



Aalto University
School of Engineering

Enhanced safety of ice-strengthened ship hulls in the Baltic Sea

ICEULTIMATE

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Objective

Sea traffic and ice
management



Ice conditions,
today and future



Steel material
characterization



Ice-structure
interaction



**To increase maritime safety and security based on advanced
capacity of maritime actors**



Maritime administrations

Ship owners

Meteorological institutes

Steel manufacturers

Research institutes (sea
traffic management in ice)

Ship yards

Classification societies

Design offices

Main scope and relation to PA Safe

ICEULTIMATE supports the EUSBSR 'Save the Sea' sub-objective 'Clean and safe shipping' by addressing several important challenges for the safety of ships. In particular, the main scope of the project is to decrease the gap in knowledge related to the definition of the ice-conditions in which ships can “really” operate safely, when they have been designed, manufactured and maintained according to a FSICR.

Partners

AALTO

FMI - Finnish Meteorological institute

TUT – Tallinn University of Technology

TUHH – Hamburg University of Technology

Chlamers

SSPA Sweden AB

Sveriges Meteorologiska och Hydrologiska Institut (SMHI)

Kotka Maritime Research Association

Arctech Helsinki Shipyard Inc

Aker Arctic Technology Oy

The Hamburg Ship Model Basin (HSVA)

TRAFI-Finnish Transport Safety Agency

Finnish Transport Agency (LiVi)

Tallink Grupp AS

Estonian Maritime Administration (EMA)

Main outputs

- Piloting a sensor technology in which a ship under ice operation will be used as a “sensor” to local and real ice conditions. After calibration corrected weather and ice conditions will be sharable with other vessels in the area
- Assessment of limits of ship hull structures, particularly frames and plating, designed according to IACS Polar Classes and Finnish-Swedish Ice Class Rule resulting in the evaluation of safety levels of the current ice class rules
- Foresight study on future ice cover scenarios depending on climate-change scenarios which could induce variations to sea ice characteristics
- Novel risk based design method to optimise future ship hull design and plan the shipping activities in the ice covered waters

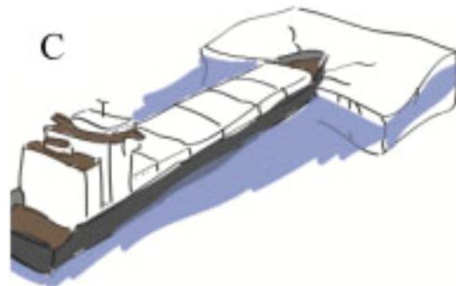
Feedback from the first round

- As many outputs seem to be of scientific nature the project would need to better describe not only their theoretical applicability, but also how the outputs would be used in practice already during the project implementation by those target groups not representing scientific organisations.
- In the current description it seems that many outputs will be based on statistical evaluations and material testing. In case of a 2nd step application the project would need to better explain whether and how the project outputs would be used practically by the target groups outside of the scientific domain and outside of the project partnership.
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ICEULTIMATE

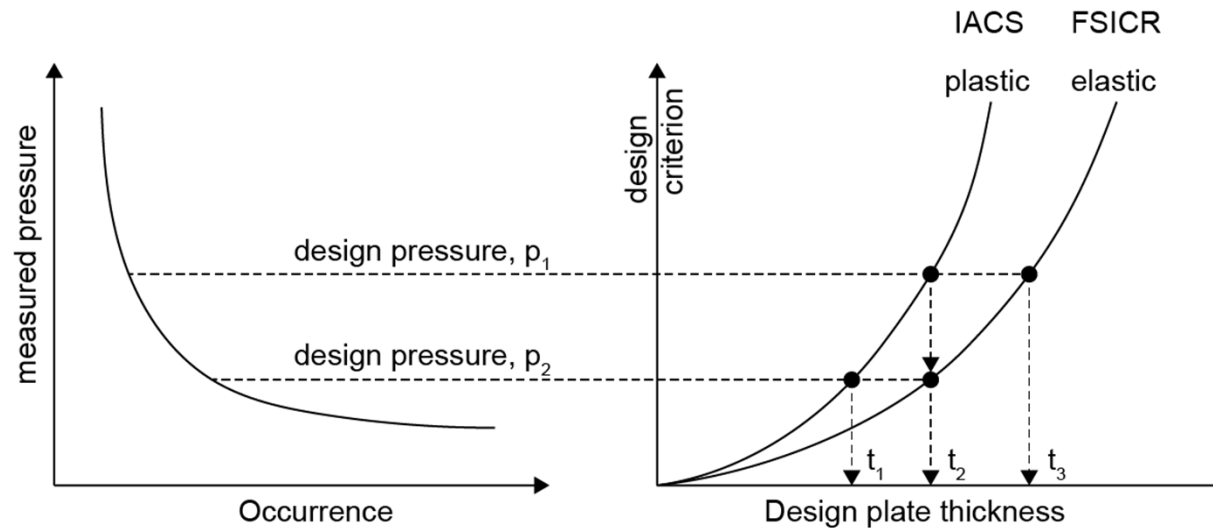
- Main objective is to assess, analyze and define different limit states for ice strengthened ship structures
 - *Limit states associated with large structural deformation such as permanent set and fracture initiation*
- **Will form the basis for future optimum and safe design of ship structures for navigation in the Baltic Sea**
- Current ice strengthening according to IACS Polar Code and Finnish-Swedish Ice Class Rule
 - These rules present conservative design loads, as the finite element analyses reveal a considerable amount of load carrying capacity beyond the design load level.
 - What is the safety margin in present design rules?
 - How does safety interact with economic criteria. Ships are safe but not efficient in terms of cargo-carrying capacity.

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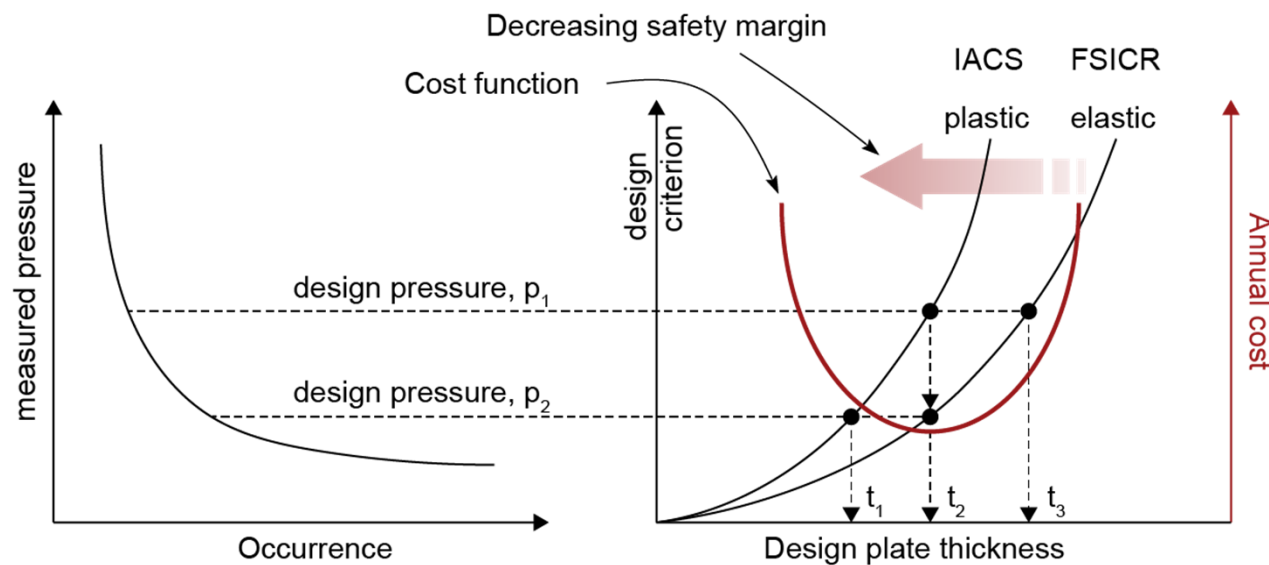
Present situation

- **Present deterministic rules**



Implications of ICEULTIMATE

- By combining safety margin with long-term load measurement data we can determine the lowest annual cost for ice strengthened ship

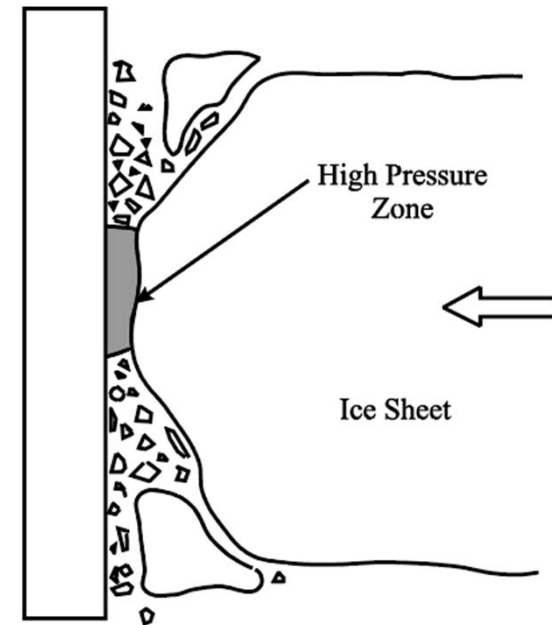


Ice-structure interaction

- **Ice-induced loads are known to have a strong stochastic nature due to the stochastic nature of ice strength properties and the ship-ice interaction process**

ICEULTIMATE sub-objectives

- **Characterize ice-structure interaction:**
 - Ice as a material for different conditions
 - the spatial and temporal variation in the interphase pressure
 - load for different ice conditions and
 - the resulting structural strength including the load distribution through the structural members until rupture



Sea-traffic and ice-management

- Ship as sensors: integrated on-board measurements of ice-conditions and ice loads
- Voyage planning tools to predict the ice-induced damages and to reduce the risk of getting stuck in ice
- Sharing information among ice-going vessels for a safer navigation in ice covered waters
- The ice conditions provide the foundation for the evaluation of ice-ship interaction forces
- Ice loads in design cycle
 - The quantitative knowledge of the ice conditions in the operational area is required.
- Statistical analysis of ice conditions in the Baltic Sea
- Future-oriented ice cover scenarios as climate-change could induce variations to sea ice characteristics.

Material and structural characterization

- Characterize steel behavior under large deformations to facilitate the shift towards plastic limit states
 - Benchmarking the effect of corrosion, thickness, stress state and low temperatures on the steel response
- Large-scale grillage experiments to provide benchmark information for non-linear finite element simulations
 - double pendulum type of frame that enables mounting of large ice cones and swing them to dynamically load the structure.
- Explicit definition of limit states through extensive numerical simulations and analyses

