THRUSTERS

Ice-Breaking with Steerable Thrusters

Roland Schwandt

Schottel, Germany

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Ice-Breaking with steerable thrusters

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Introduction

Growing demand of supply vessels with ice braking capability, due to growing oil exploration in remote areas like the Caspian sea

Operating in ice in general

Different ice classes

Different ICE_Classes:

Finish/Swedish	GL	DNV	LRoS	BV	ABS	MRoS		CCS	RINA
						old	new		
IA super	E4	ICE 1A*	Ice Class 1AS	Ice Class 1A SUPER	Ice Class 1AA	ULA	LU 5	Ice class B1*	Ice Class 1A SUPER
1A	E3	ICE 1A	Ice Class 1A	Ice Class 1A	Ice Class 1A	L1/UL	LU 4	Ice class B1	Ice Class 1A
1B	E2	ICE 1B	Ice Class 1B	Ice Class 1B	Ice Class 1B	L 2	LU 3	Ice class B2	Ice Class 1B
1C	E1	ICE 1C	Ice Class 1C	Ice Class 1C	Ice Class 1C	L 3	LU 2	Ice class B3	Ice Class 1C
II	E	ICE-C	Ice Class 1D	Ice Class 1D		L4	LU 1	Ice class B	Ice Class 1D

Discription of the ice-classes:

II "Soft-Ice-classes", e.g. drift ice in the mouth of a river

1C Max. ice thickness 0,4m; for normal traffic in light ice conditions minimum installed power > 740 kW

1B Max. ice thickness 0,6m; for normal traffic in medium ice conditions minimum installed power > 740 kW

1A Max. ice thickness 0,8m; for normal traffic in heavy ice conditions minimum installed power > 740 kW; travelling astern possible

1A super Max. ice thickness 1,0m; for normal traffic in extreme ice conditions minimum installed power >2600 kW; travelling astern possible

Ice influences

Ice influences:

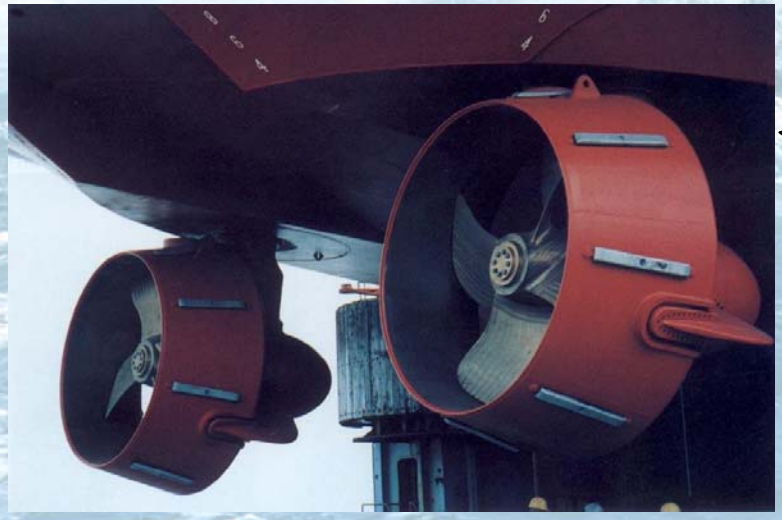
- Higher power requirements due to increased ship resistance
  - > $T_i = R_i + R_w$
  - > Motor torque reserves may be required
- Ice hits the propeller
  - > increased dynamical load at the gear set, shaft and propeller
- Ice hits the underwater housing of the thruster
  - > increased dynamical load of the structure
  - > increased wear of the housing surface
- cold environmental conditions
  - > viscous lub oil
  - > Increased risk of condensation
  - > Brittling of the material

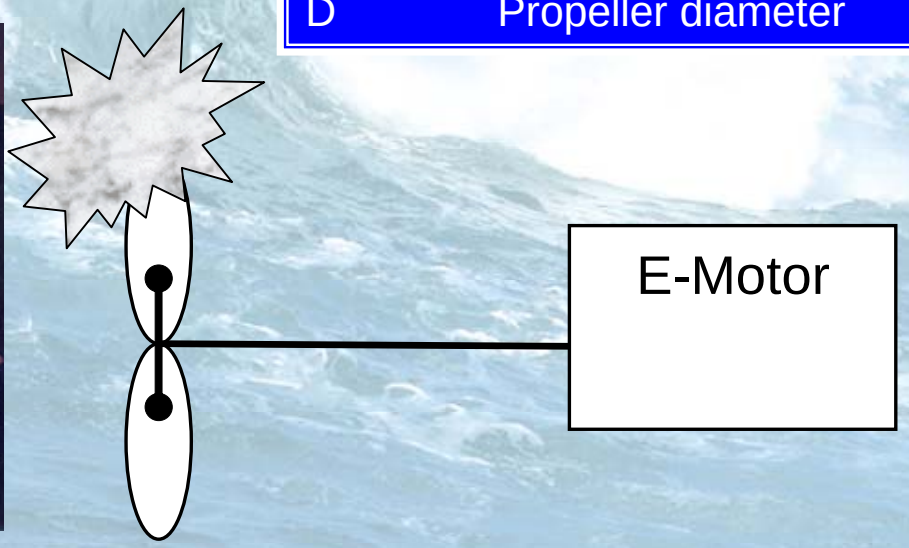
Mechanical thrusters in ice operation

Ice class formula for gear sets

$$T_{ges} = T_N + \frac{m \bullet D^2 \bullet \frac{J_M^*}{J_{M+}^* J_P}}{1}$$

T_{ges}	Total torque
T_N	Nominal torque
m	Ice class factor
J^*_M	reduced moment of inertia of the drive chain
J_P	moment of inertia of the propeller
D	Propeller diameter





Ice class formula for gear sets

$$\frac{T_{ges}}{T_N} = \frac{T_N}{T_N} + \frac{m \bullet D^2 \bullet \frac{J_M^*}{J_{M+}^* J_P}}{T_N}$$

T_{ges}	Total torque
T_N	Nominal torque
m	Ice class factor
J^*_M	reduced moment of inertia of the drive chain
J_P	moment of inertia of the propeller
D	Propeller diameter

T_N increases	> With increased power the ice torque influence decreases, i.e. the necessary ice reinforcements for larger units are smaller, but of course T_{ges} increases too
m increases	> higher ice classes mean higher ice torque ducted propeller (nozzle) decreases the ice class factor m
D increases	> Ice torque increases by square
J^*_M big	> Part of the ice torque increases
J_P big	> Part of the ice torque decreases

Ice class formula for propeller shafts

$$d_W = 11.5 \bullet \sqrt[3]{\frac{\sigma_b \bullet ct^2}{\sigma_y}}$$

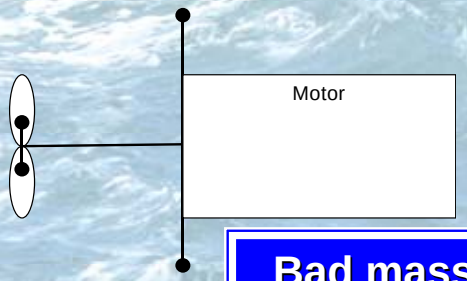
d_W	shaft diameter
s_b	Material hardness of the blade
s_y	Material hardness of the shaft
ct^2	Resisting force of the blade

Philosophy: The propeller blade breaks first with overload

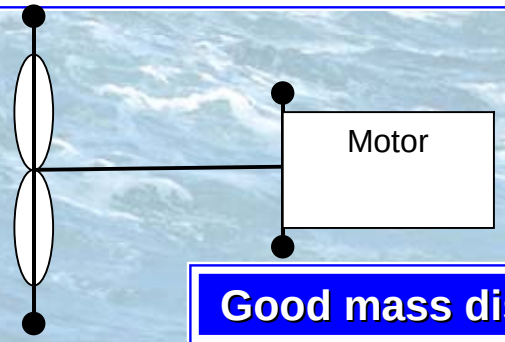
- **Shaft diameter is determined by the hardness of the blade and shaft material**
- **Is the number of blades increased, each single blade is more weak which leads to a smaller propeller shaft diameter**
- **The selection of hardness increased material leads to smaller propeller shaft diameters, too**

Improvement measures

- Decrease propeller diameter
- Increase propeller speed
- Nozzle (but: Nozzles have the tendency to be blocked by ice)
- Increase tip clearance
- Select a light e-motor
- Short drive chain to save weight
- Fluidcoupling
  Moment of inertia will be disengaged => Coupling as close as possible to the power input
- Decrease the propeller arm length to reduce the bending moment
- Niresist (stainless steel cast) underwater housing decreases the risk of corrosion due to damaged painting drastically
- Special paints like Inerta for corrosion protection
- Stainless steel propellers have a higher wear resistance



Bad mass distribution

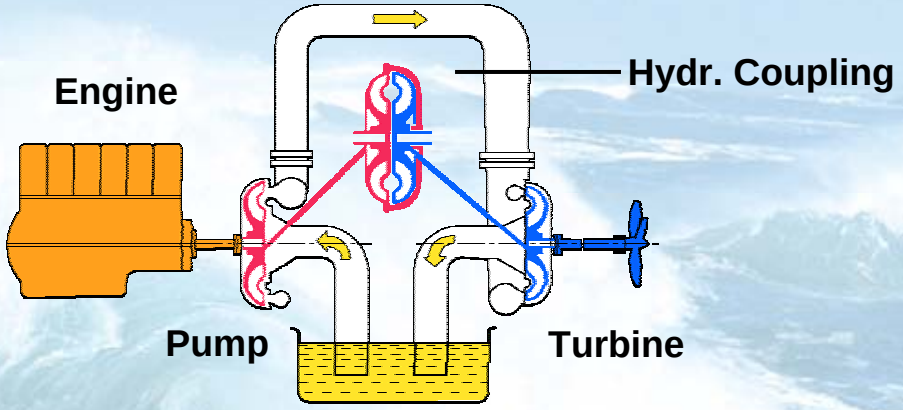


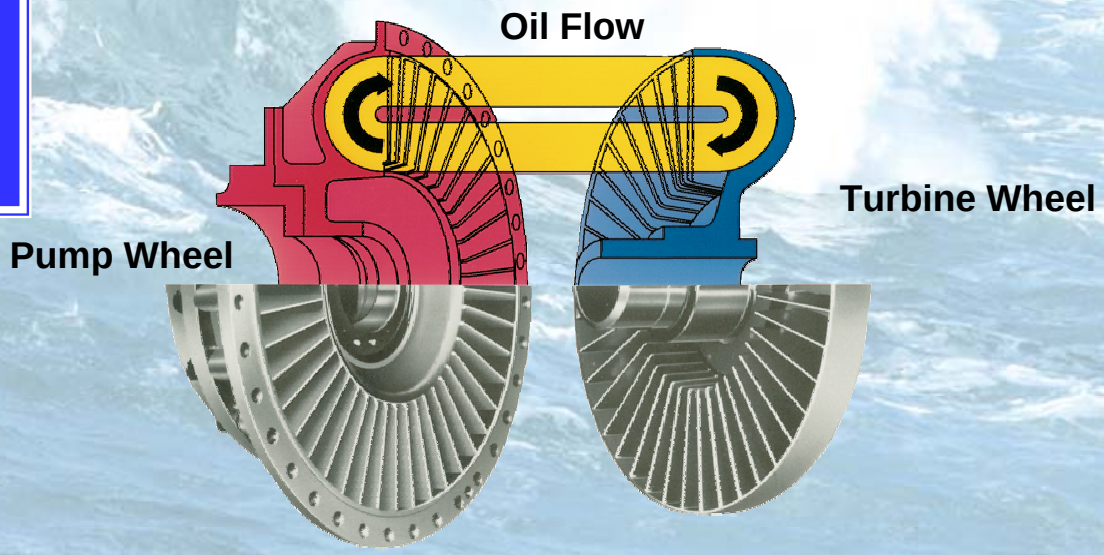
Good mass distribution

Fluid coupling

Foettinger´s Concept

Fluid used instead of gears! Hydrodynamics is used instead of a mechanical connection for power transmission - Prof. Dr.-Ing. Hermann Föttinger‘s ingenious idea was utilized for the first time in 1909.
The power generated by a high-speed diesel engine was transmitted without torsional vibration or torque spikes to the propeller of the ship.





Electrical pods in ice

Baltic sea ice braking vessel „ARKONA“ with two 2000kW steerable electrical pods

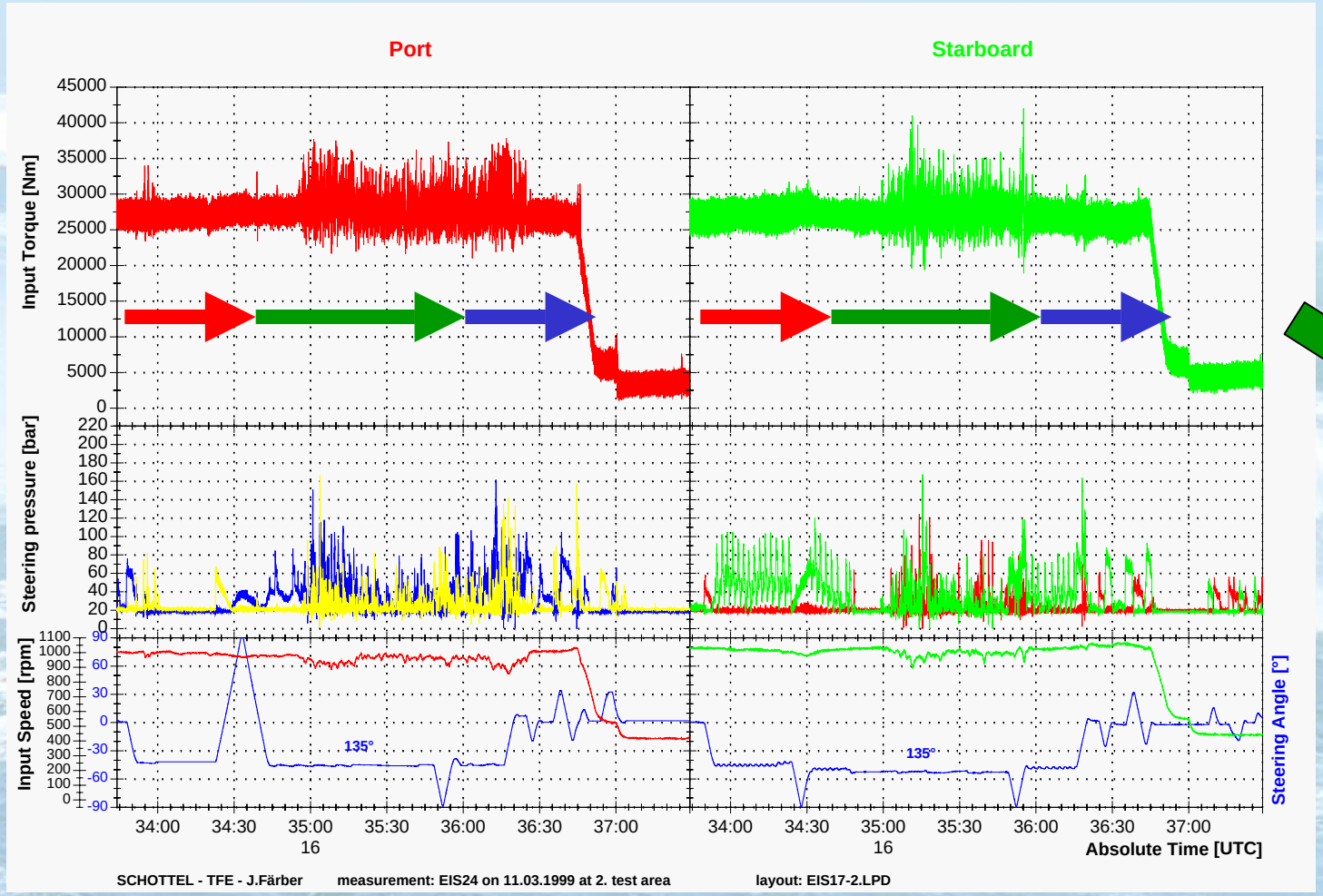
Major advantage over mechanical thrusters in ice

- **No gearsets therefore higher torque possible**

- **No gearsets; the critical point therefore is the connection between propeller, shaft and rotor**

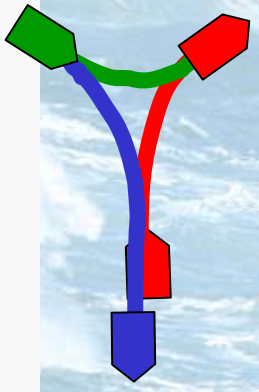
Advantages of steerable propulsion in ice operation

Standard 3 step turning manouver

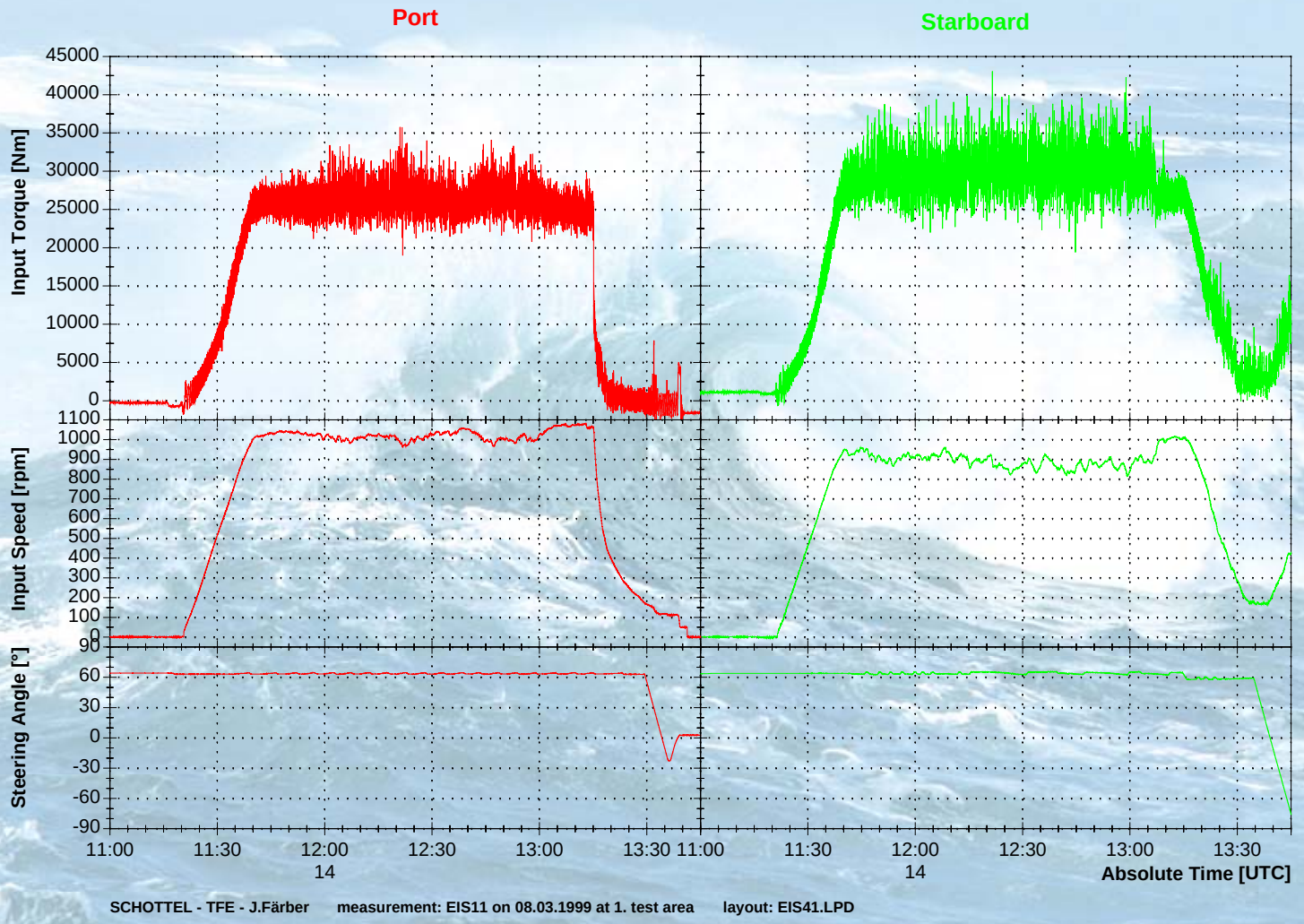


3 min.

180°

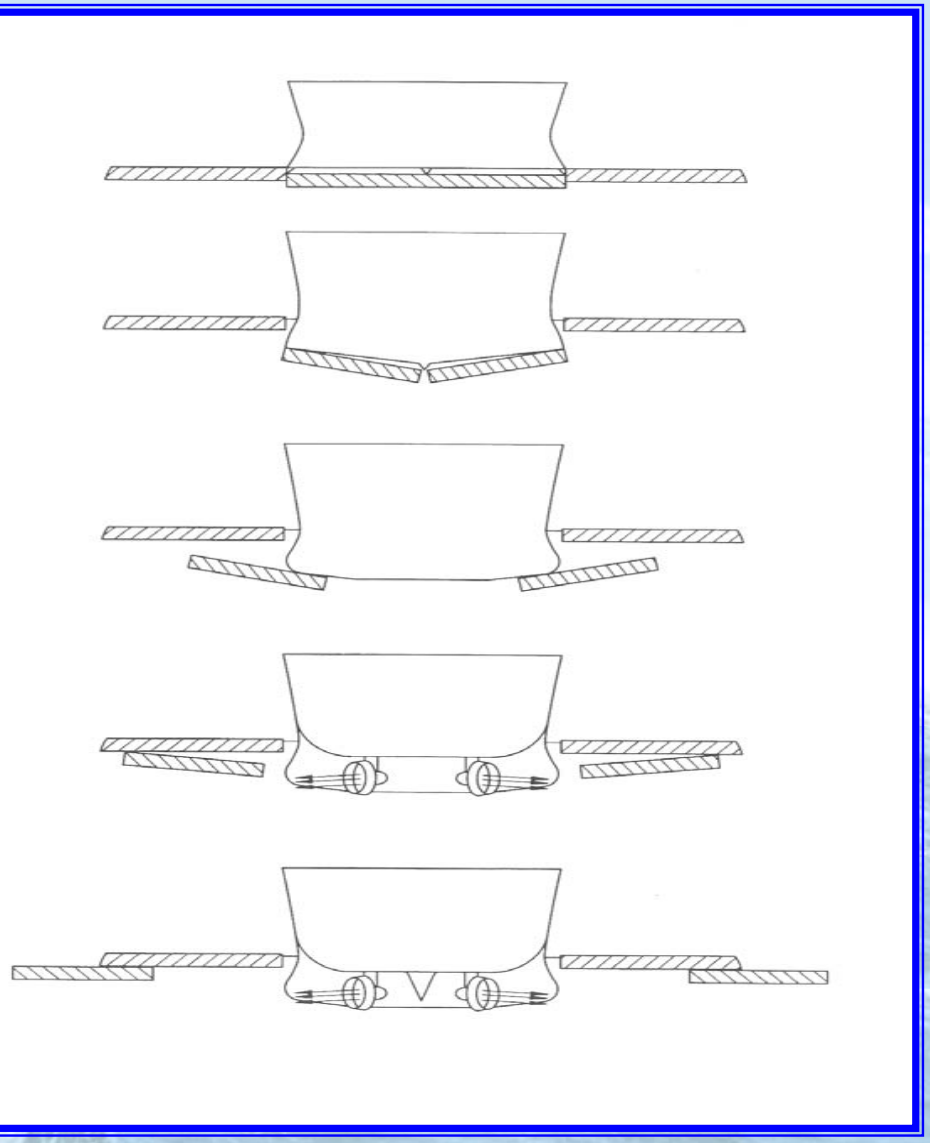


Turning on the spot



1.6 min.
360°

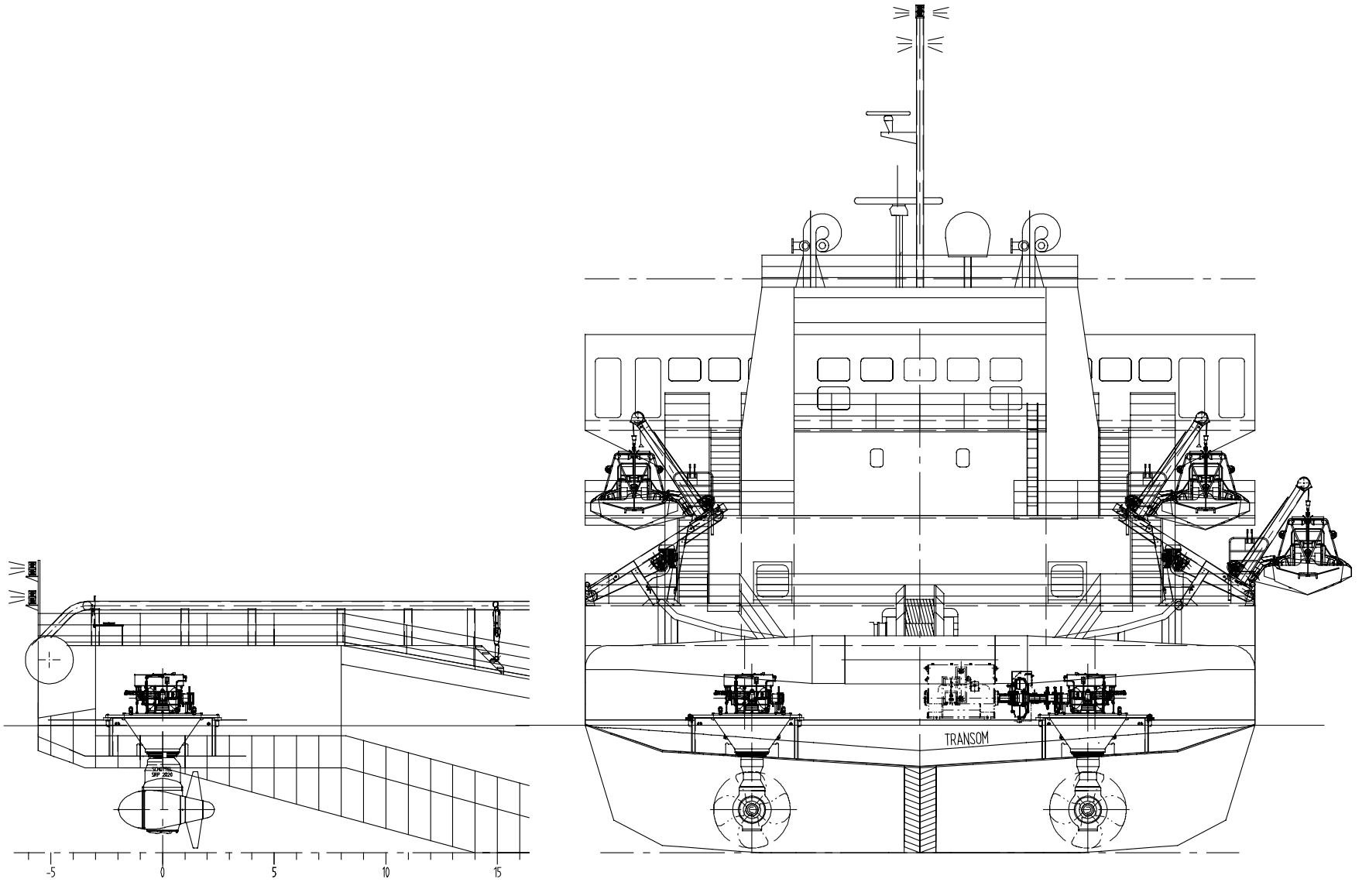
Ice Management



After braking the ice by toeing out the thrusters a free channel can be created and maintained much longer as with conventional systems

Ice milling with pull propellers

Ice milling with pull propellers



Thank you for your kind attention