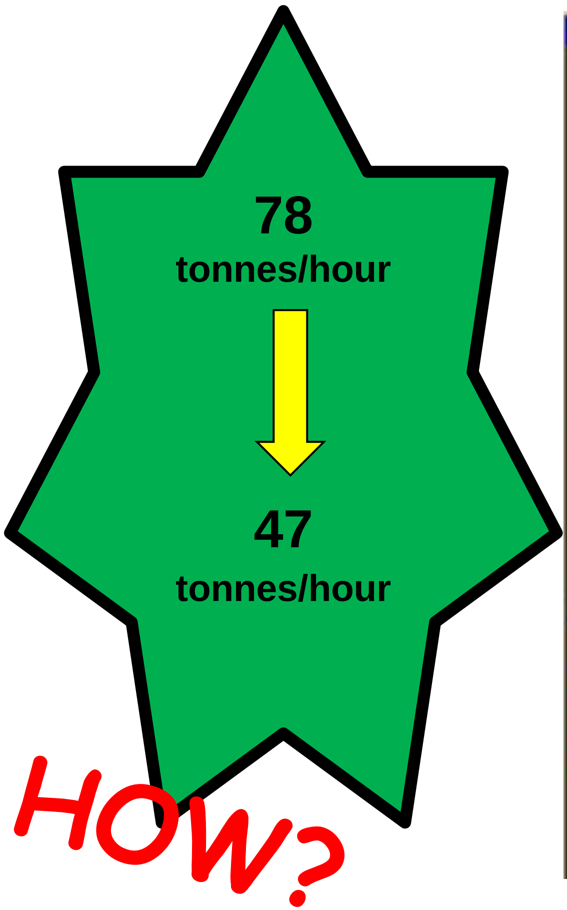
Factors considered:

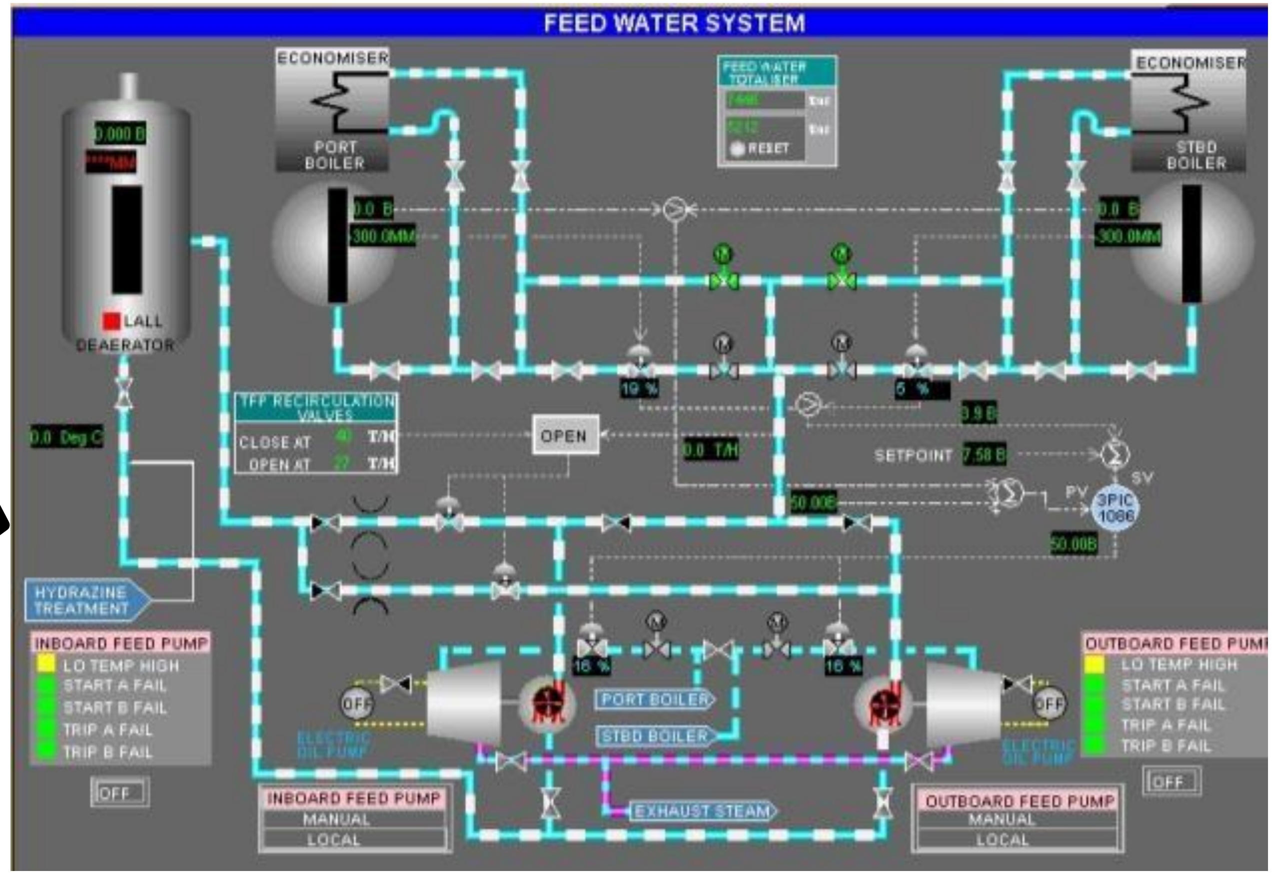
Low boiler load – Affect life cycle of turbo feed pumps

High boiler load – Reduce life cycle of superheated tubes

78 tonnes/hour → 47 tonnes/hour

Boiler Challenges





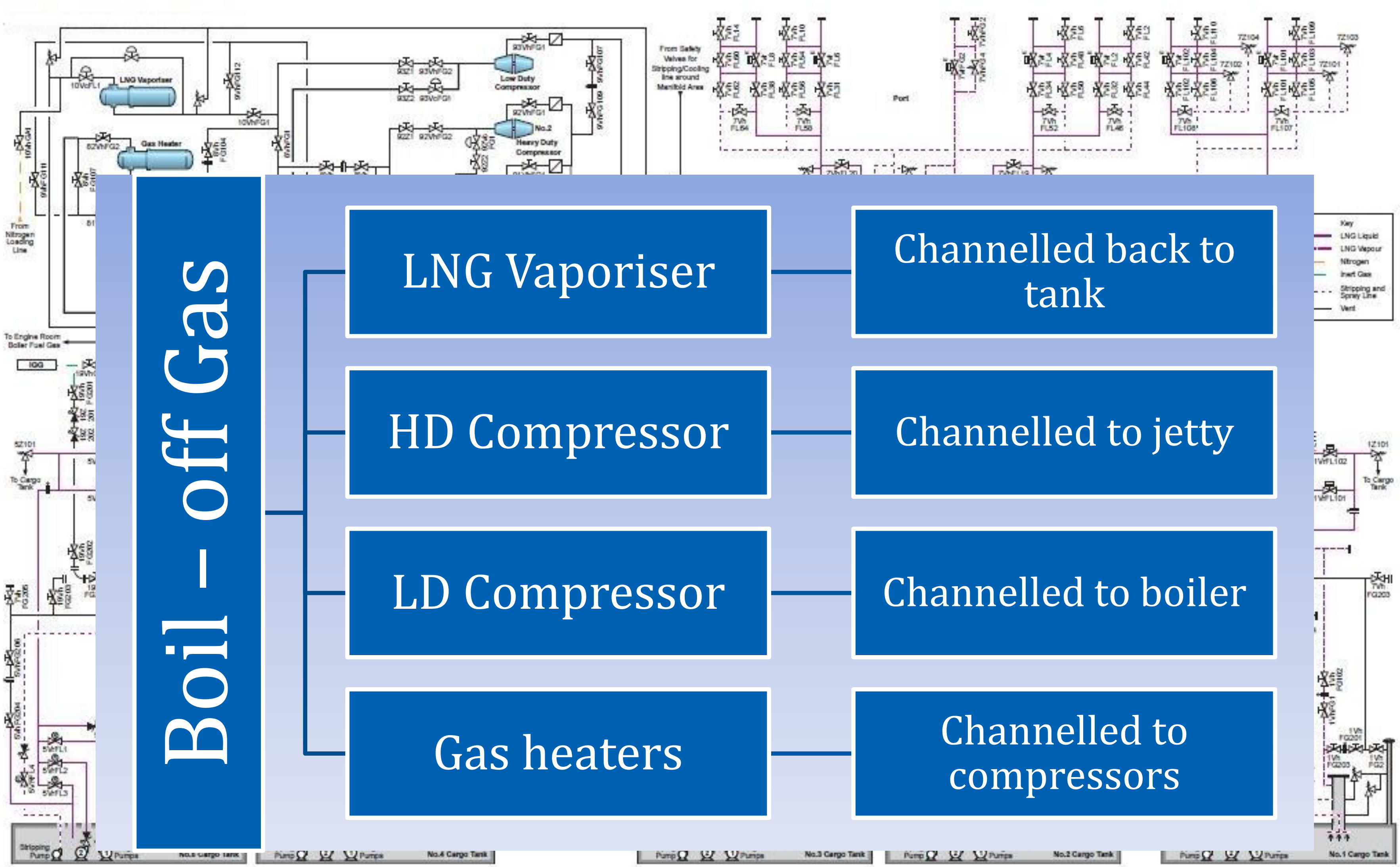
Reduce amount of feed water to the boiler.

Feed pump:

Reduce size of nozzle at turbine side + Downsize the impeller at pump side

Cargo piping

Cargo piping



New Cargo Piping System

Offloading Line

- New offloading manifold to offload LNG from cargo tank to JRU.
- To have separate system from loading operation.
- To allow simultaneous loading and unloading operations.

Nitrogen Line

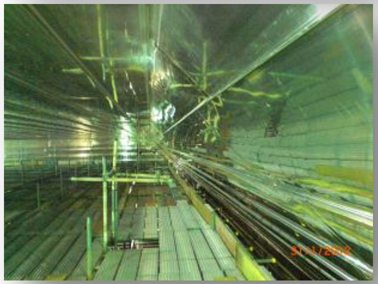
- To perform simulataneous operation; maintain supply N2 to operating tank and pull vacuum for tank that is due for internal inspection.

Vent and Purge Line

- To purge and inert specific tank during 1 tank inspection.
- Vent piping connected to vapour outlet of each cargo tank and purge piping connected to the LNG filling inlet

New Cargo Piping System

One Tank Inspection



- FSU is designed for 20 years operation without drydocking and one tank inspection is the most important facility for this vessel.
- One tank inspection will allow any single tank entry during operation for maintenance by emptying LNG in the selected tank.

- Modification of existing pipeline has been carried out to allow single tank entry.
- For this facilty to work, new additional piping is required - offloading liquid line, vent and purge line and nitrogen line.

Cargo Piping Insulation

Insulation

- Increased thickness than existing cargo line.
- 2 layer of polyurethane, each connected by glue and polyurethane foam.
- PU foam must be used in-situ if the gap between PU segment joint width > 5mm.
- This is important to prevent cold spot in operation.

Cargo Piping System Test

Cold Test

- Overall test for each and every pipe line, either new or existing with insulation, with new valves, flange connection in operational condition without any leakage
- Preparation was done to ensure there is no SUS dust, and other solid or liquid inside the pipelines before starting cold test

- Test is started by inerting pipelines using dry nitrogen gas to make sure no water moisture in pipe during cooling test.
- Cool nitrogen gas was introduced into pipeline as starting procedure. This test is finished when temperature at liquid and gas line reaches -100 degree C and temperature at purge and vent line reaches -70 degree C.
- This is when the insulation plays important role for protecting personnel from injury due to cold cryogenic temperature.

Ship-shore link

Ship-shore link

Conversions on FSU and JRU

Conversions on FSU and JRU

- Initiation of PSD signal on the JRU will:

a. Stop send out operation from FSU in send-out mode.

b. Shut down all process equipment

- Additional means of JRU-FSU communication:

a. PSD signal between JRU-FSU

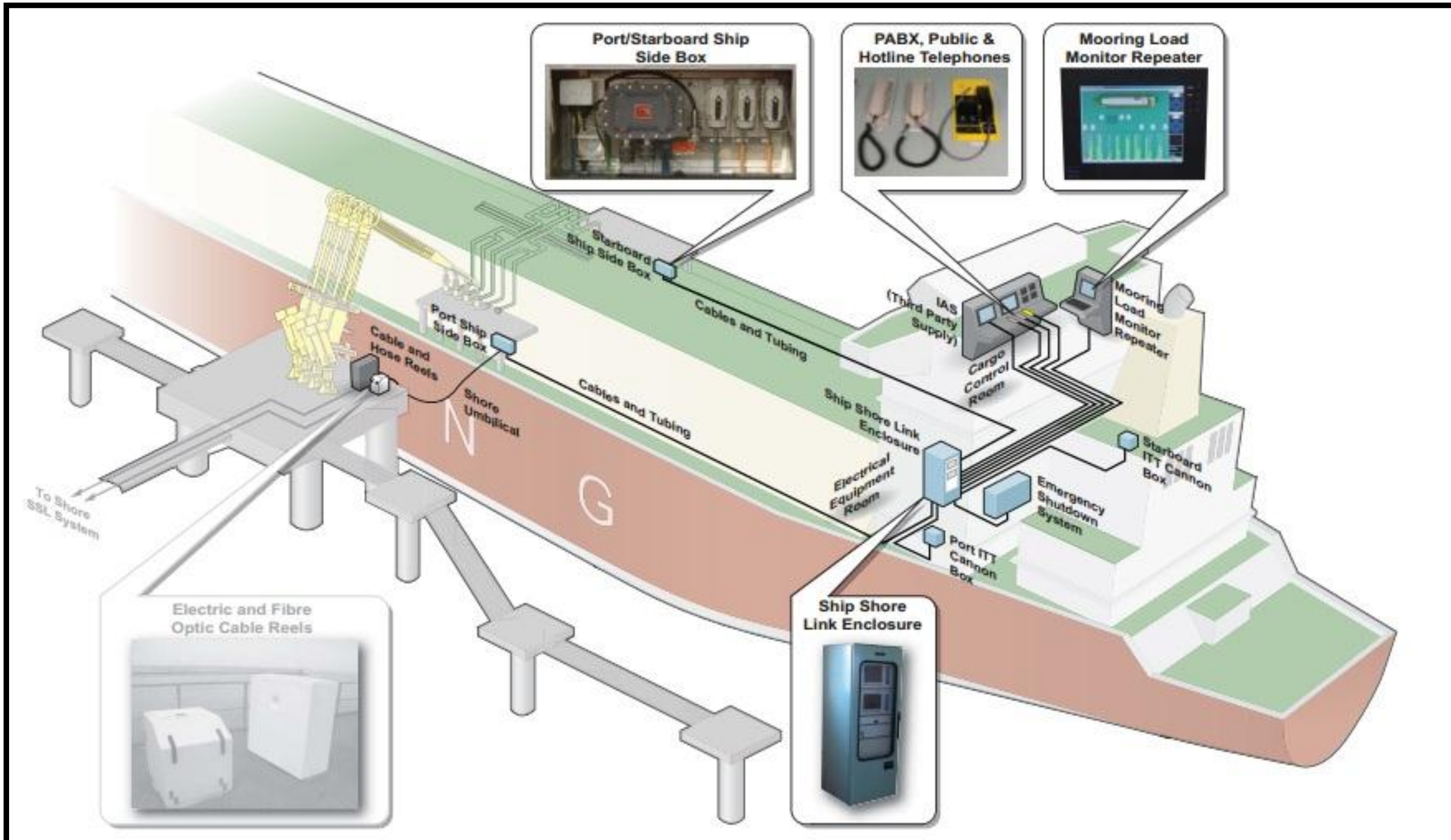
b. Data transfer from FSU DCS to shore DCS via fibre-optic

c. Internet and VoIP Phone

d. Point-to-multipoint (PMP) radio as standby for radio communication between FSU and JRU control room.

Ship-shore link

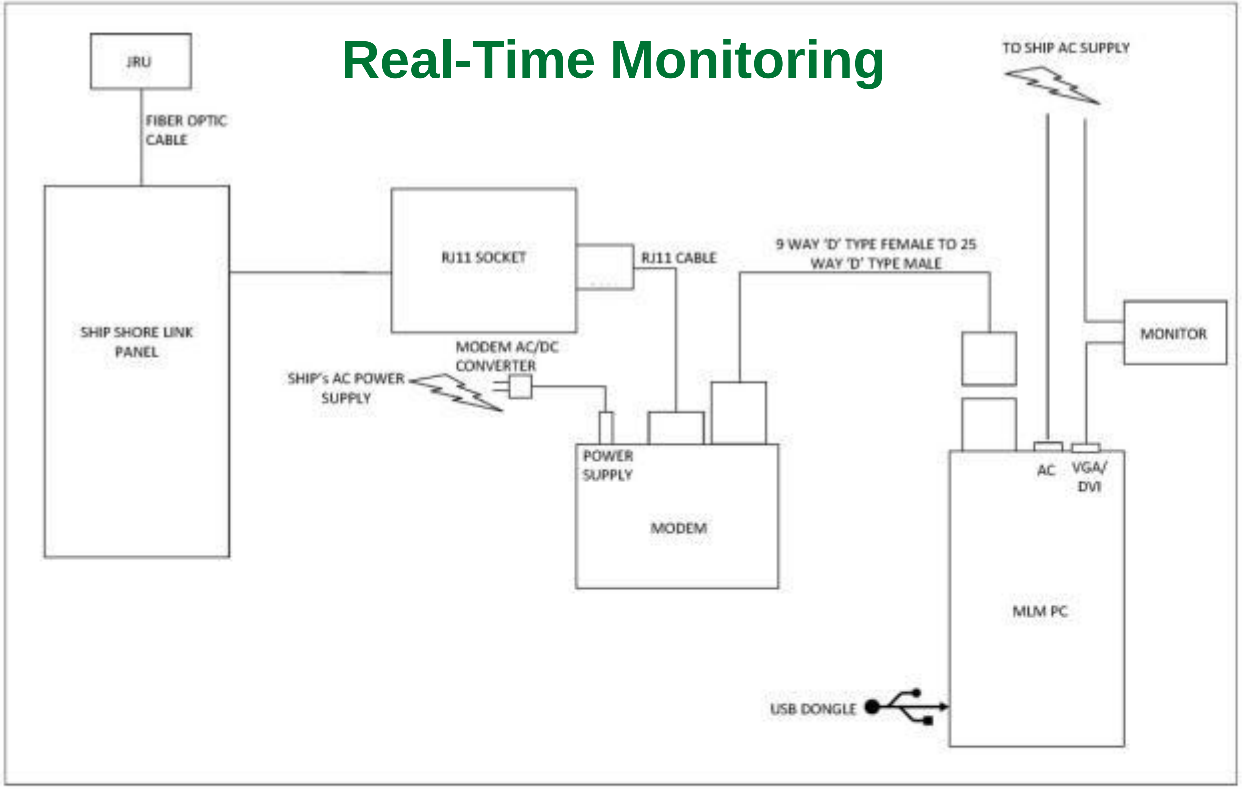
Conversions on FSU and JRU



Ship-Shore Link

Mooring Load Monitoring System

Centralized load monitoring system



Dangerous loads & Imbalance between mooring lines detection system

Regulatory challenges

Regulatory challenges

MARPOL 73/78

- Exemption from Annex V and Annex VI

Ballast water management

MODU and Loadline Certificate

ILO 92 / ILO 133 for Crew Accommodation

Application of Occupational Safety and Health Act

COLREG 1972

- **Only applies to towing**

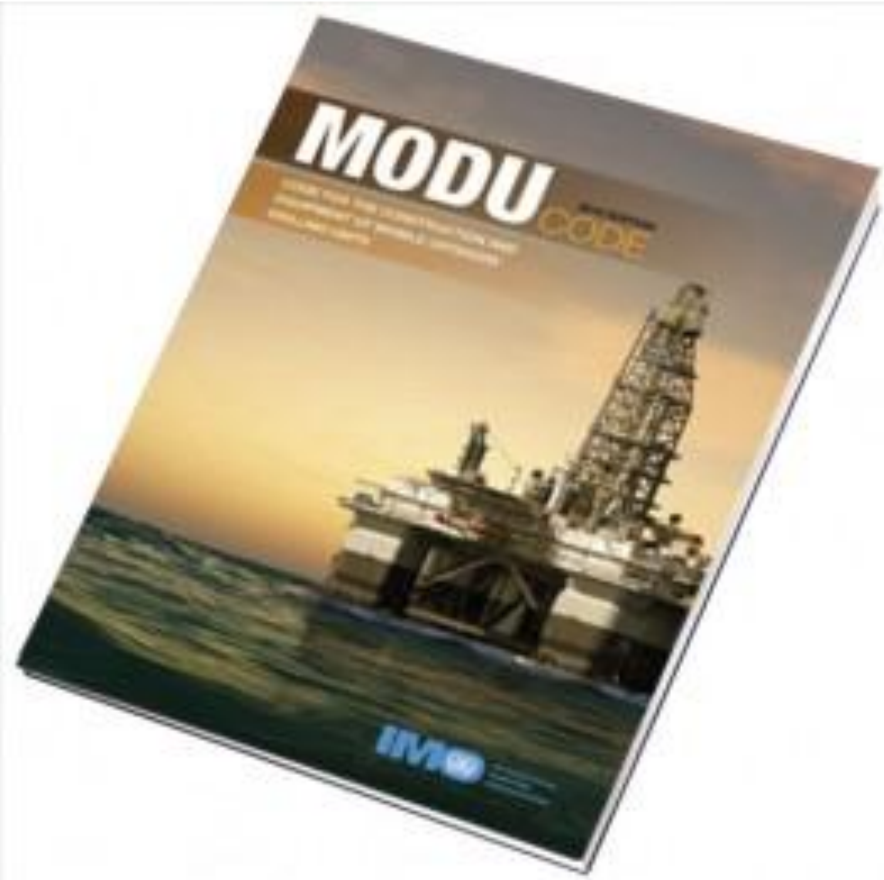
Safe manning certificate

Certification of entire mooring system

Inclining test vs lightship survey

Award of Class Certificate

Regulatory challenges



Implementation of MODU code

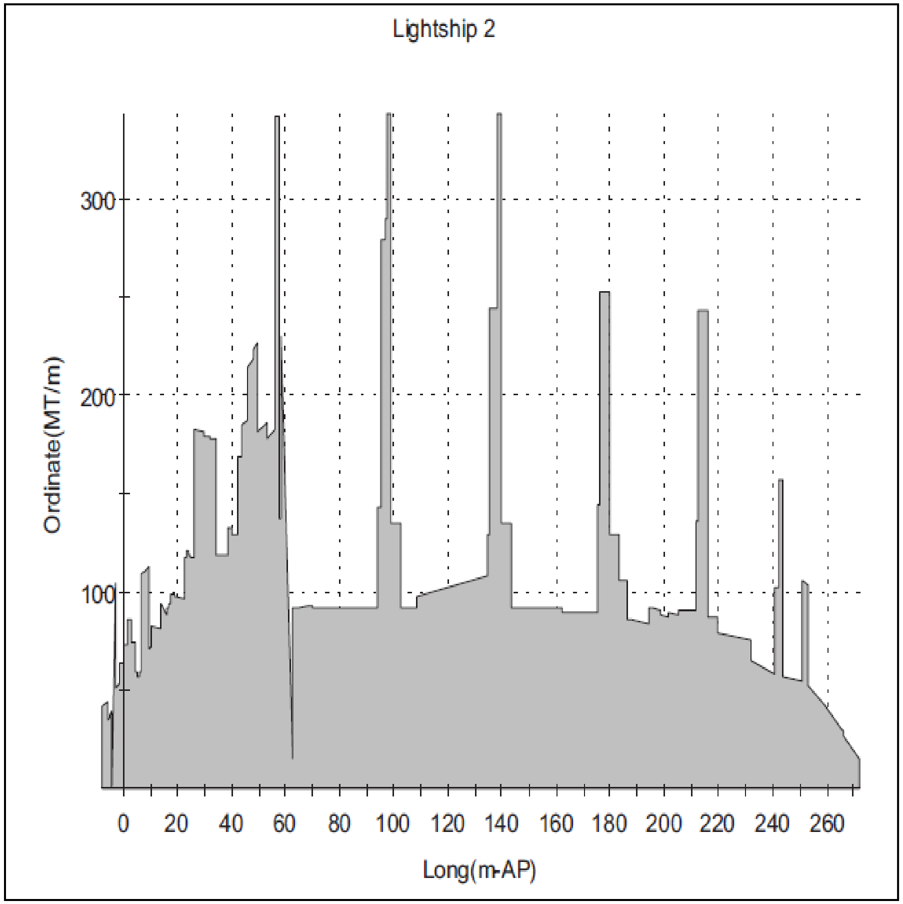
- MODU 1989 and MODU 2001 are used.
- Ch 3 Sec 1: Inclining test

  - Exemptions from inclining test as change in lightship weight is less than 2% following lightship survey
- Ch 9: Fire fighting appliances

  - Portable alarm in each cabin
- Ch 12: Lifting devices

  - Exemptions due to decommissioning of certain systems

Regulatory challenges



Inclining test vs lightship survey

- MSC/Circ. 1158 – Deviation of less than 2% in lightship weight and 1% of LCG will allow lightship survey to be done in place of inclining test.
- Timing of lightship survey is key:

  a) too early: results will lack accuracy

  b) too late: trim and stability calculations may not be approved in time for sailing
- Weight control report is used to determine new VCG.

Conclusion

Conclusion

- Challenging times for the energy industry have resulted in opportunities for serious global players.
- The successful conversion of Tenaga Satu and Tenaga Empat marks many lessons learnt.
- Conversion of Tenaga Satu and Tenaga Empat into FSUs involves various studies apart from Detailed Engineering to ensure uninterrupted operation for the next 20 years.
- Future of LNG floating solutions: FSRU and FLNG.

Questions & Answers

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