FLENSBURGER
SCHIFFBAU-GESELLSCHAFT

(Fuel) Efficiency versus Safety in Ship Design

STG´s Ship Efficiency Conference 2009

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Definition of Ship Efficiency/Performance

Efficiency/Performance can be defined based on:

- Cargo capacity
- (Hydrodynamic) Performance on the anticipated route
- Harbour performance
- Investment & Maintenance costs
- Comfort ?!
- Ship & Cargo safety ?!

Boundary conditions which can NOT be influenced include

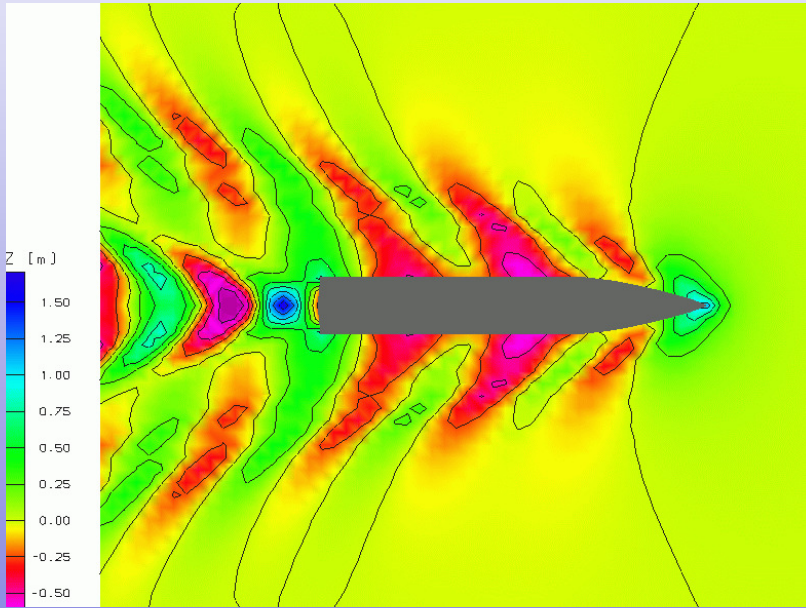
- Characteristics of the anticipated route (e.g. water depth)
- Restrictions in main dimensions (e.g. harbour restrictions)

Thus there is no universal “Ship Efficiency Index”
Ship performance needs to be compared based on the task!

Sometimes a comparison is easy

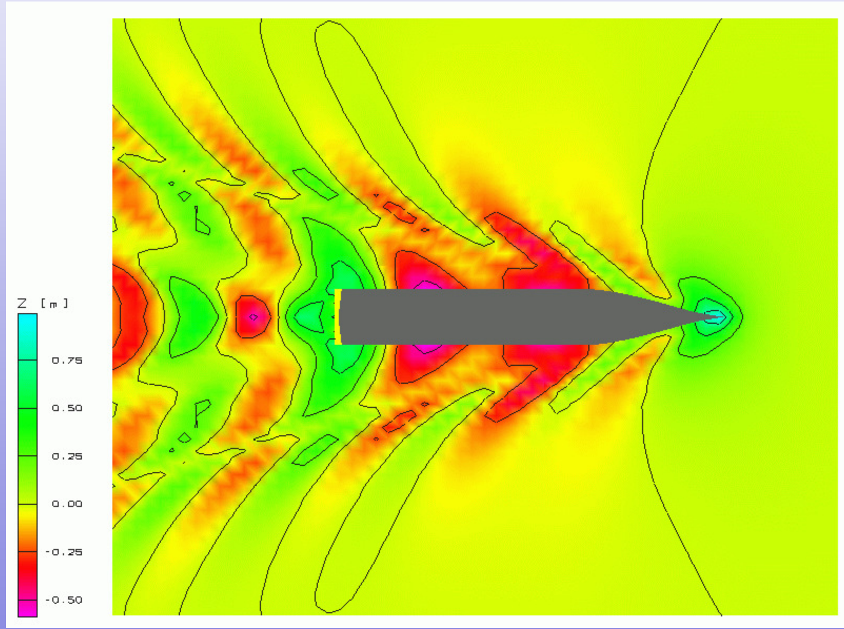
The FSG design has the same main dimensions & slightly more cargo capacity

Competitor at 19 knots



11000 kW

ConRo200 at 19 knots

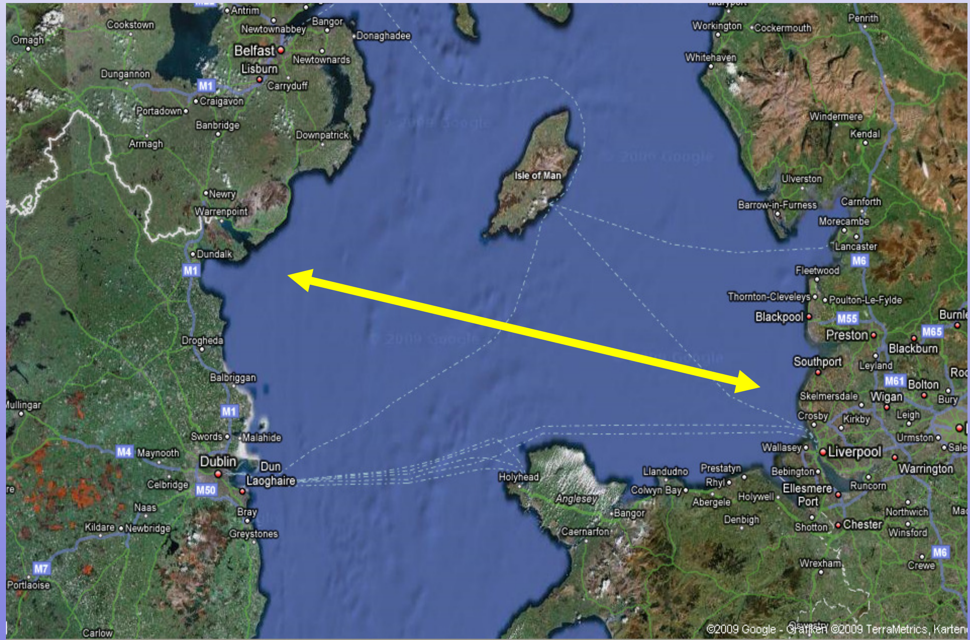


8400 kW

Design challenge

Target:

RoRo for the Irish sea
2150 lane meters
21 knots
2x 8MW MCR



Problem

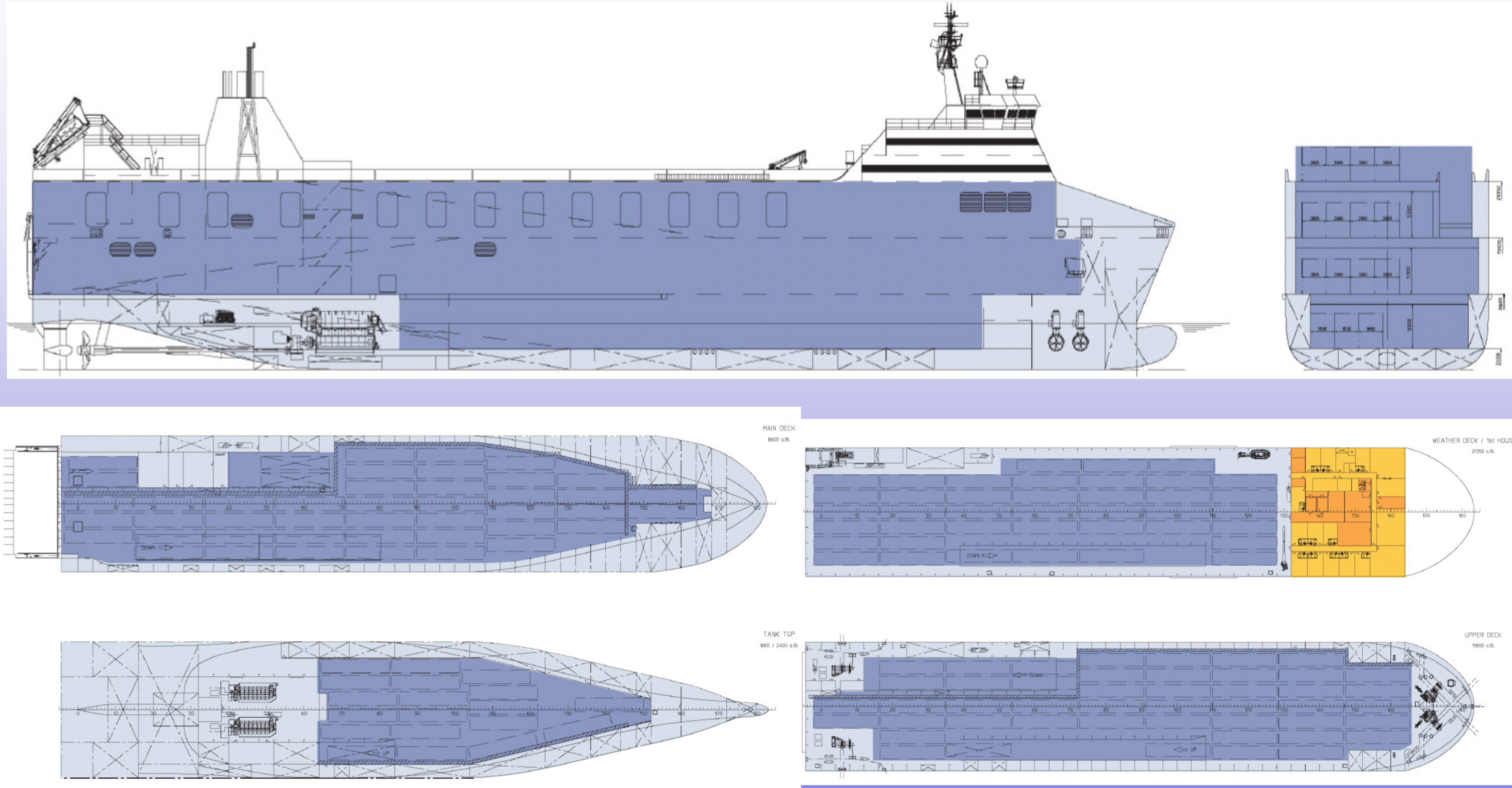
Main dimension restrictions:
L < 142m (Fn = 0.29)
B < 25 m
T < 5.2 m
High block coefficient

4 weeks for design work before contract!

Solution

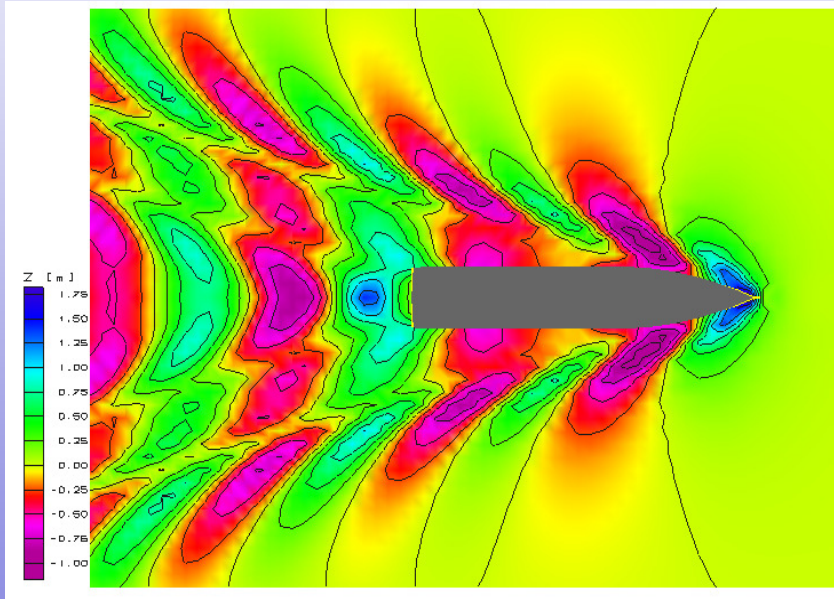
Four decks
Extensive wave resistance- and wake field optimization

General Arrangement

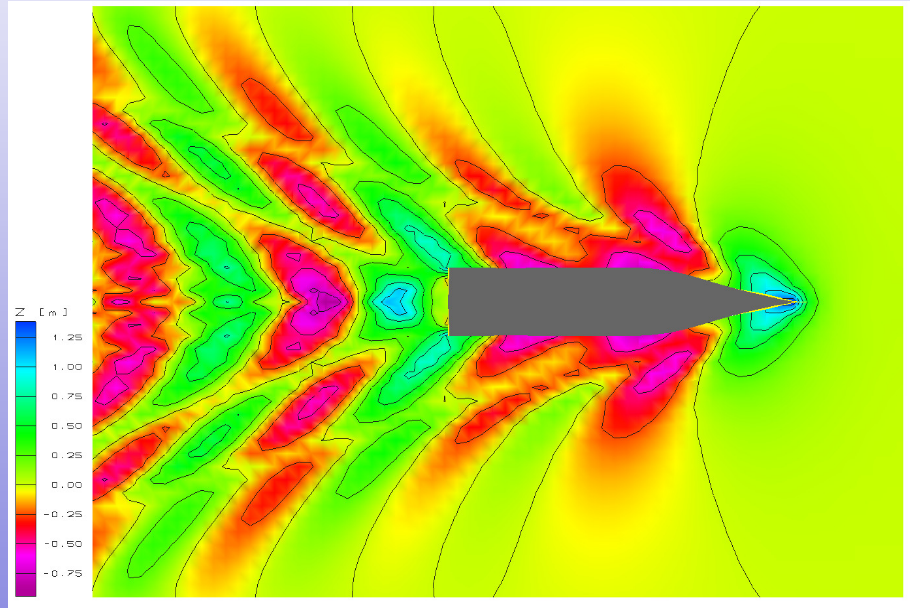


Resistance Optimisation

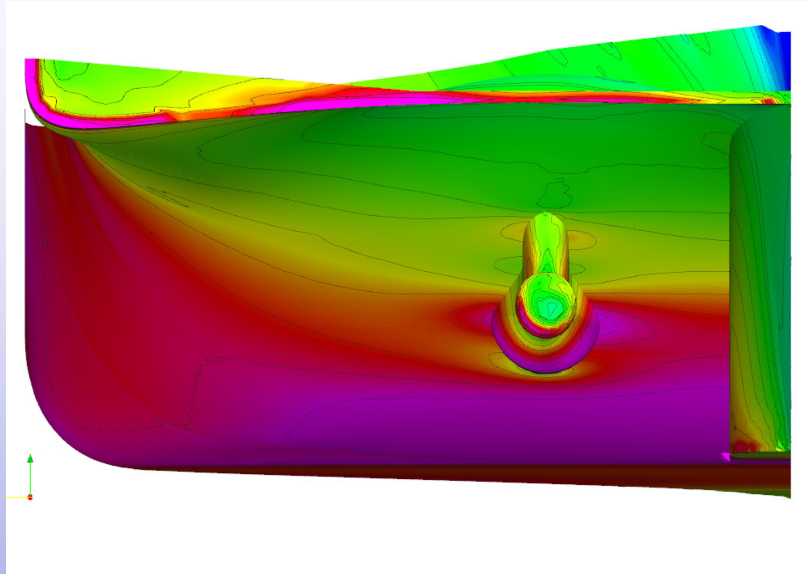
Competitor Design
3-Decks at 21 knots

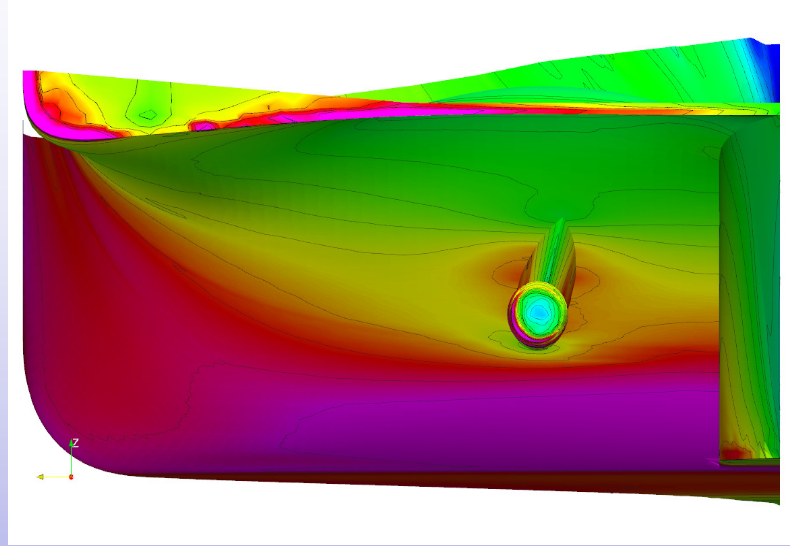


FSG Design
4-Decks at 21 knots



Appendage Optimisation





A better wakefield enables more degrees of freedom in propeller design for

- reduced pressure pulse
- cavitation control
- better efficiency

More details were presented in TUHH/FSG paper by Haack & Vorhölter at IMDC 2009

Reasons for an „extra“ Design-Loop

At this stage the design (over) fulfilles all requirements and standards from:

- The specification and contract
- Classification
- IMO (e.g. Intact and Damage stability requirements)

BUT:

The vessel does not pass FSG´s dynamic stability standard

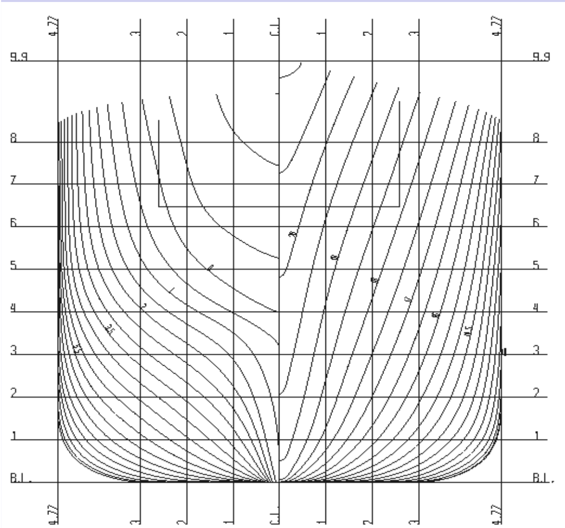
and

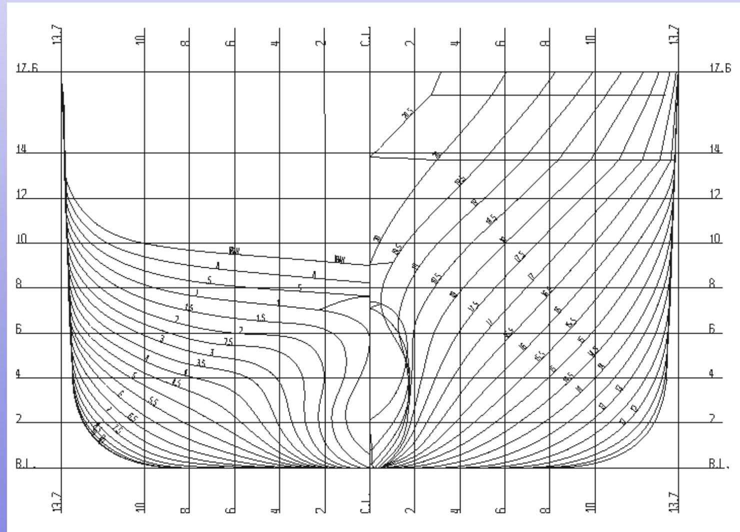
- Generally „likes to roll“
- The wakefield is still challenging

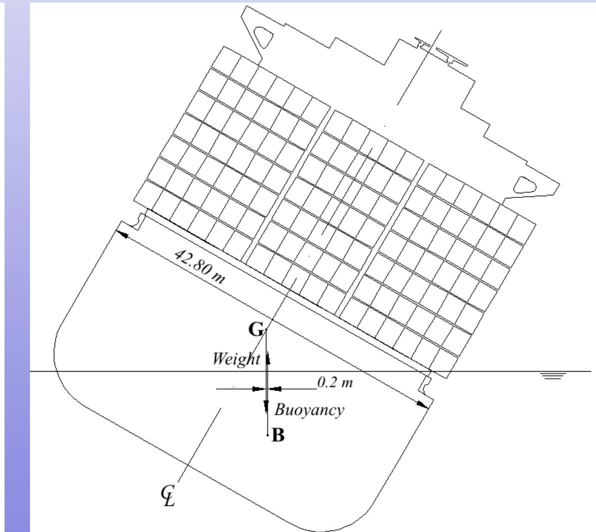
FSG´s dynamic stability standard
Motivation

The current intact stability rules are not sufficient:

- Dynamic Effects are not taken into account
- IMO A.749 based on statistics including vessels mostly <100m; dates back to early 20th century
- Limiting values un-scaled

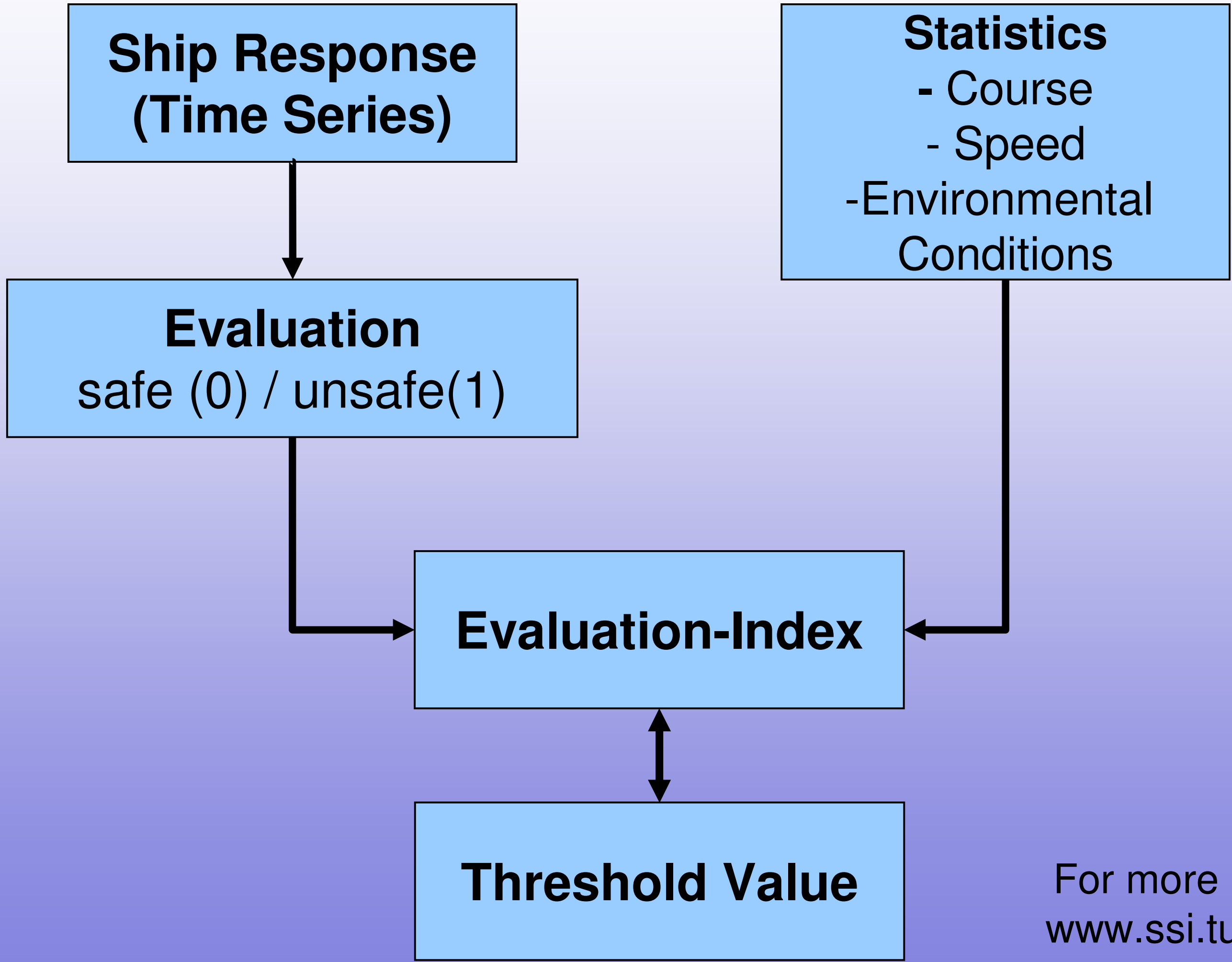






Evaluation Concept

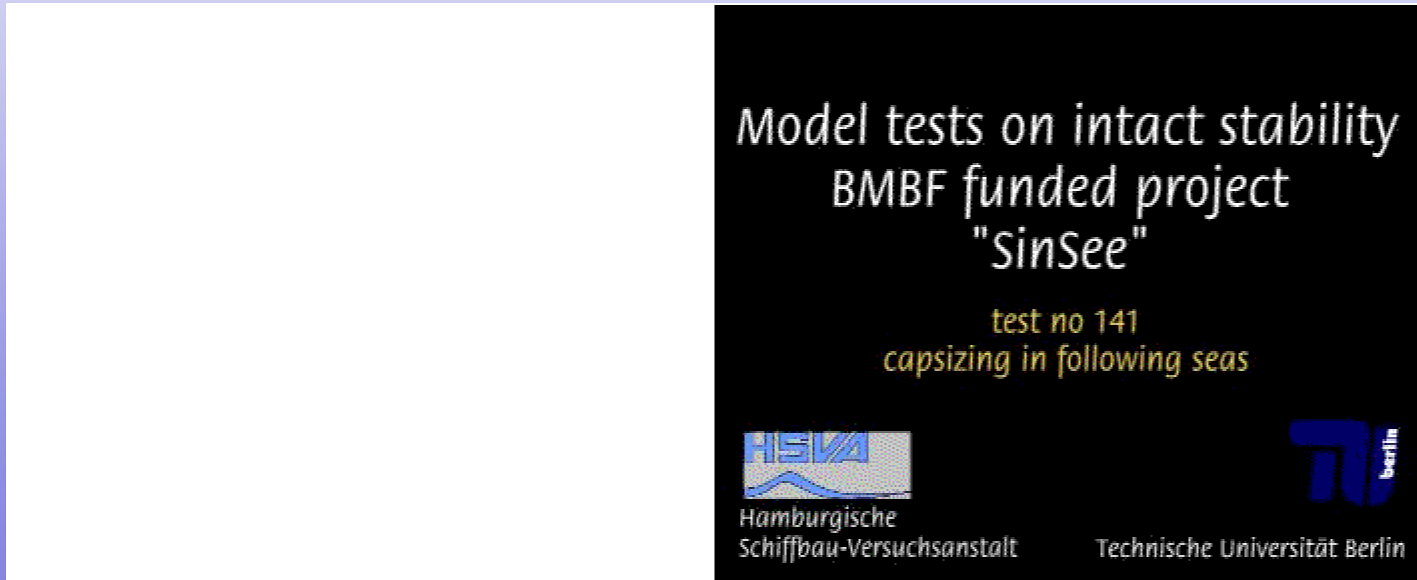
(Joint development with TUHH-SSI within BMWI research projects SinSee and LaSSe)



For more information:
www.ssi.tu-harburg.de

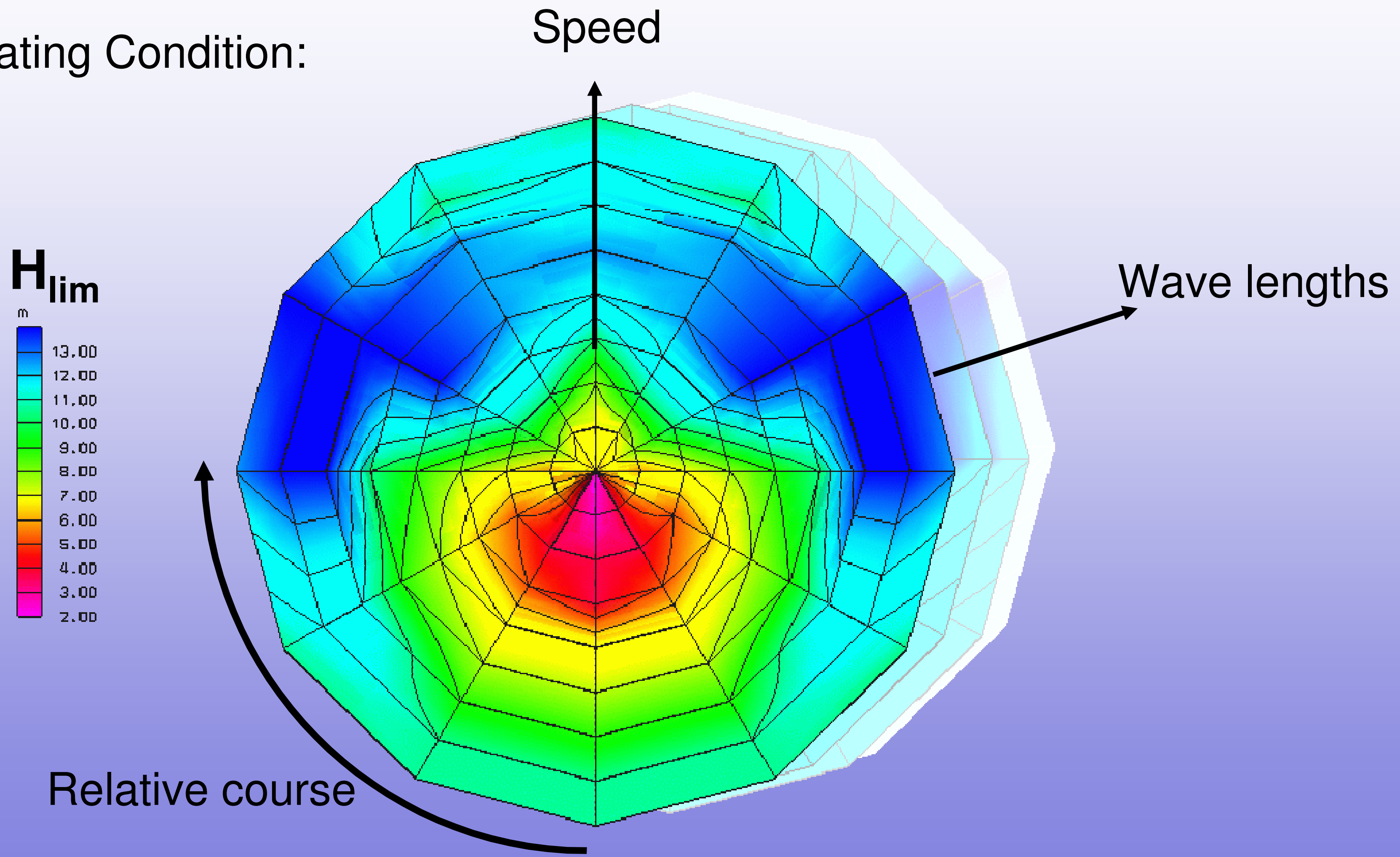
Assessing the Seakeeping Behaviour by Numerical Simulations

- **E4-Rolls: Non-linear sea-keeping simulation**
- **Delivers the ship response in waves 6 Degrees of Freedom**
- **Natural Seaway (irregular,short crested waves) modelled by wave spectra (e.g. JONSWAP)**
- **Flume tanks, stabilizer fins, cargo shift can be considered**
- **Validated by model tests in various research projects**

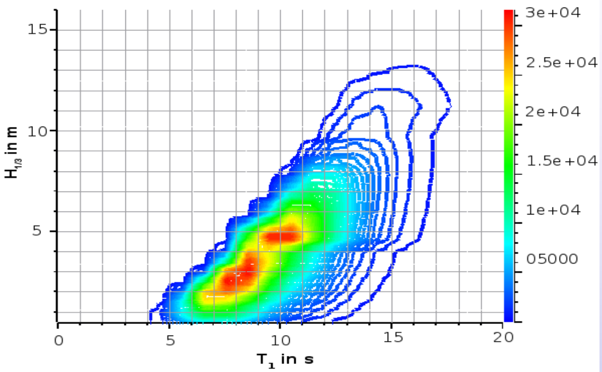


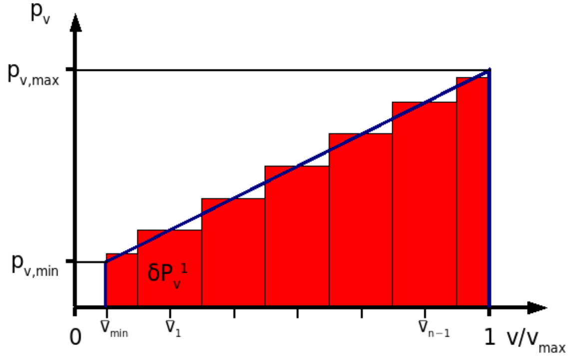
Consideration of operating conditions

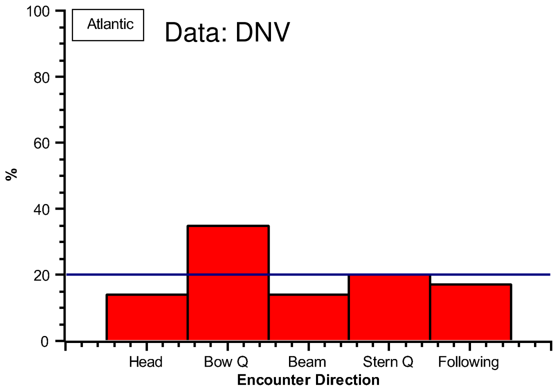
Operating Condition:



Statistical Analysis







- Area of reference: North-Atlantic
- Assumption course probability: Equal distributed
- Assumption for speed: Linear distribution
- V_{max} takes into account added resistance

$$ISEI = \sum_{\substack{\text{All unsafe}\\ \text{operating conditions}}} Pseaway * Pspeed * Pcourse$$

Evaluation Concept

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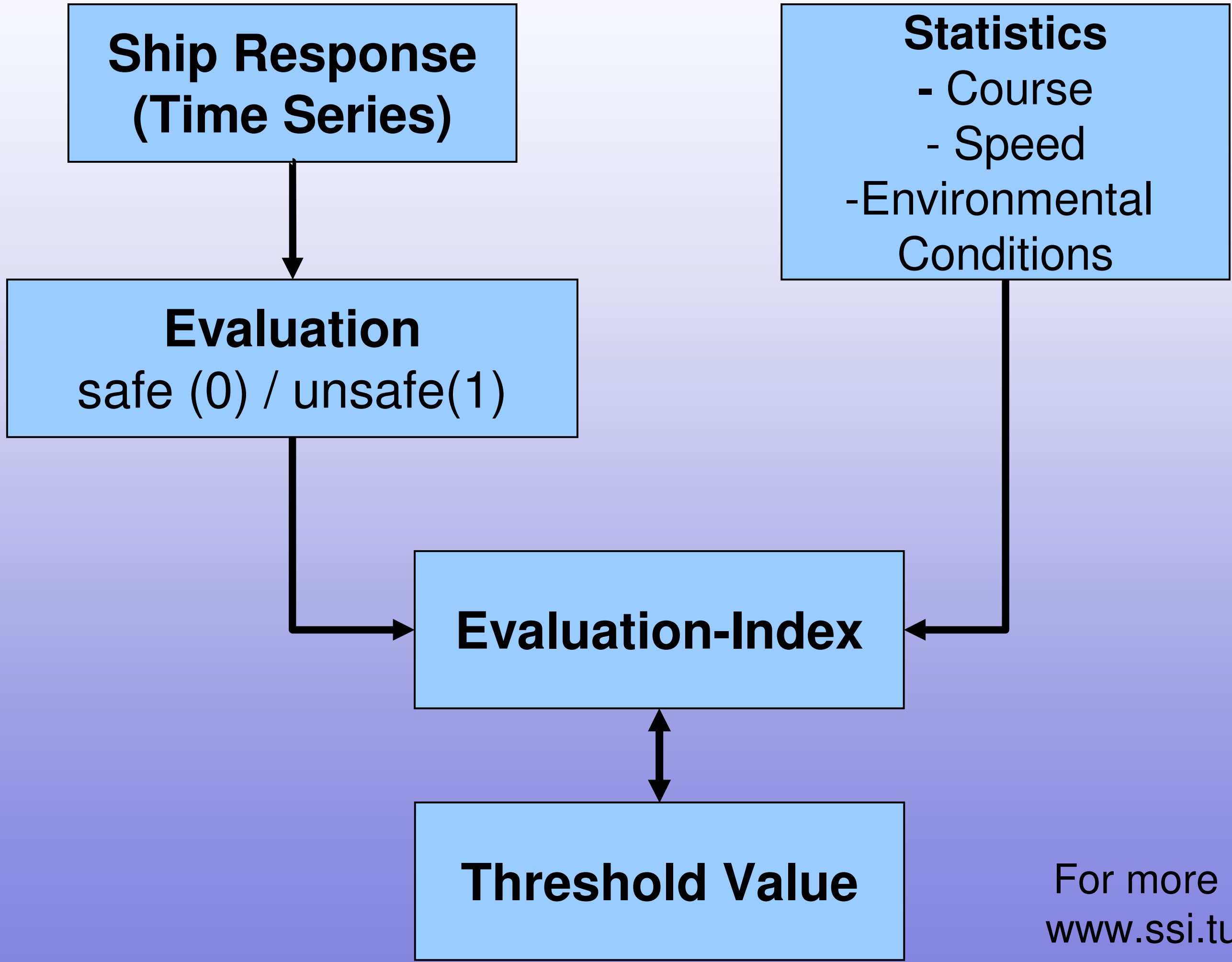

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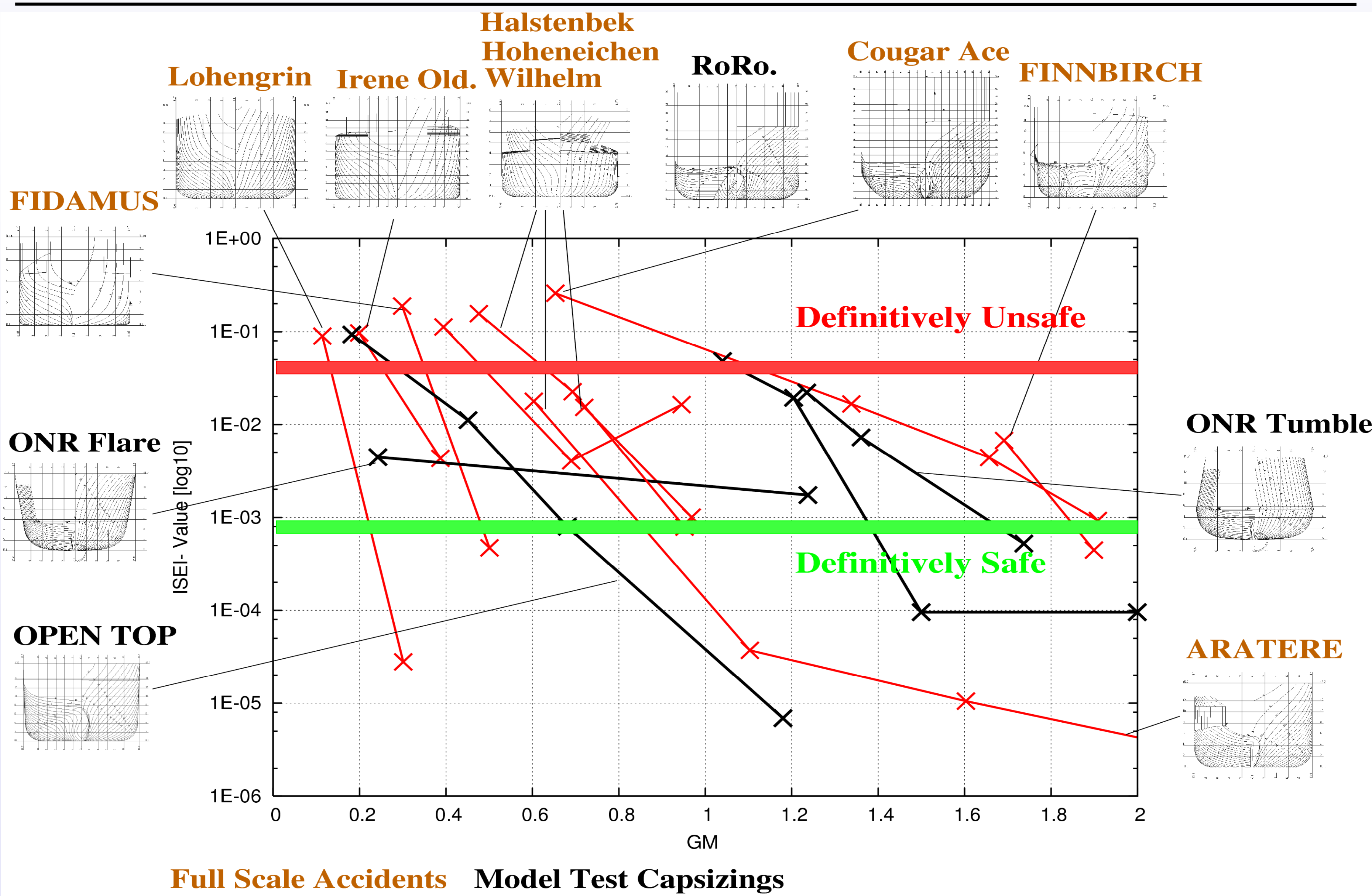
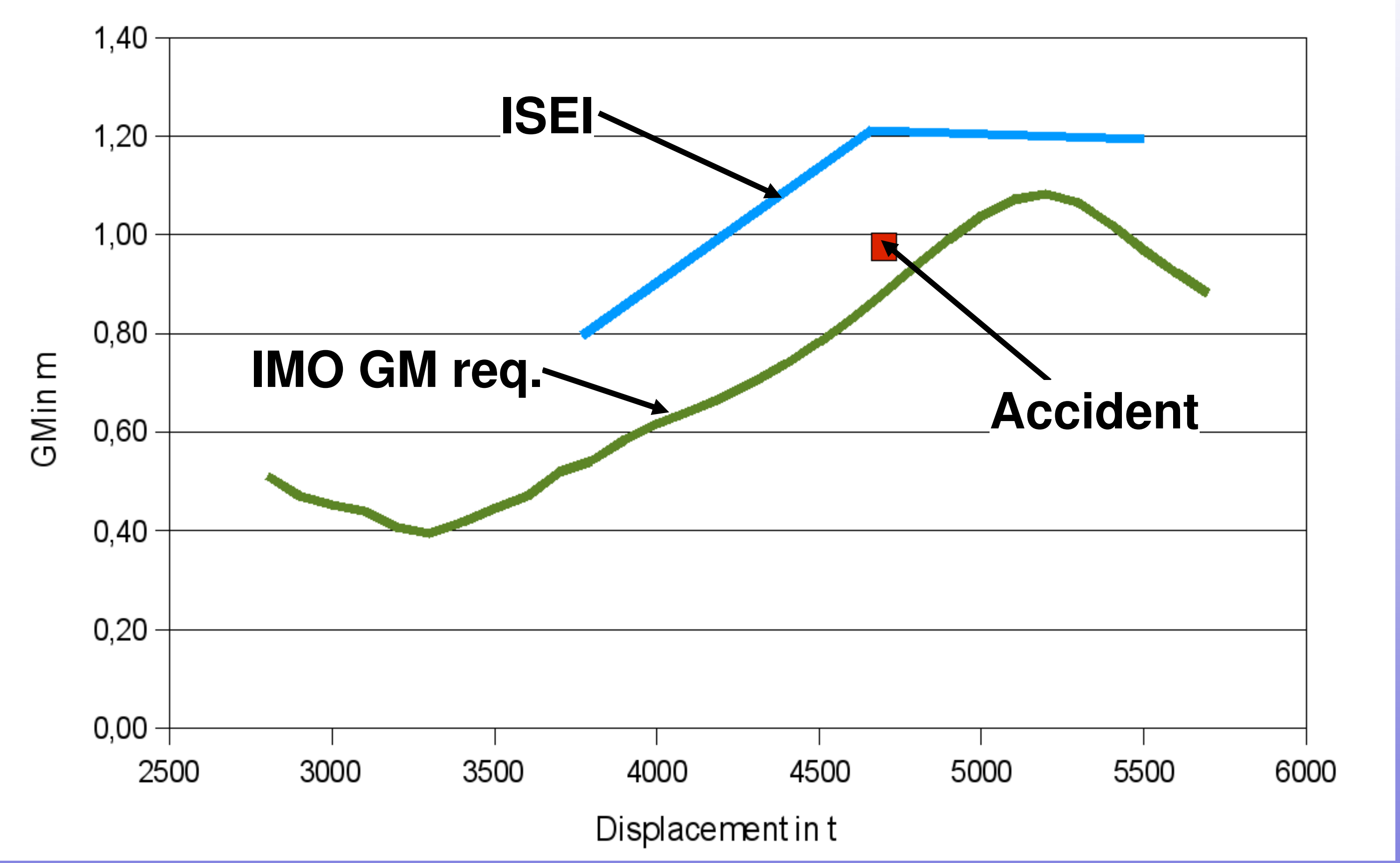
Threshold Value

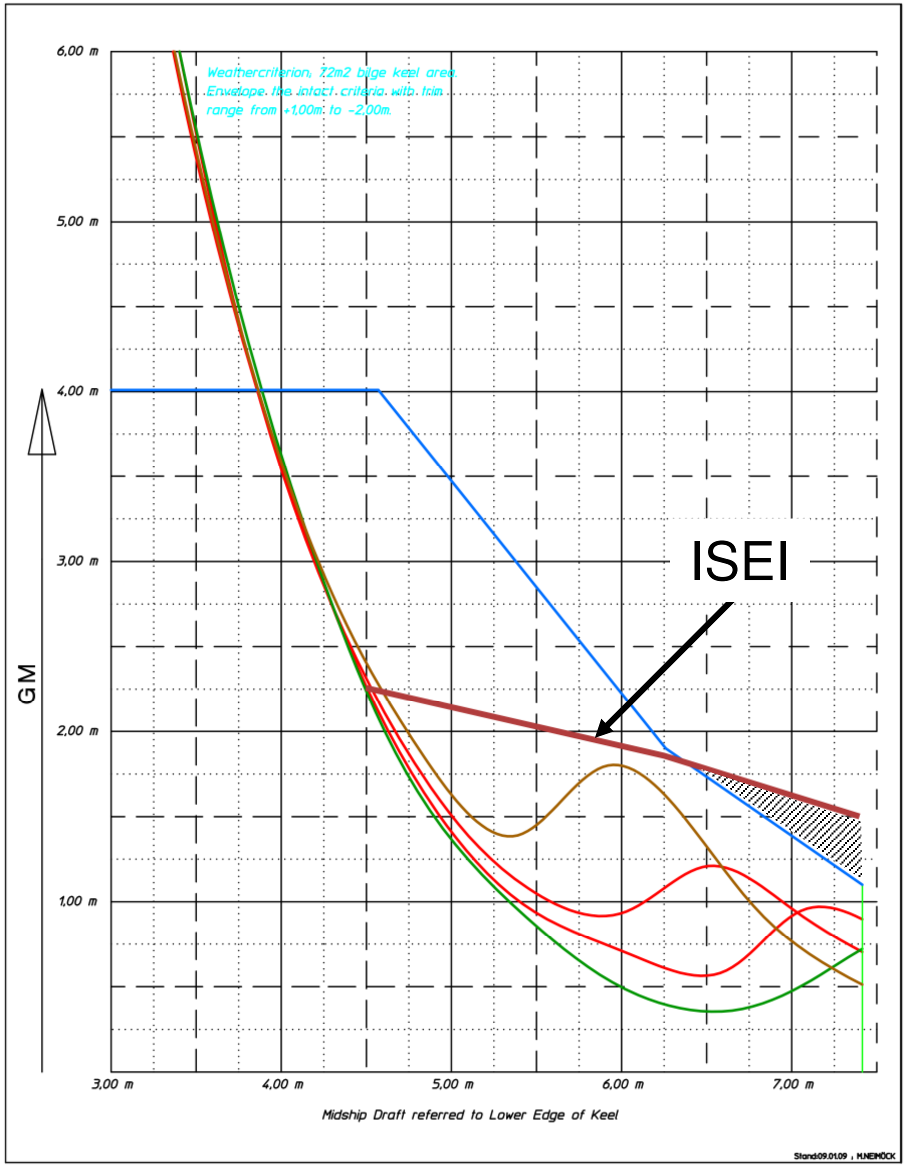


Accident investigation

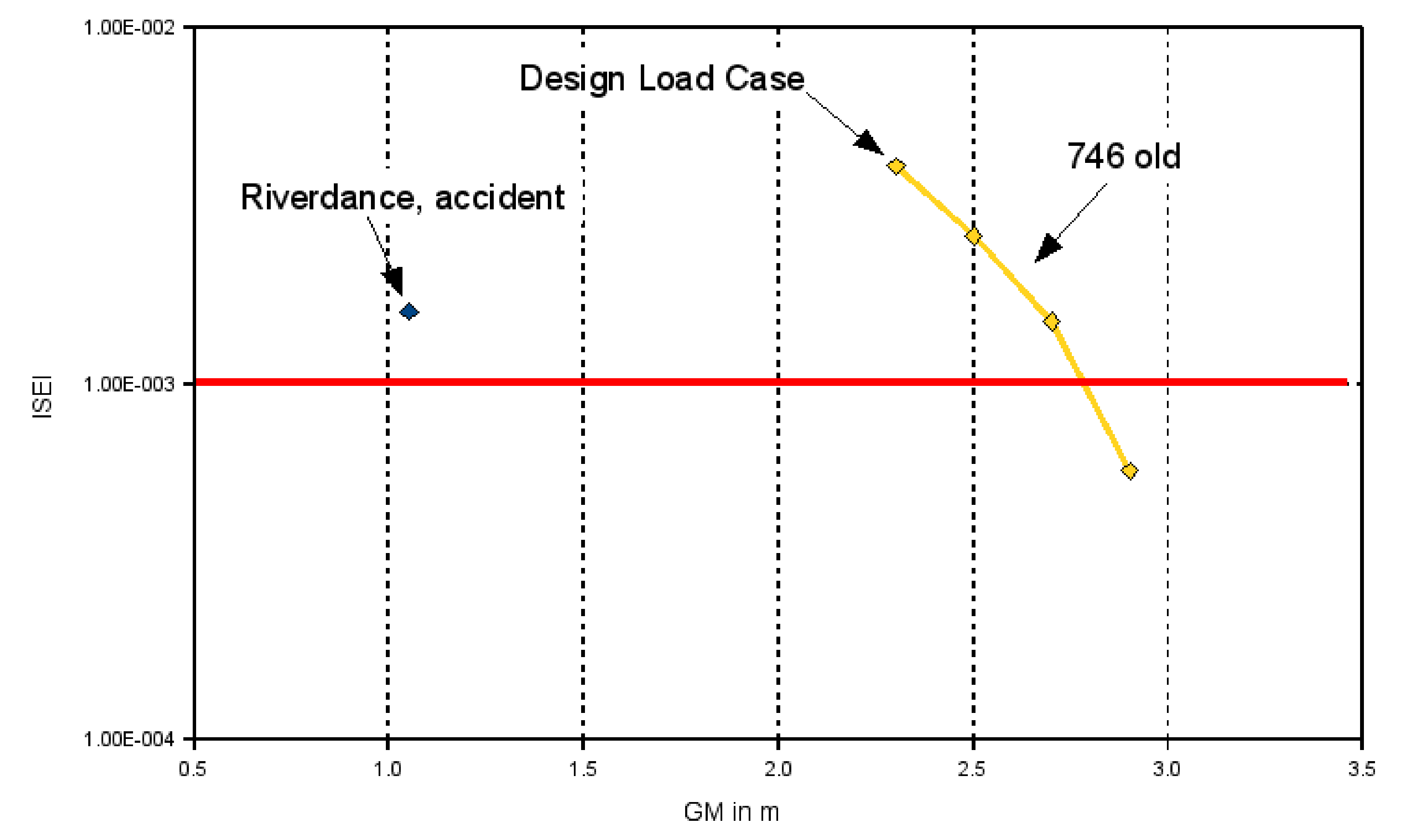


Modified Stability Booklet

- ISEI curve represents dynamic stability limit
- More conservative than intact stability rules
- In some situations even stricter than damage stability limit
- Allows for a better representation of roll damping devices
- Included in all FSG stability booklets



ISEI-Index for the Initial Design



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Design Goals & Options

Goals:

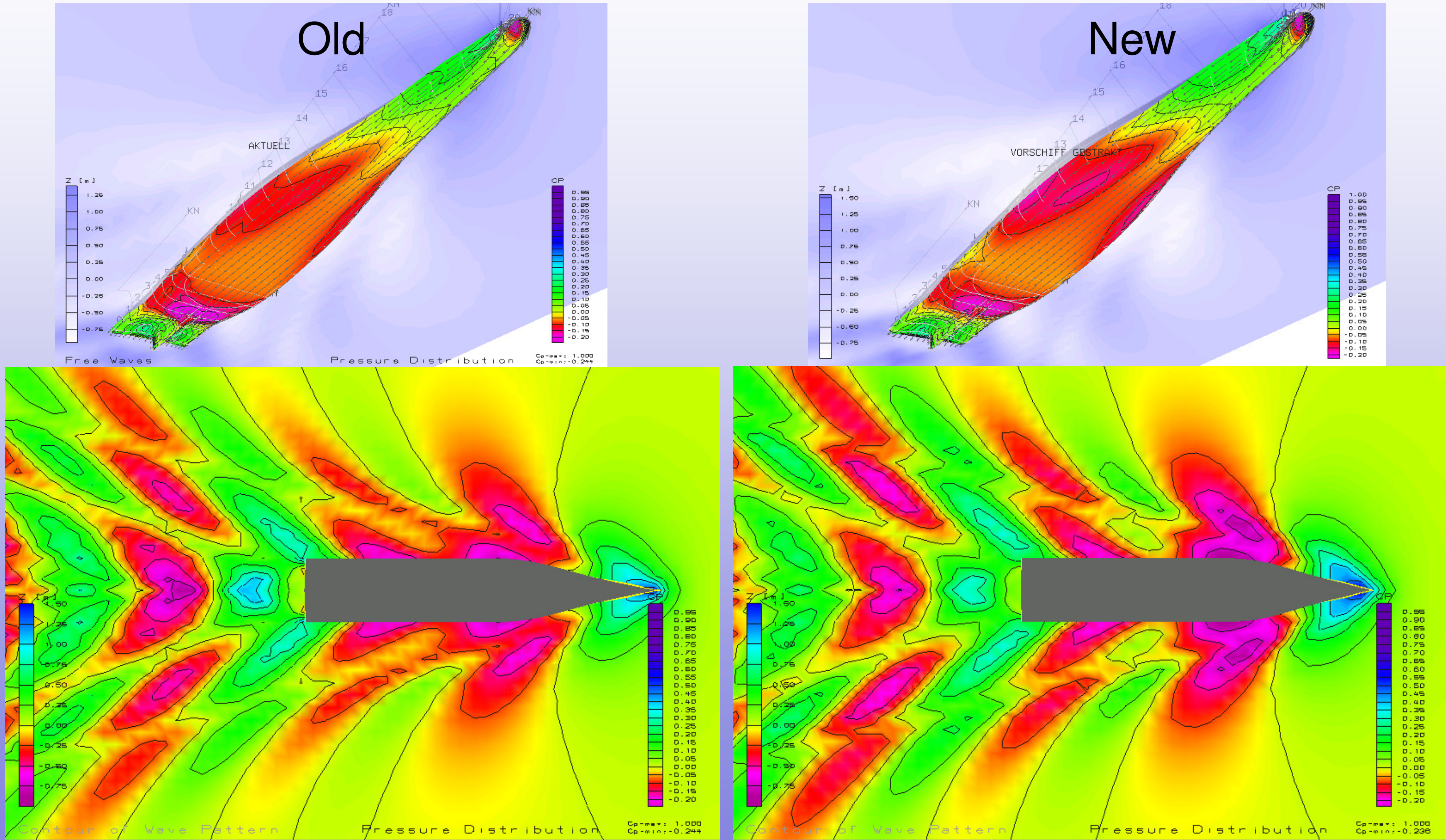
- Keep Cargo Capacity
- Improve Seakeeping / Dynamic stability
- Improve Wakefield
- Minimize influence on Speed-Power performance

Options:

- Keep hullform and increase roll damping via larger bilge keels and/or fins

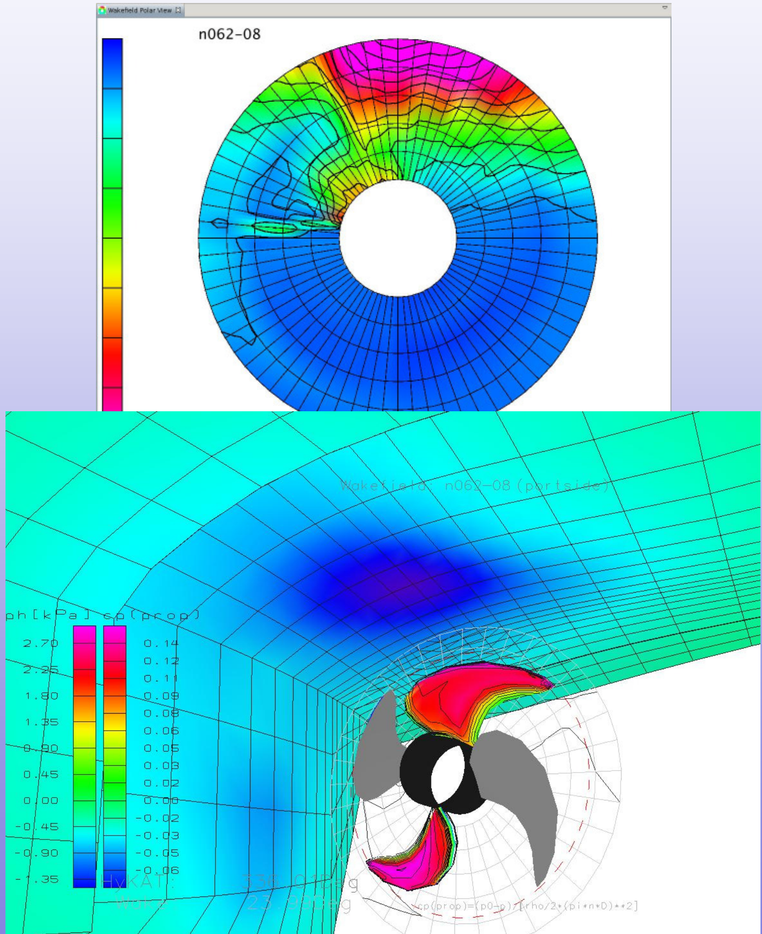
- Design new hullform (and GAP!) with better seakeeping and wake characteristics and include a FLUME tank

CFD Analysis

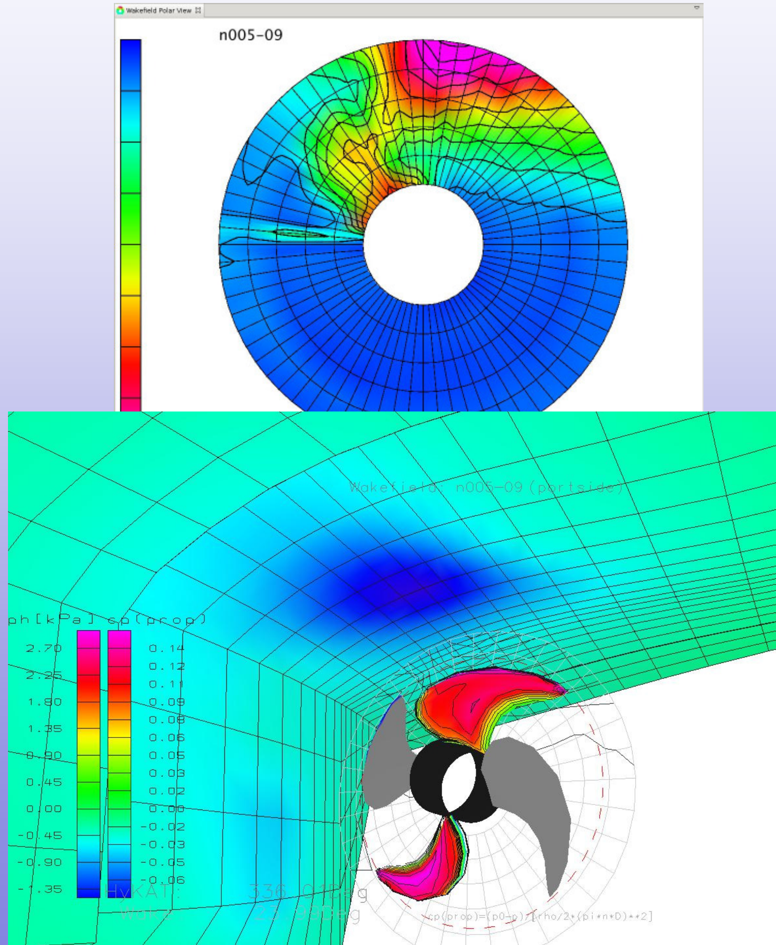


Wake Field Comparison

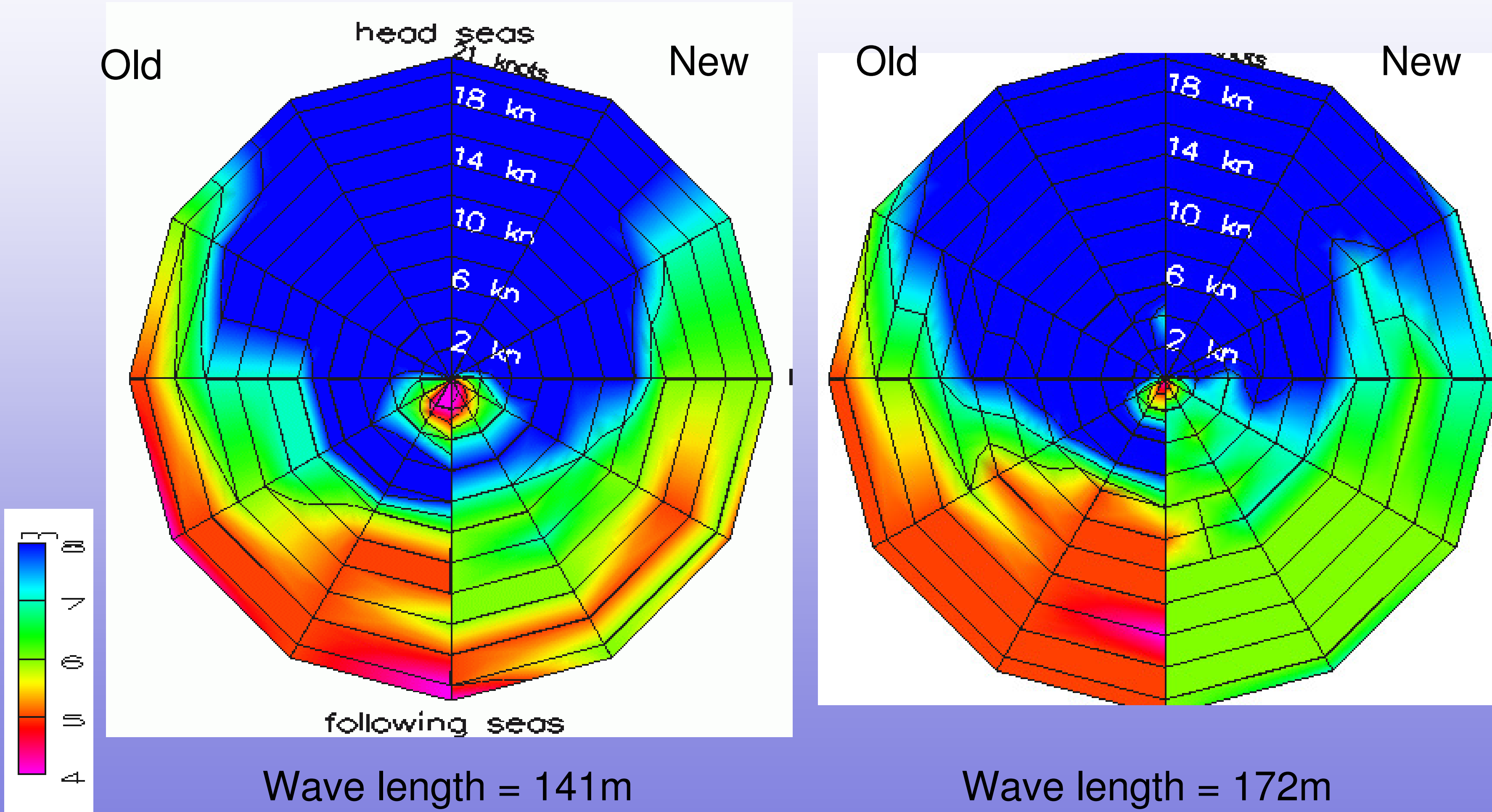
Old



New



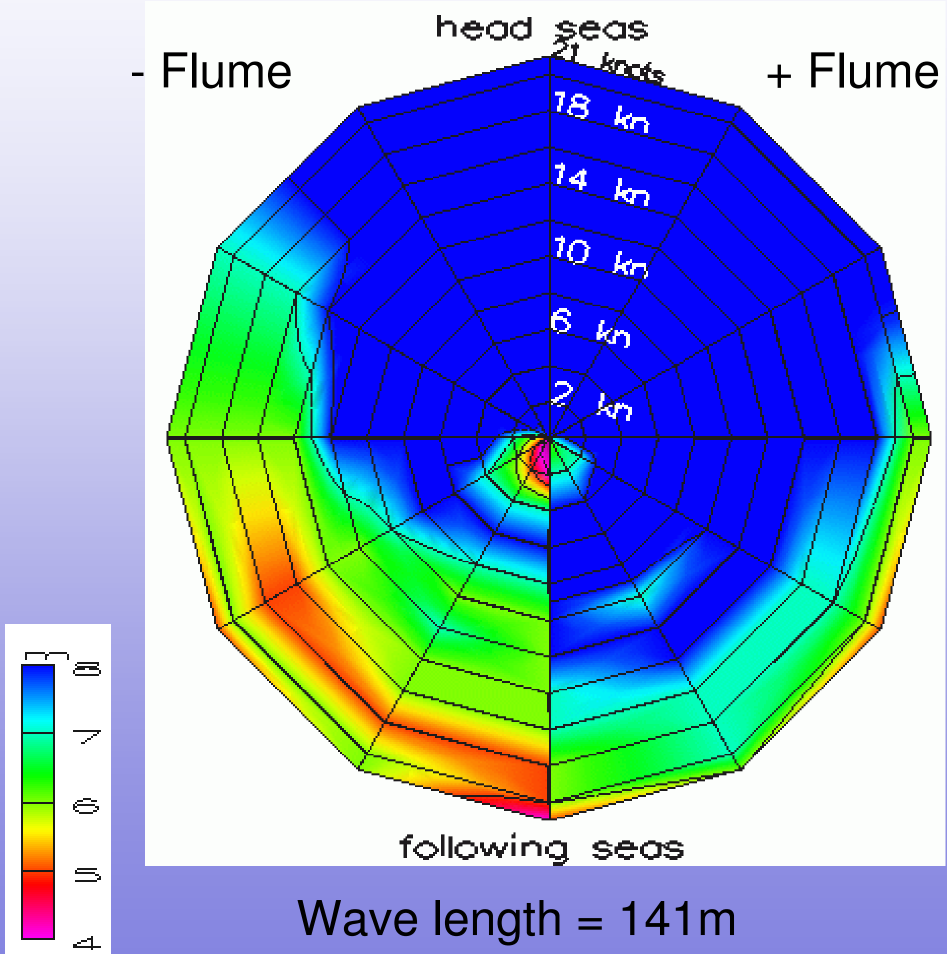
Maximum Roll Angle of 30° For the Initial and the New Design



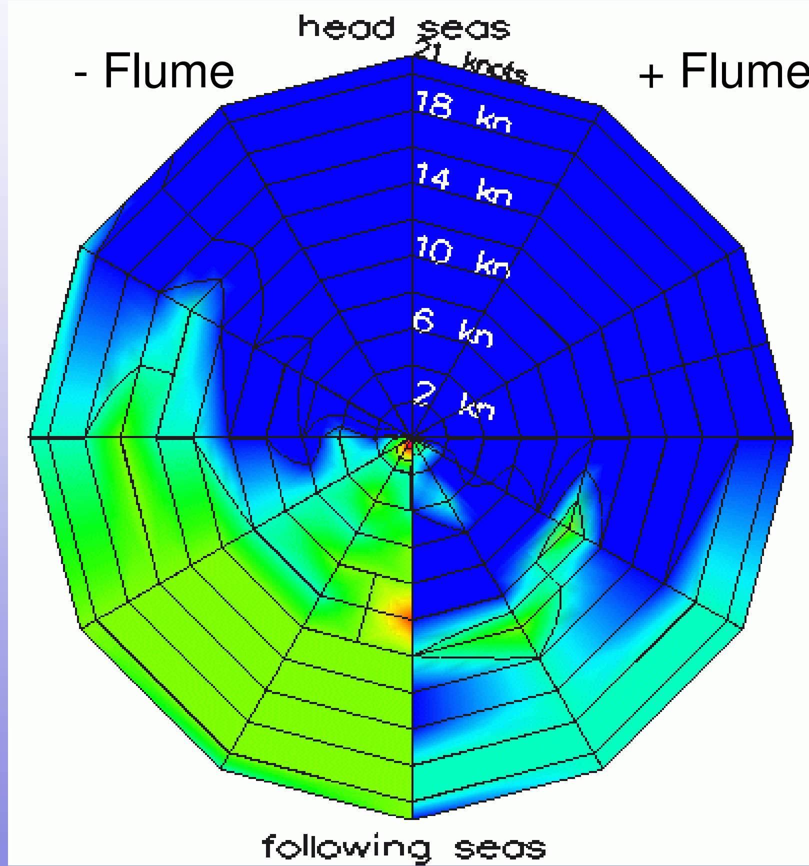
Wave length = 141m

Wave length = 172m

Maximum Roll Angle of 30° With and Without Flume Tank

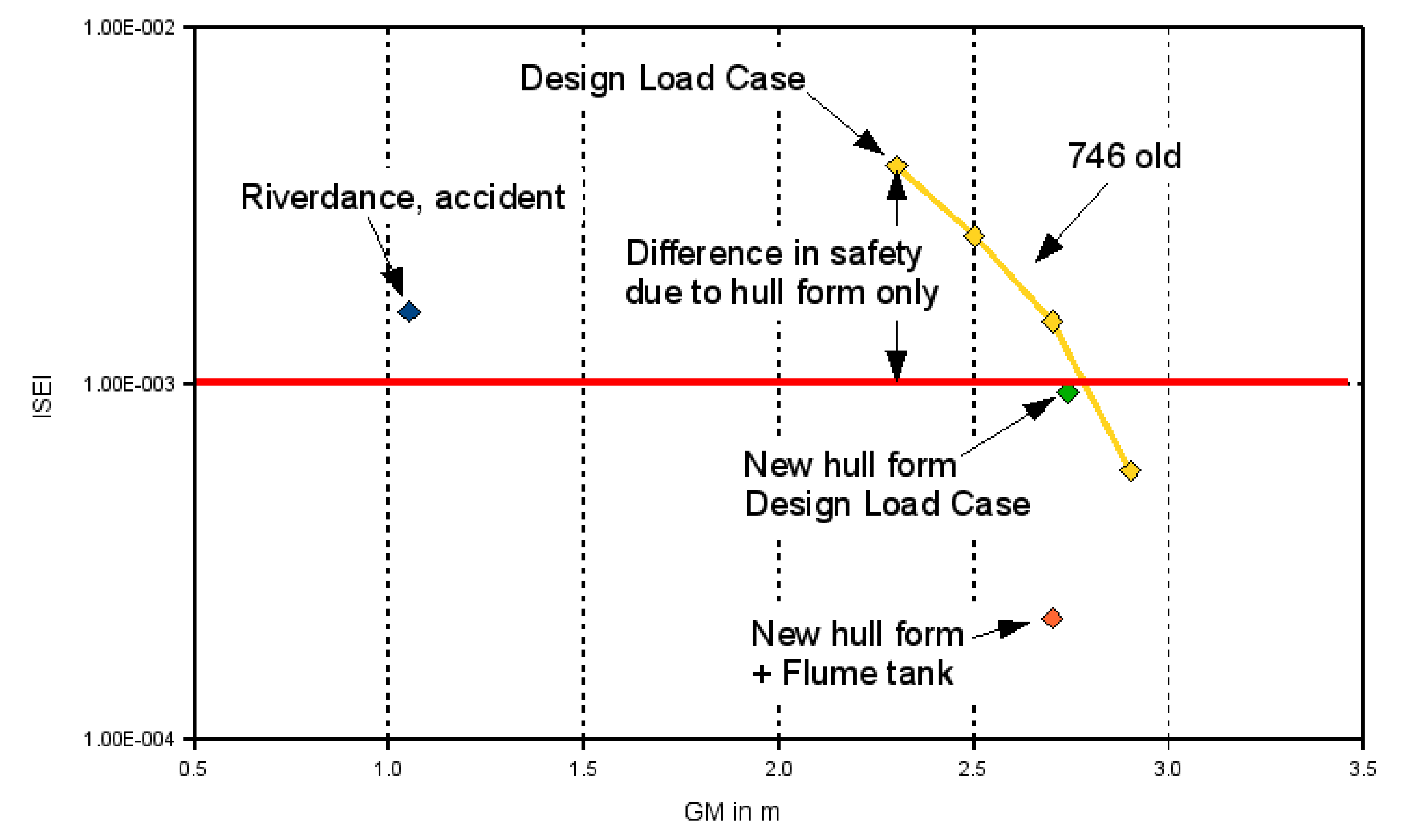


Wave length = 141m



Wave length = 172m

ISEI-Index Comparison



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Design Goal Check

Goals achieved:

- Keep Cargo Capacity
- Improve Seakeeping / Dynamic stability
  - Hullform has better seakeeping characteristics
  - FLUME tank for enhanced cargo safety
- Improve Wakefield
  - Better propeller efficiency
  - Less pressure pulses
- Minimize influence on Speed-Power performance (additional 150 kW are necessary)

New Hullform delivers an improved overall hydrodynamic performance!