The Propulsion and manoeverability of double- ended ferries

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1. Design Requirements
2. Preliminary Studies
3. Hullform/Propulsion
4. Manoevering
5. Active Pass
6. Conclusions

BCF- Requirements Super C-Class

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BCFerries

The Super C Program

370 Vehicles
1500 Passengers
21 knot service speed

2 Car Decks, single casing, *no ramps*

Dimensions Compatible with all Mainland Terminals

2 Passenger Decks:
- **Lounges/cafeteria/gift shop/snack bar/quiet lounge**
- **3 Vertical Zones arranged for shut-down**
- ***Scope for expansion***

ABS Classification Standards
Transport Canada Compliant

High Lift Rudders
-docking performance

Super C-Class

Diesel-Electric CPP constant speed propulsion plant:
Reliability, Life-cycle costs

Double-Ended based on C-Class Configuration
- transit/access

Design Constraints

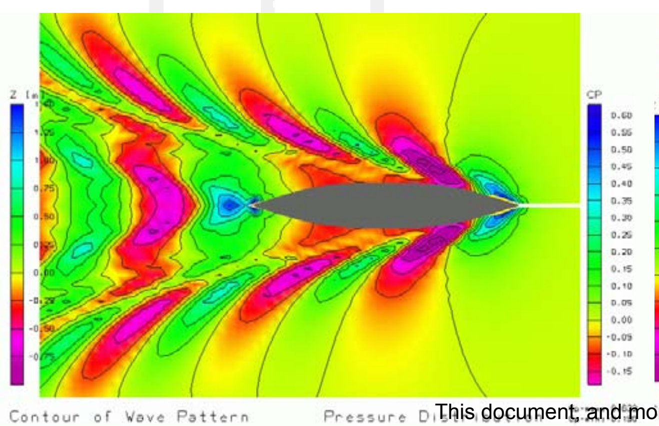
1. Deck WL fixed (Berth)
2. Lane- Capacity 370 AEQ, 1500 Pax
3. L < 160 m, T> 5.75 m und < 6.00 m
4. Deplacement ca. 9600 t incl. Growth Margin 500t
4. 21 kn w. 4 Prime Movers, 20kn w. 3 und 18kn w. 2 incl. Fouling Margin
5. Diesel- Electric Plant
6. Turning Rate > 90 Deg./min in Turning Circle
7. Acceleration and Crash Stop specified for 21 kn
8. 20/20 Overshoot less than 12.5 Deg (1/2 IMO)
9. Comfort ABS COMF+ (abt. DNV COMF 1), despite Propeller- „Tree- Class“ (1A- Super)

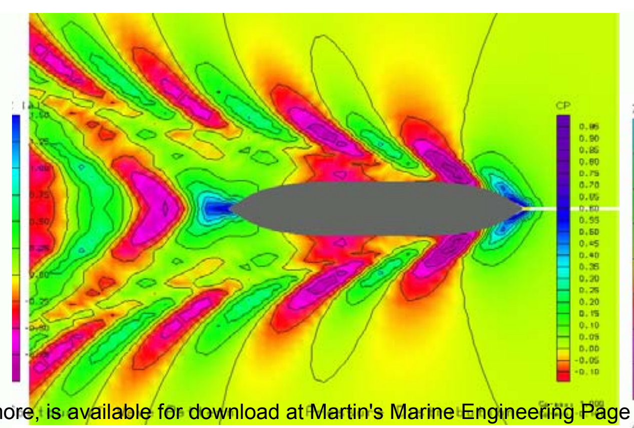
Some Double Ender Concepts

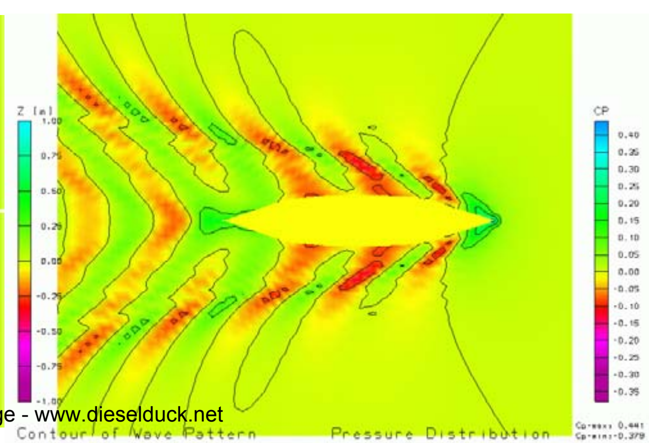
WEENTACHEE
L=140m v=21kn
Bow-Stern Propeller

SCHLESWIG-HOLSTEIN
L=142m v=22kn
4 x Aquamaster CRP35

SKEENA QUEEN
L=110m v=14kn
4 x Niigata ZP 24







Considerations for Propulsion

Requirement: Diesel- Electric plant

Prime- Mover: 4 or 6 (Costs vs. Redundancy)

Propulsors :	**2 (Bow- Stern) or**	**4 outside CL**
	Pods	**Pods**
	FPPs	**-**
	CPPs	**-**

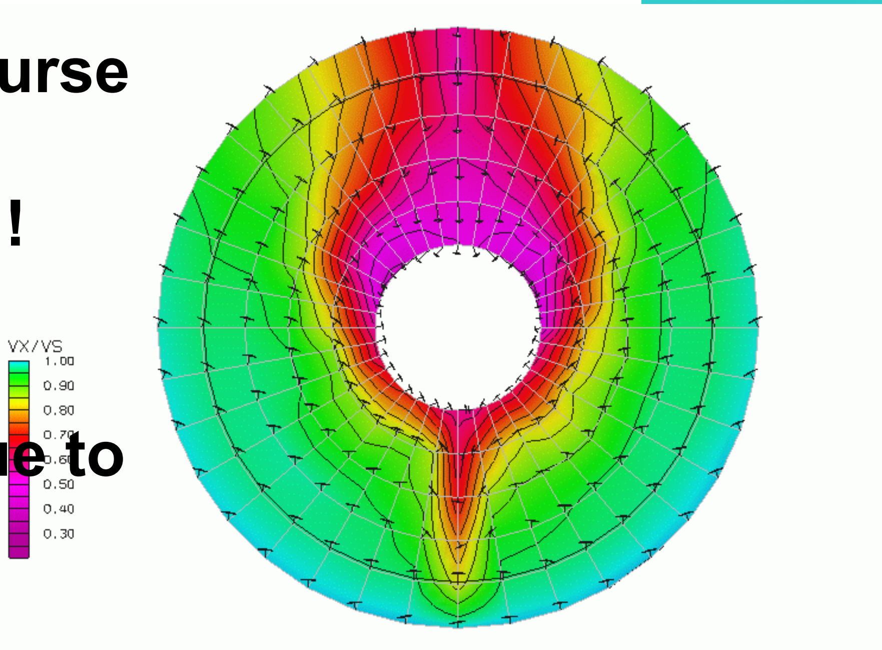
6 Prime- Movers or 4 Pods not competitive (costs too high)

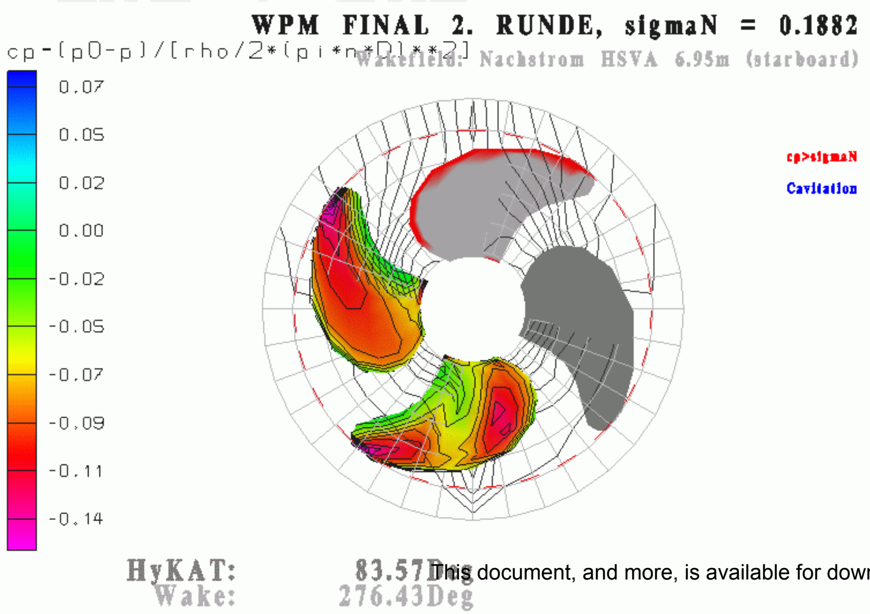
→ Solution must be Bow/Stern- Propulsor, 4 Prime Movers

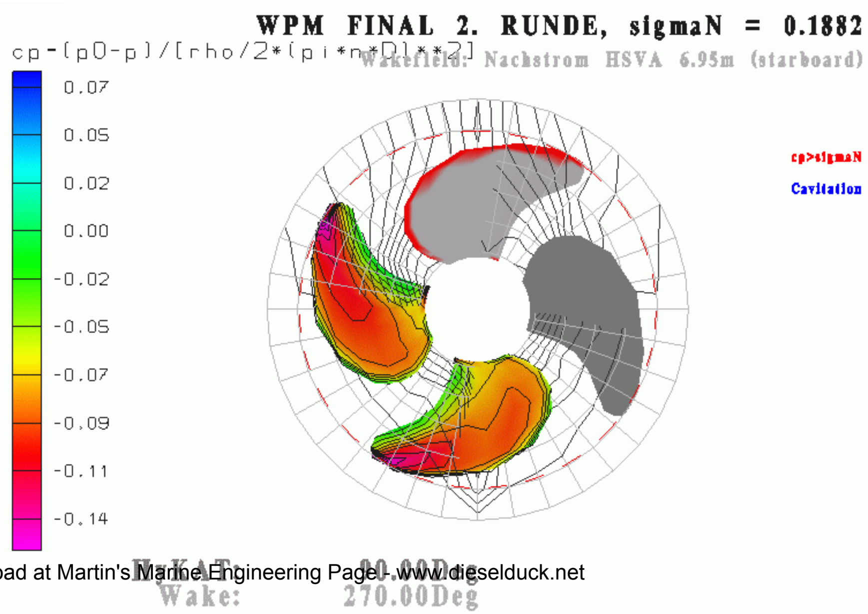
Problem: Wakefield 2-Prop. Concept

Center Skeg essential for course keeping
Disturbes wake field heavily !

Example: Steering Fin DFDS
1100 kW additional power due to Flow Separation at Blade.







Power Sharing Considerations

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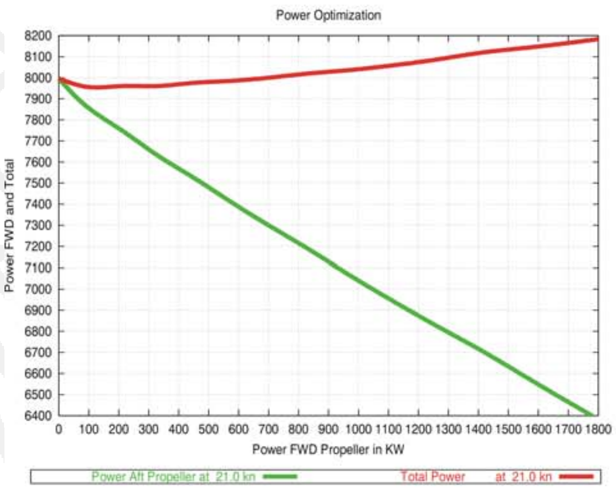

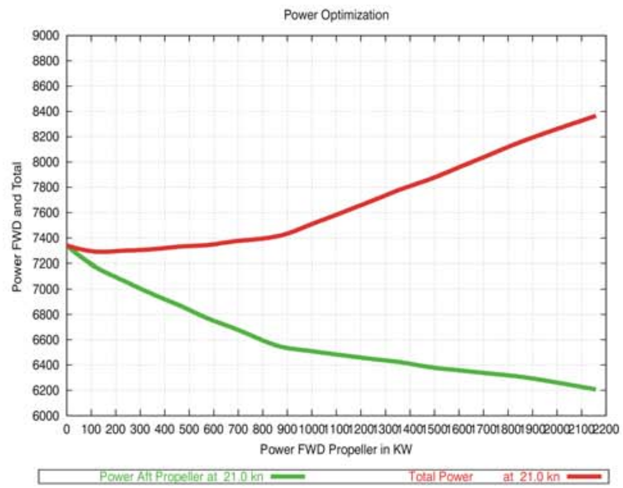

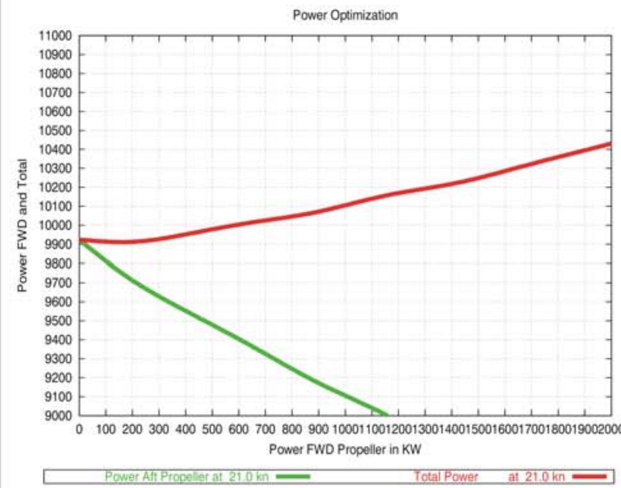

Queen of Oak Bay (BCF)

Propeller Diameter: 3.80m
P/D abt. 1.1 (MARIN)

Propeller Diameter: 3.80m
P/D abt. 1.67 (IOT)

Super C-Class

Propeller Diameter: 5.0m
P/D abt.1.4 (WPM)

Power- Sharing makes sense only at high thrust loadings of stern propeller !

Stern Prop. To be designed sub- optimal: Larger Pitch !

Abt. 20% Power to be installed only for FWD Propulsor !

Consequences for Propulsion

1. Extremely large stern prop required to avoid power sharing (large thrust deduction)

2. Low resistance and thrust deduction required (system is senstive w. respect to thrust loading)

3. Pods not competitive as prop. torque too high

4. Pods strut resistance for large prop. too high.

5. Therefore Bow/Stern Prop as large CPP with constant revs.

BCF- Model Test Program

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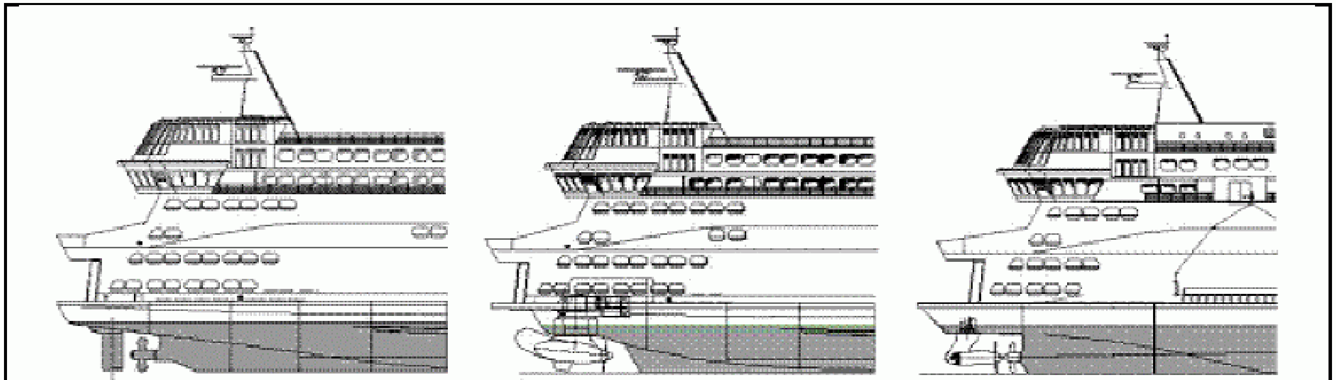
The Super C Program

2. Hydrodynamic Model Tests – Double Ended Concepts

Original C-Class tested in 1973; new program developed with several objectives:

I. Develop a baseline dataset for assessment of SY offers: hull form known to be extremely efficient baseline but no data at larger displacements

II. Explore new propulsion concepts; application of podded systems to a double-ender; cost-benefit evaluation



Concept A | Concept B | Concept C

BCF- Model Test Program

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BCFerries

The Super C Program

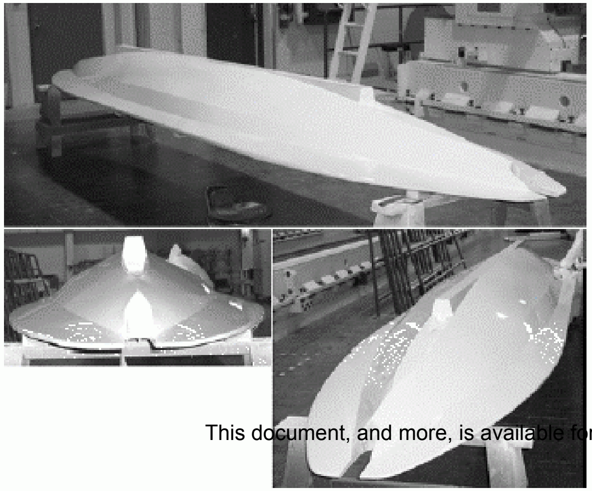
2. Hydrodynamic Model Tests – Double Ended Concepts

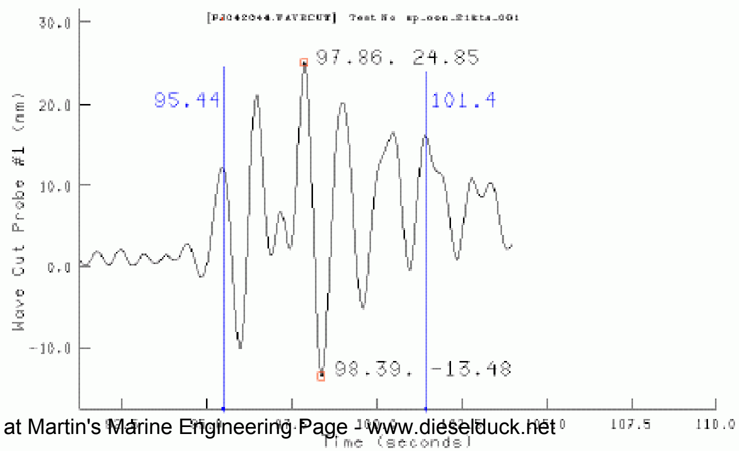
Program objectives (continued):

III. Investigate power sharing issues (bow/stern);

IV. Investigate appendage drag issues; propeller feathering; parasitic drag of rudders

V. “Wave cuts” for calibrating wake wash

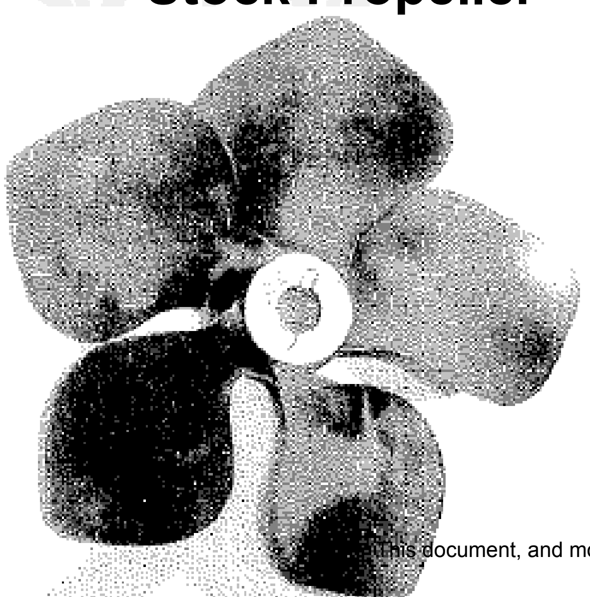


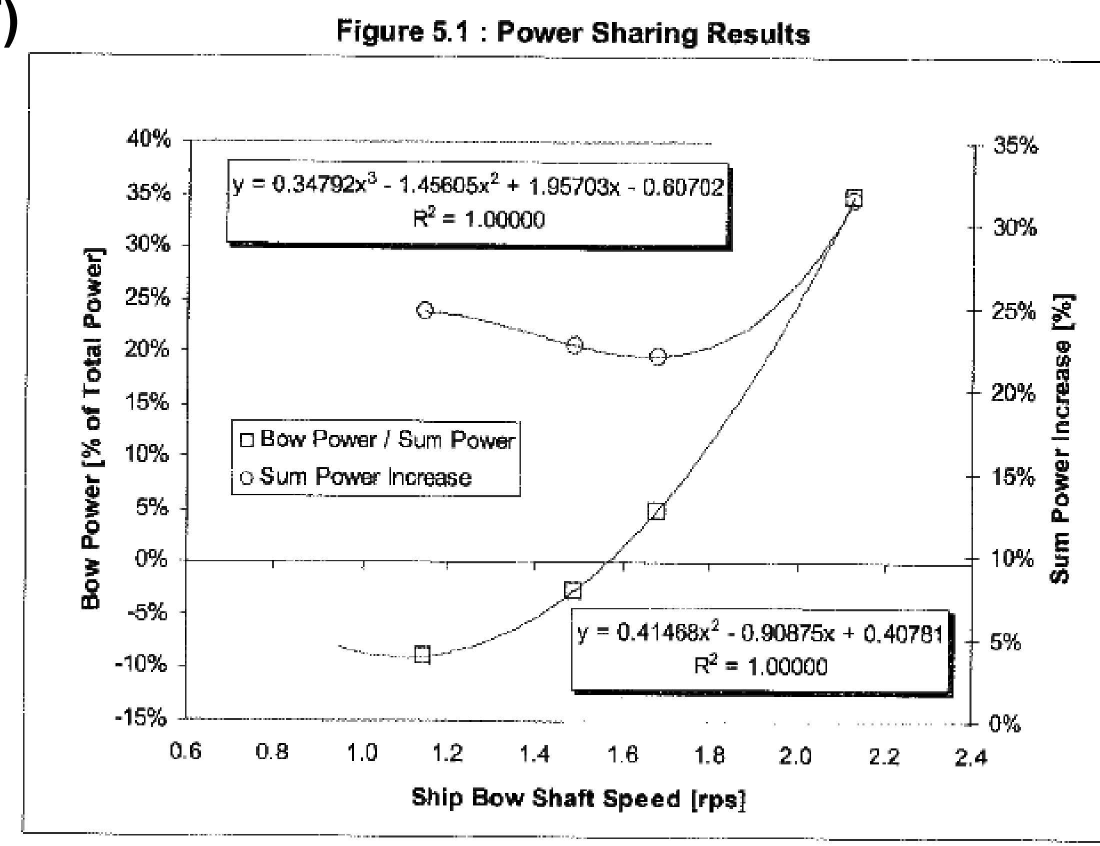


Model Tests IOT Queen of Oak Bay

Model Queen of Oak Bay /IOT)

Stock Propeller





Power Sharing Results

Lessons learned from St. John´s

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1. Existing Hull Form and Propulsion were not efficient (our point of view)

2. Our CFD Code was able to predict the wave pattern correctly despite numerical difficulties.

3. Our calculations for power sharing have shown to be sufficiently accurate.

4. The hull form should have extremely fine waterlines and buttocks at the ends.

5. The hull form should not disturb the wake but must provide sufficient course stability.

6. The appendage resistance of the bow rudder is significant and must be optimized.

7. Hull should dynamically trim by stern to improve course stability.

Hull Form Design TUHH/FSG

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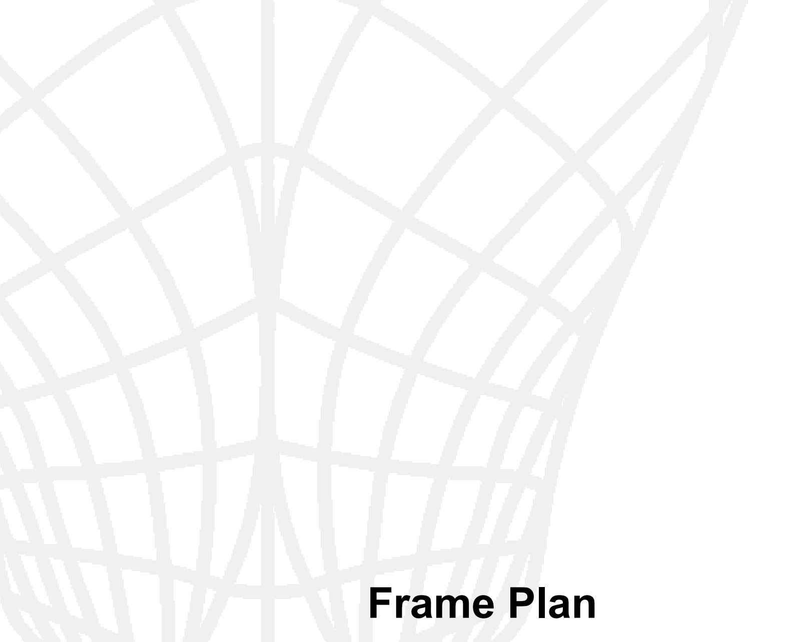
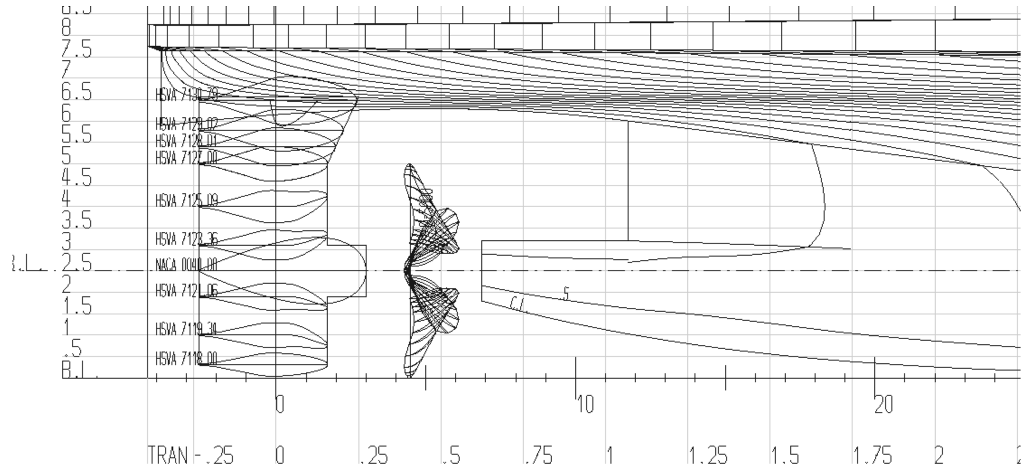


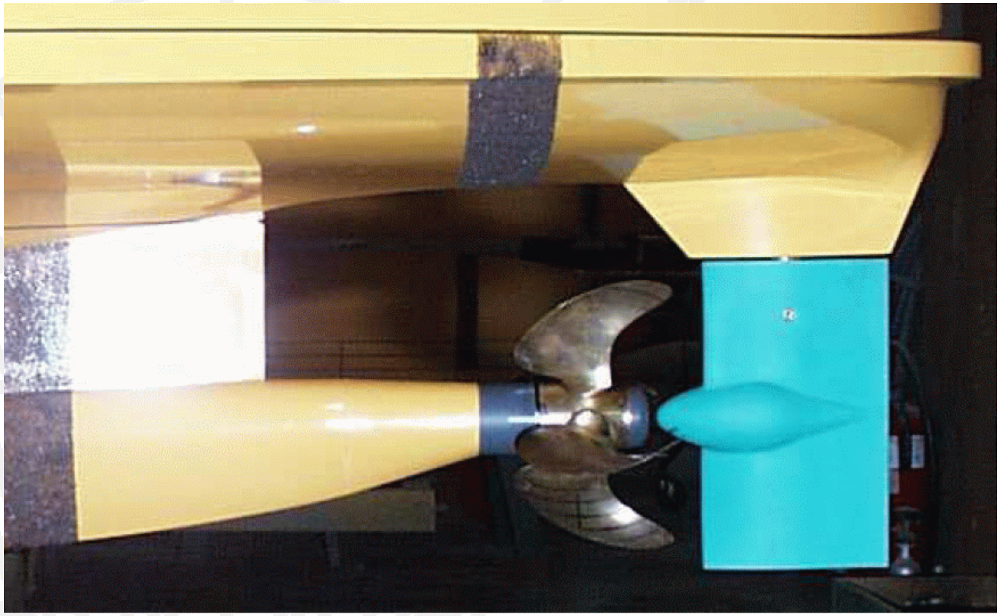
Frame Plan



Appendages w. WPM CPP and FSG-TF- Rudder

HSVA- Model fitted with Final- Prop. and TF-Rudder

Feathering Concept



HSVA- Model

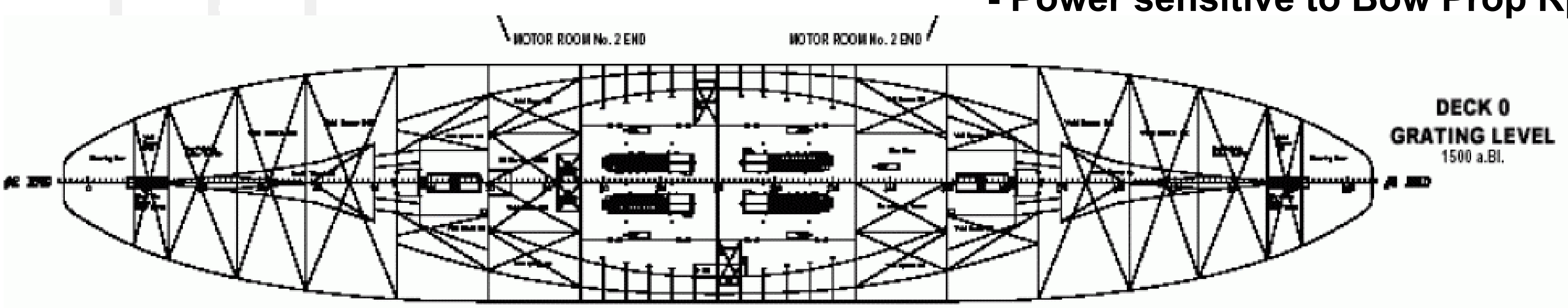
fitted with

Stock- Prop. and Stock-Rudder,

Trailing Edge Feathering

Trailing Edge Feathering required due to:

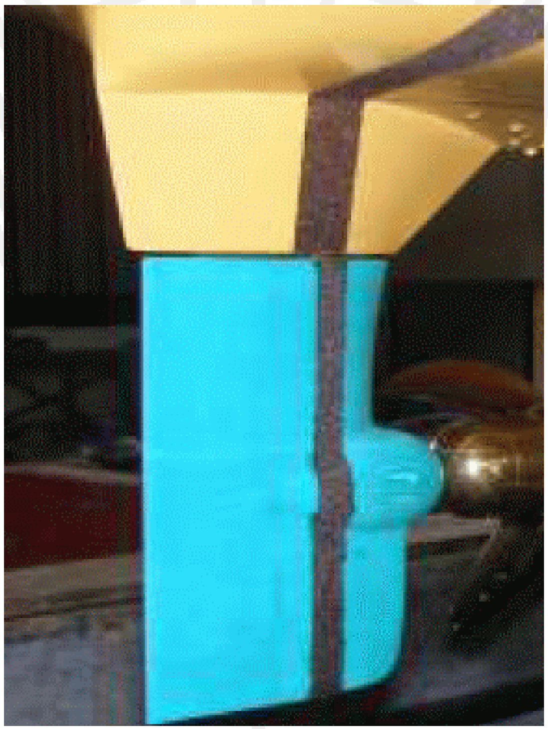
- **Limited hub range (115 Deg)**
- **No clutch in shaft line**
- **Power sensitive to Bow Prop Rpm**



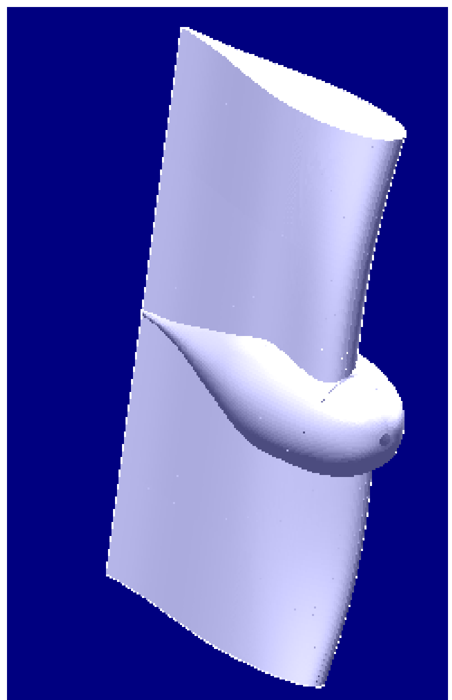
TF- Rudder Optimization

High- Lift FSG- TF Rudder designed wit bulb and profiles optimized for reverse condition.

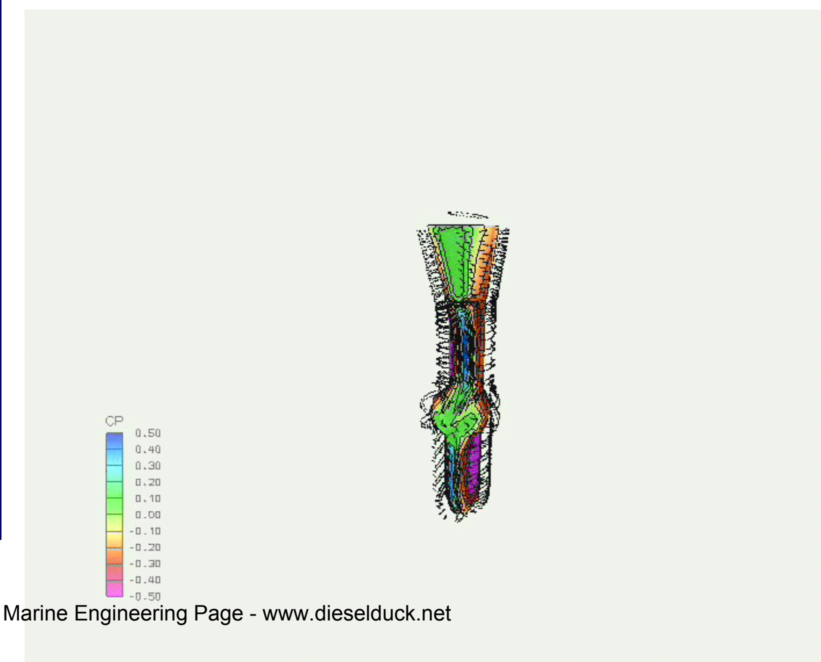
Hardware



CAD- Model



Flow Simulation



Model Tests HSVA

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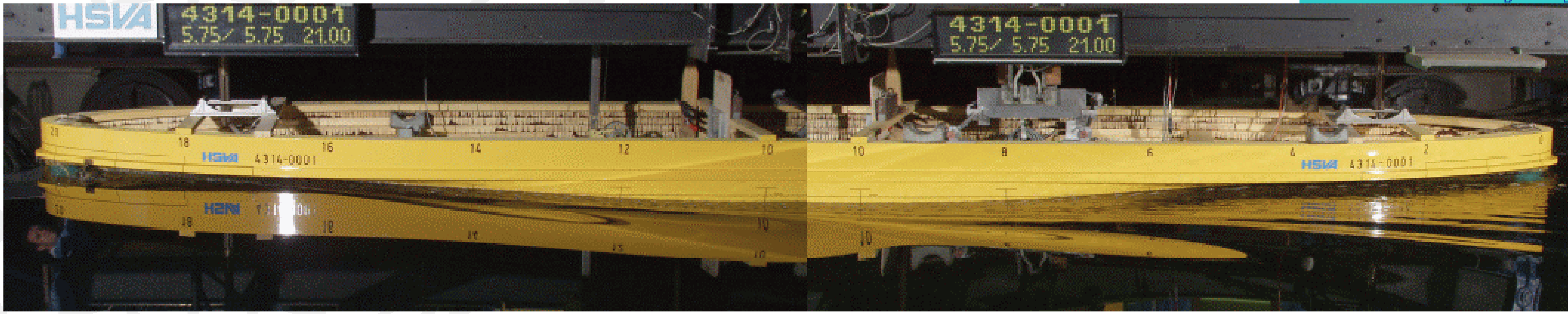
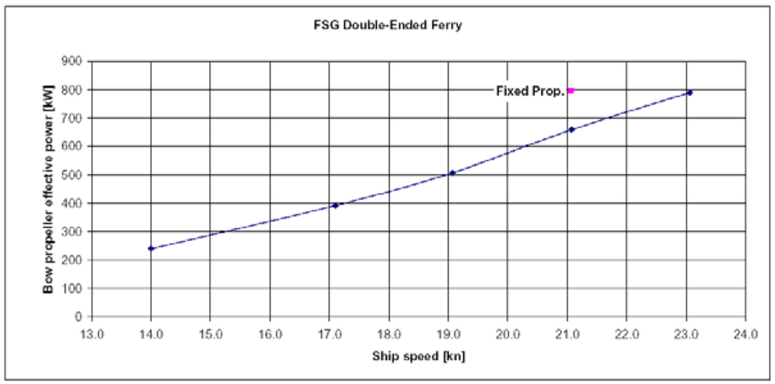
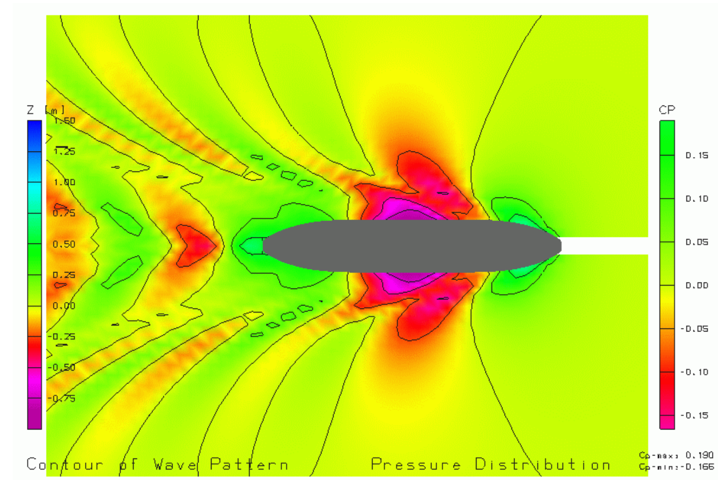
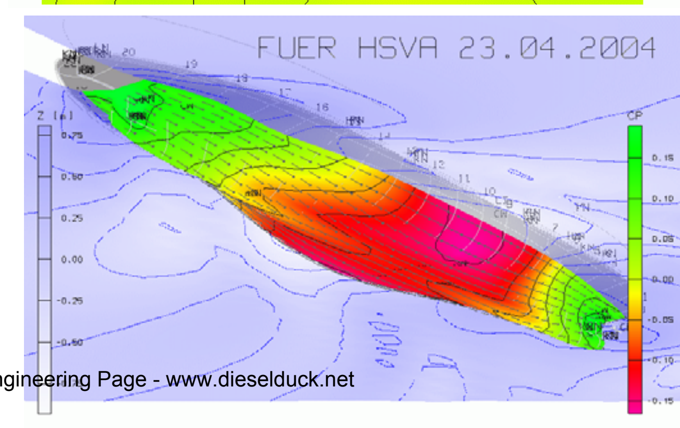






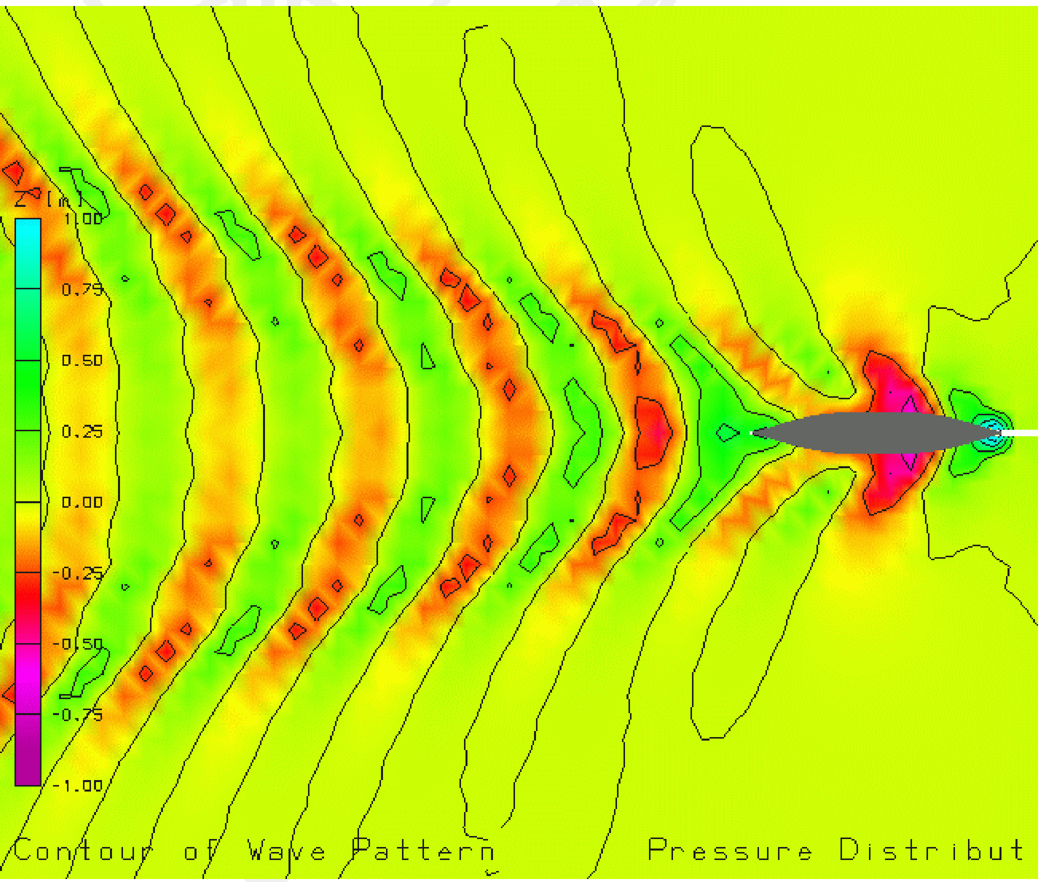


HSVA- Tests confirm Concept, CFD-Calculations and performance.

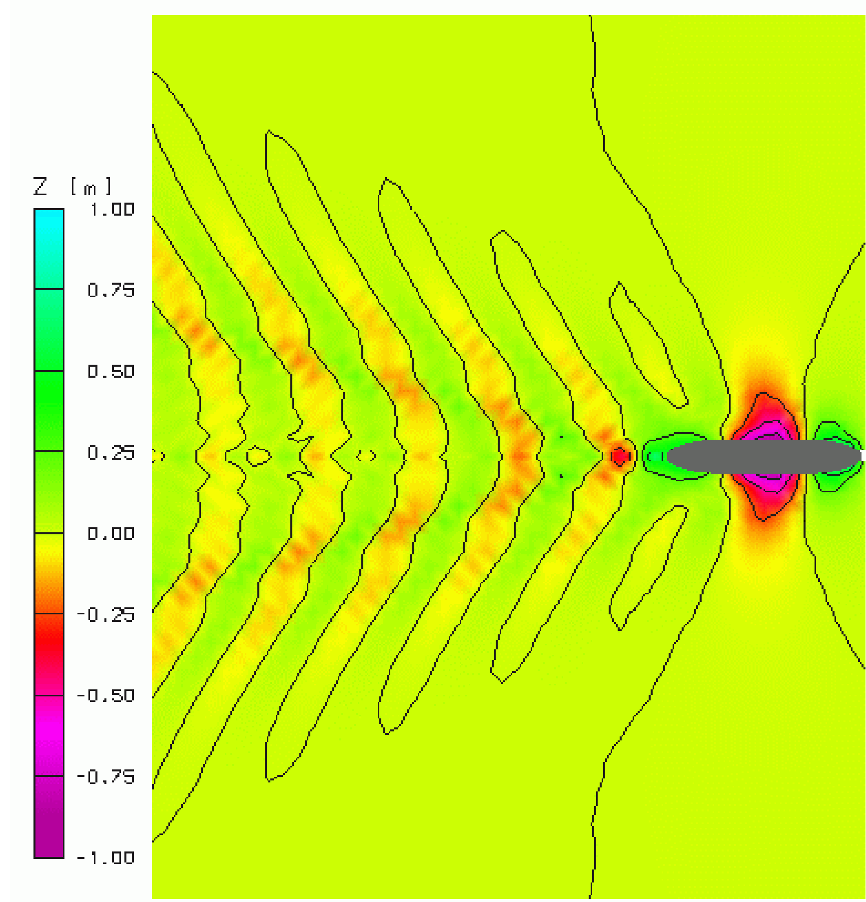
Problem: Scaling Laws, Feathering-position of Bow Prop.

BCF Wake Wash Requirements

Existing C-Class, 21 knots, 5850 t

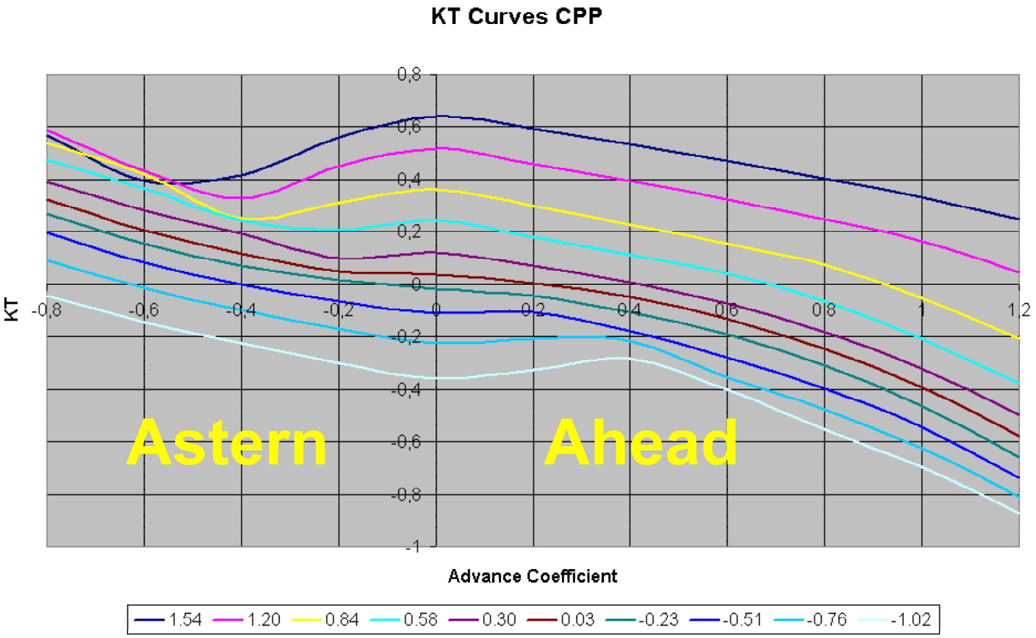


Our Design, 21 knots, 9600t



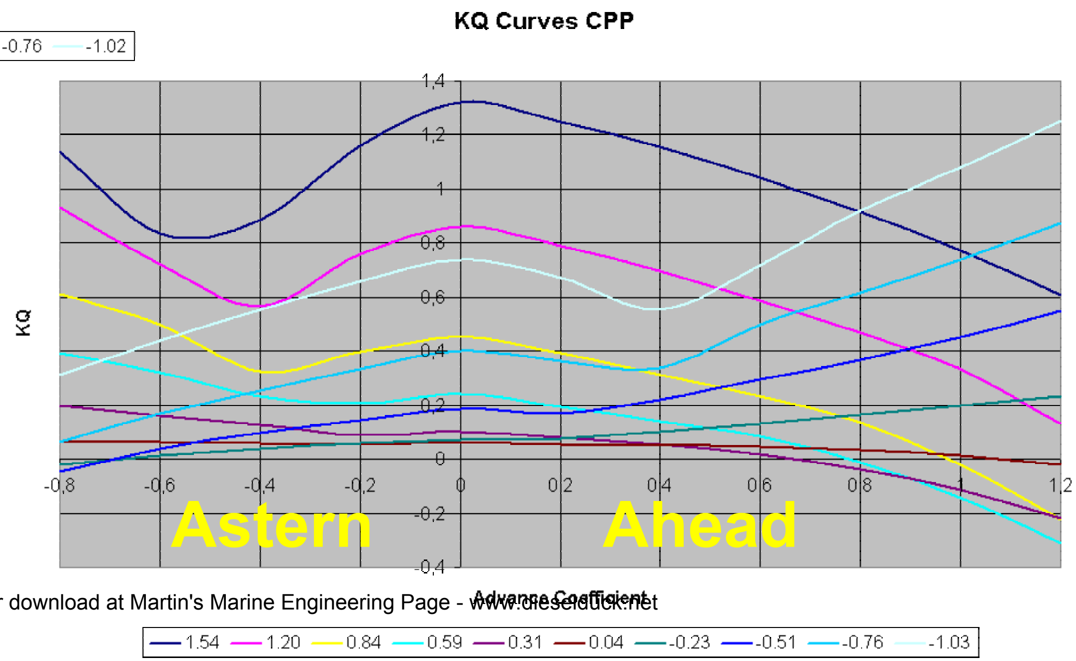
Comparison shows TC – requirement clearly met.

Preparing Manoevering Simulations

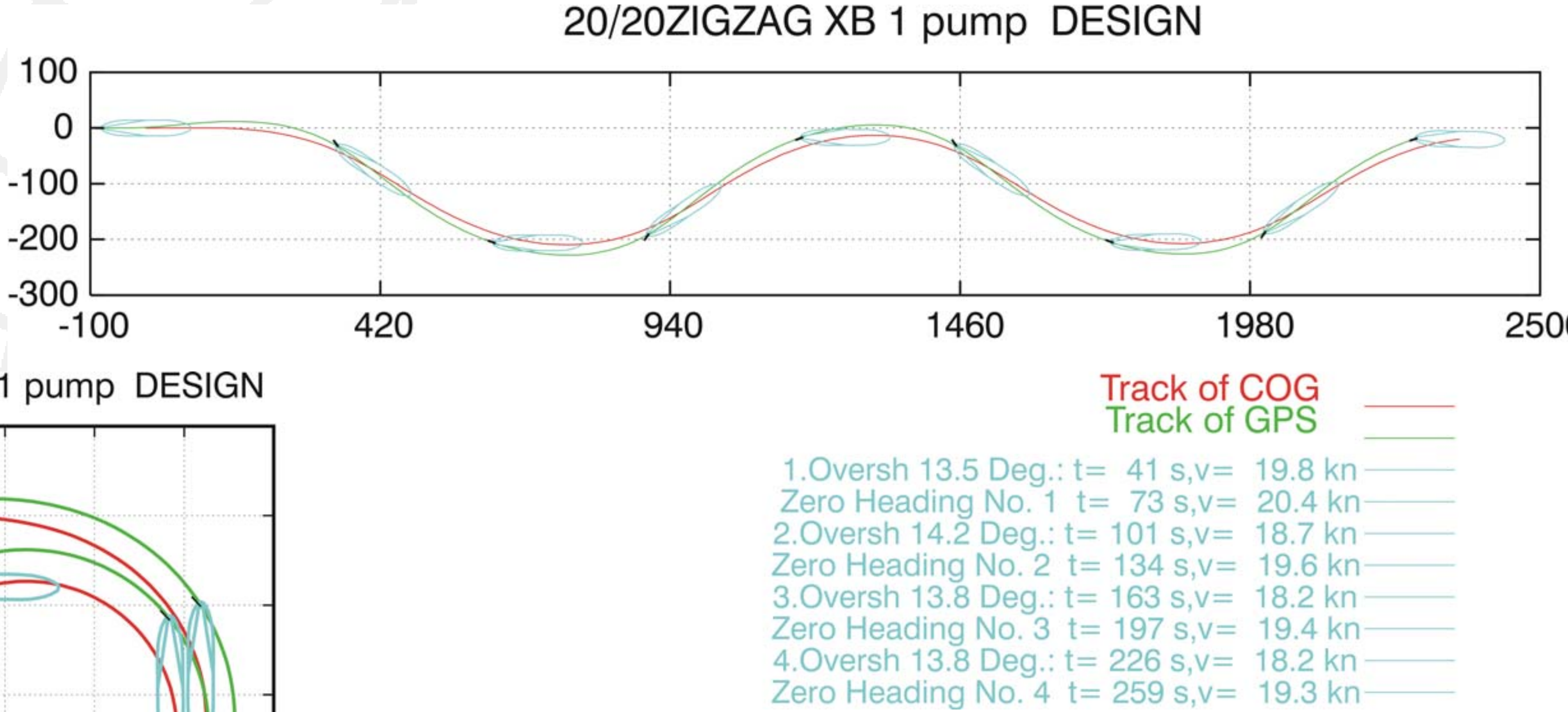


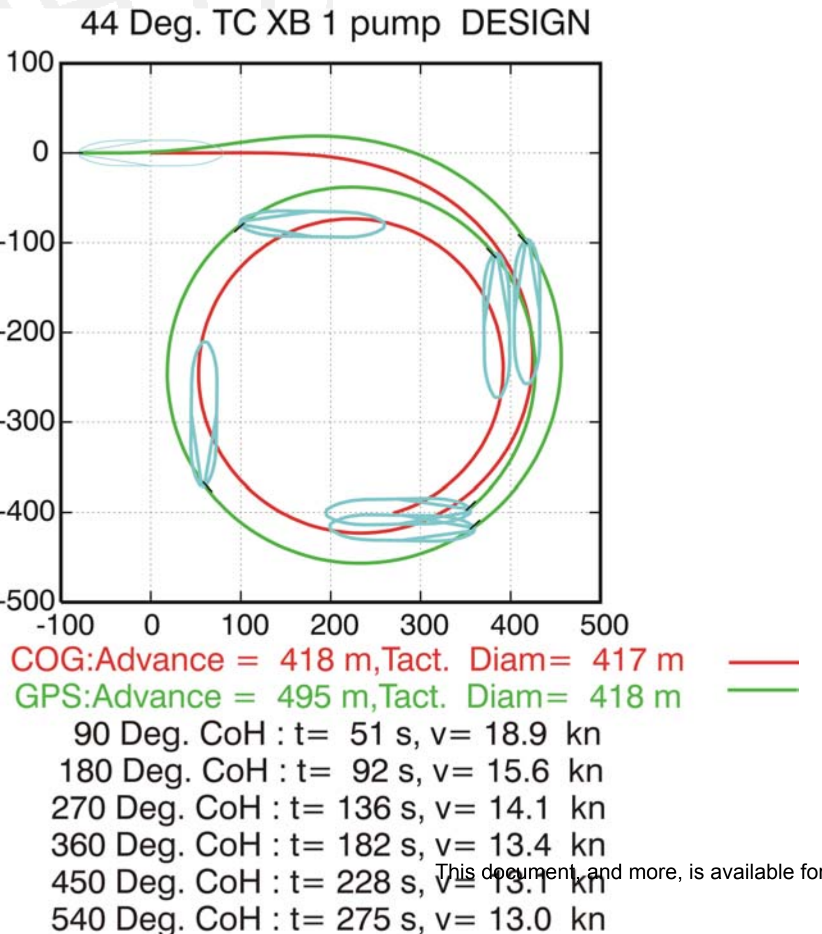
Stock- Prop. (WPM/Nörönna) tested in HSVA-Cav. Tunnel in 2 Quadrants and 10 Pitches.

Results used to calibrate TUHH lifting line model.



Manoevering (1)



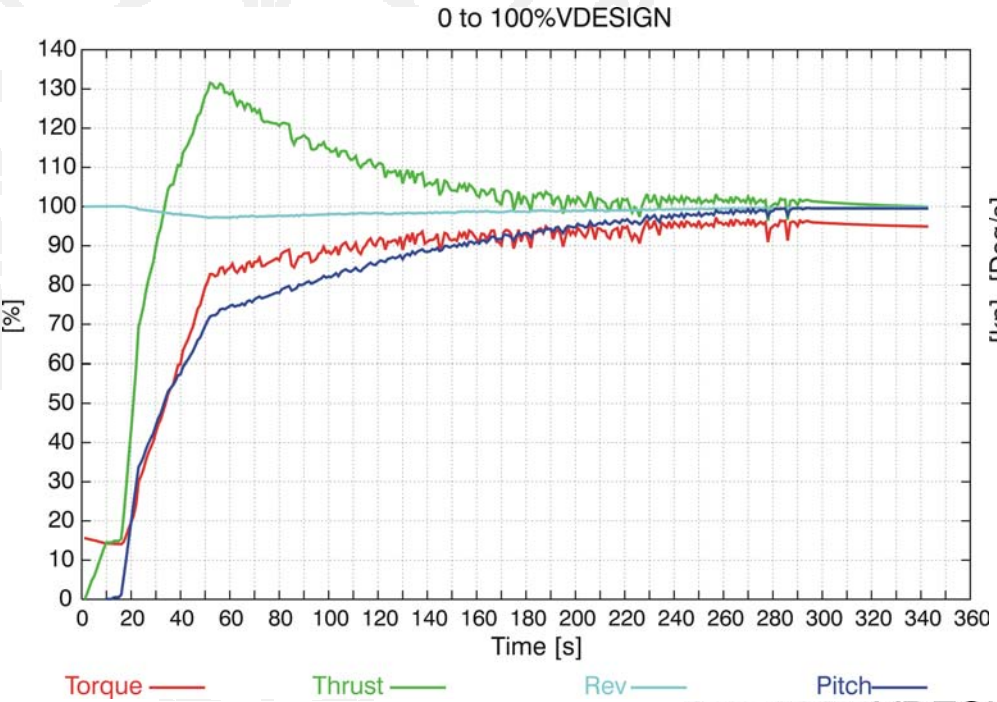


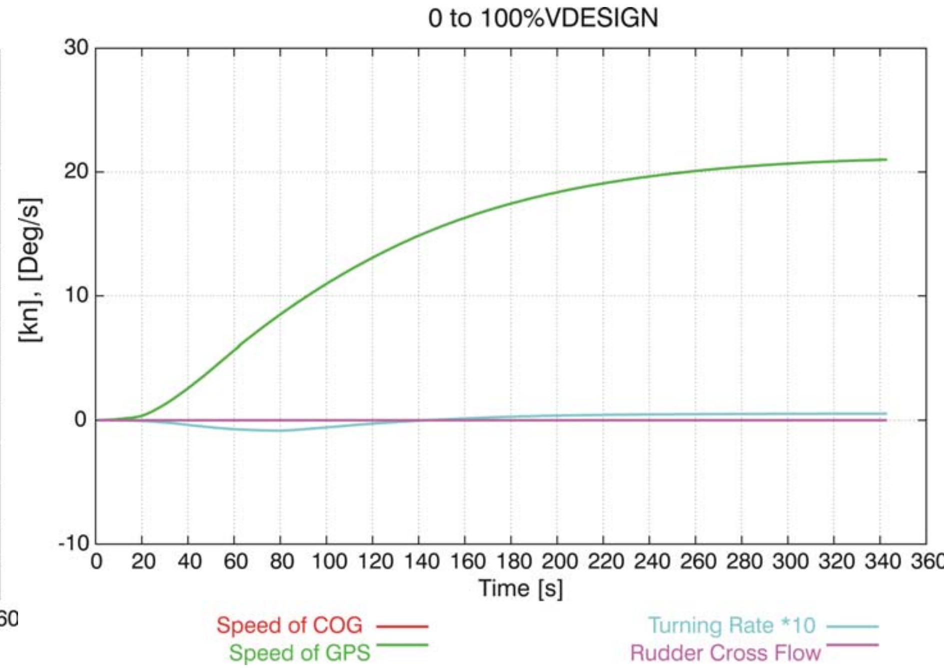
Manoevering Simulations confirm turning rate and overshoot.

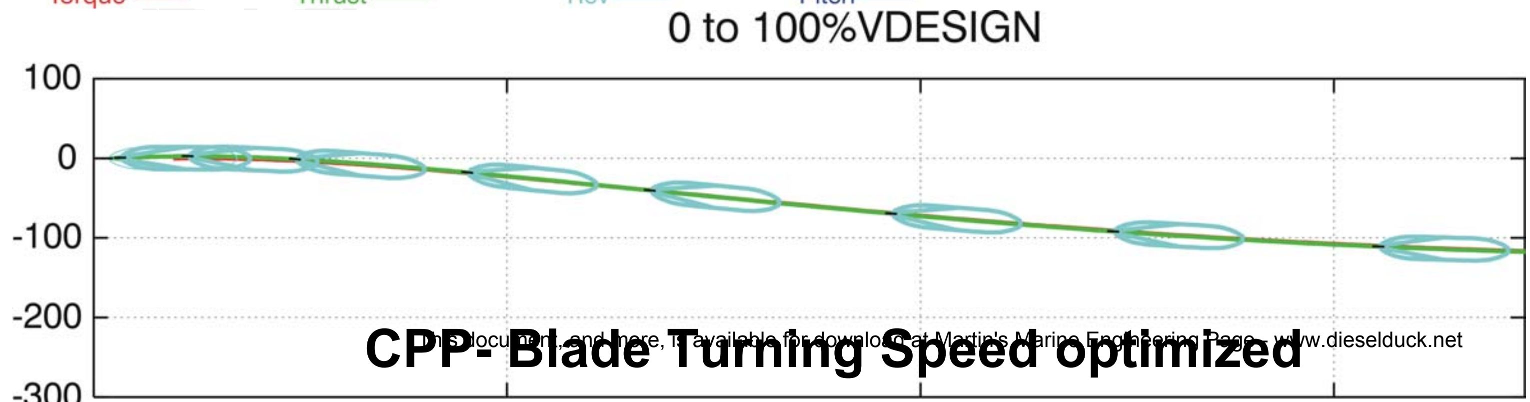
Building- Spec. accepted.

Manoevering (2)

Acceleration Manoevre w. WPM- CPP, 4 MaK 8M32, STN Drive Motors and Propulsion Control System







CPP- Blade Turning Speed optimized

Manoevering (3)

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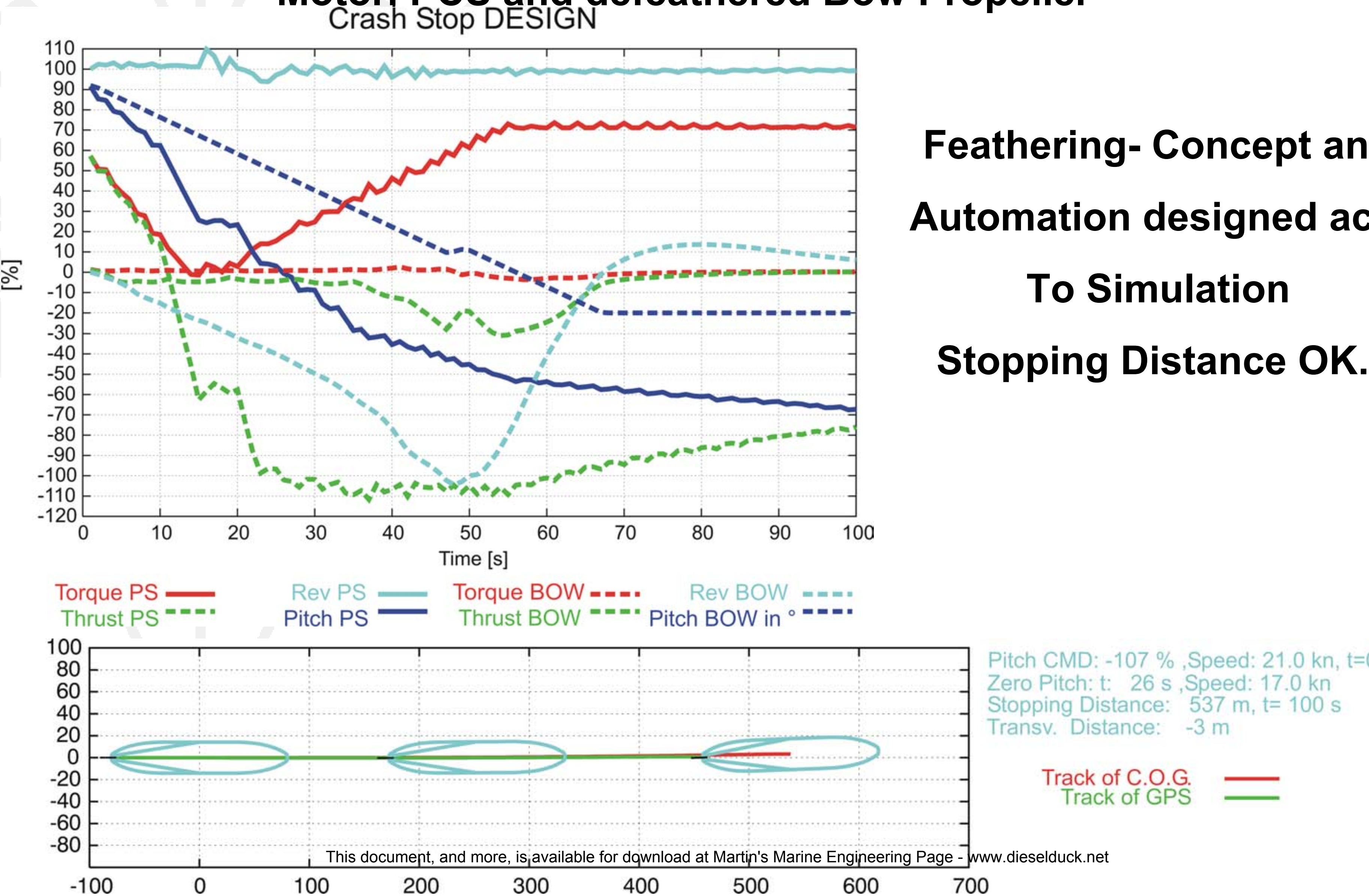
Crash-Stop Manoevre w. WPM- CPP, 4 MaK 8M32, STN Drive Motor, PCS and defeathered Bow Propeller



Feathering- Concept and Automation designed acc. To Simulation Stopping Distance OK.

Active Pass- Problem

Active Pass:

extreme Current up to 8 kn

Difficult waters, many rocks

Tranport- Canada requirement

Active Pass- Ability clear requirement of BCF.

How to demonstrate it ???

Active Pass Full Mission Simulation

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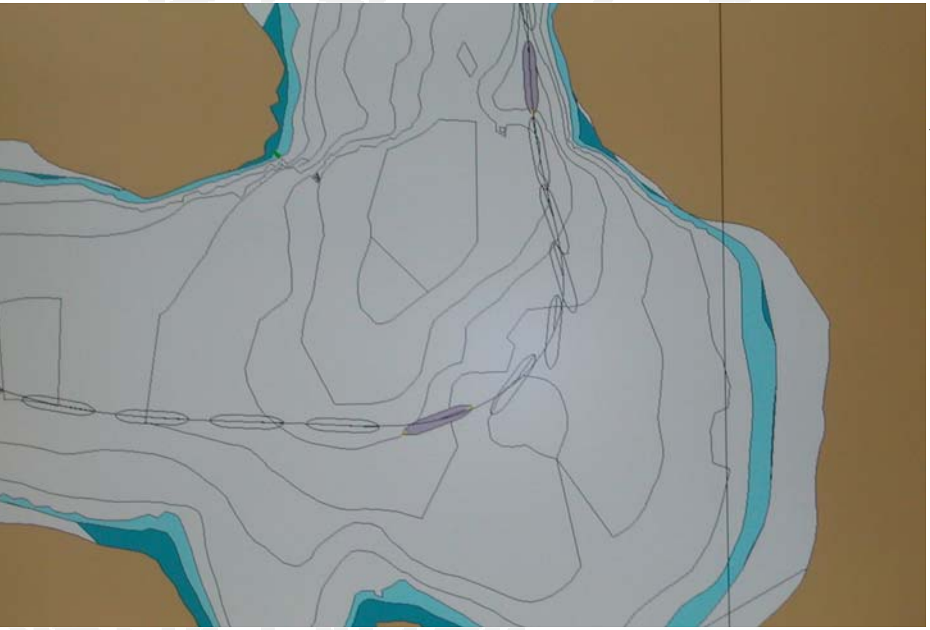

Virtual Testing of Active Pass at DMI /Lyngby.

TUHH/FSG- Manoevering model transferred to DMI- SIMFLEX.

Both Models agree in manoevering performance.

Active Pass shows no problems.

BCF accepts performance.

Conclusions

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1. The new concept is competitive.

2. New concepts require detailed investigations based on first principle design methods

3. New concepts require multi disciplinary engineering on a high level

4. Nothing is more practical than a goood theory !!