6.11.2025

When thrust is a must – The propulsion innovations of new technology icebreakers

STEERPROP PROPULSOR TECHNOLOGY FOR ICE

Steerprop in Brief

Steerprop is the leading designer and manufacturer of high-performance propulsion systems for the most demanding applications and toughest conditions. Since our founding in Finland in 2000, we have delivered fit-for-purpose propulsion units for vessels working in the arctic, offshore, tug, workboat, cruise and ferry industries.

We are expanding our offering as the demands of our customers become more diverse.

Employs more than

90

Order book

>130 MEUR

Units delivered

over 950

Operates direct or with authorized distributors or agents in

more than 50 countries

Condition monitoring

in every delivery

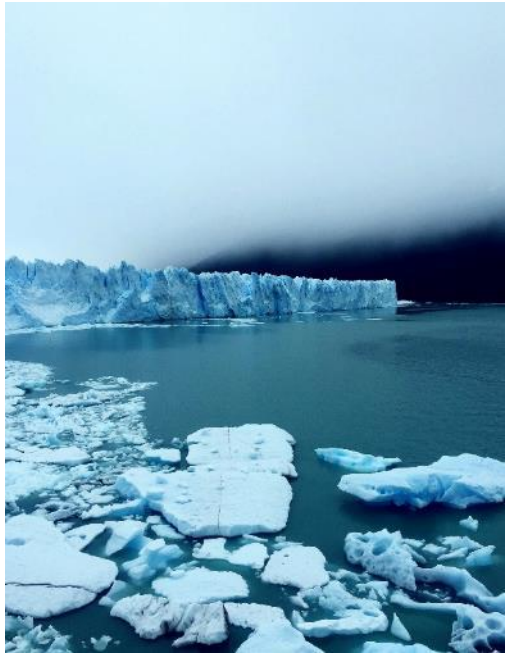
Operating hours in total

over 12 million

Steerprop propulsion systems

in every third azimuth icebreaker

Supporting Wide Range of Applications



ARCTIC & NAVAL

OFFSHORE

CRUISE & FERRY

TUGS AND WORKBOATS

STEERPROP

Steerprop Propulsors

All Steerprop propulsors match each application and built up to 12 MW for ice classes or 20 MW for open water.

	Steerprop W	Steerprop T	Steerprop CRP	Steerprop CRP ECO	Steerprop CRP ECO ARC	Steerprop PULL ARC	Steerprop ARC	Steerprop R	Steerprop TT
Power range [kW]	900–7000	1000–2800	600–3500	5000–20 000	Up to 12 000 (depending on ice class and application requirements)			850–3500	500–7000
Propellers available	Open and ducted		Contra-rotating propellers			Open pulling	Open and ducted	ducted	tunnel
Typical ship types	Tugs, workboats, offshore vessels, AHTS, DP vessels, cruise ships, ferries and research vessels				Ice breaker, ice-going vessels			Offshore, DP vessels	All vessel types

SP ARC family (1AS – PC2)

SP 60 CRP ARC

Icebreaking Tugs

Baltic IB classification:
Harbor icebreakers

2.5 – 3.8 MW, 1AS – PC4

SP 120, 150 CRP ARC
SP 60, 90 PULL ARC

Small to Medium Icebreakers

Baltic IB classification:
C to B class I/B

2.5 – 7.0 MW, 1AS – PC4

SP 230, 260, 290, 410 CRP ARC
SP 110, 130, 160, 200 PULL ARC

Medium, Large and Polar Heavy Icebreakers

Baltic IB classification:
B to A class I/B

6,5 – 12 MW, PC4 – PC2

Ice class units for icebreakers

SP CRP ARC LM

Up to ~12 MW

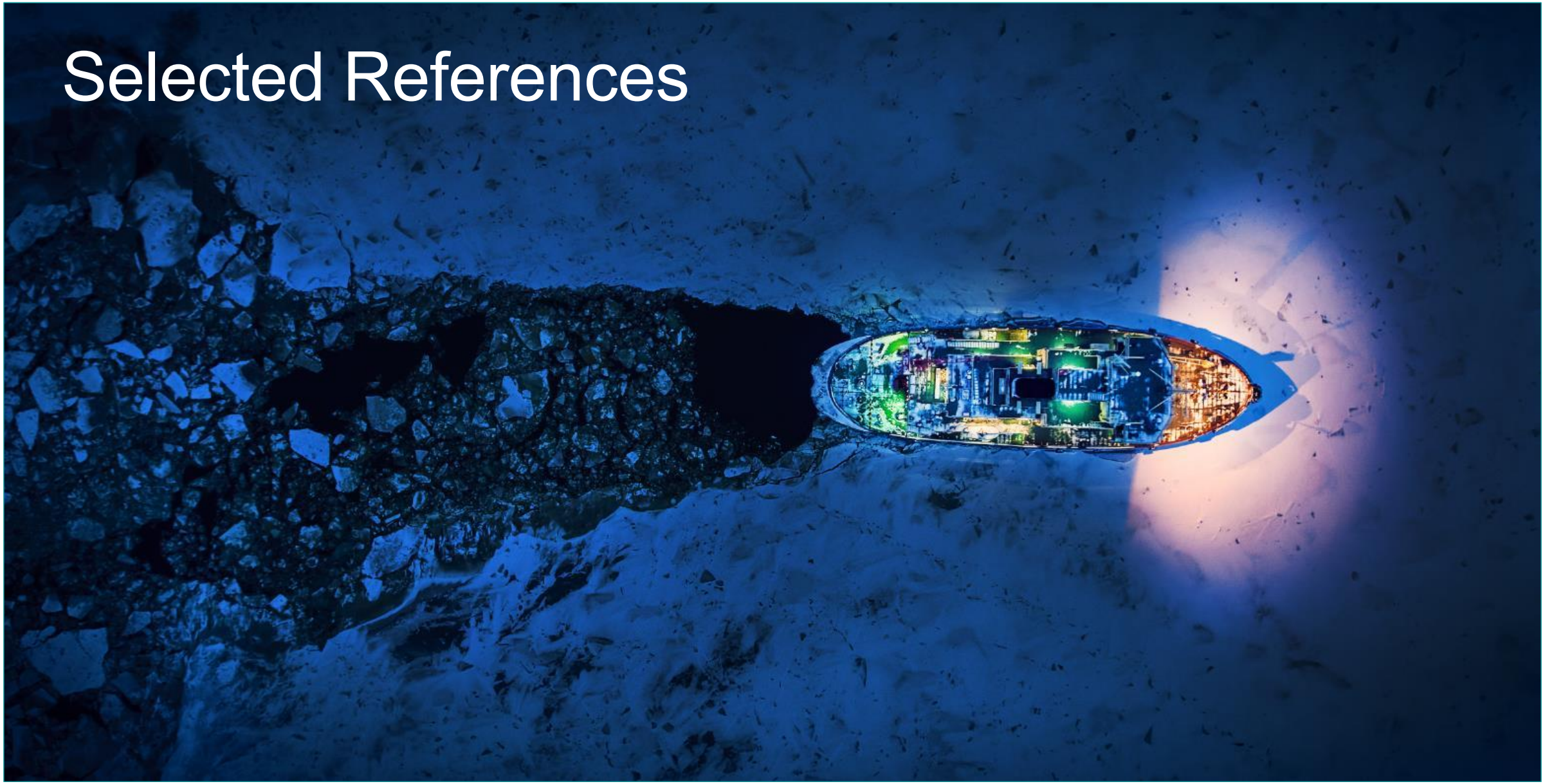
SP PULL ARC LM

Up to ~11 MW

ARC Tunnel Thrusters

- Designed for high ice loads
- Does not require ice grids
- Up to PC 2 ice class
- Same rigorous hydrodynamic design standards as with non ice classed models
- FP design which removes risk of hydraulic oil leaks

Selected References



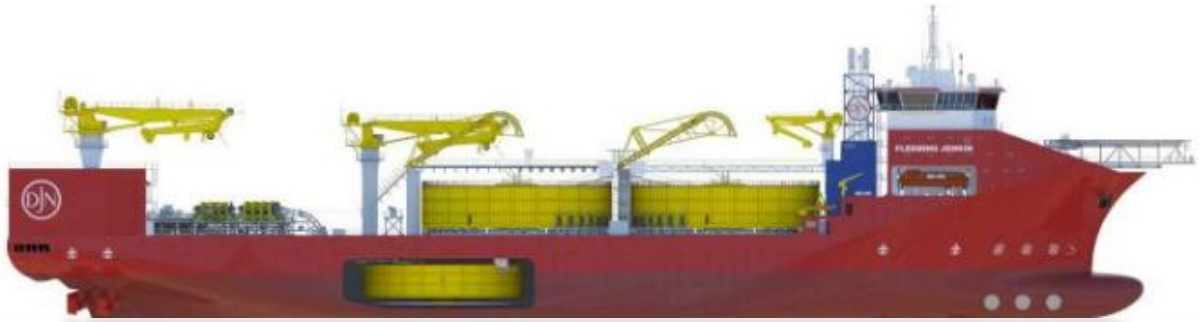
244 Offshore O&G and Renewables Vessels to Date

Including following owners:

- Jan De Nul – 2 CLV
- DOF - FSV
- Maersk – 1 WTIV*
- Esvagt - 10 W2W SOV’s
- Vestland – 1 SOV
- Bourbon – 104 OSV’s
- Tidewater – 15 OSV’s
- REM Offshore - 4 OSV’s
- Seacor – 7 OSV’s
- Viking Supply – 2 OSV’s

Picture: DOF


Picture: Maersk Offshore Wind


Picture: Jan De Nul

STEERPROP

Jan De Nul XL CLV - Steerprop Scope

Main Propulsion	Retractable Thrusters	Transverse Thrusters
4 x SP 45 W D L (+1 spare)	**2 x SP 45 R**	**3 x SP 40 TT**
L-drive	L-drive	L-drive
2 600 kW*	2 600 kW*	2 100 kW*
3.1 m	3.2 m	2.8 m
	8-degree tilted propeller	Special trunk-type installation

All thrusters:

- CFD-optimized propellers
- Air-type shaft seals
- Vibration monitoring
- Oil condition monitoring

*) Owner factors applied

Picture: Jan De Nul

DOF- FSV Steerprop Scope

Main Propulsion

2 x SP 50 W D
Z-drive
3 300 kW
3.0 m
Steerprop Shaft Seal condition monitoring

Transverse Thrusters

2 x SP 25 TT
L-drive
1 500 kW
2.2 m
5-blades, 28 m/s tip speed

Retractable Thrusters

1 x SP 20 R
L-drive
1 500 kW
2.2 m

Picture: DOF

Cruise References

Celebrity Flora

Loa	101,5 m
Beam	17 m
Power per unit	1,25 MW
Main propulsion	2 x SP 20 CRP
Built by	De Hoop
Owner	Celebrity Cruises

Silver Origin

Loa	101,5 m
Beam	17 m
Power per unit	1,25 MW
Main propulsion	2 x SP 20 CRP
Built by	De Hoop
Owner	Silversea

MS Spitsbergen

Loa	101,0 m
Beam	18 m
Power per unit	3 MW
Main propulsion	2 x SP 35 CRP
Built by	ENVC
Owner	Hurtigruten
Ice class	1C

Vladivostok, Murmansk & Novorossiysk

ICEBREAKERS

The vessel:

Classification:	RS Icebreaker 7
Length overall:	119.79 m
Breadth:	28 m
Gross tonnage:	11,720 tons
Owner:	Rosmorport
Shipyard:	Vyborg Shipyard / Arctech Helsinki Shipyard Oy
Operating area:	Arctic Ocean

Steerprop propulsion units:

Type:	2 x SP 110 PULL ARC
Power:	9,000 kW unit
Year of delivery:	2015

The largest mechanical azimuth propulsors in the world.

Victoria (Damen ASD 3413 ICE)

ICEBREAKING TUG

Photo: DAMEN

The vessel:

Classification:	RS ARC 6 (PC 4 equivalent)
Length overall:	33,45 m
Breadth:	12,53 m
Gross tonnage:	573 tons
Owner:	Luleå Hamn Ab
Shipyard:	Damen Song Cam
Operating area:	Bay of Bothnia (Luleå)

Steerprop propulsion units:

Type:	2 x SP 60 CRP ECO
Power:	3,700 kW per unit
Year of delivery:	2022 / 2025

STEERPROP

Six MPI for CCG (up to 16 planned)

´MULTI PURPOSE ICEBREAKER

Photo: Aker Arctic

The vessel:

Classification:	PC 4 Icebreaker
Length overall:	99,9 m
Breadth:	20,0 m
Gross tonnage:	573 tons
Owner:	Canadian Coast Guard
Shipyard:	Seaspan Vancouver Shipyard
Operating area:	Arctic / Canada

Steerprop propulsion units:

Type:	2 x SP 120 CRP ECO ARC LM
Power:	3,600 kW per unit
Year of delivery:	202X-

Type:	2 x SP 25 TT ARC
Power:	1,350 kW per unit
Year of delivery:	202X--

CCG Polar Icebreaker

HEAVY POLAR ICEBREAKER

The vessel:

Classification:	PC2 Icebreaker
Length overall:	158.2 m
Breadth:	28.0 m
Draught:	10.5 m
Owner:	Canadian Coast Guard
Shipyard:	Seaspan Vancouver Shipyard
Operating area:	Arctic / Canada

Steerprop propulsion units:

Type:	2 x SP 40 TT ARC LM
Power:	2,000 kW per unit
Year of delivery:	Under construction soon

RV/IB Polarstern II

ICEBREAKERS

The vessel:

Classification:	PC 2
Length overall:	159.8 m (524 ft)
Breadth:	27.3 m (90 ft)
Gross tonnage:	26,300 tons
Owner:	Alfred Wegener Institut
Shipyard:	TKMS Vismar, Germany
Operating area:	Arctic Polar and Antarctic

Steerprop propulsion units:

Type:	2 x SP 160 PULL ARC
Power:	9,000 kW unit
Year of delivery:	2030

The largest mechanical azimuth propulsors in the world 2028.

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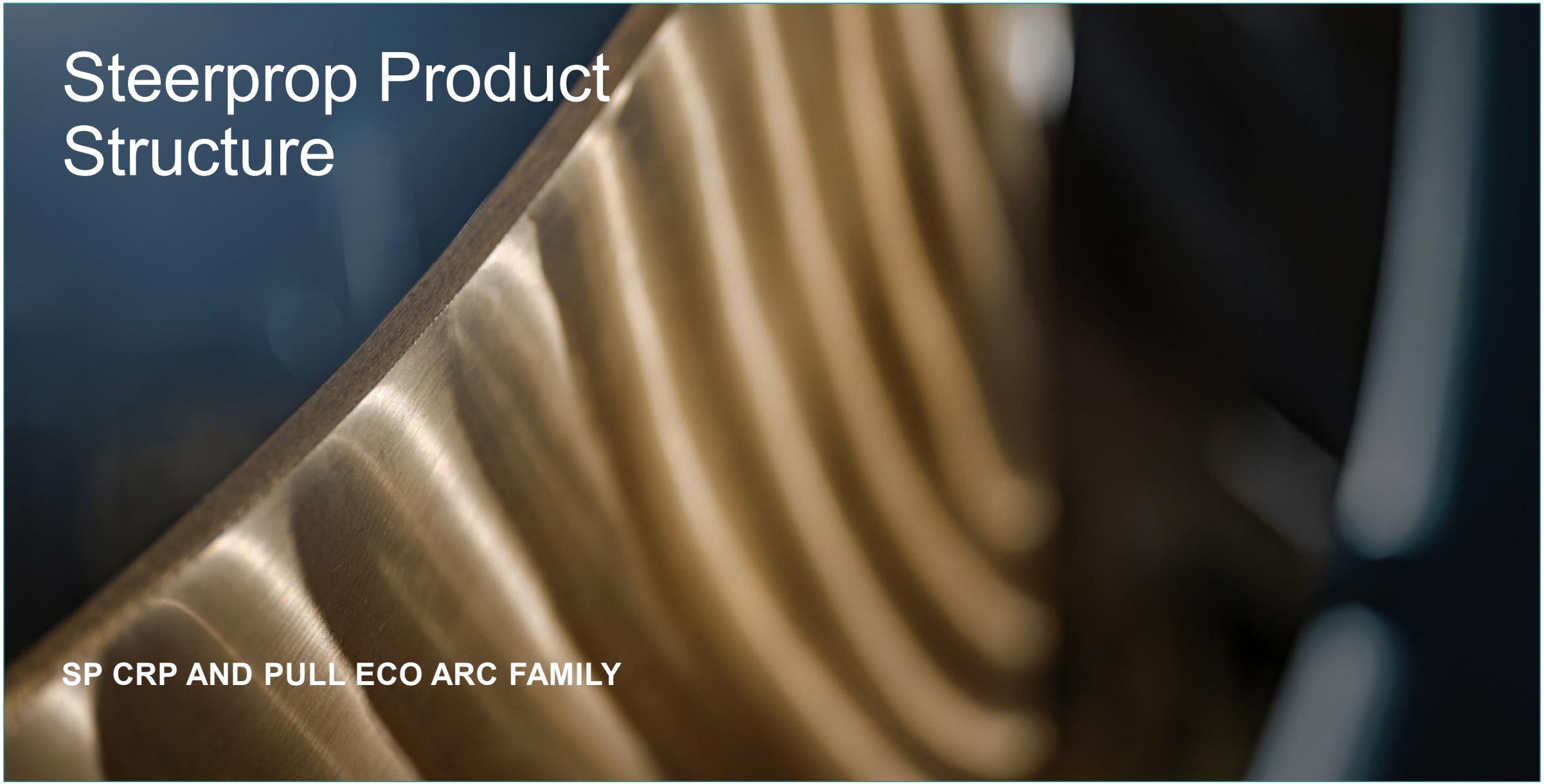
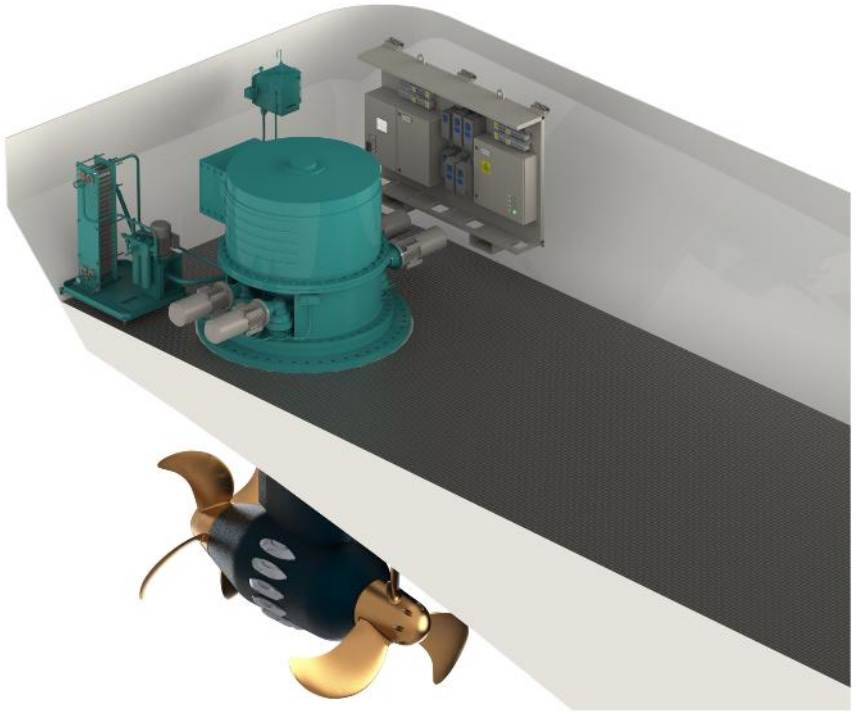
Steerprop Product Structure



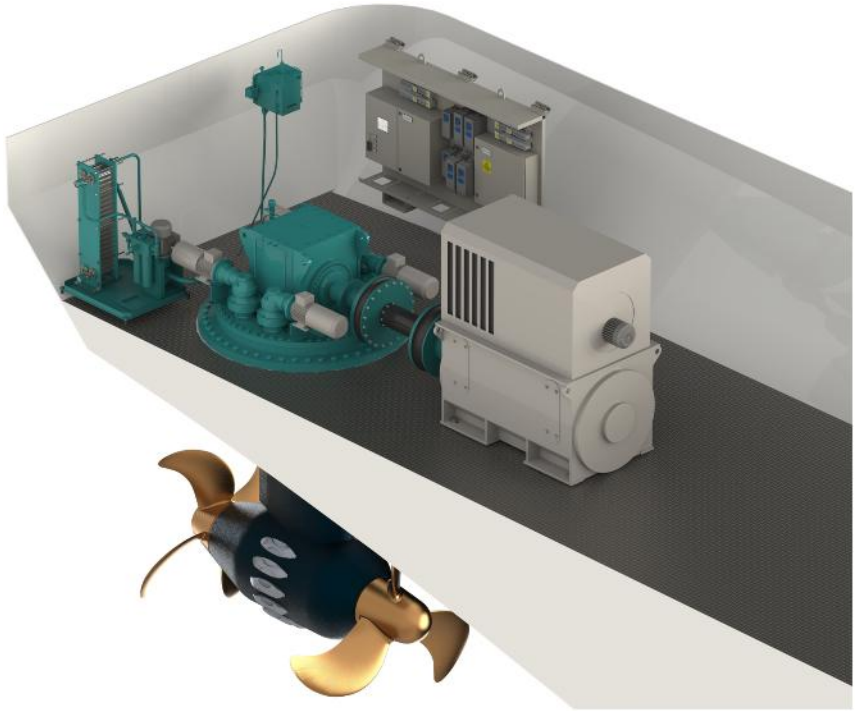
SP CRP AND PULL ECO ARC FAMILY

Optional configurations

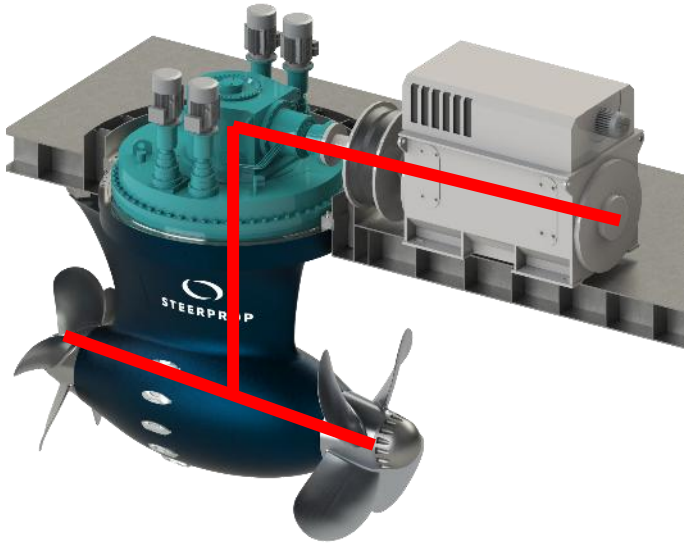
LM unit with integrated permanent magnet motor

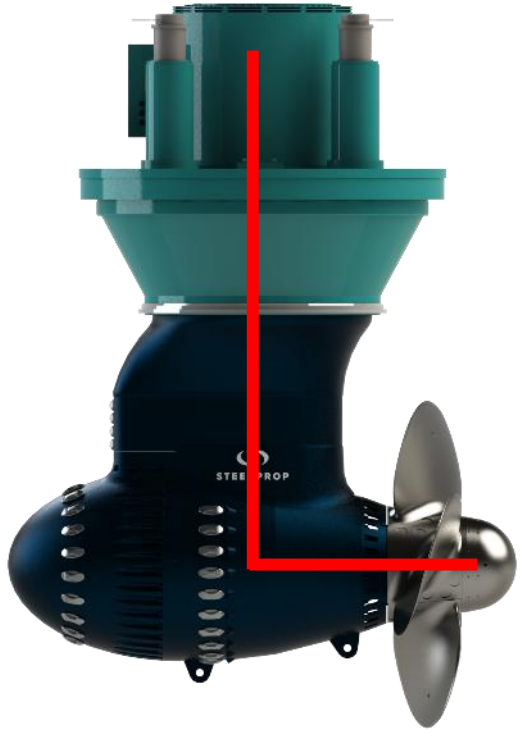


Z-drive with horizontal motor



Propulsor types





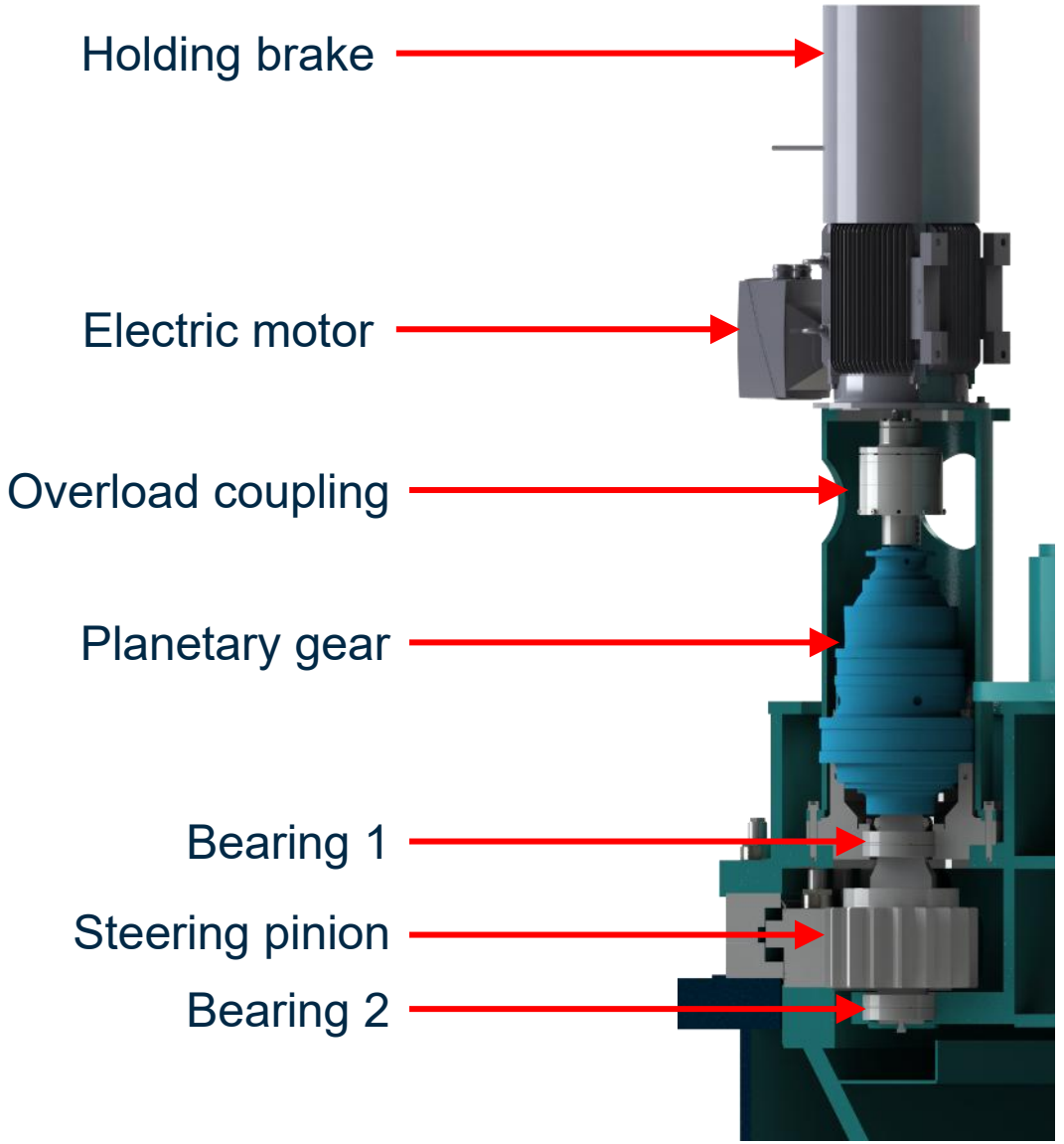
Two sets of propellers, shafts & gears

Lightly loaded contra-rotating propellers

- High efficiency
- Cavitation-free propellers
- Low pressure pulses
- Low blade area ratio
- Larger propellers with low RPM

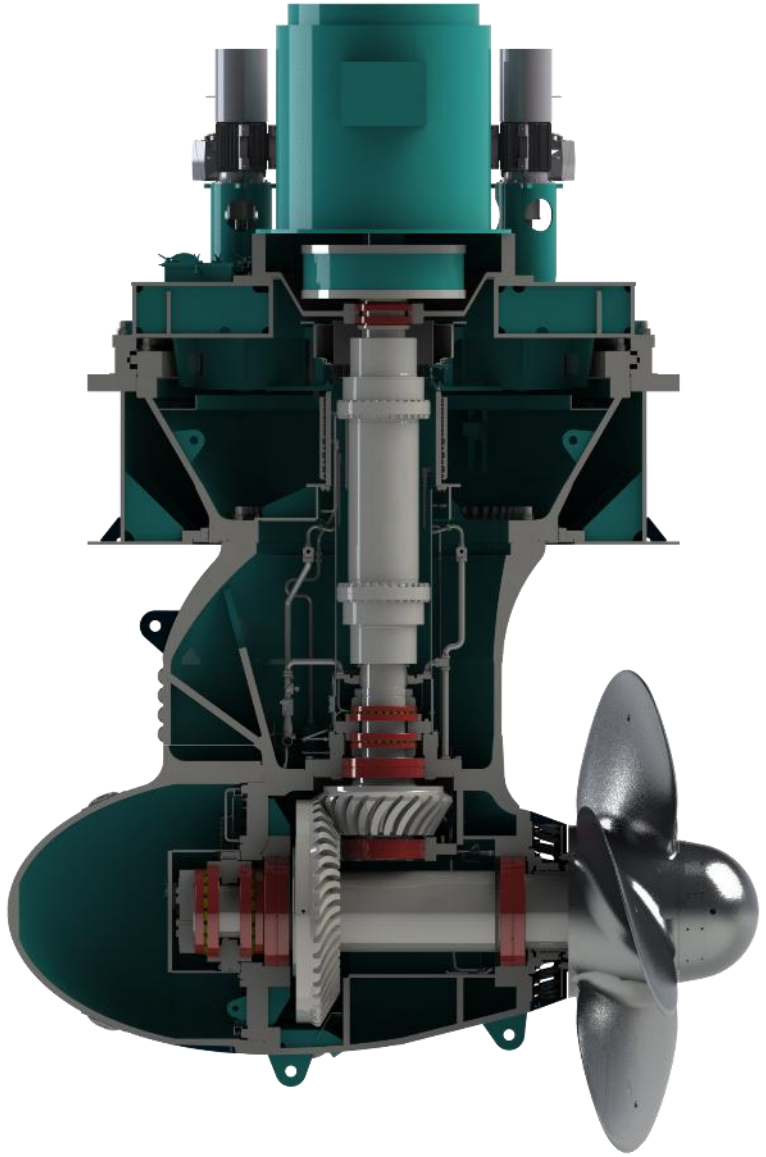
Electric steering, magnetic coupling

- All Steerprop icebreaker propulsors ever delivered have electric steering
  - Reliability has been excellent without any major issues
  - Planetary gear is dimensioned to handle ice impacts
  - Main spare parts are motor encoders, holding brake pads, and steering VFD's
- Deliveries since 2021 have a new type of overload coupling
  - New type is *magnetic type* with no mechanical contact – wear free
  - Old type was a *ball-detent torque limiter*
- Running hours for new type overload couplings is unknown, as vessels have not been visited since delivery
- No issues were noted in sea or ice trials
- All vessels are operating as intended

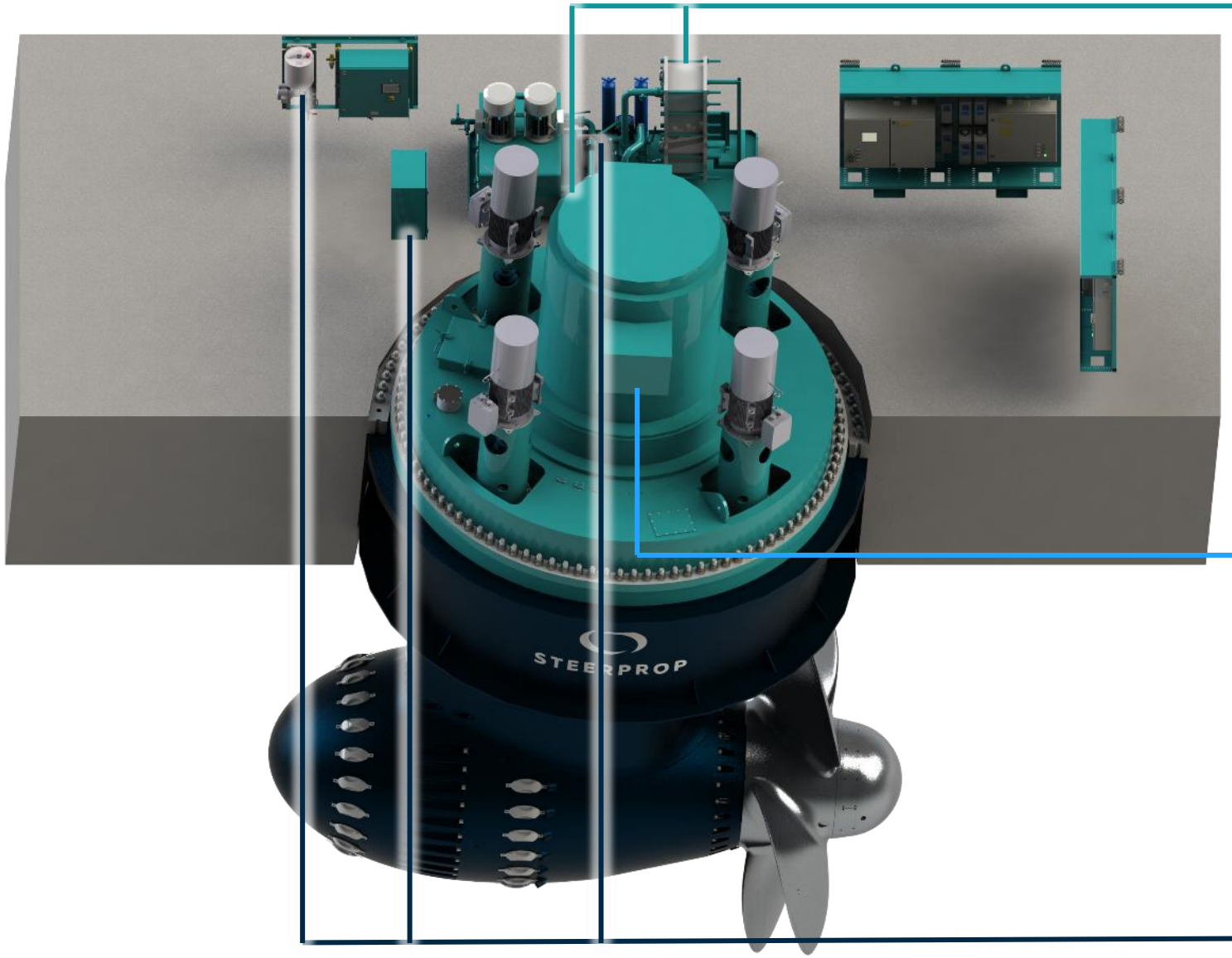


Product layout

- Tailored for the vessel
- Designed for icebreakers
  - For continuous heavy use
  - No steering angle or torque ramp limitations
  - ARC design details
- Integrated Permanent Magnet (PM) motor
- Electric steering
- Simple, robust, mechanical construction
  - Well understood (30+ years)
  - Low maintenance
  - Easy to repair



CRP Lower Assembly



Cooling water
LT 38 °C

Electrical (LV)
Automation
440/690 VAC

Electrical (MV)
3.3 kV

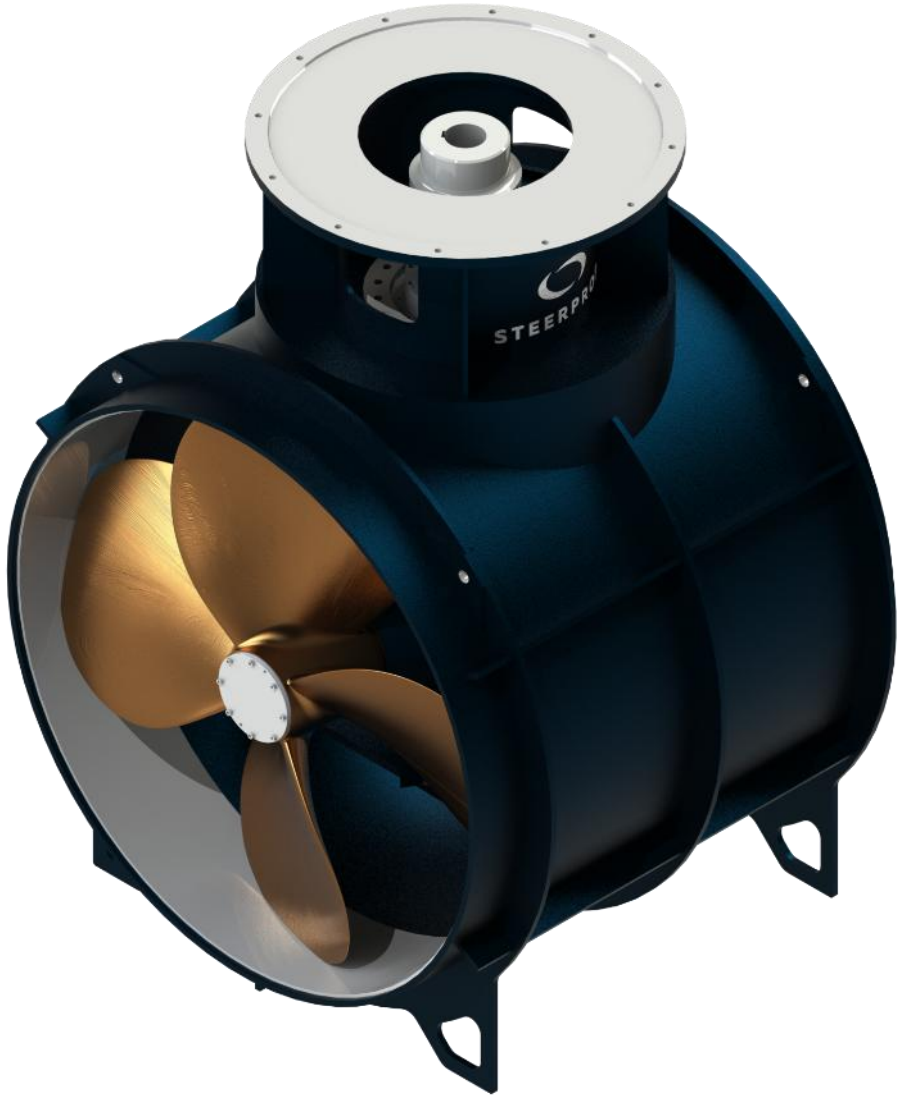
Compressed air
Work air min. 6 bar

Steerprop TT
Overview

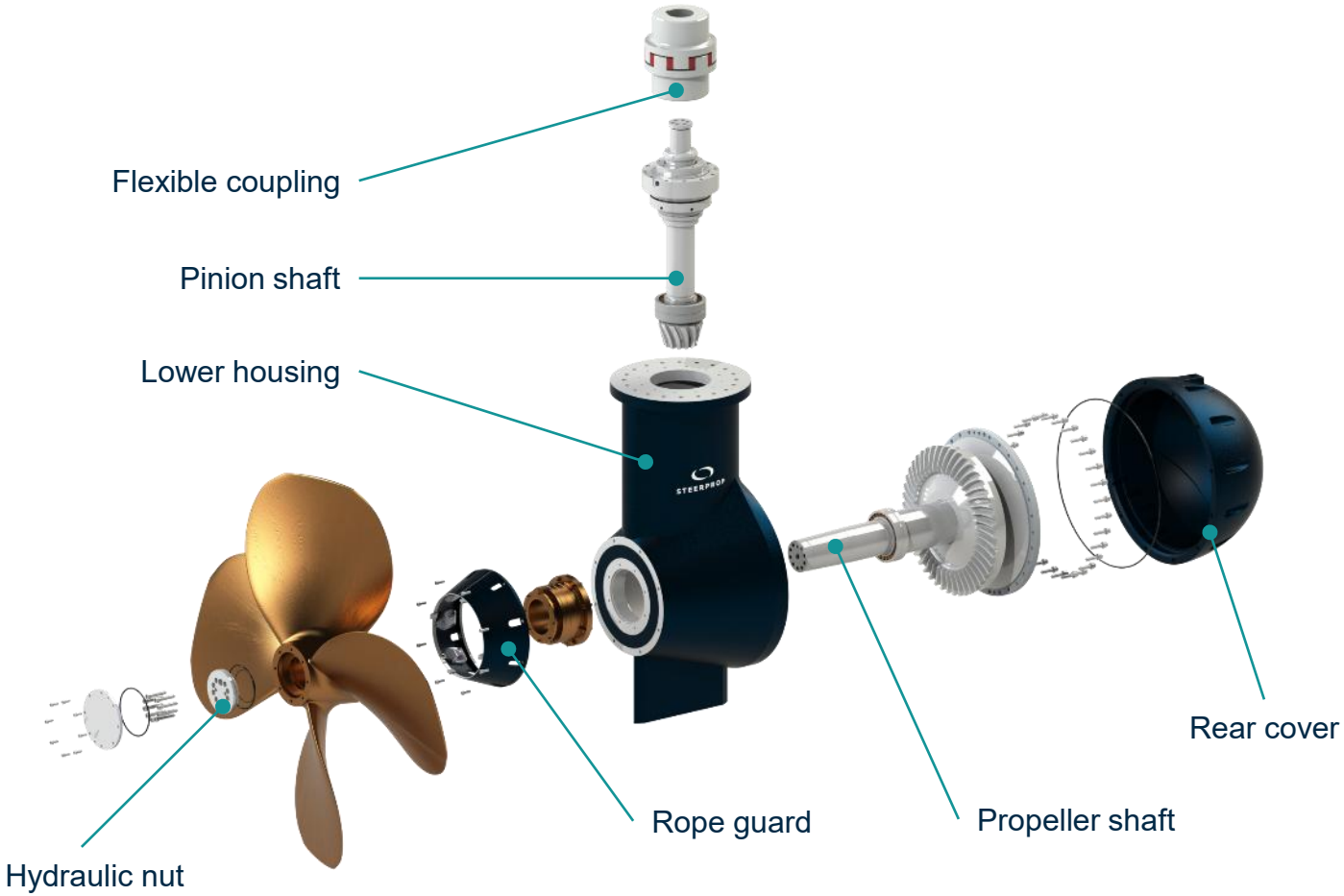
STEERPROP

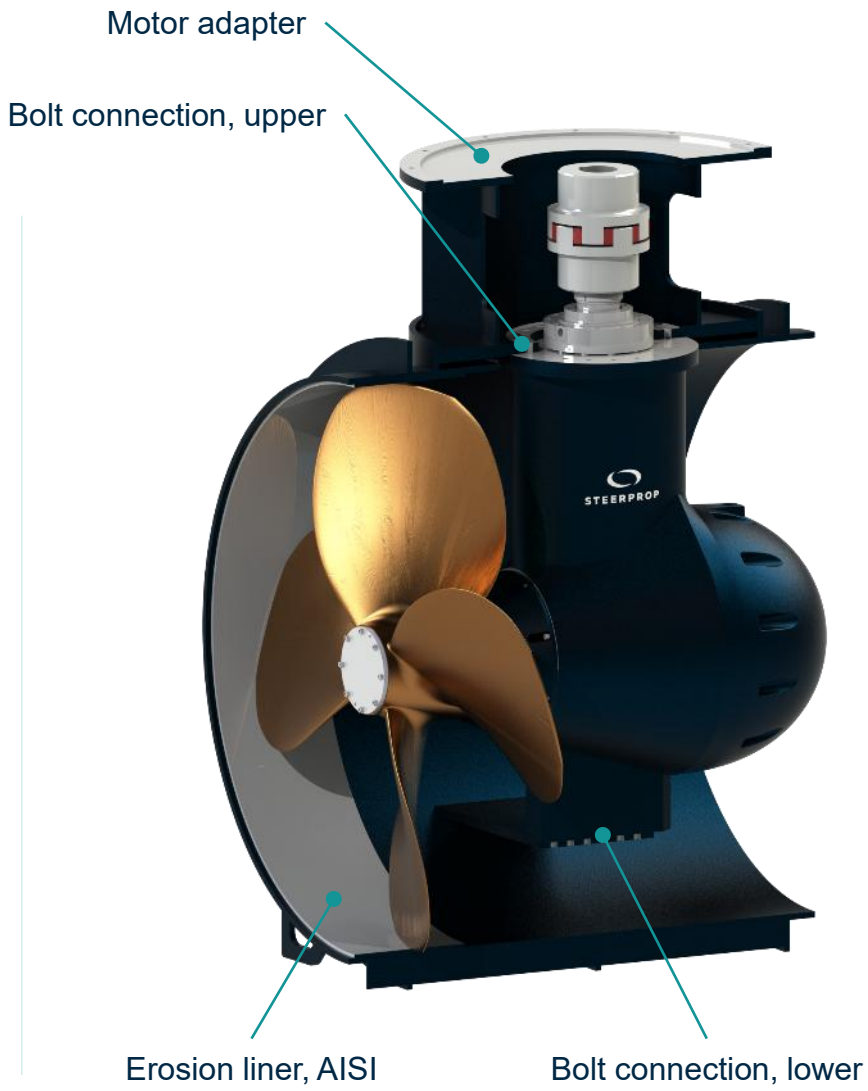
Steerprop TT

- Expanding Steerprop portfolio to provide whole propulsion system from a single maker
- Steerprop propulsion principles
  - Robust design, low TCO
  - Main azimuth design standards
  - Common parts catalog
- Power range 900 kW … 4 500 kW
- TT ARC for ice-going vessels



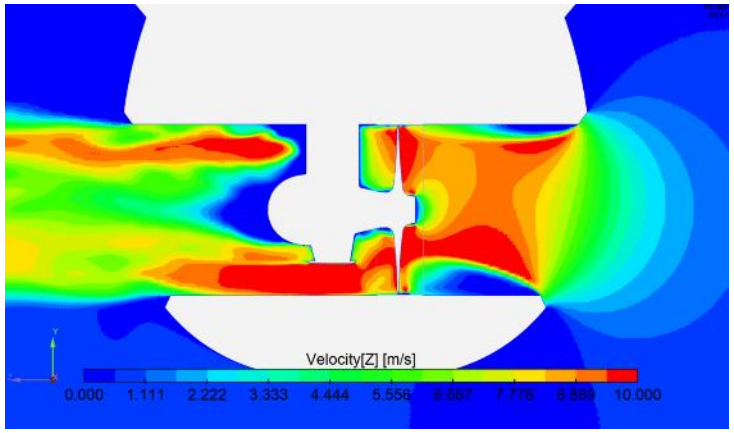
SP TT – Product structure



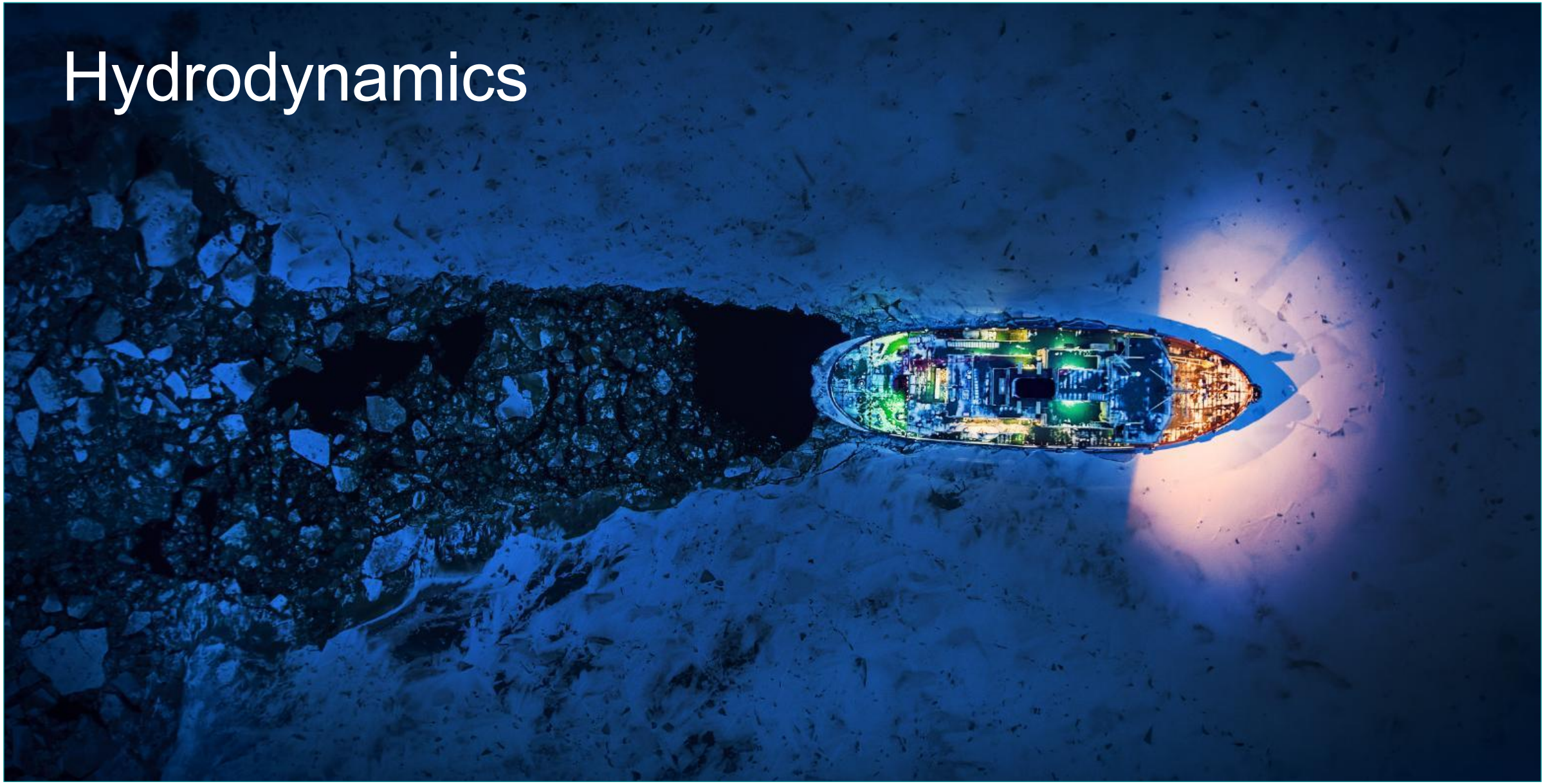


Steerprop fixed pitch TT

- Key particulars
  - Simple and robust
  - Always project optimised
  - Hull CFD optimisation for every project
- Lifecycle
  - Minimal OPEX
  - No CP mechanism
  - 15 year overhaul period

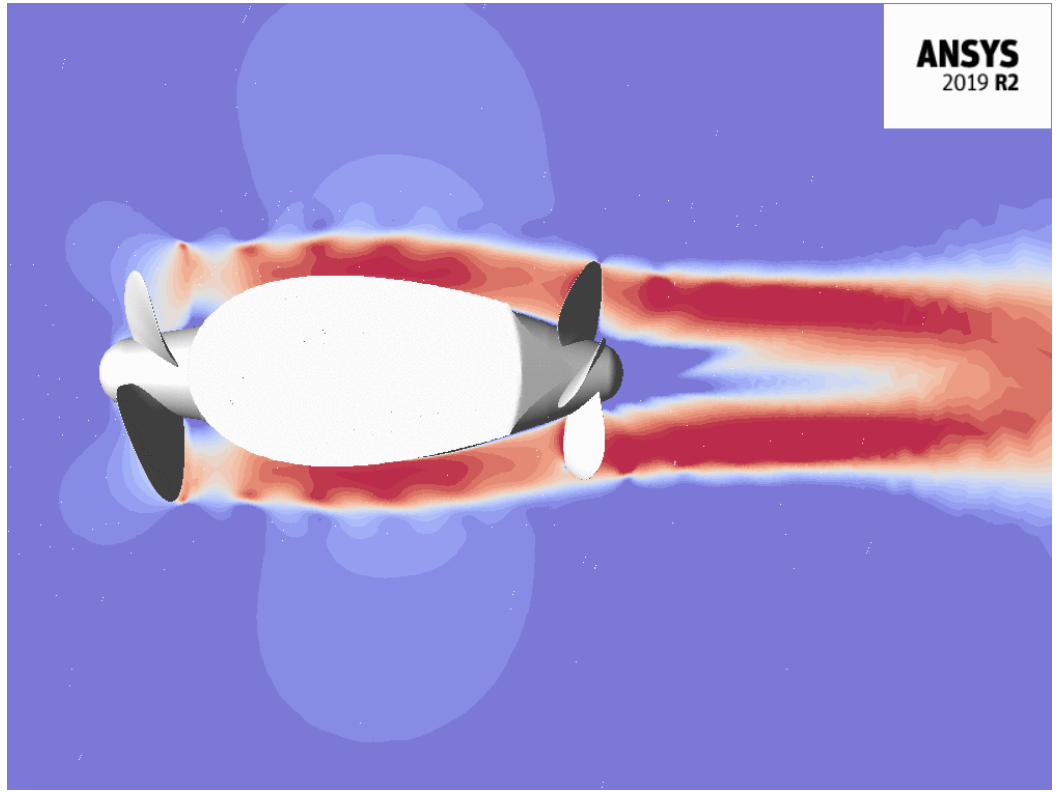


Hydrodynamics



Full Blown RANS Computations

- A very good agreement has been achieved between model scale tests and numerical results.
- Opened up a new horizon in studying detailed flow features and scaling with proper post-processing.
- RANS-CFD is used as final analysis in propeller design process.
- Prediction of Cavitation and Pressure Pulses



Ref: Steerprop Test Case CRP

Bollard pull / DP thrust

Thrust in Bollard (Propeller law):

$$Th\ [kN] = k \times (P \times D)^{(2/3)}$$

P = power in kW

D = propeller diameter in m

K depends on propeller type

Coefficient k for different propeller types

Propeller type	**k**	
Open propeller	0.81	
CRP	0.9	(+10%)
Kort nozzle (19A)	1.15	(+40%)
High efficiency nozzle	1.2	(+45%)

Example: CRP vs. open propeller

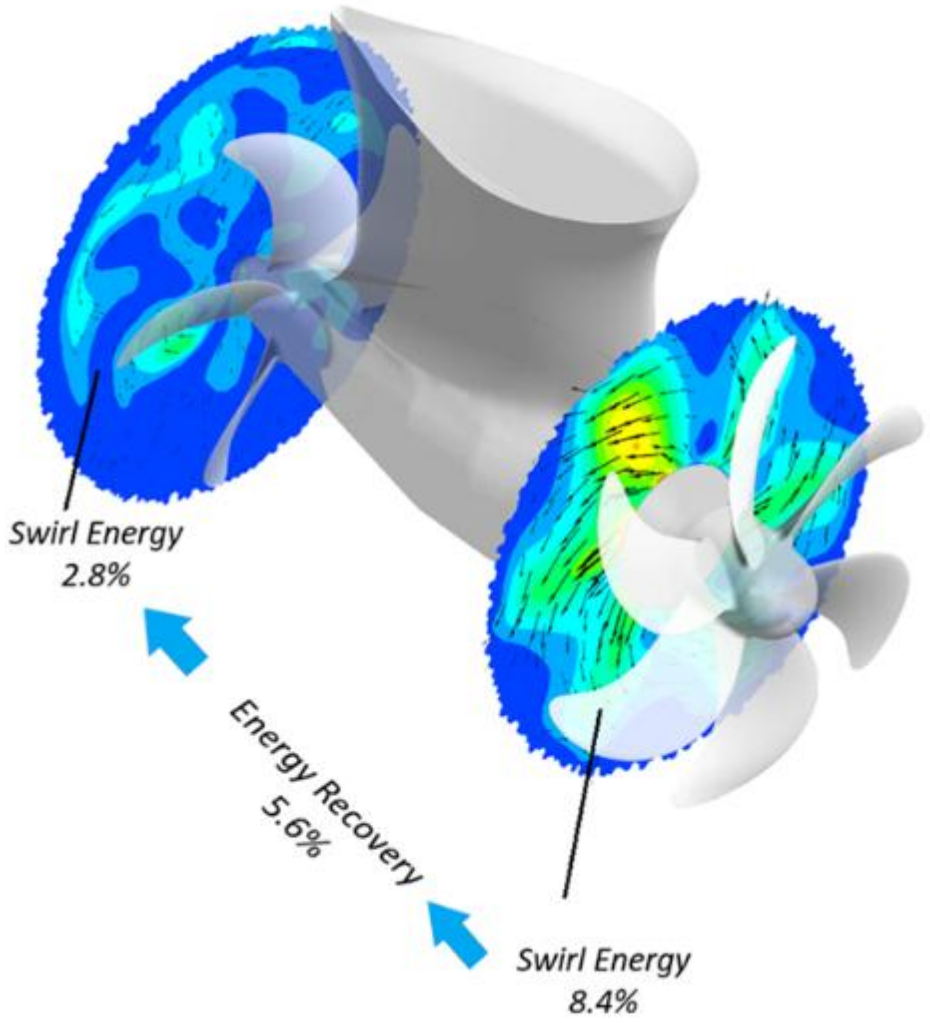
$$Th\ [kN] = k \times (P \times D)^{(2/3)}$$

Type	Open Pull (ARC):	CRP (ARC):
Th [kN] = Thrust	885	885
D = Prop dimension	4.5 m	4.5 m
k = Coefficient k	0.81	0.9
P = Power	8.0 MW	6.8 MW
Energy/fuel save	Base case	- 14.6 %

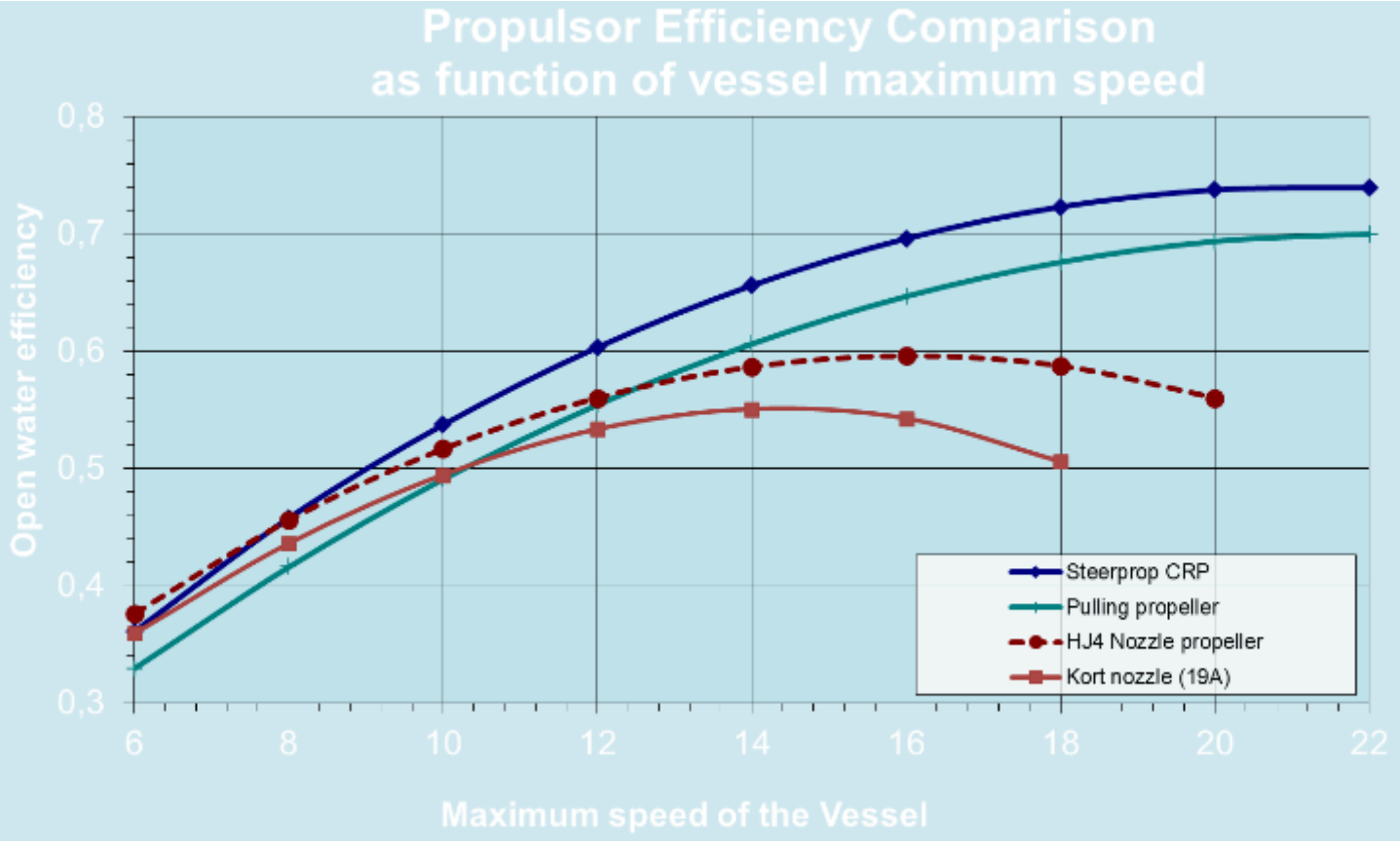
Efficiency

CRP energy recovery and hydrodynamic advantage

- The aft contra-rotating propeller retrieves rotation energy from the front propeller slipstream, leaving the ultimate wake rotation-free
- The slipstream is narrower, than that of a single propeller open unit. This increases thrust and efficiency
- Increased total blade area brings increased efficiency



Propeller efficiency vs vessel speed



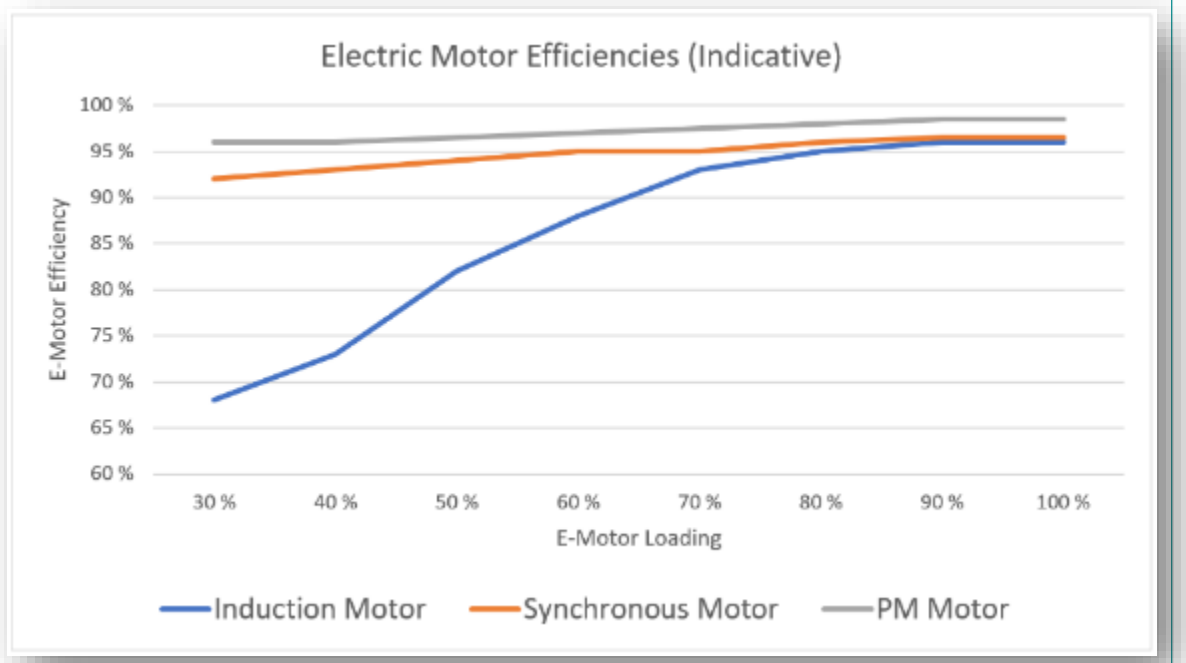
Effect of vessel speed to propeller efficiency

- CRP
- Pulling propeller
- High efficiency nozzle
- Kort nozzle (19A)

Electric Motor Types

Main electric motor types are:

- Externally exited induction motor
- Synchronous motor
- Permanent Magnet (PM) motor



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Cooling

Air Cooling

- Requires fans for air circulation
- Power demand above 100kW

- LT Cooling water requirement double compared to the Liquid cooling

- Certain applications require chilled water
  - Additional chiller & compressor capacity

Liquid Cooling

- Cooling carried out by lubrication
  - Lubrication pump
    - Frequency converter controlled

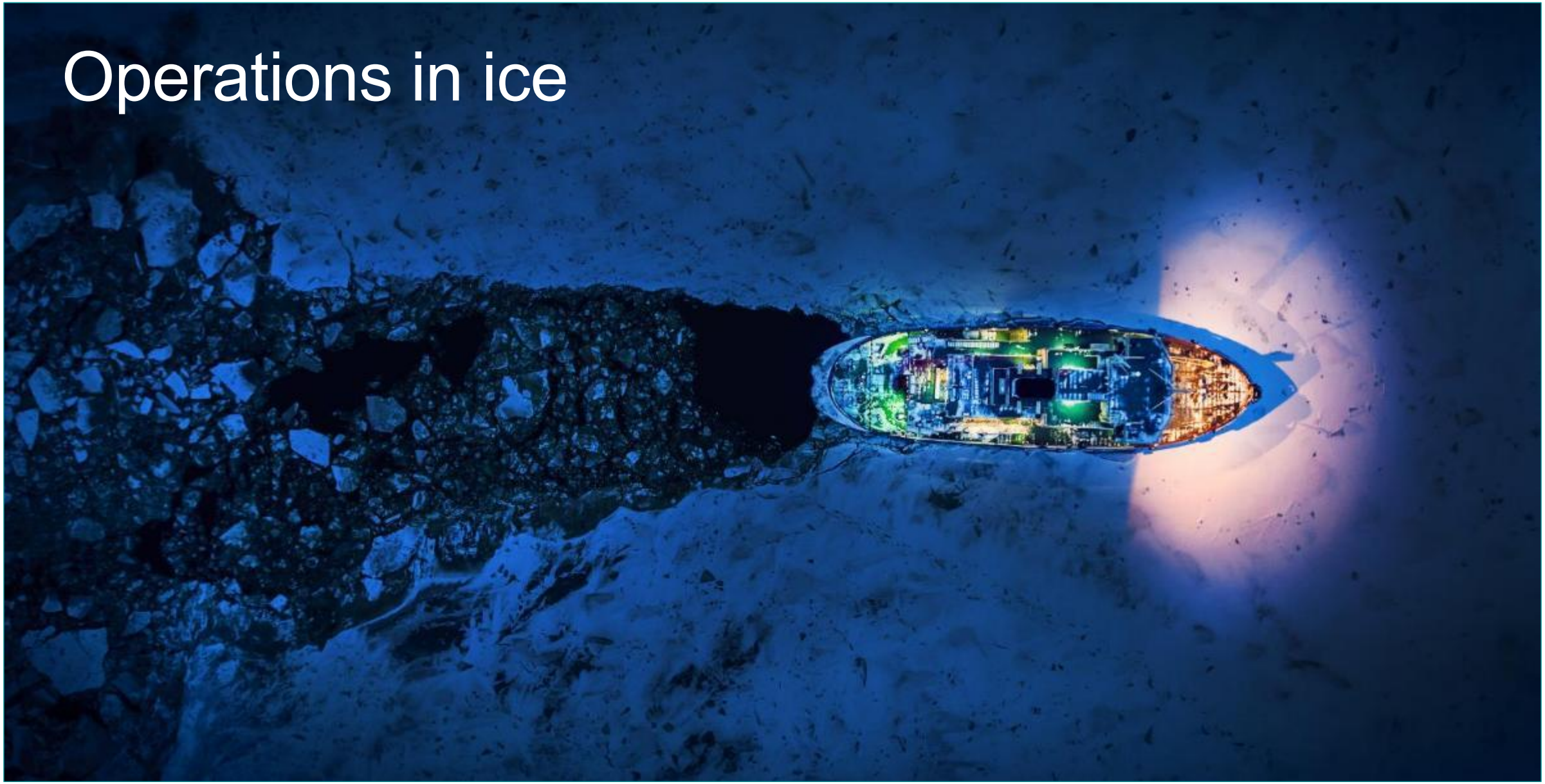
- Heat exchanger needed
  - LT or Seawater

- No additional power consumption

Steering

	Electric steering gear	Hydraulic steering gear
Redundancy	System is naturally redundant onto mechanical part. Drives are independent.	Hydraulic power pack is redundant. Redundant steering motors makes the system complicate.
Control response	Fast and accurate	Not so accurate. Response time complicated to calculate.
System structure	Simple and straightforward	Complicated, separate electric and hydraulic system.
Space demand and weight	Small	Bigger
Efficiency and losses	Low losses, ca 0.2 ...0.5 % of the propeller motor energy consumption.	High losses, ca 3...5 % of the propeller motor energy consumption
Dimensioning power / equal steering torque	50-60 %	100 %
Noise	Less noise	More noise.
Cooling	Air cooling (high efficiency)	Water coolers
Environment	No oil, less energy needed.	High pressure oil, filters, more energy needed.

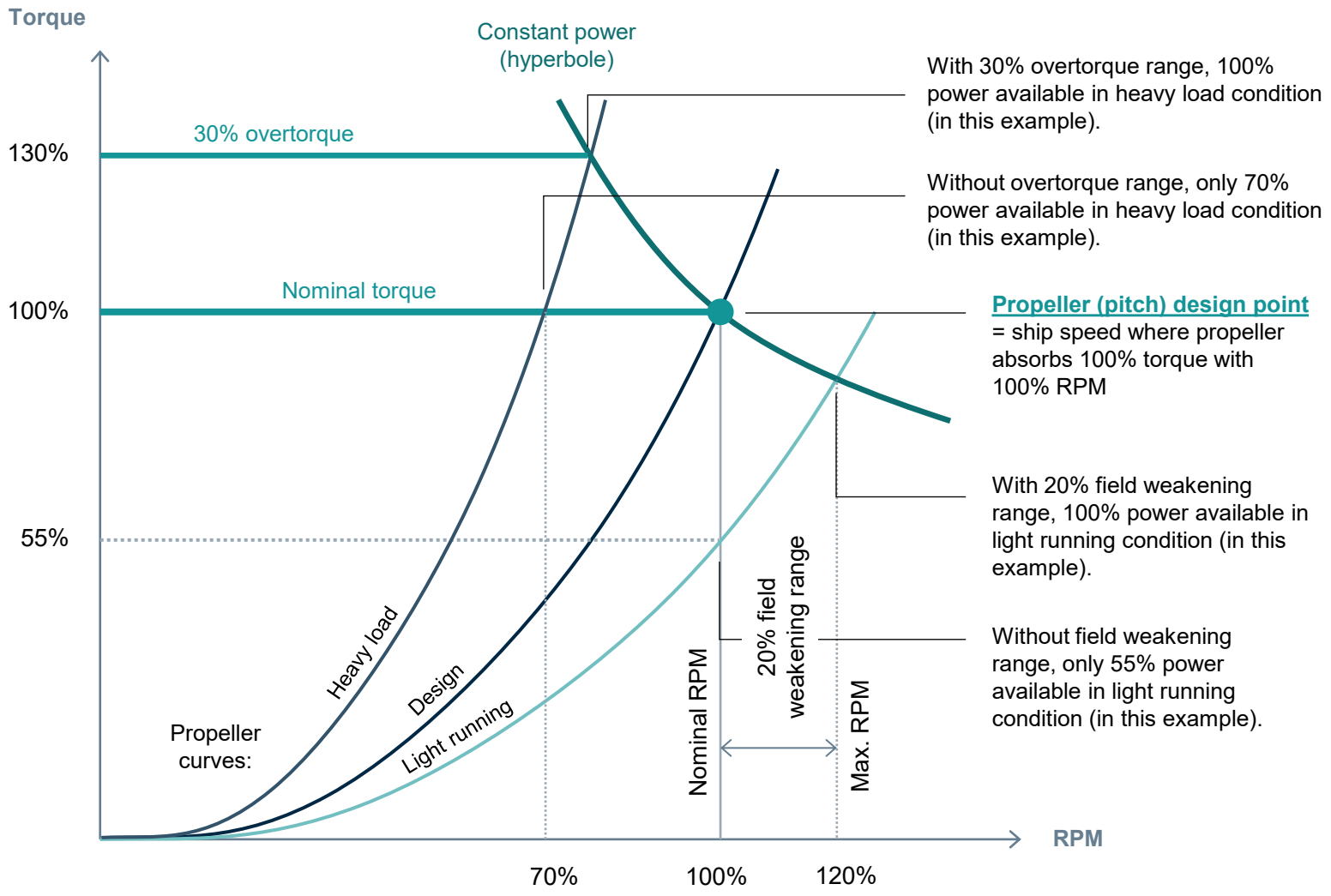
Operations in ice



Power absorption vs. limits

To match:

- ☑ torque limit
- ☑ RPM limit
- ☑ propeller curves
  - ☑ Fixed Pitch Propeller



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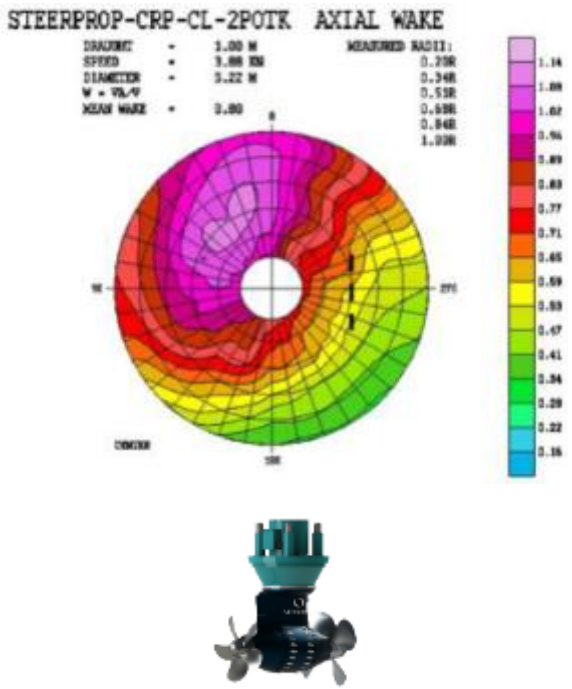
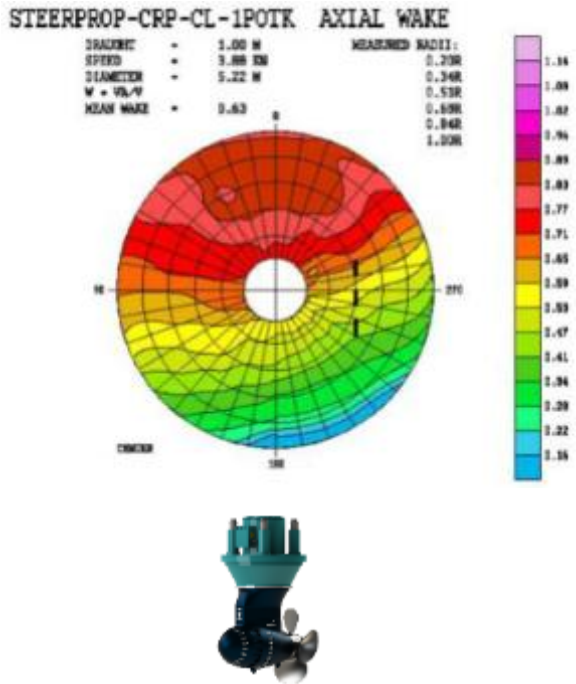
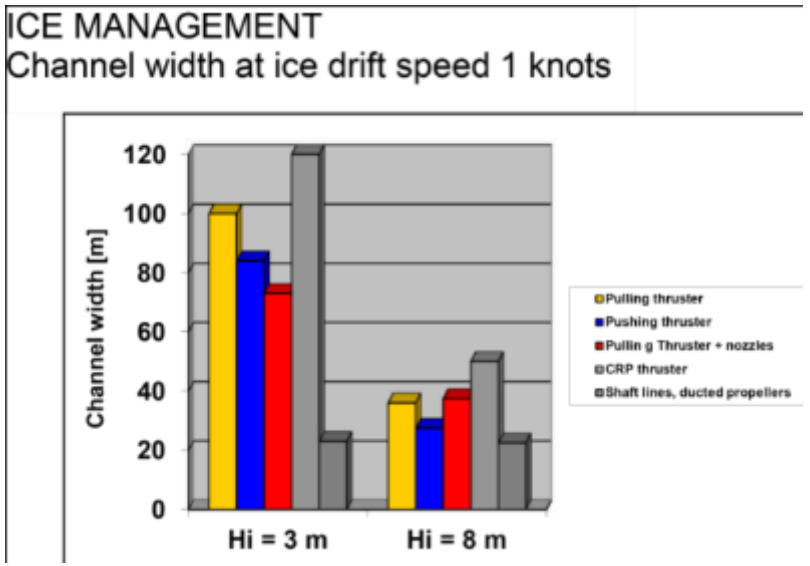
CRP benefits in ice compared to pull and others

CRP

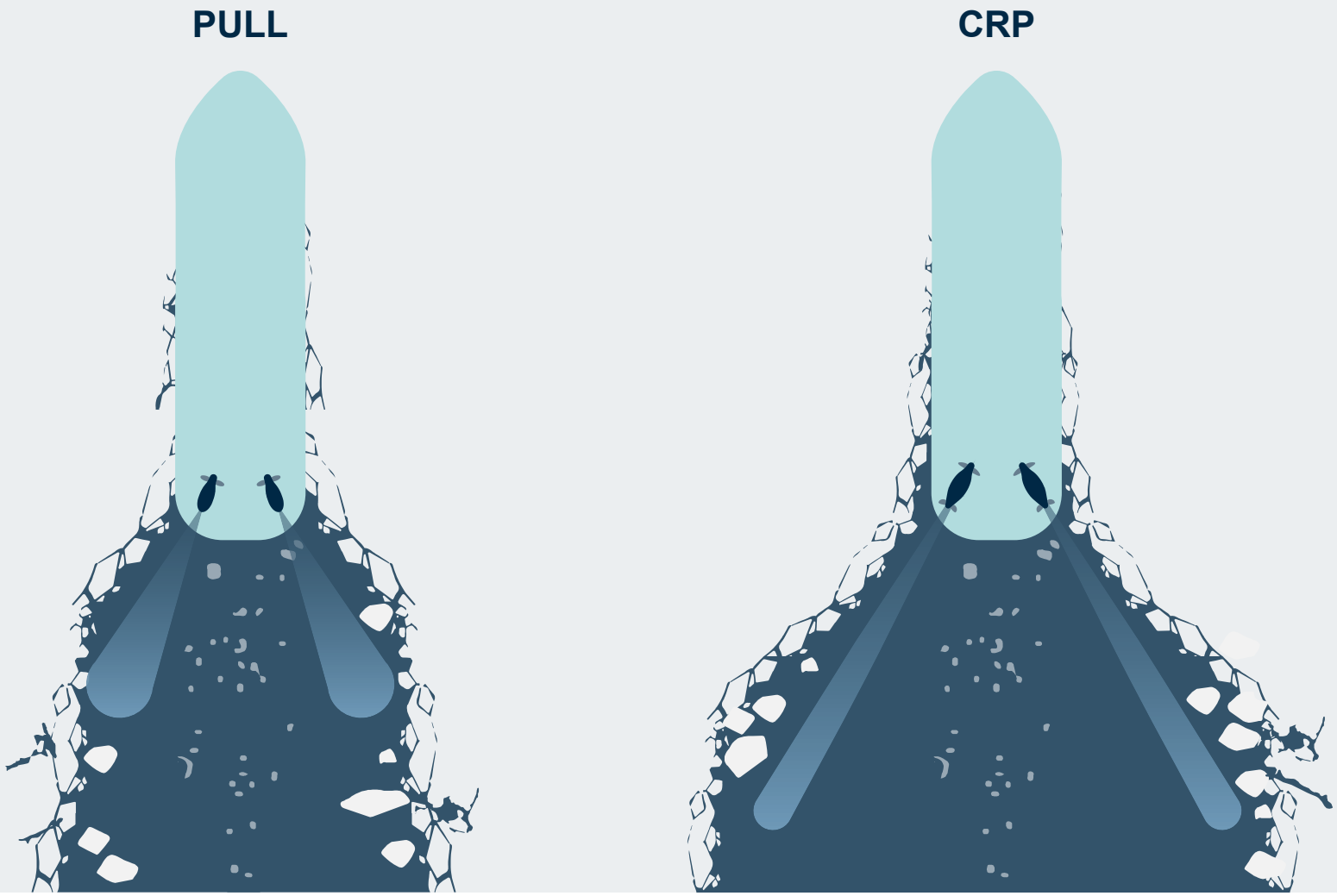


PULL

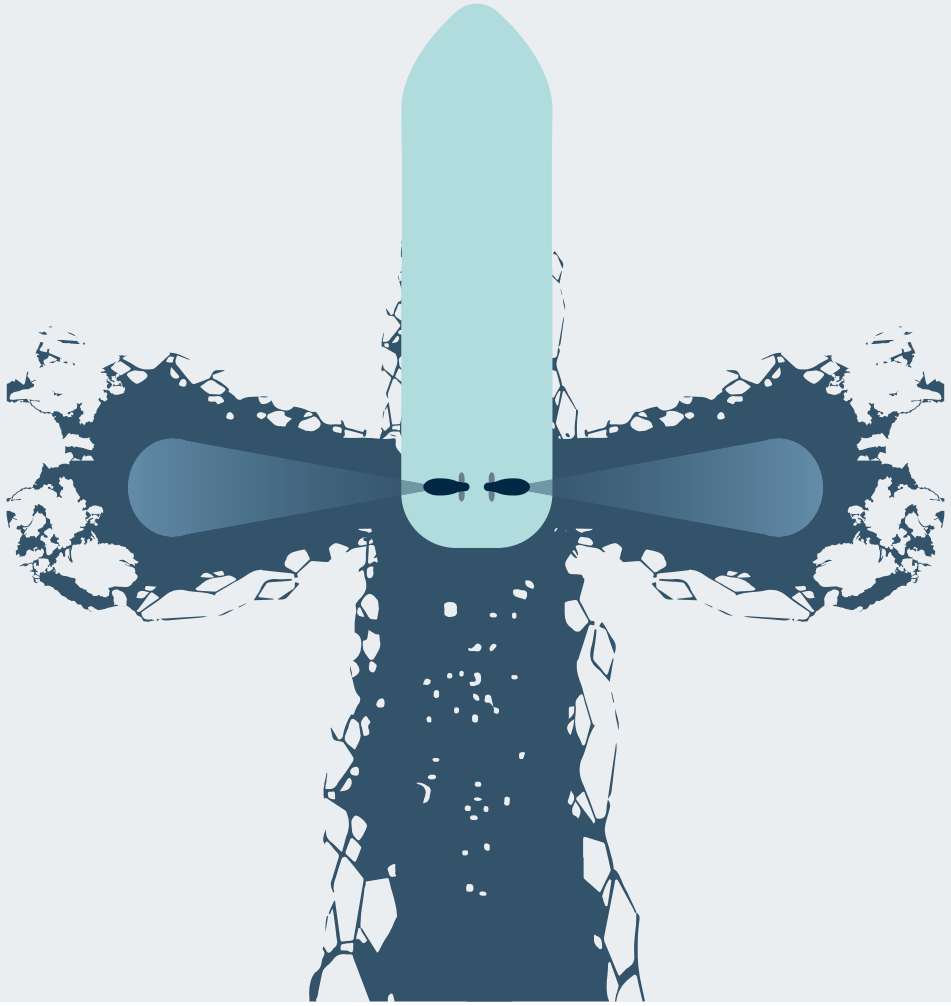


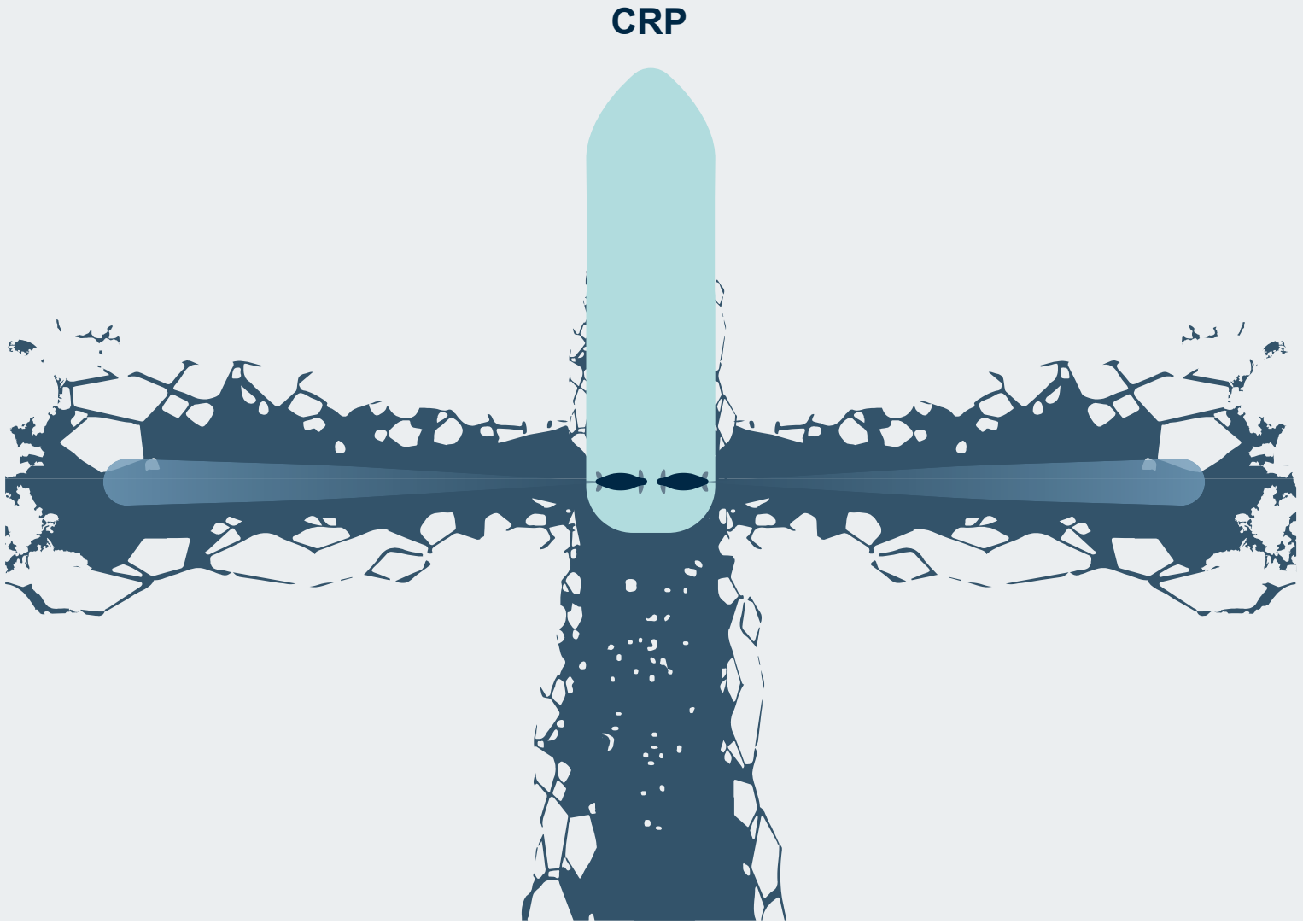


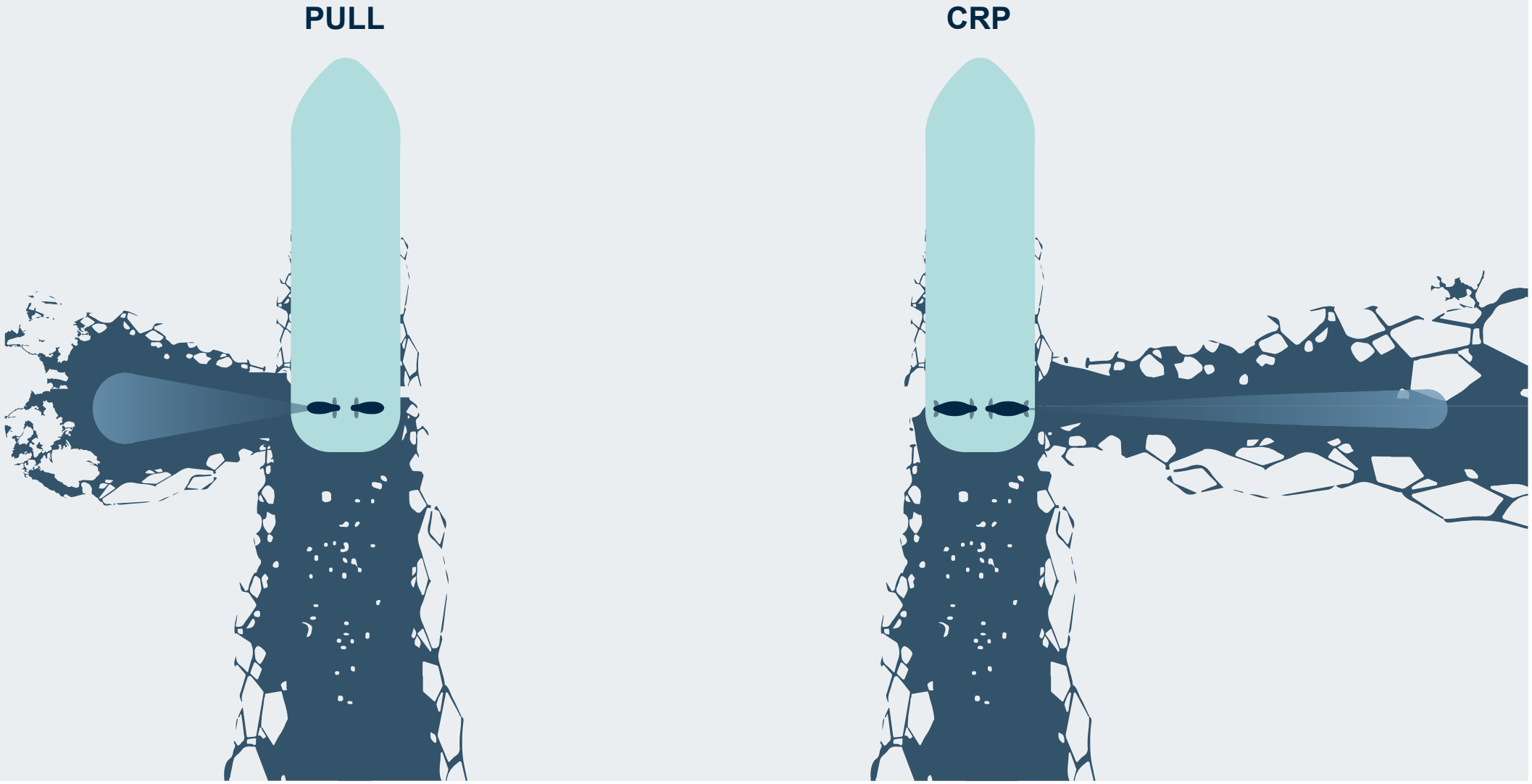
STEERPROP


PULL
CRP

PULL

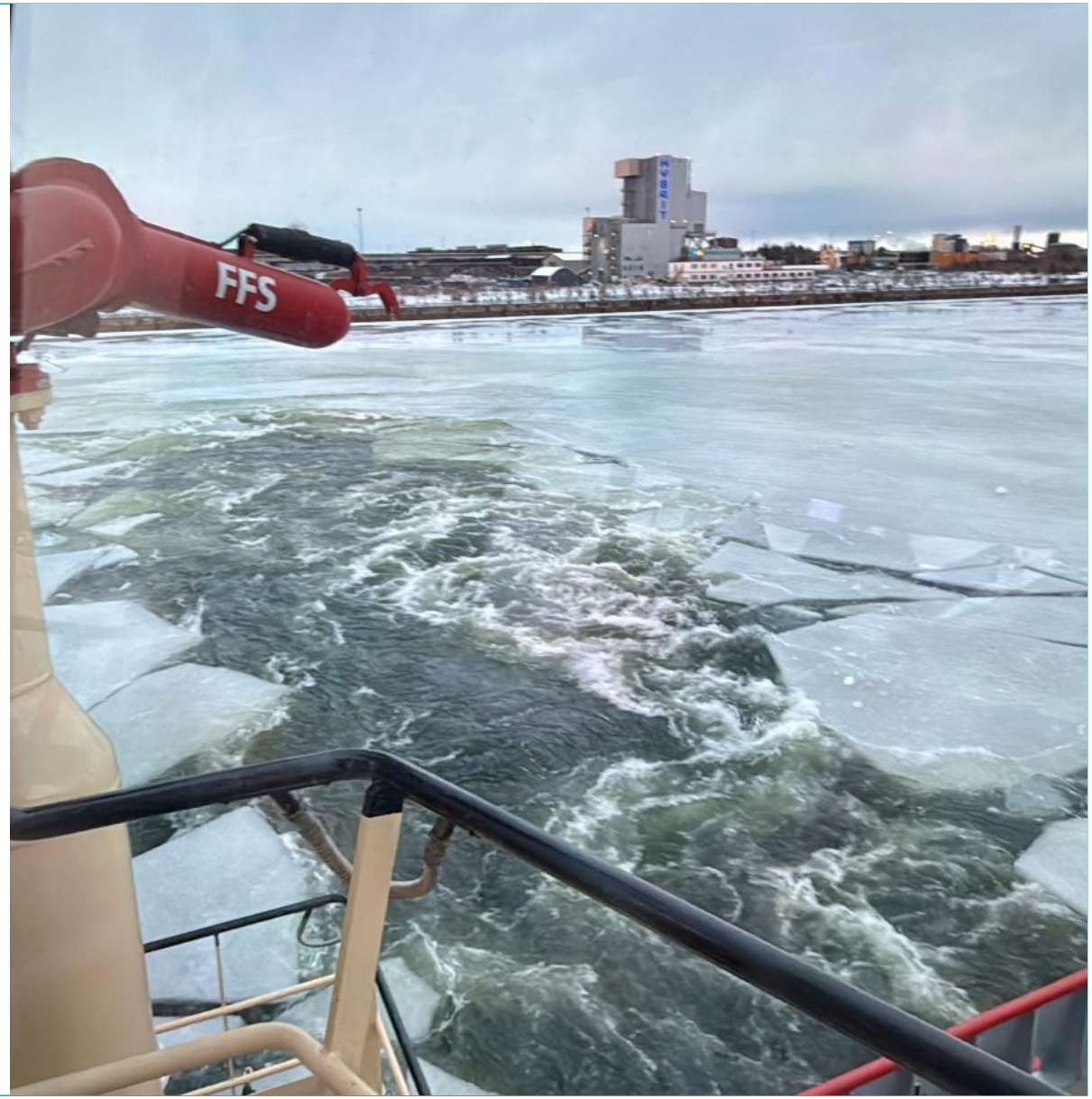




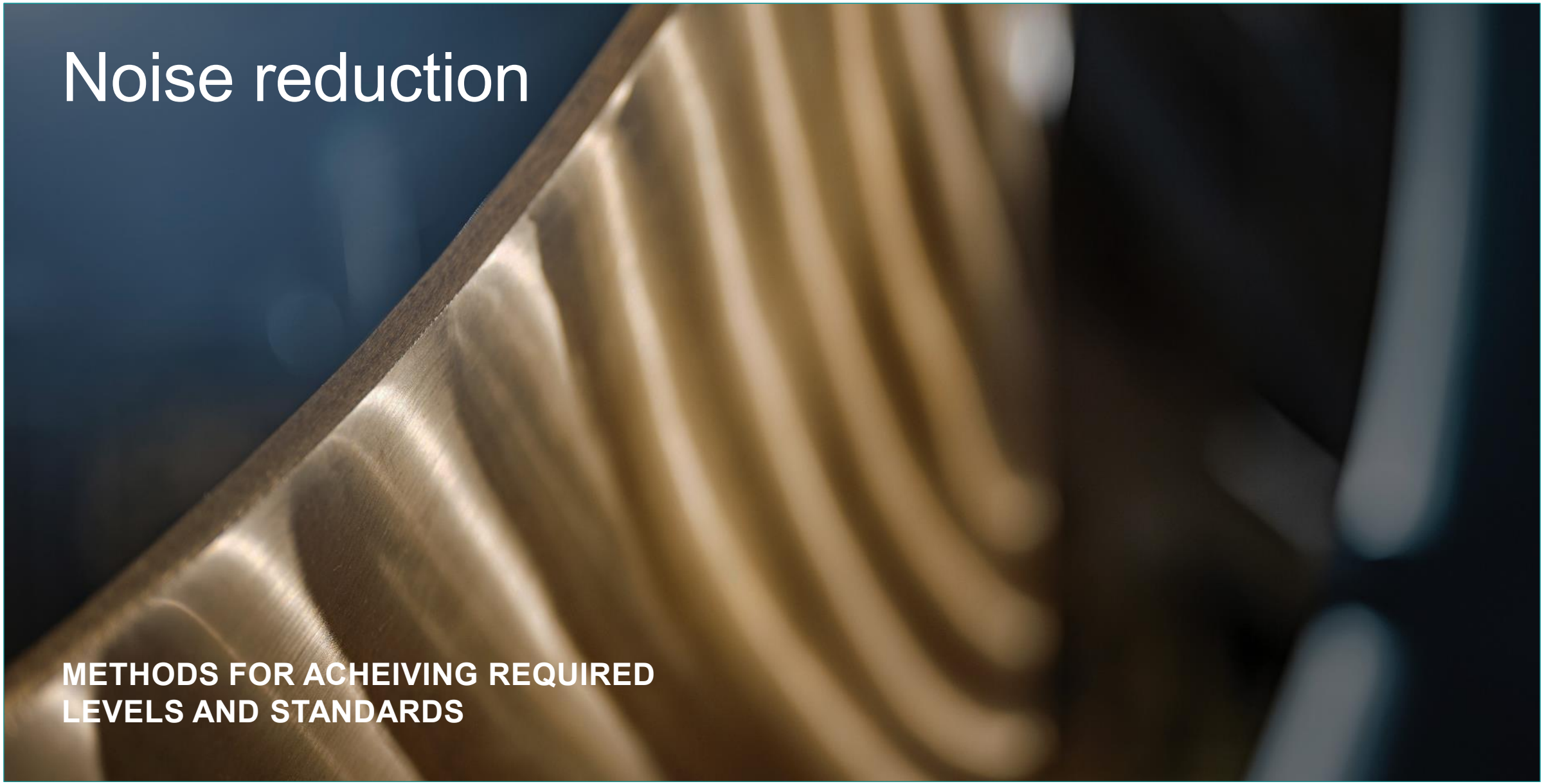

PULL
CRP

ASD Tug VICTORIA ice trials

- Time: 2025 March
- Location: Luleå, Sweden
- Units type: SP 60 CRP ARC
- Power: 3.6 MW
- Level ice 50 cm
- 90 degrees test
- Lever setting: 90 % thrust
- Test time 4 min
- Result channel length: 50 m from side
- Note: Slip stream channel proved to be narrow as predicted with minimal spread further into the slip stream channel (see picture)



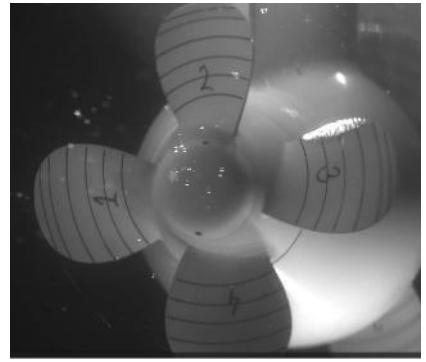
Noise reduction

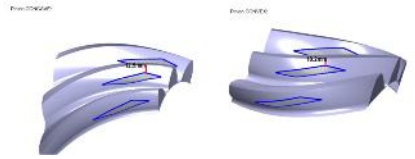


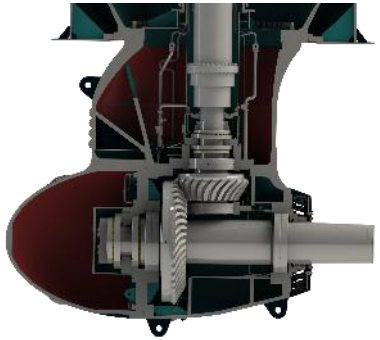
METHODS FOR ACHEIVING REQUIRED LEVELS AND STANDARDS

Noise measures (URN, Shipboard Noise)

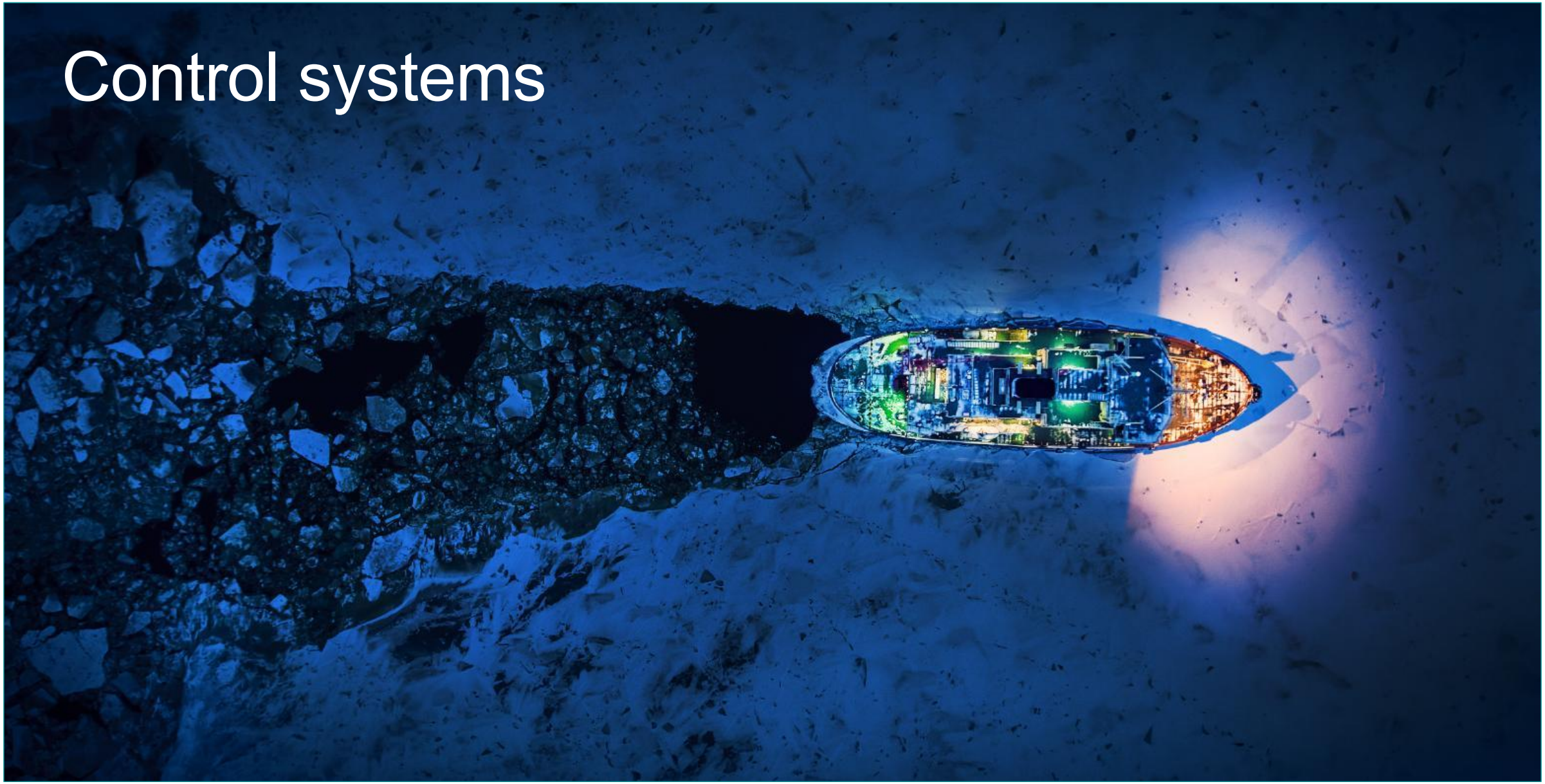
- Propeller design and interaction
  - CFD, good wakefield, cavitation free
- Mechanical measures
- Unit physical design features
- Simulations
- FAT tests





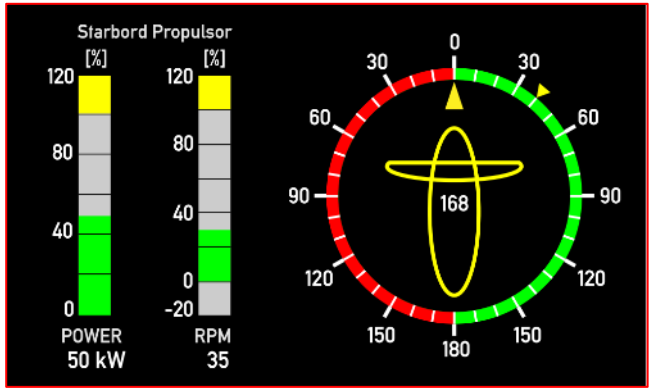


Control systems



Controls

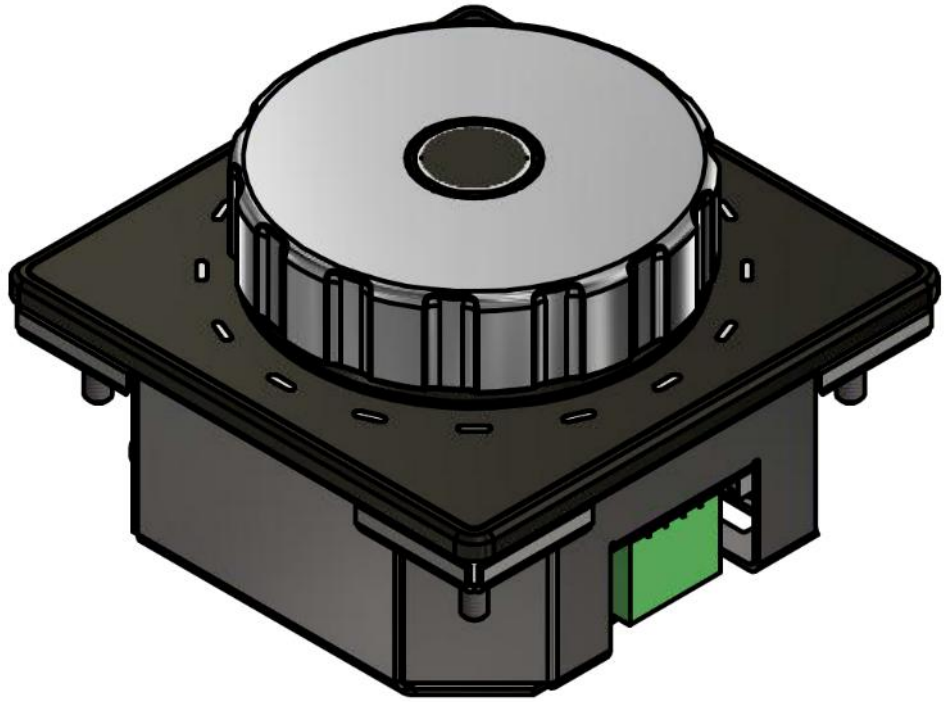
- Example of default view of SDI display



- Example of default wheelhouse control panel solution

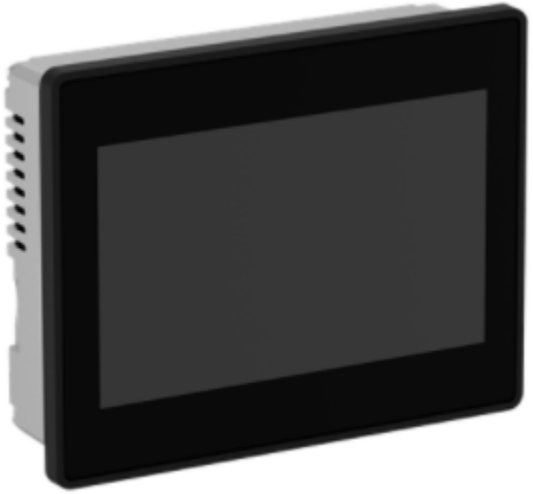
Toe angle selector wheel

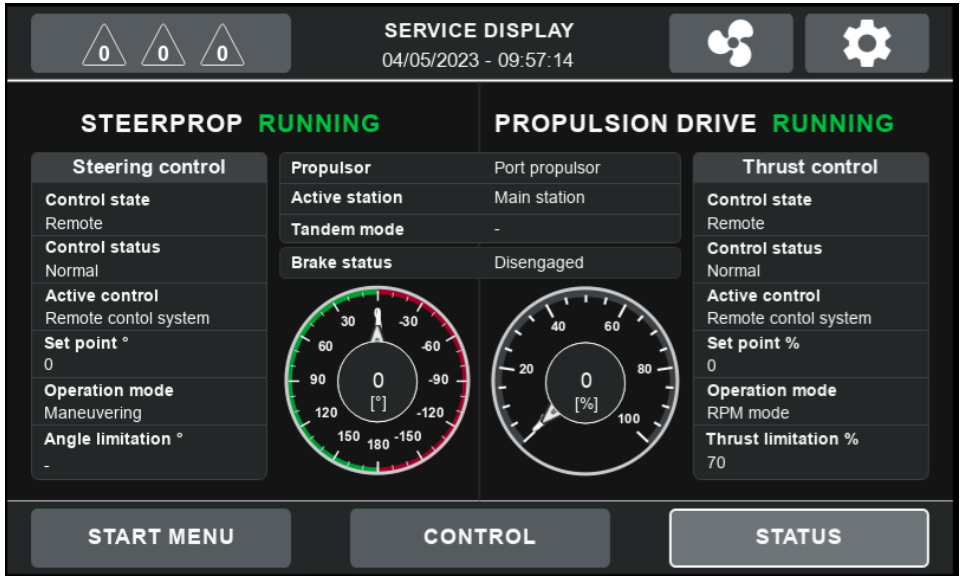
- Used in combination with modes as on previus slide
- Toe angle can optimally be limited to for example to 120° toe in and 45° toe out or as decided in workshops

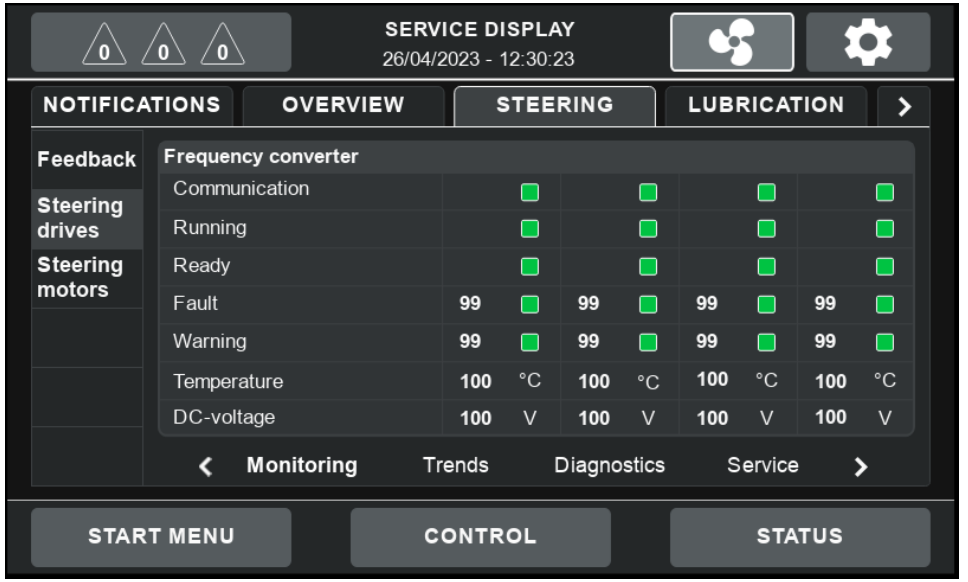


Service display (SED)

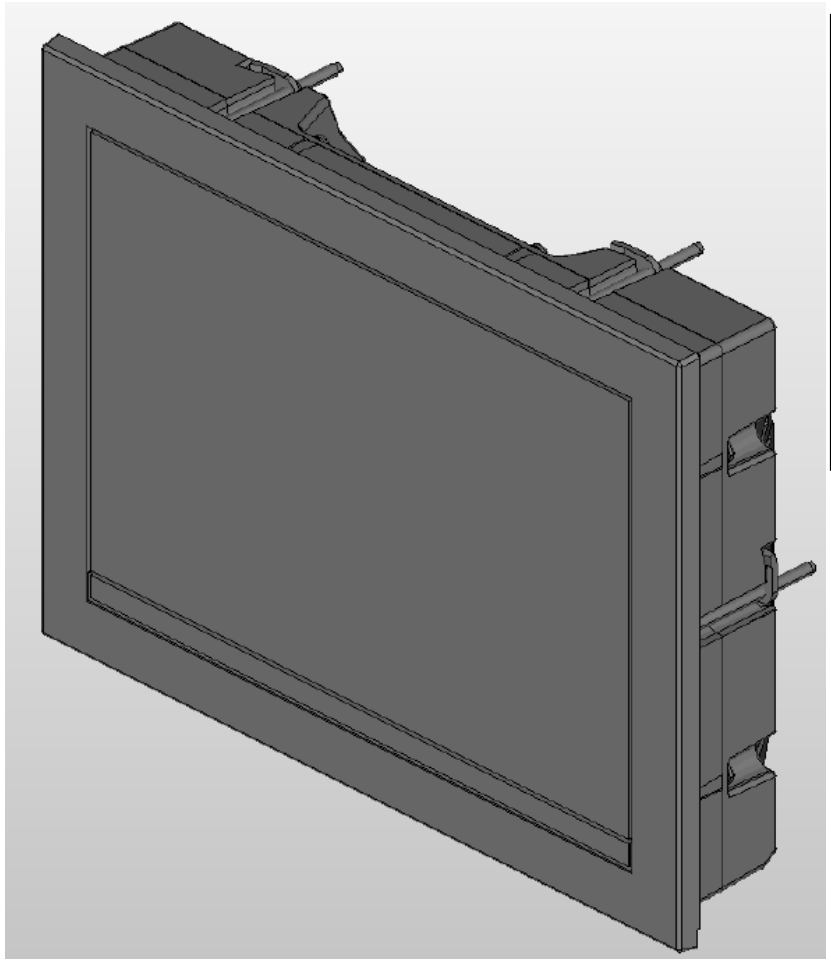
- Always
- Shows all detailed technical information & monitoring about the whole system
- Settings & calibrations
- Target crew: Chief engineer etc.

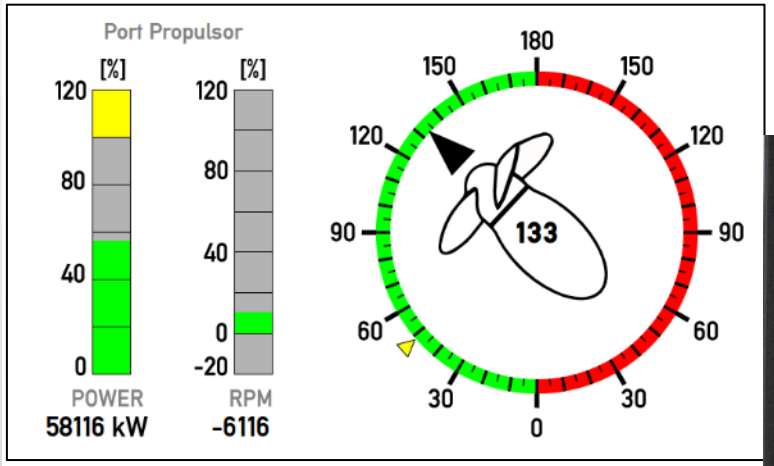


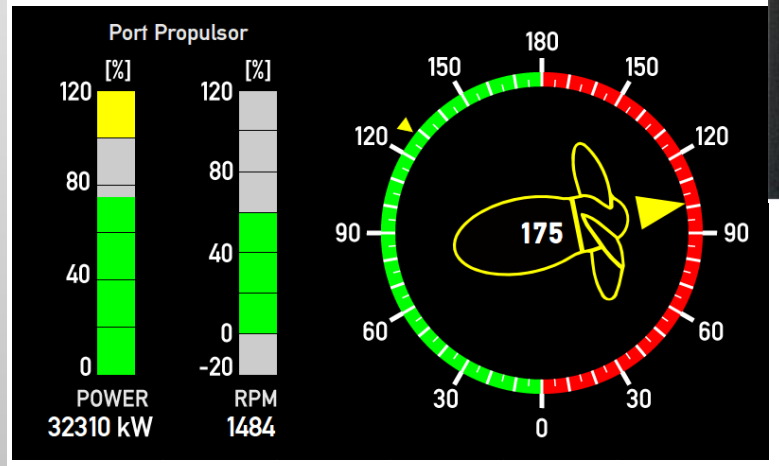


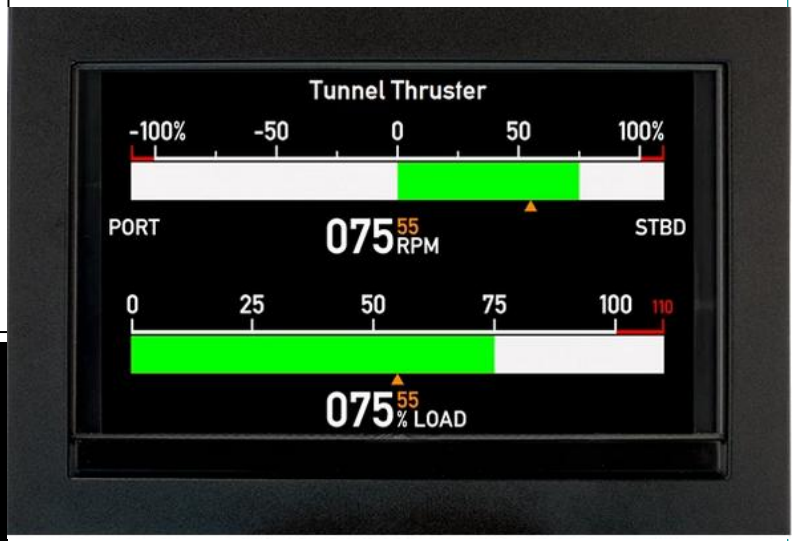


Wheelhouse angle/rpm/power combination indicators (SDI)







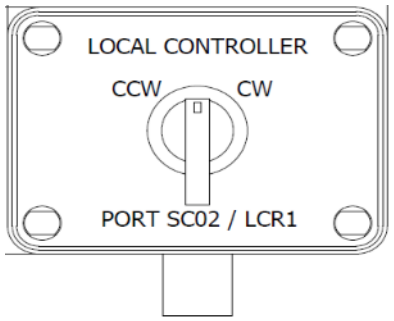


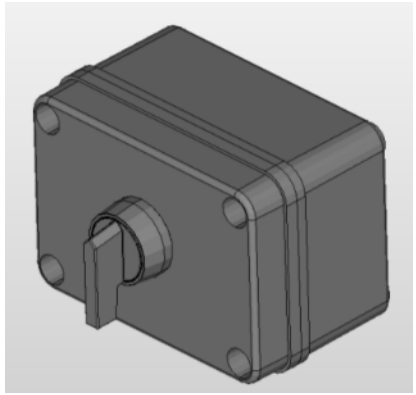
STEERPROP

Mechanical angle indicator (STU)

- Includes sensors for main control system, backup control system and indication system
  - Automatic switchover to backup sensor
- Used in combination with local steering controller

Local controller (LCR)





Control modes

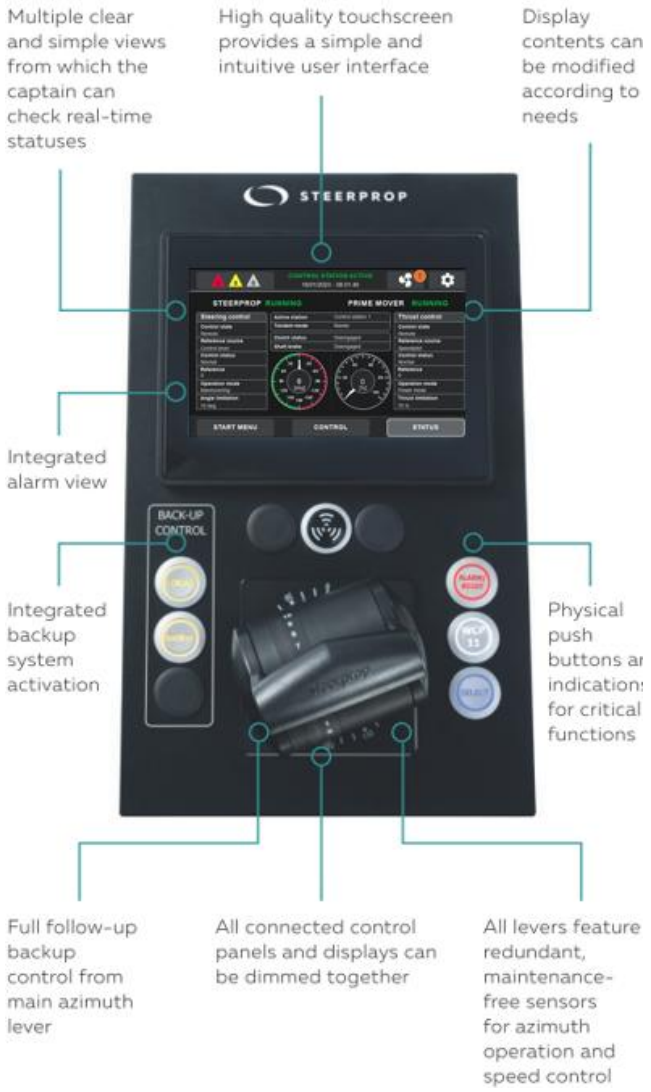
- DP, autopilot, speedpilot etc. external controllers

- Transit mode vs maneuvering mode
  - Angle limits?
  - Turning speed
- Autopilot
  - synchronous & asynchronous
- Manual tandem mode
  - Synchronous & asynchronous
- Toe in & toe out
  - Fixed (in AP mode) or adjustable
- Backup mode
- Environmental modes

Control combi-modes in zero offset or toe in/out operations

- Sychronous
  - Both stern units turn in sync
- Assymethric (recommended)
  - The ”inner” unit turns
- Bow assisted
  - Bow thruster assists
  - This mode is helpful in ice channel

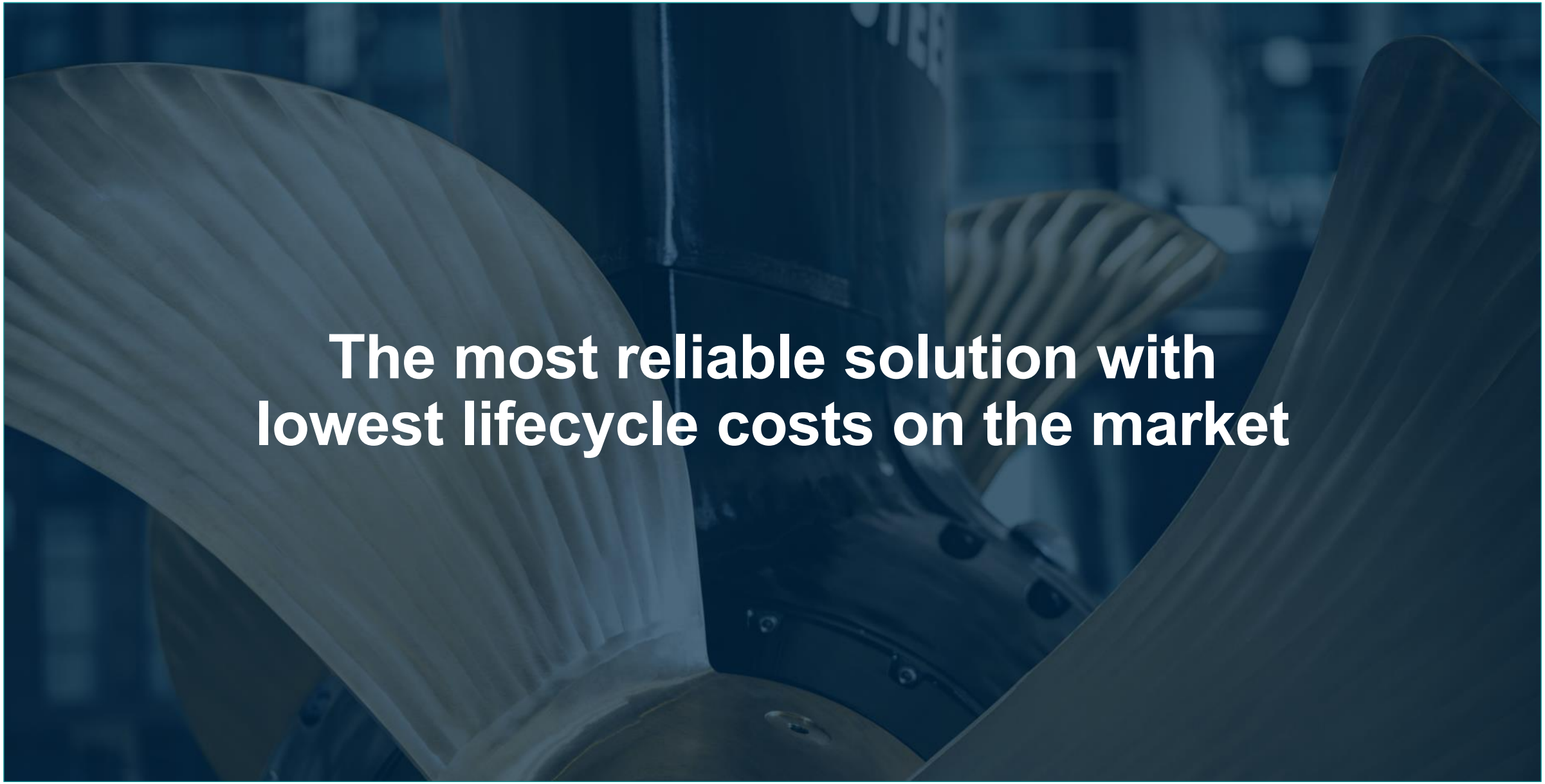
- Above modes operated in manual from one single lever (exising or fourth)
- Above with zero-max offset toe angle
- Autopilot input can replace manual



STEERPROP

Reliable Operations, Day In and Day Out

- First icebreaker delivery in 2008
- Continuous operations in all weather conditions – **No major overhauls**
- The cumulative number of operating hours in our ARC units exceeds 600,000 hours


The most reliable solution with
lowest lifecycle costs on the market

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