



Impact of Alternative Fuel on Vessel Design

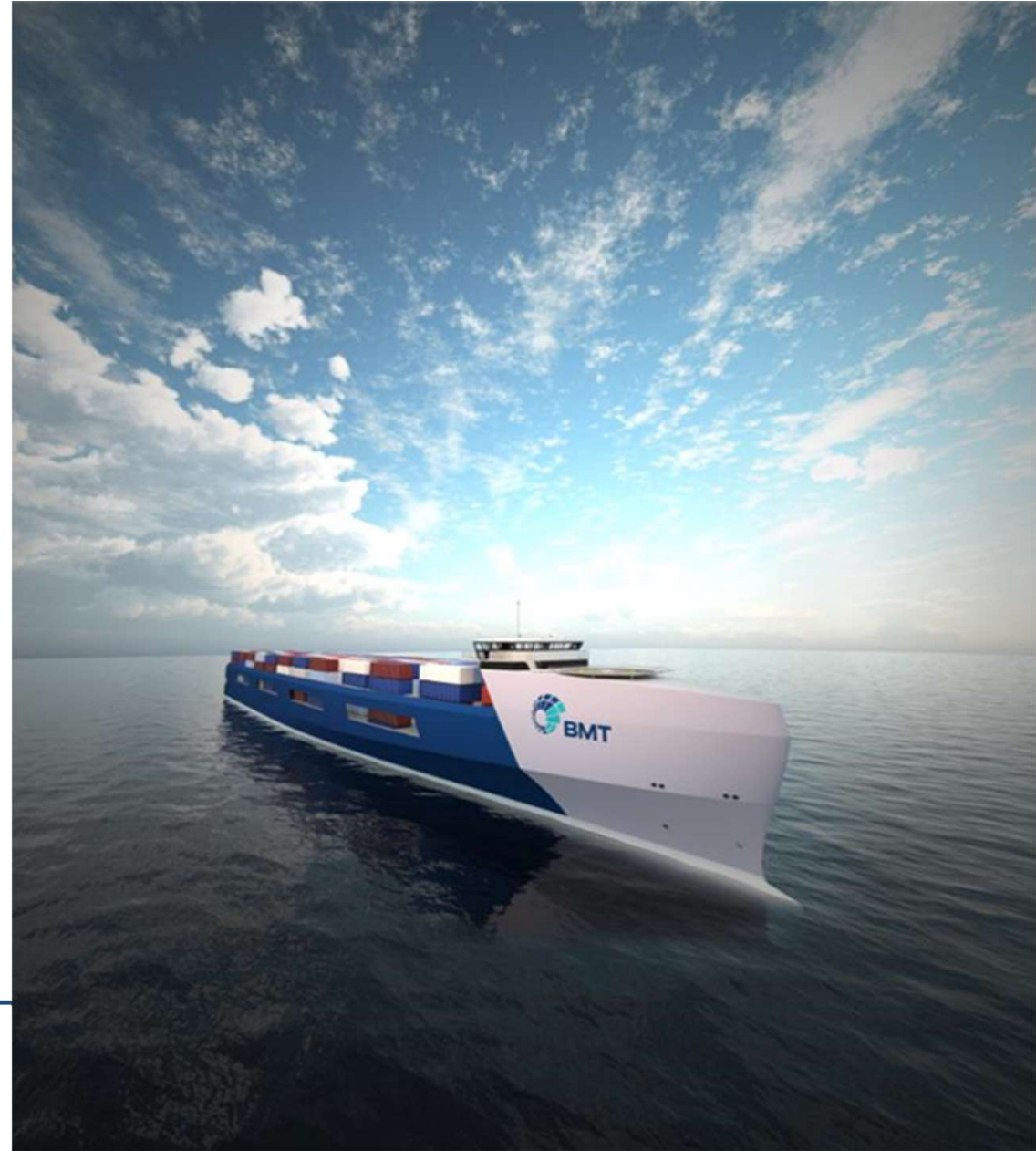
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Dr. Thomas Beard



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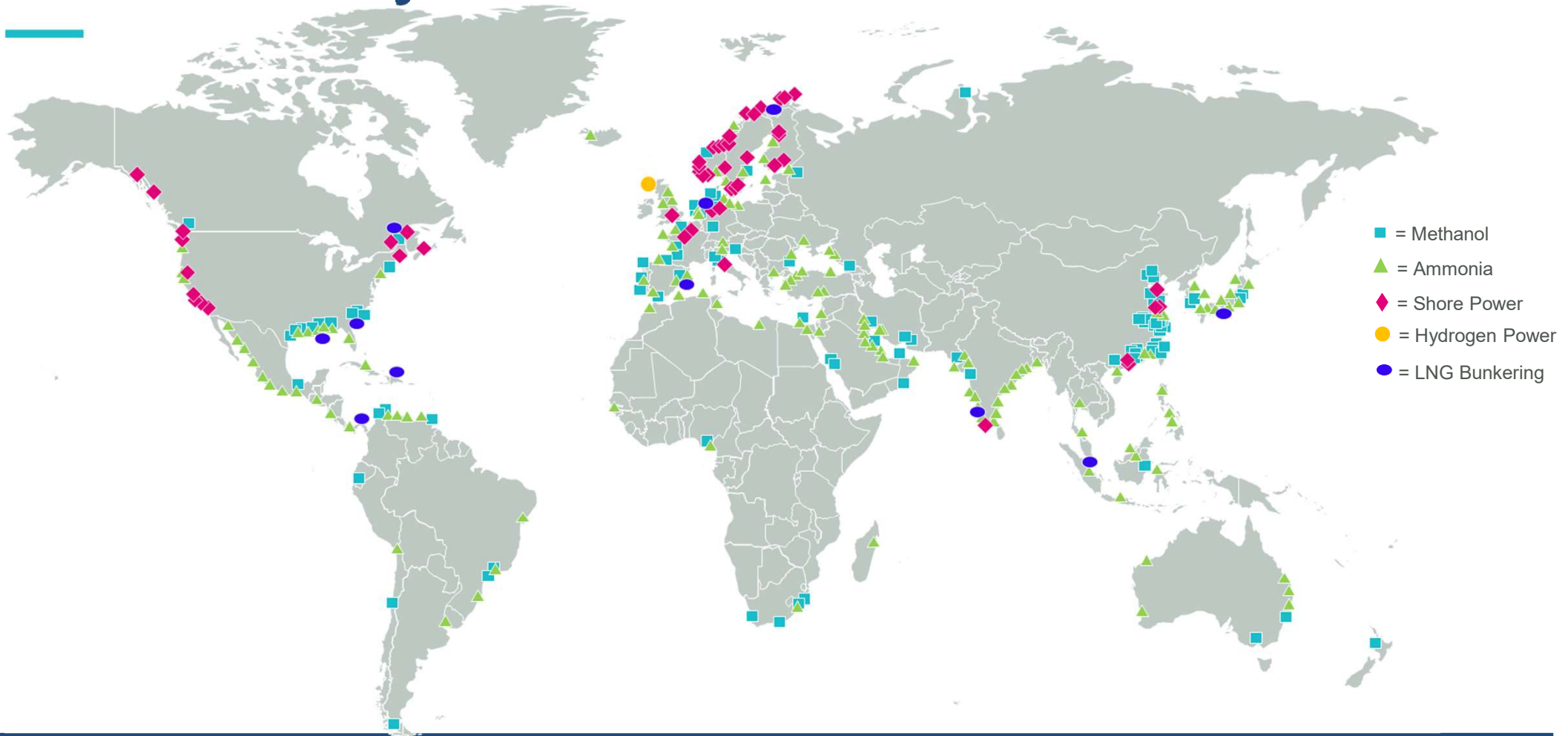
Fuel Options

Nuclear not considered viable for all vessels.

Electric not considered viable for all vessels.

	Hydrogen, H ₂	Liquified Natural Gas (LNG), CH ₄	Ammonia, NH ₃	Methanol, CH ₃ OH	REFERENCE (F-76)
With Tank (Gross) Volumetric Energy Density (MJ/L)	2.7 – 7.9	13.2	11.5	14.2 – 15.1	27.3 – 31.0
General Storage Conditions	Cryogenic (or Pressurised)	Cryogenic	Cryogenic (or Pressurised)	Ambient	Ambient
Space Requirement	7.7 – 15.7	3.2	3.4 – 6.4	2.3	1.0
Flash Point	-253°C	-162°C	-33°C	+12°C	+61.5
Flammability Limits in air (vol%)	4.0 – 75.0	5.3 – 15.0	15.0 – 28.0	7.3 – 36.0	0.7 – 5.0
Minimum Ignition Energy in air (mJ)	0.02	0.29	8.0	0.14	20.0
Explosion Risk	Large flammability range with low ignition energy	Medium flammability range with reasonable ignition energy	Medium flammability range with high ignition energy	Medium flammability range with reasonable ignition energy	Small flammability range with high ignition energy
Toxicity	None	None	Highly toxic to humans and aquatic life	Toxic to humans, but very low-toxicity to aquatic life	
Combustion Emissions	NO _x	NO _x & lower CO _x	NO _x	NO _x & lower CO _x	CO _x , NO _x , SO _x & PM

Fuel Availability



Regulations and Guidelines



IGF & IGC Codes

- No toxic cargo can be used as a fuel.
 - Flag states can overrule this.
- Specifics for LNG with guidance for all.
- Alternative design approach required.
- Limitations of explosion consequences.
- Emergency shutdown of equipment in case of leaks.
 - Gas only engines require fuel shutdown.
 - 40 - 60% LFL activation (6 – 9% vol.)
 - Maximum 30 minute sampling interval



Bureau Veritas

- Direct venting in normal operations is not permitted
- Venting in failure must not result in dangerous conc.
- Piping at least 800mm from hull
- Cmpt exclusions; accommodation, control, etc
- Separate bilge system
- Water mist system for ammonia leakage, 30ppm trigger.



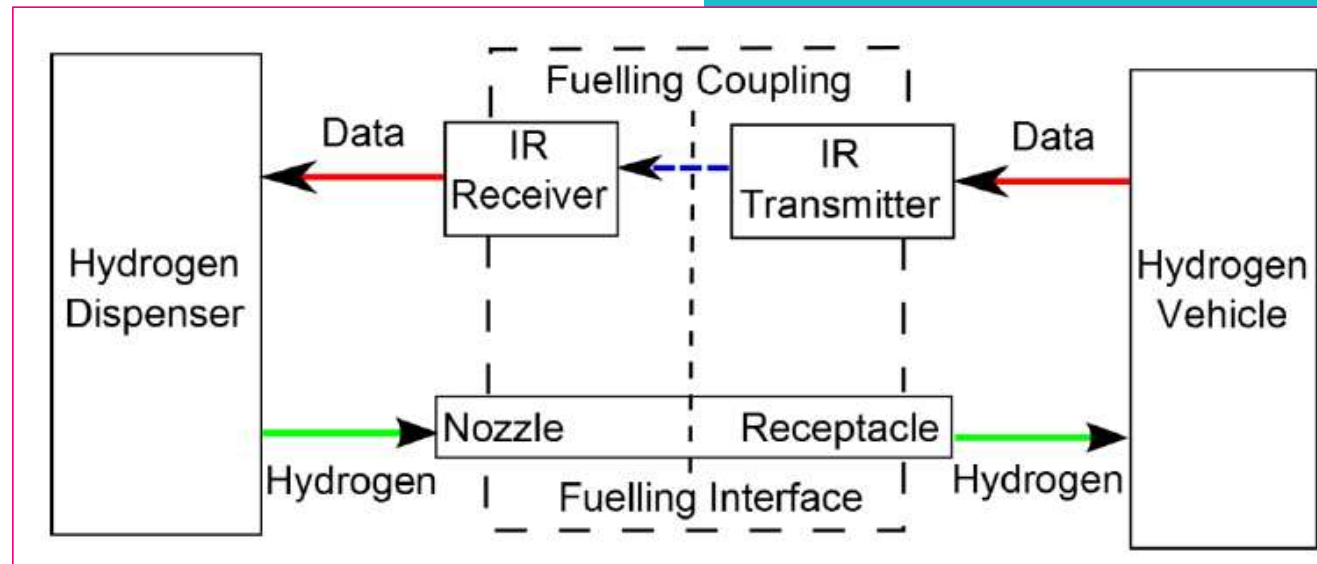
DNV

- Material Selection to mitigate corrosion
- Segregation – protect fuel from external events
- Double barriers – protect ship from leakage
- Leak detection & automatic isolation
- Enclosed spaces are zone 1
- Open deck non-hazardous
- Need toxic zones defined

Bunkering Safely

How do we bunker the fuel onboard safely?

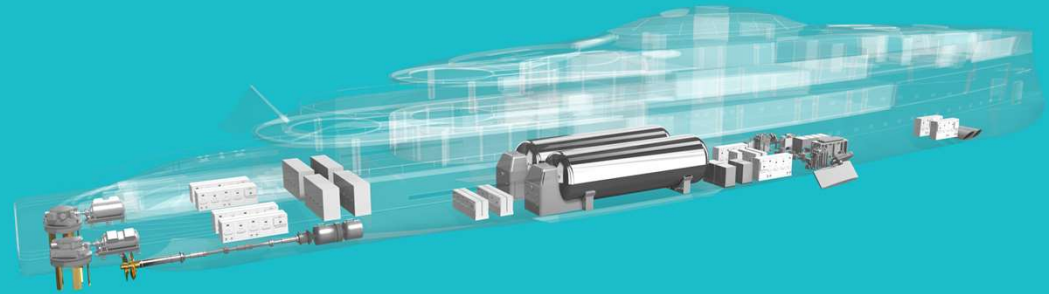
We need to learn from other industries.



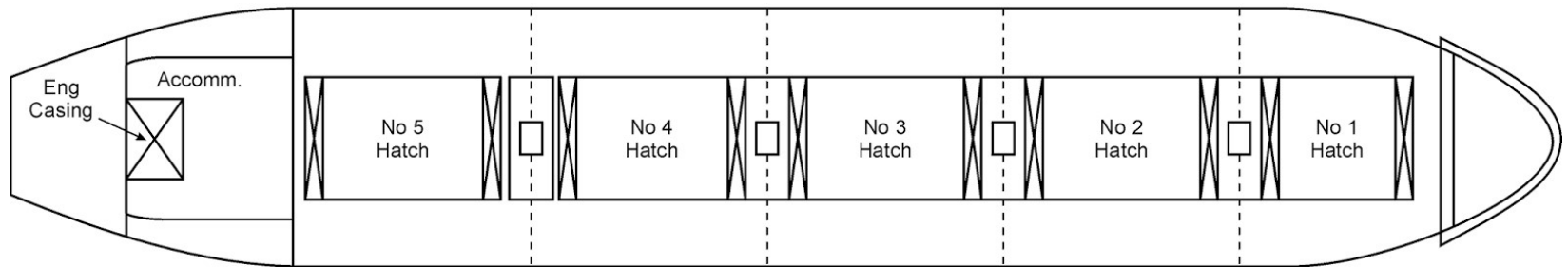
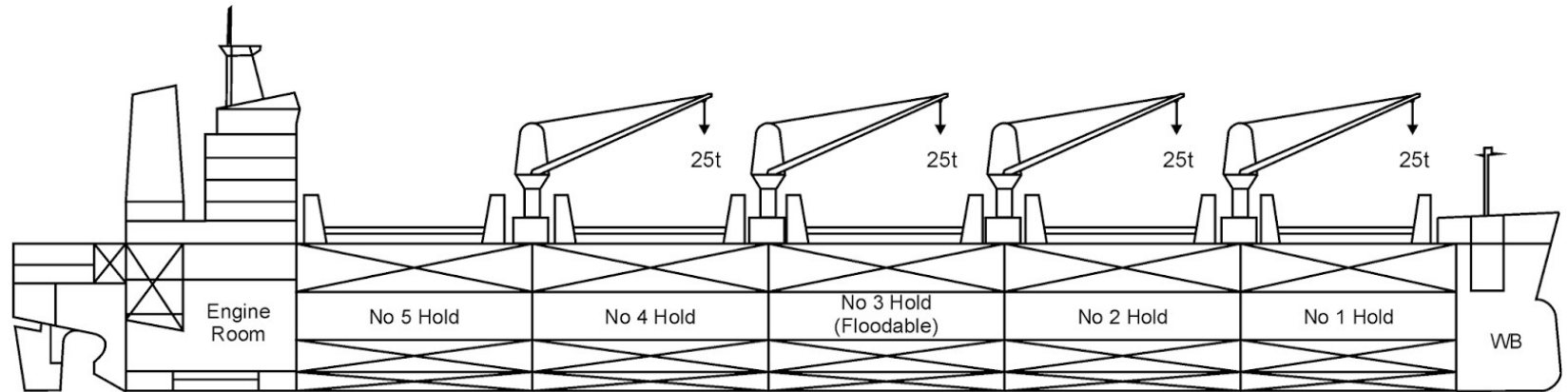
Basic Hydrogen Gas Fuelling Design, SAE J2799

Design Considerations

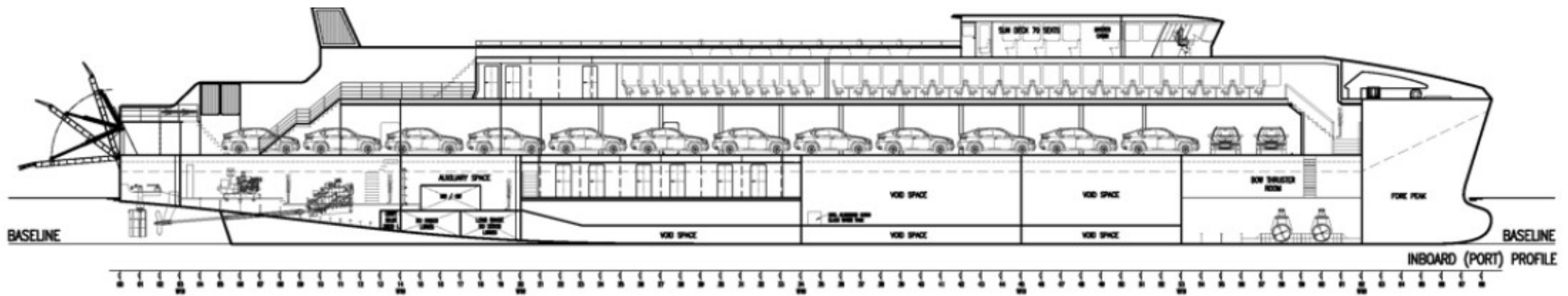
- Gas tight boundaries
- Airlocks & Water Curtains – with alarms outside
- Safety stations
- ‘Double walled’ pipes
- Redundancy
- Explosive & Toxic Atmospheres
- Ventilation
 - Dedicated ducts – alarms near open decks
 - Continuously operating fans
 - Scrubbers



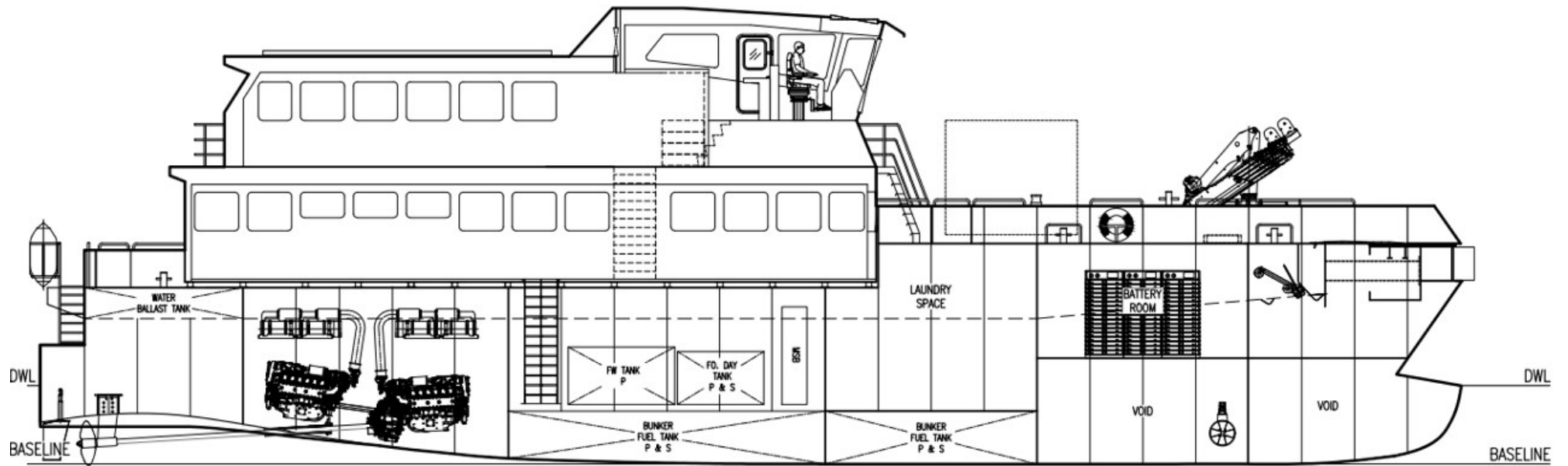
Large Ships - Cargo



Large Ships - People



Smaller Vessels



Conclusions

- Regulations are in progress.
- Currently using Risk Based Certification.
- There are several similarities across the different fuels.
- Design variation is more around the vessel user case.

**SAFETY UNDERPINS ALL FUTURE
VESSEL DESIGNS**





Thank you for listening

Any questions or queries please email me at:
Thomas.beard@uk.bmt.org