
RINA (WA) 2018

Ken Goh - GM, Knud E. Hansen Australia

# DESIGN OF ICEBREAKING VESSELS

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# KNUD E. HANSEN

- Ship design, engineering, HVAC & ShipSpace
- Concept design of highly specialised vessels
- Vessels types include Cruise, Ferries, Ro-Pax, Ro-Ro, Ro-Con, Offshore, Yachts & Icebreakers
- Consecutive annual ShipPax & Significant Ships awards
- 80 staff, offices in Denmark, USA, UK, Greece & Australia



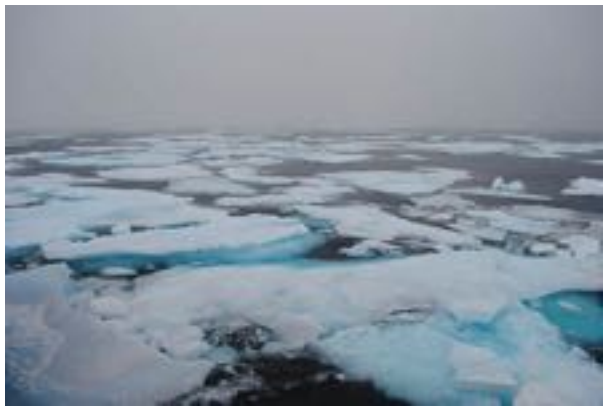


# ICEBREAKERS TYPES

- **Escort**
  - Ice Management
  - Break out beset vessels
  - Towing
- **Cargo**
  - Container, bulkers, tankers, general
  - Maximise cargo volume
  - Double acting, podded propulsion
- **Research & Supply**
  - Very low underwater noise
  - Dynamic positioning
  - Moon pool, drop-keels, winches, lots of toys


# ICE TYPES

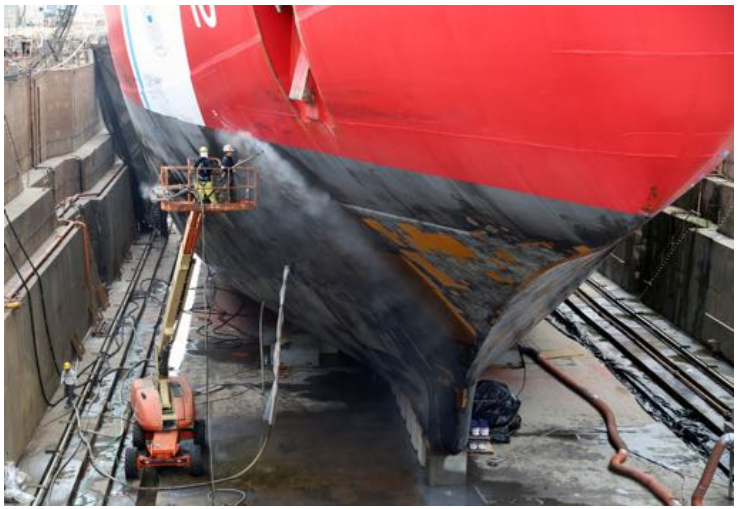
- **First Year Ice**
  - Seawater, low strength (~500 kPa)
  - Level ice for icebreakers
  - Many different formations
- **Multi-Year Ice**
  - Much harder & thicker
  - Inclusions in FYI
- **Glacial Ice**
  - Fresh Water
  - Very high strength (2-3 times FYI)
  - Hard to see in open water

# HULL FORMS

- **Polar Star** (1975)
- L 122m x B 25.4m x D 9.4m
- Block = 0.58
- Traditional bowl, smooth
- No parallel mid-body
- 56 MW shaft power
- 2.0m ice @ 3 kns



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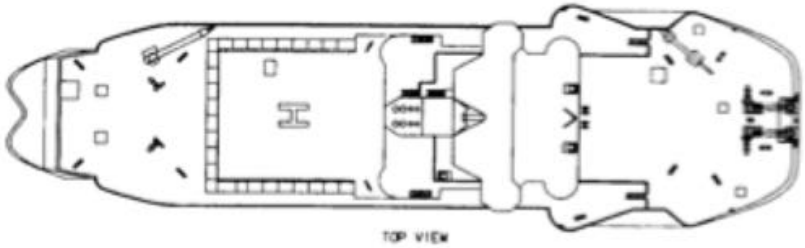
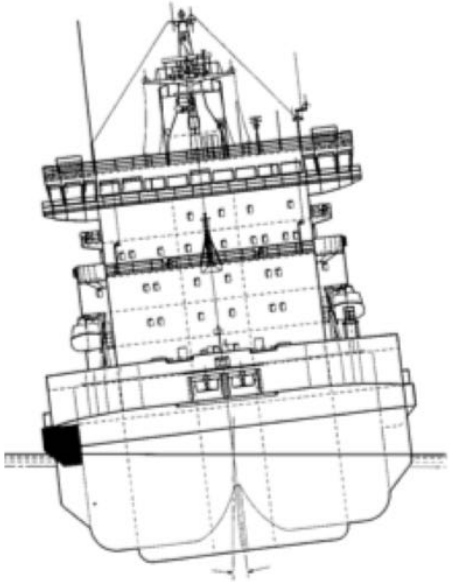
# HULL FORMS

- **Oden** (1989)
- L 108m x B 25m x D 8.5m
- Block = 0.61
- Spoon bow
- Reamers & heeling
- 18 MW shaft power
- 1.8m ice @ 3 kns

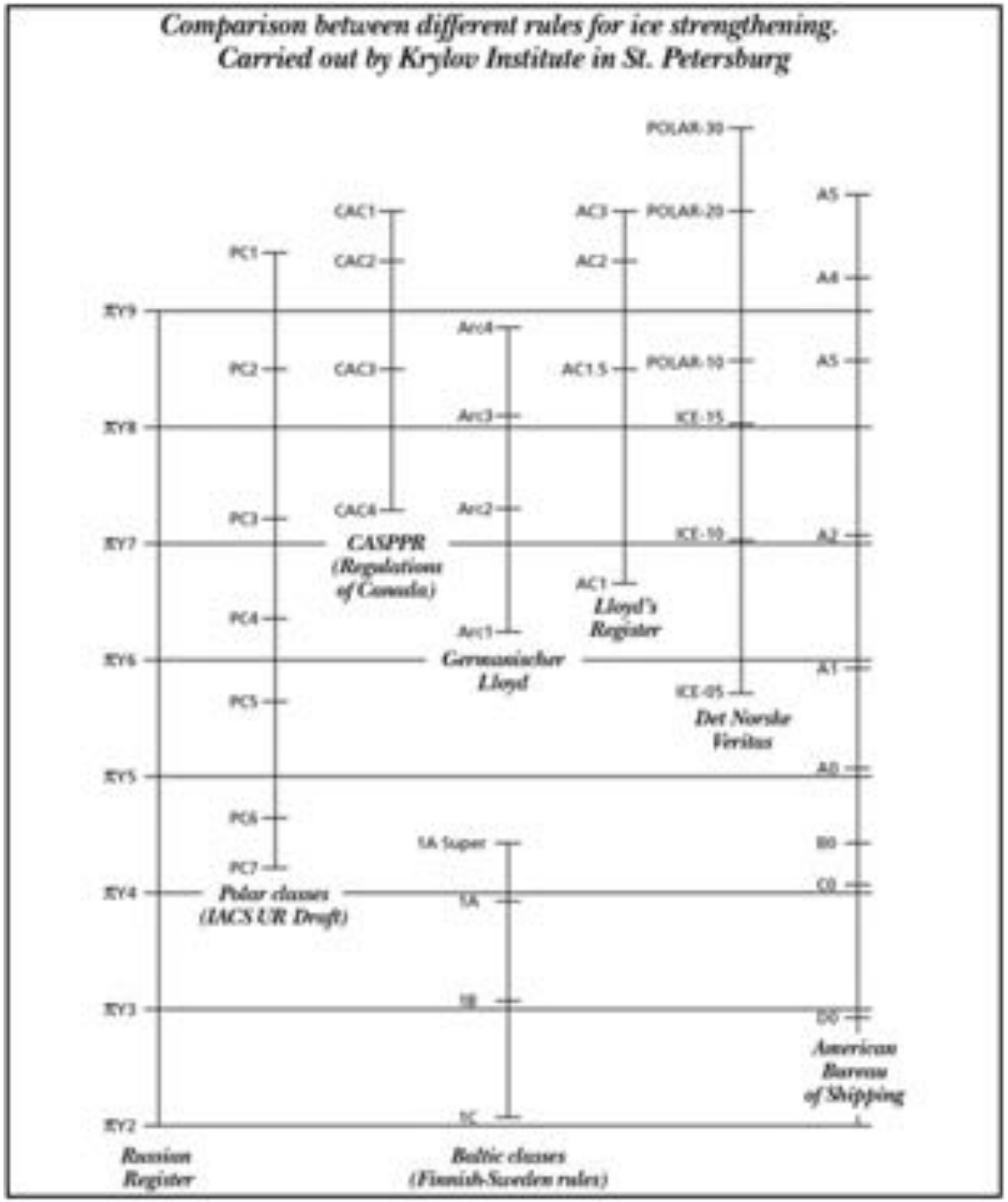




# HULL FORMS

- Thyssen-Waas
- Oblique
- Trimaran
- Hovercraft

# REGULATIONS

- **IMO - Polar Code**
  - North & South of 60 degrees
  - Safety & Environment
  - Design & Operations
- **IACS – Polar Class**
  - PC1 – PC7
  - Hull icebelt materials & strength
  - Propulsion capacity & strength
- **Flag State**
  - Addition Regulations
  - Environmental
  - Labour



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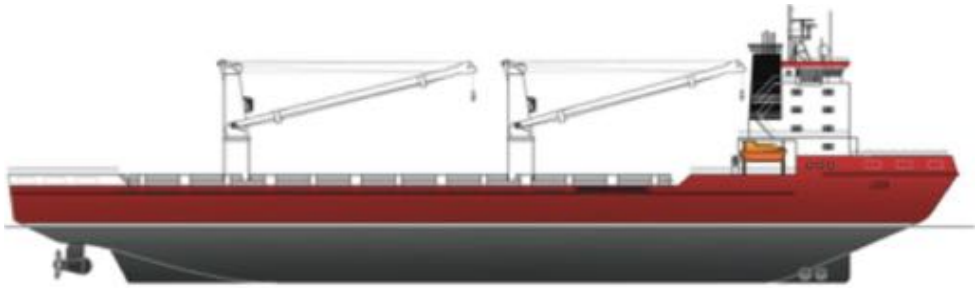
# CARGO VESSEL COMPARISON

## Conventional Container Ship

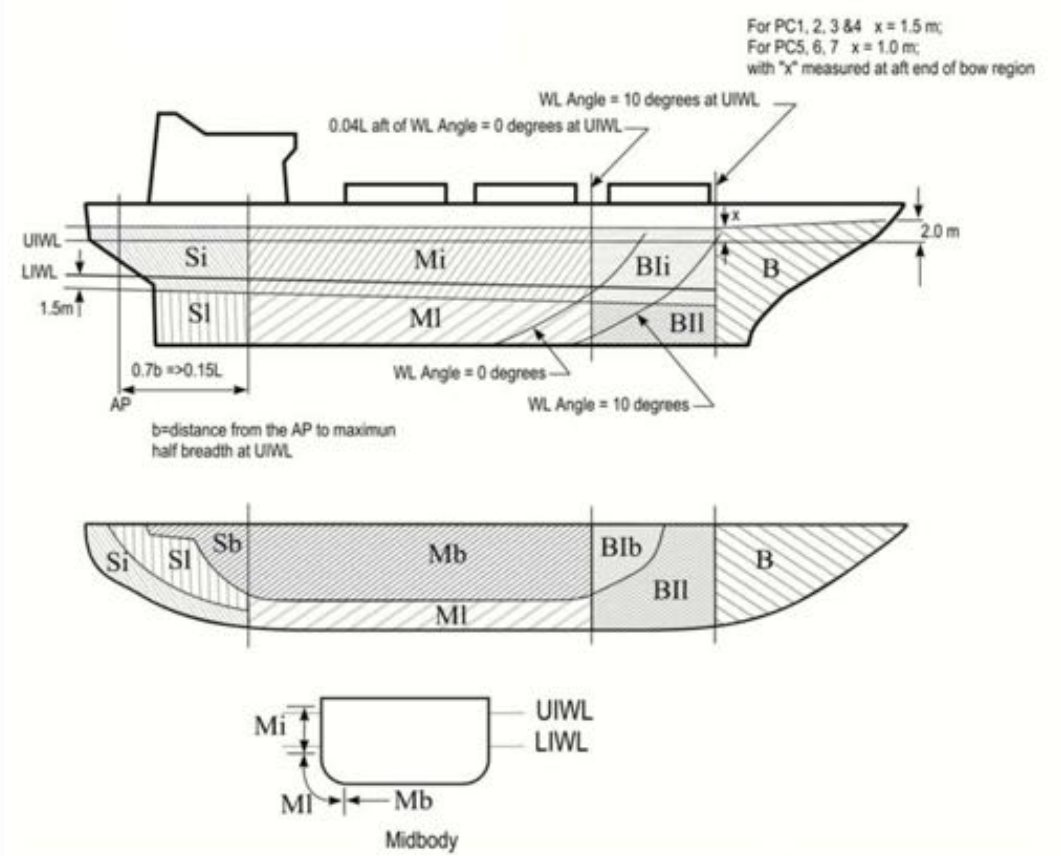
- Capacity - 1,000 TEU
- Deadweight - 10,000 DWT
- Lightweight - 7,000 T
- Length - 144 m
- Beam - 22.6 m
- Draft - 8.0 m
- Block - 0.70
- Speed - 20 kns
- Power - 10 MW



## Icebreaking Container Ship

- Capacity - 1,000 TEU
- Deadweight - 10,000 DWT
- Lightweight - 8,500 T
- Length - 145 m
- Beam - 23 m
- Draft - 8.5 m
- Block - 0.71
- Speed - 16 kns
- Power - 17 MW

# STRUCTURE




| Hull Area | | Area | Polar Class | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | PC1 | PC2 | PC3 | PC4 | PC5 | PC6 | PC7 |
| Bow (B) | All | B | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Bow Intermediate (BI) | Icebelt | $BI_i$ | 0.90 | 0.85 | 0.85 | 0.80 | 0.80 | 1.00* | 1.00* |
| | Lower | $BI_l$ | 0.70 | 0.65 | 0.65 | 0.60 | 0.55 | 0.55 | 0.50 |
| | Bottom | $BI_b$ | 0.55 | 0.50 | 0.45 | 0.40 | 0.35 | 0.30 | 0.25 |
| Midbody (M) | Icebelt | $M_i$ | 0.70 | 0.65 | 0.55 | 0.55 | 0.50 | 0.45 | 0.45 |
| | Lower | $M_l$ | 0.50 | 0.45 | 0.40 | 0.35 | 0.30 | 0.25 | 0.25 |
| | Bottom | $M_b$ | 0.30 | 0.30 | 0.25 | ** | ** | ** | ** |
| Stern (S) | Icebelt | $S_i$ | 0.75 | 0.70 | 0.65 | 0.60 | 0.50 | 0.40 | 0.35 |
| | Lower | $S_l$ | 0.45 | 0.40 | 0.35 | 0.30 | 0.25 | 0.25 | 0.25 |
| | Bottom | $S_b$ | 0.35 | 0.30 | 0.30 | 0.25 | 0.15 | ** | ** |

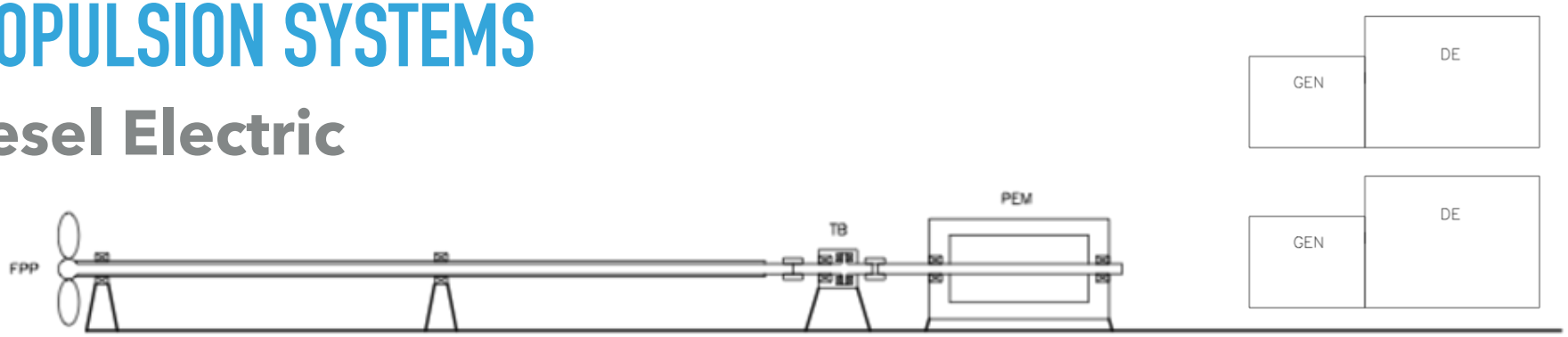
| Polar Class | Crushing Failure Class Factor ($CF_C$) | Flexural Failure Class Factor ($CF_F$) | Load Patch Dimensions Class Factor ($CF_D$) | Displacement Class Factor ($CF_{DIS}$) | Longitudinal Strength Class Factor ($CF_L$) |
|---|---|---|---|---|---|
| PC1 | 17.69 | 68.60 | 2.01 | 250 | 7.46 |
| PC2 | 9.89 | 46.80 | 1.75 | 210 | 5.46 |
| PC3 | 6.06 | 21.17 | 1.53 | 180 | 4.17 |
| PC4 | 4.50 | 13.48 | 1.42 | 130 | 3.15 |
| PC5 | 3.10 | 9.00 | 1.31 | 70 | 2.50 |
| PC6 | 2.40 | 5.49 | 1.17 | 40 | 2.37 |
| PC7 | 1.80 | 4.06 | 1.11 | 22 | 1.81 |

# PROPULSION SYSTEMS

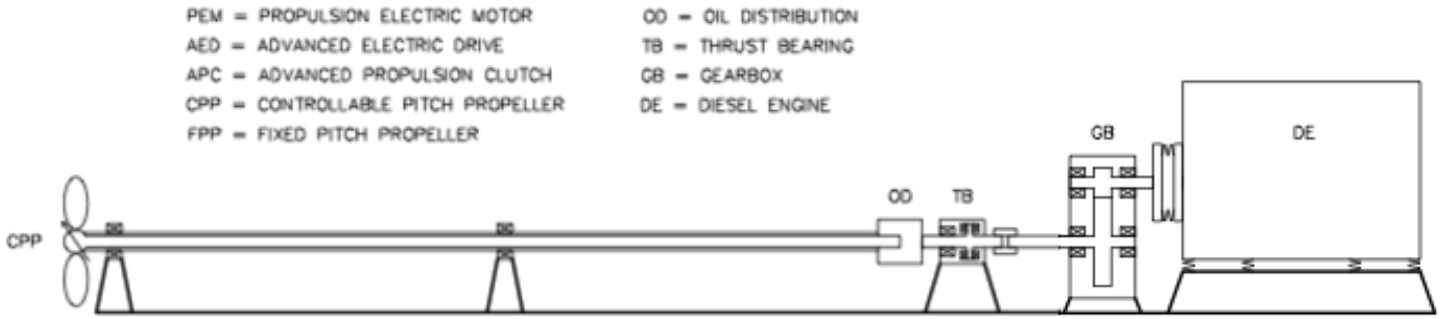
- **Conventional**
  - Enclosed shafts
  - Propeller type, nozzles
  - Rudder, large spade, protection
- **Pods & Thrusters**
  - Very good manoeuvrability
  - Ice milling & flushing
  - Little experience with MYI
- **Power Plant**
  - Diesel electric
  - Diesel mechanical
  - Hybrid

# PROPULSION SYSTEMS

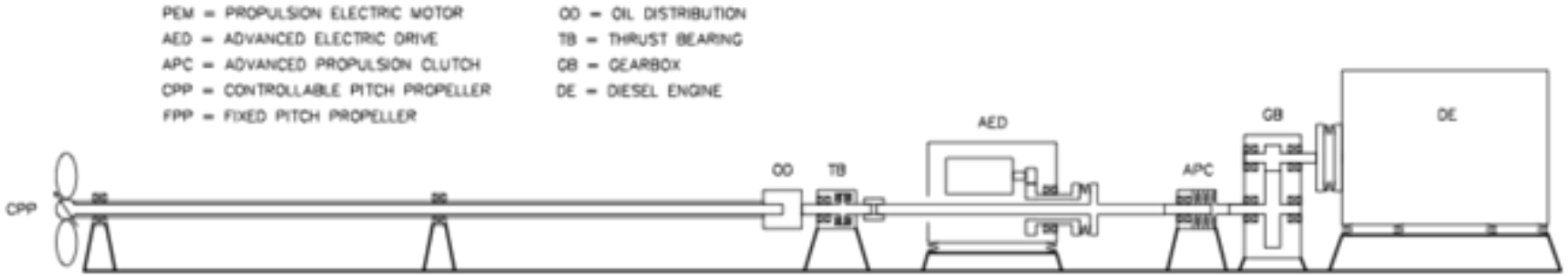
## Diesel Electric




## Mechanical




## DE/Mech Hybrid



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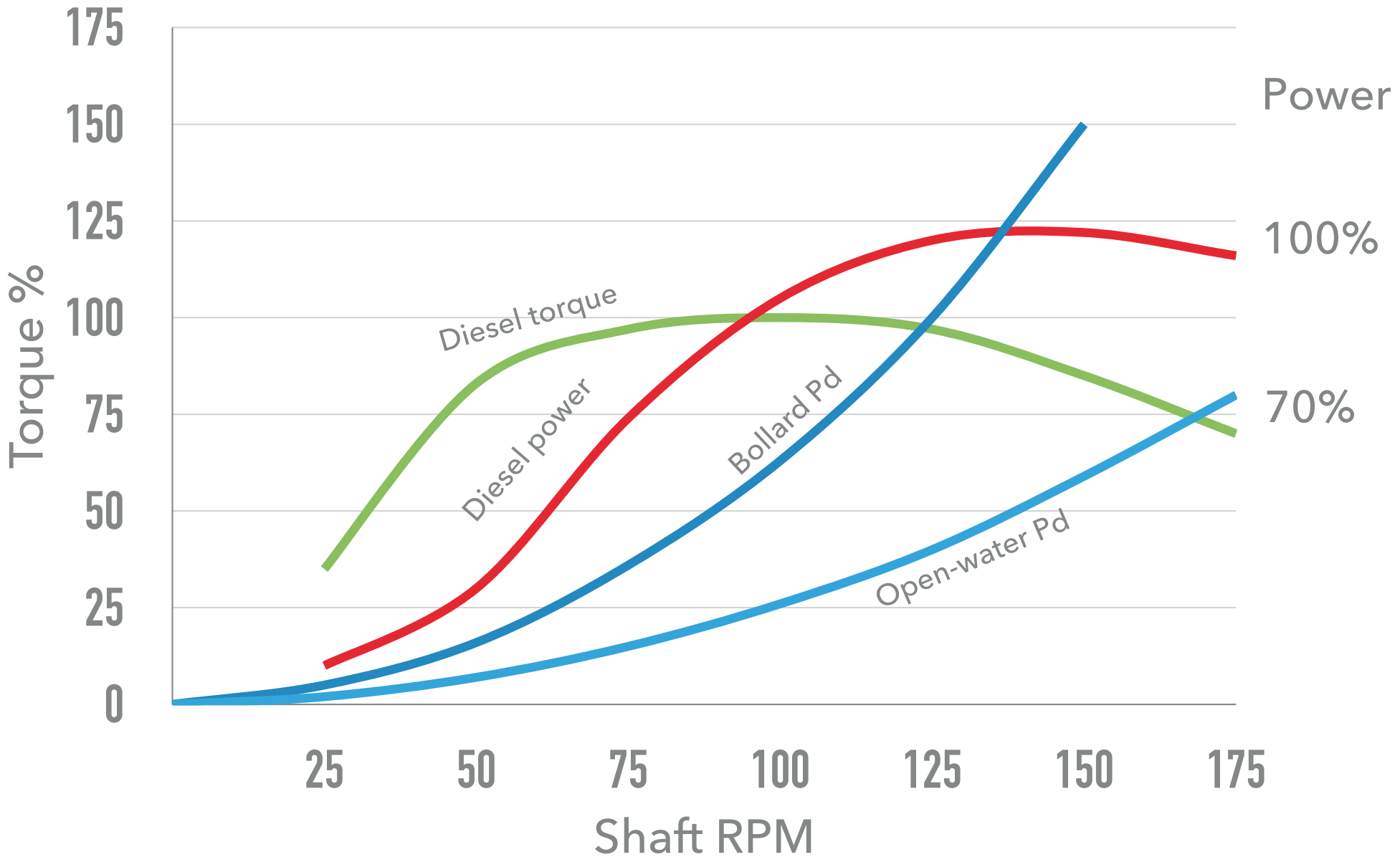
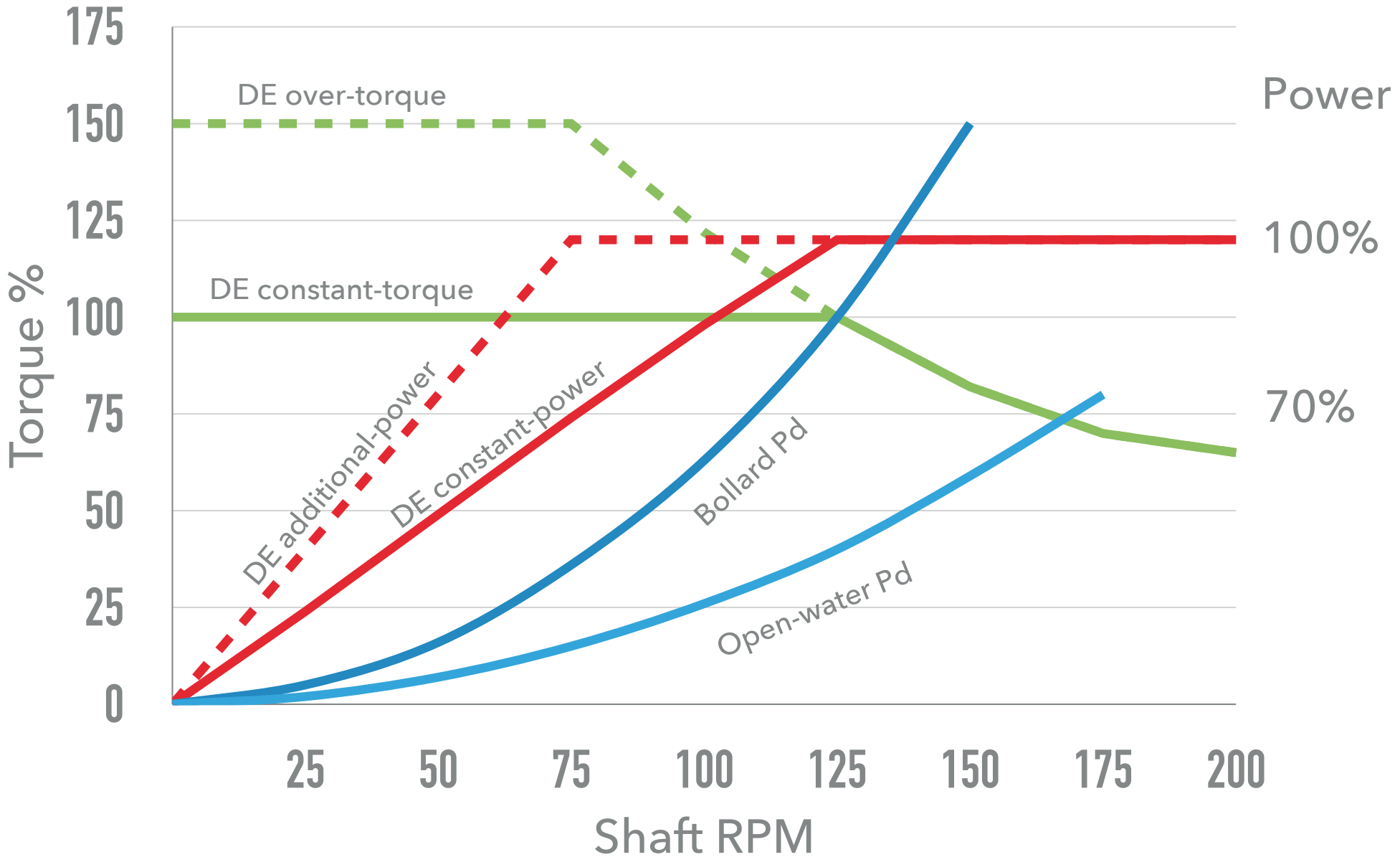
# DIESEL PROPULSION – BOLLARD OPTIMISED

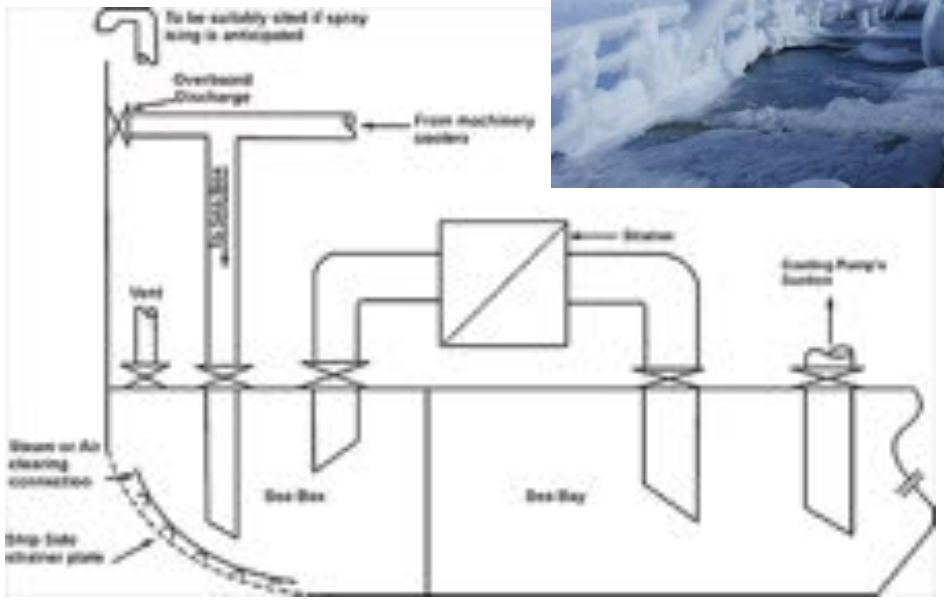


# D.E. PROPULSION – BOLLARD OPTIMISED



# ICEBREAKER SYSTEMS

- **Auxiliary Icebreaking**
  - Bow wash, bubbler
  - Fast powerful heeling
  - Hull coatings, SS cladding
- **Winterisation**
  - Temperature rated (design/operation)
  - Tank, deck & equipment heating
  - De-icing steam
  - Besetment (safe haven)
- **Machinery**
  - Ice box, sea-bays
  - Ban on residual fuels
  - Engine low-temp limit
  - Emissions control



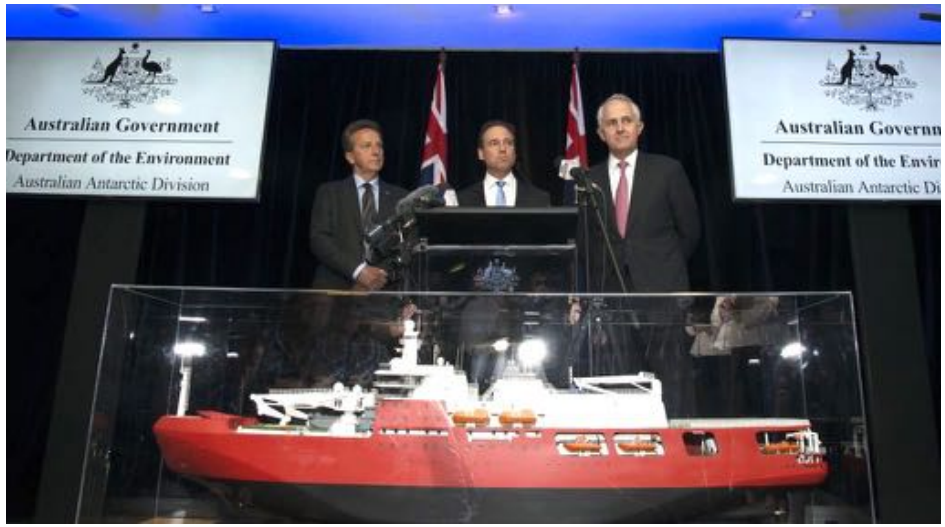
# AUSTRALIAN ANTARCTIC TERRITORY

- Australia claims 42% of the Antarctic Continent
- Australian Antarctic Division (AAD) operates 4 permanent stations
- Resupply is primarily by ship during 6-7mth 'summer season'
- Typically 5-6 voyages per season
- Southern Ocean has highest average waves (SS5-SS9)
- Sea ice is **increasing** in Antarctic waters (significant multi-year ice)

# PROJECT HISTORY

- Existing RSV Aurora Australia in operation since 1989
- **Request For Proposal** released in January 2013 for Design, Build, Operate & Maintain contract
- DMS Team
  - DMS (Prime contractor & Operator)
  - Damen (Shipbuilder)
  - Knud E Hansen A/S (Designer)
- **Request For Tender** released July 2014 for short-listed teams
- DMS preferred tenderer October 2015
- Keel laying June 2017
- **RSV Nuyina** naming October 2017
- operational 2019/2020 season

DAMEN DMS MARITIME a serco company KNUD E. HANSEN



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# MISSION PROFILE – SUPPLY

- Dry Cargo: 1,200 tons or 100 TEU
- Wet Cargo: 1,900m$^3$ Fuel Oil + 200m$^3$ Fresh Water
- Over-ice resupply using tracked & wheel vehicles
- Over-water resupply using landing barges
- Amphibious resupply using LARCs & helicopters
- Fuel oil transfer using hose reels & booster pumps

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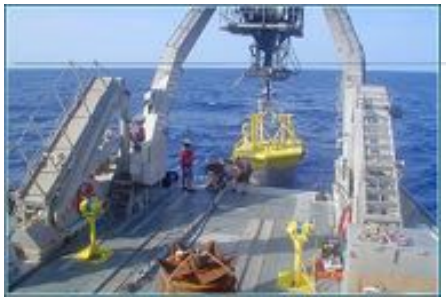
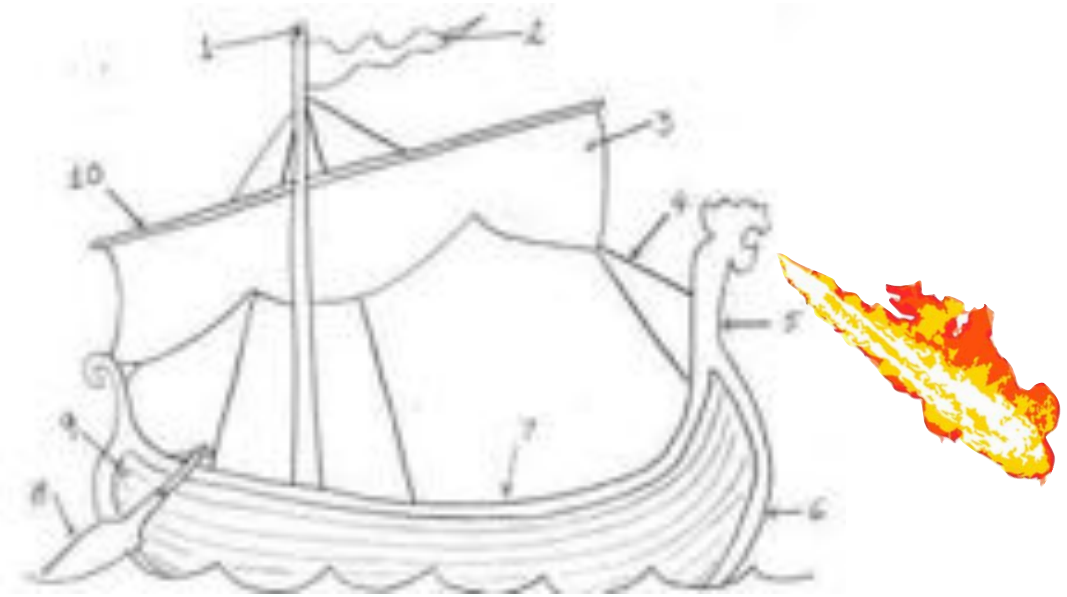
# MISSION PROFILE – RESEARCH

- 500m$^2$ science laboratories & offices
- 20 modular science containers
- CTD side & bottom deployment system
- 8 meter stern A-frame
- Twin Drop Keels: 2 x 1 meter sensor
- Moon Pool: 4 x 4 meter aperture
- Seabed long corer: Up to 24m cores
- Weather doppler radar
- 9m RHIB science tender



# PRIMARY REQUIREMENTS

- IACS PC3 Icebreaker, -40C (Polar Code – Cat. A)
- IMO Polar Code - New damage stability requirements
- Safety Regime - IMO Special Purpose Ship code
- Environment - **Clean design 'Green Passport'**
- Icebreaking Criteria
  - **1.65 m 700kPa ice + 300 mm snow loading @ 3 kns**
- Icebreaking Endurance
  - 30 days @ 60% MCR + 9,000 nm @ 12 kns SS5
- **Redundant Propulsion System**
- Dynamic Positioning
  - **DP2 in SS4, Beaufort Force 8, current 1kn**
- Acoustic Performance - **DNV Silent R**
- Mission Endurance
  - 90 days with 180 day survival capability
- **Good Seakeeping**



# RSV NUYINA

- **Dimensions**
  - Length OA = 160m
  - Beam moulded = 25.6m
  - Depth to main deck = 19.2m
  - Draft max. = 9.5m
  - Air draft max. = 41m
  - Displacement full load = 25,000T


- **Performance**
  - Speed max. = 18+ kns
  - Speed eco. = 12-14 kns
  - Speed silent = up to 8 kns
  - Icebreaking = 1.65+ meters @ 3kn
  - Range = 16,000+ nm
  - Endurance = 90+ days

# DESIGN OF ICEBREAKING VESSELS

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Barge Operations

ShipSpace Real-time cross-continent design & collaboration

Helicopter & LARC Operations

Refuelling Operations

Over-ice Operations

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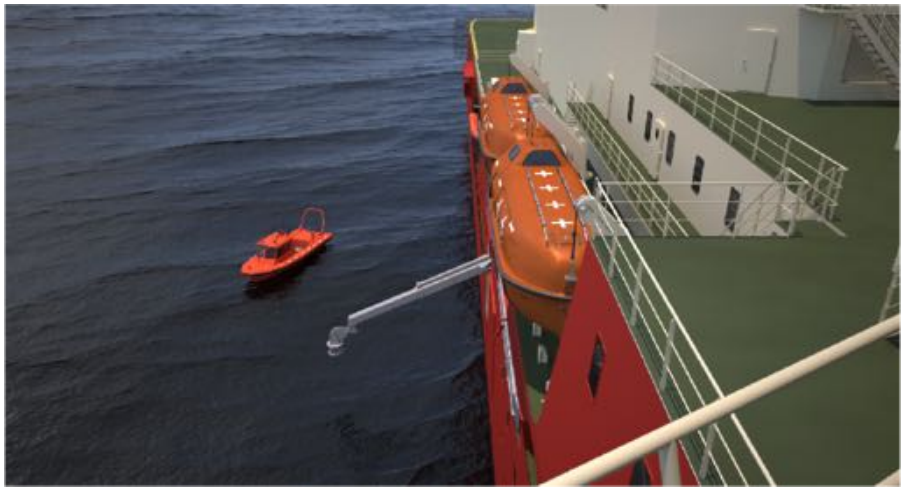
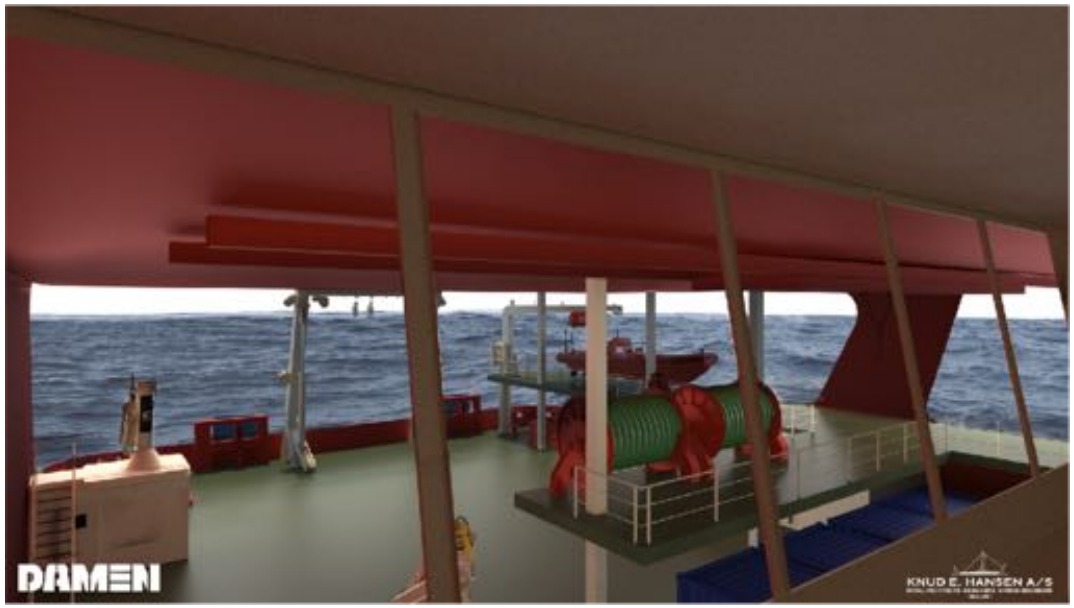


CTD Operations

ShipSpace Real-time cross-continent design & collaboration




Winch Control Room

Over/under Ice Research

Aft Science Deck


AWESOME
LEGO


LEGO