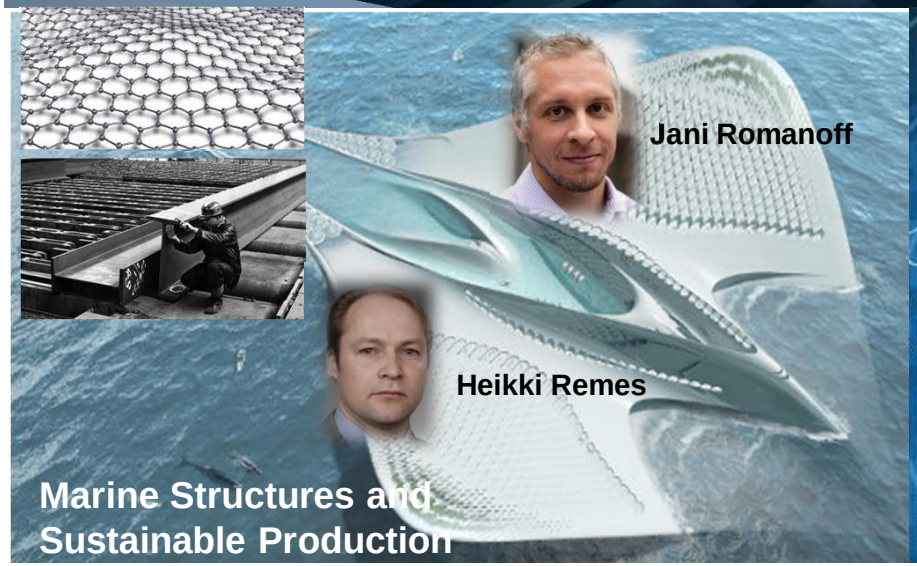
Aalto University
School of Engineering

Arctic Marine Technology at AALTO

Pentti Kujala
Professor, Vice Dean (Research)

07.02.2021

Marine Technology, Focus areas and Faculty Members



Arctic Research at Aalto

Research focus area in Aalto ENG

- 3+ professors, lab manager, 4 post docs, 10 doct students
- Aalto Ice Tank,
- 7 professors in 5 countries (FIN, NOR, CAN, GER, NL)
- NEW:
- - NTNU, DTU Nordic co-operation

Main international networks

- LRF Center: *Arctic Shipping and Operations, 2013 – 2021* Aalto, NTNU, MUN, TUHH, UH; Risk and safety
- SAMCoT, Center for Arctic Marine Technology at NTNU, 2012-2019: Ice mechanics
- IUTAM Symposium on Physics and Mechanics of Sea Ice, 2019

Arctic Marine Technology

Professor Pentti Kujala

- *Chair of the new LRF center of Excellence for Arctic Shipping and operations, 2014-2021*
- *Research interests: Marine traffic safety, Arctic technology, lightweight structures, statistical methods for loads*

Post-docs:

PhD Martin Bergström

- *Risk based design for Polar waters*
- *Future regulatory approaches for autonomous ships*

Ketki Kulkarni, *Industrial Engineering and Operations Research, Simulation-optimization, Transportation and Logistics*

Mikko Suominen, *Model- scale and full- scale measurements Ice load statictics*

Doctoral students

Roman Repin

- *Krylov State Research Centre (2011-2016)*
- *Research interests: ice mechanics, micromechanical modelling, experimental mechanics, FEM*

Liangliang Lu
M.Sc. Aalto & NTNU
Research interest: Shipping in ice, risk management, ice loads

Aleksandr Kondratenko
Fleet system based design for the Arctic Krylov Stae Research Center (2014-2019)

Fang Li

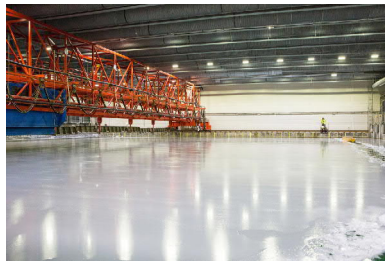
- *Ship performance in ice, ship-ice interaction, full-scale measurement data analysis, numerical simulation*

Full-scale – Laboratory – Modeling

Full-scale tests

mimic

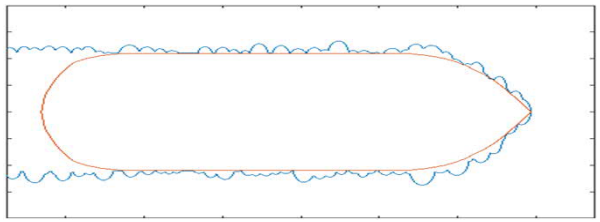
Model-scale tests



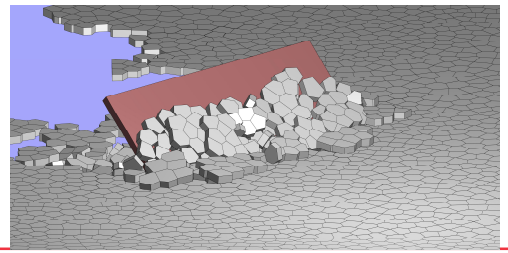
simulate

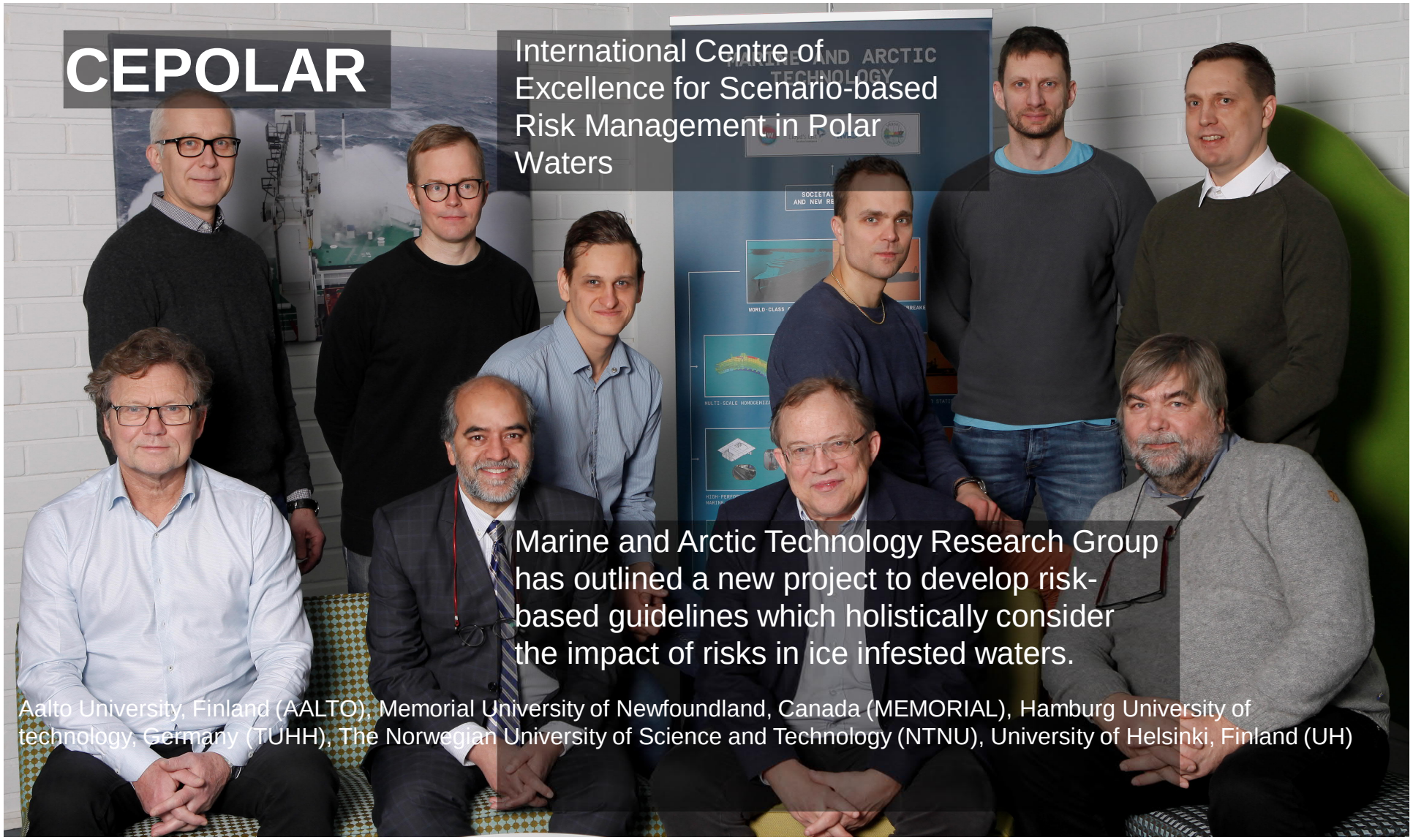
validate

validate



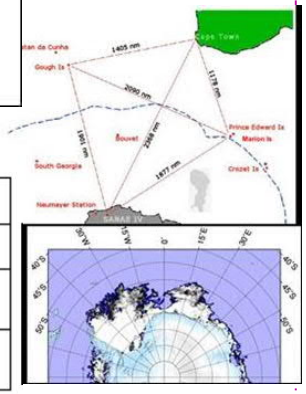
Modeling




CEPOLAR
International Centre of Excellence for Scenario-based Risk Management in Polar Waters
Marine and Arctic Technology Research Group has outlined a new project to develop risk-based guidelines which holistically consider the impact of risks in ice infested waters.
Aalto University, Finland (AALTO), Memorial University of Newfoundland, Canada (MEMORIAL), Hamburg University of technology, Germany (TUHH), The Norwegian University of Science and Technology (NTNU), University of Helsinki, Finland (UH)

Application of full-scale data to validate POLARIS

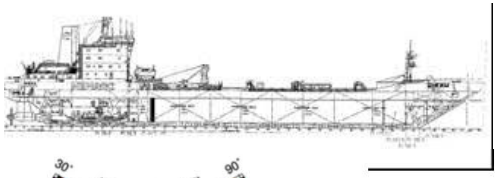
SA Agulhass 2012-2017

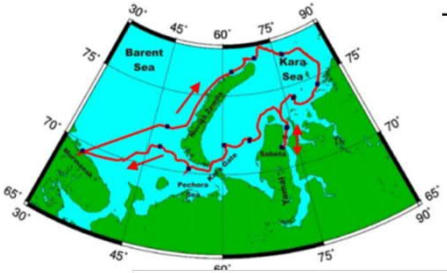


RIO_{SHIP}	Ice classes PC1-PC7	Ice classes below PC 7 and ships not assigned an ice class
RIO ≥ 0	Normal operation	Normal operation
-10 ≤ RIO < 0	Elevated operational risk*	Operation subject to special consideration**
RIO < -10	Operation subject to special consideration**	Operation subject to special consideration**

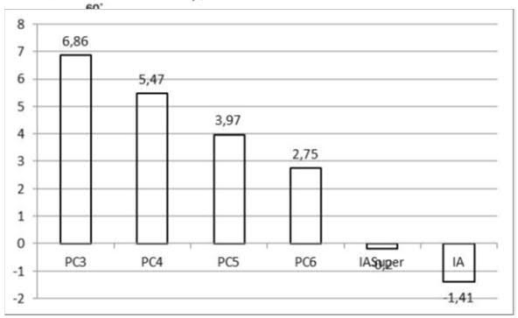
$$RIO=(C_1 x RIV_1)+(C_2 x RIV_2)+\ldots(C_n x RIV_n)$$

Validation of the Polar code for the independent navigation (PC3 Optimum)





ARCDEV
MT Uikku
1998



Validation of the Polar code for the navigation behind IB (PC6 Optimum)

Kujala, P., Kämäräinen, J. & Suominen, M., 2019, Validation of the new risk based design approaches (Polaris) for arctic and antarctic operations, POAC 2019 - 25th International Conference on Port and Ocean Engineering under Arctic Conditions, June

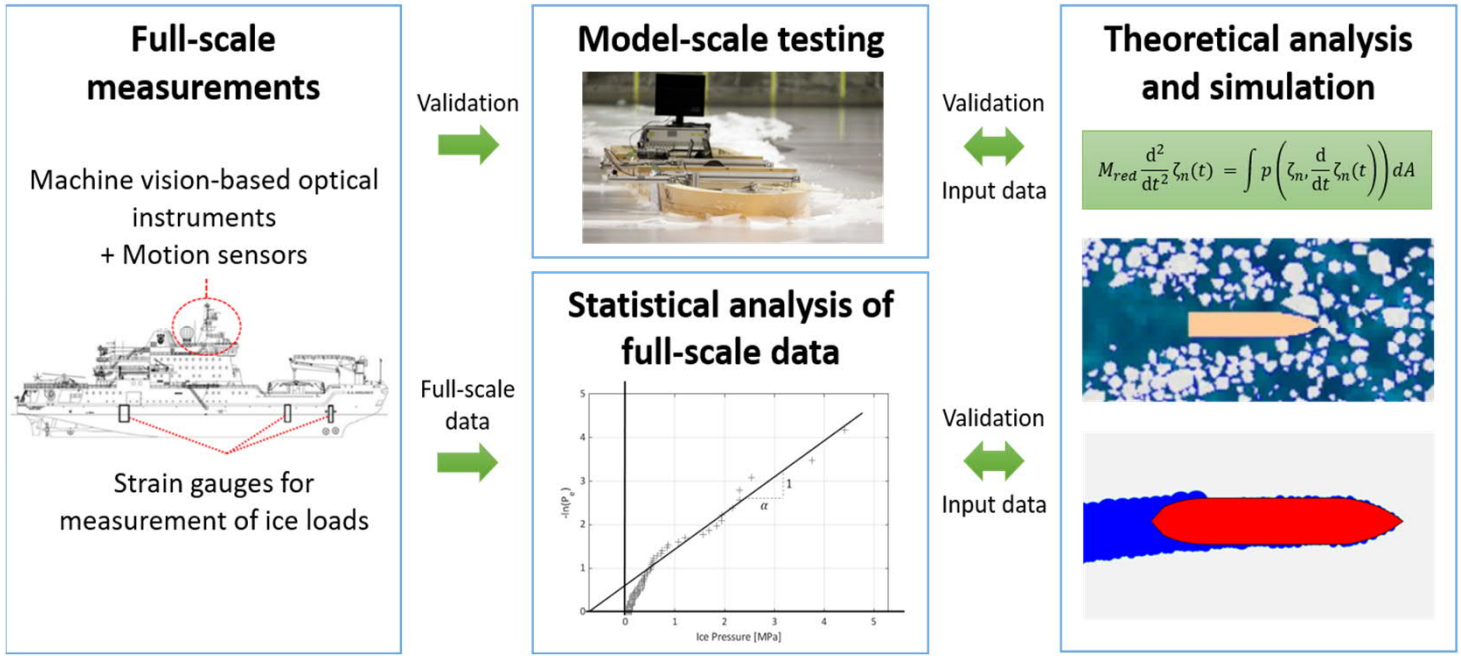
Update POLARIS (Ongoing)

Table 1.4 Risk Index Values – Winter Conditions

Category	Ice Class	Ice Free	New Ice	Grey Ice	Grey White Ice	Thin First Year Ice, 1st Stage	Thin First Year ice, 2nd Stage	Medium First Year Ice	Medium First Year Ice 2nd	Thick First Year Ice	Second Year Ice	Light Multi Year Ice	Heavy Multi-Year Ice
A	PC1	3	3	**3**	3	2	2	2	2	2	2	1	1
	PC2	3	3	**3**	3	2	2	2	2	2	1	1	0
	PC3	3	3	**3**	3	2	2	2	2	2	1	0	-1
	PC4	3	3	**3**	3	2	2	2	2	1	0	-1	-2
	PC5	3	3	**3**	3	2	2	2	1	0	-1	-2	-2
B	PC6	3	2	2	2	2	1	1	0	-1	-2	-3	-3
	PC7	3	2	2	2	1	1	0	-1	-2	-3	-3	-3
C	IA Super	3	2	2	2	2	1	0	-1	-2	-3	-4	-4
	IA	3	2	2	2	1	0	-1	-2	-3	-4	-4	-4
	IB	3	2	2	1	0	-1	-2	-3	-3	-4	-5	-5
	IC	3	2	1	0	-1	-2	-2	-3	-4	-4	-5	-6
	Not ice strengthened	3	1	0	-1	-2	-2	-3	-3	-4	-5	-6	-6

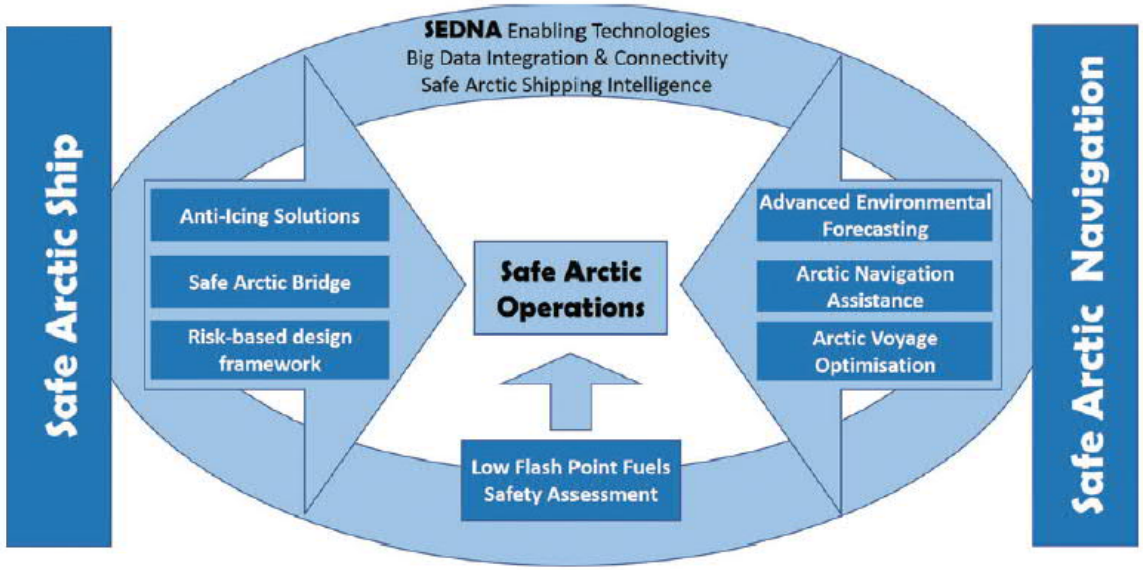
The idea is to update the risk numbers based e.g. on the amount of oil or number of passengers onboard

Comparison of full-scale data and simulation models



GPU-Event-Mechanics (GEM) simulation by Claude Daley and comparison with Agulhass II data

SEDNA-Safe Maritime operations under extreme onditions- The Arctic case



Project duration: Three years (2017-2020)
Funding: EU Framework Programme for Research and Innovation (Horizon 2020)
Partners: BMT Group Ltd, University College London, the MET Office, University of Southampton, and Lloyd's Register EMEA IPS (UK); Chalmers University of Technology, and Stena Rederi AB (Sweden); The Oslo School of Architecture and Design, and Ulstein Power & Control AS (Norway); Cork Institute of Technology (Ireland); Aalto University, and Aker Arctic Technology Oy (Finland); Dalian University of Technology, Harbin Engineering University, and China COSCO Shipping Corporation Limited (China)
Budget: €6,498,752.50

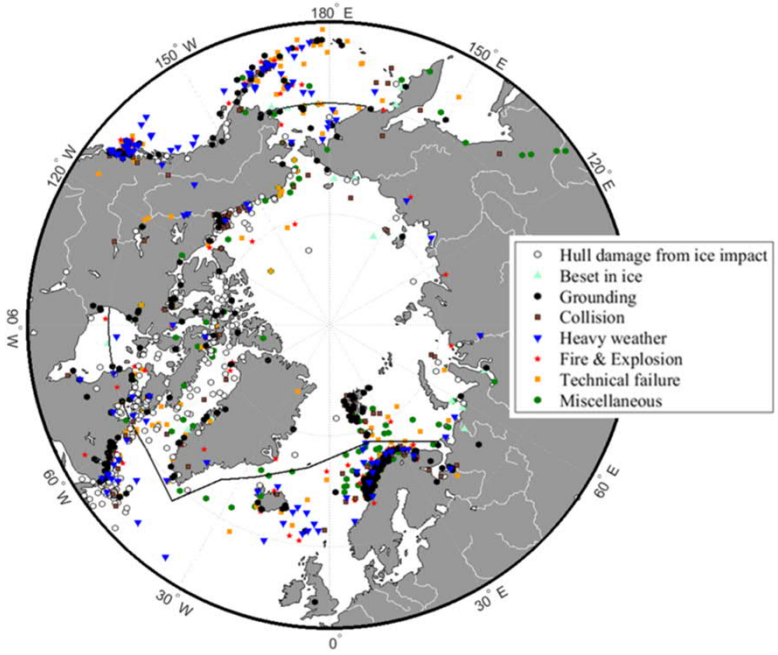
Analysis and development of design tools for risk-based design

Assessment of the risk of accidental events in Arctic maritime operations

- Accident data may help designers to identify typical operating specific accidental events, and to assess their likelihood

  → *We compiled all publically available Arctic maritime accident data into a comprehensive database*

  - Data on 3,362 accidental events from 1975-2018 involving ships above 500 GT

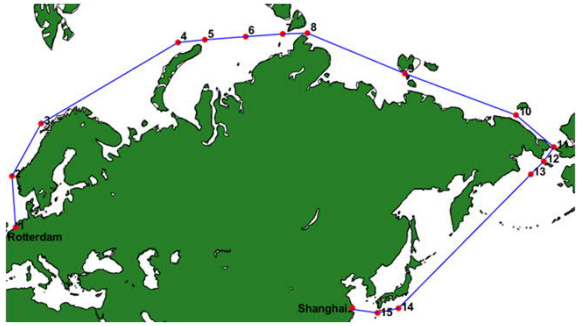


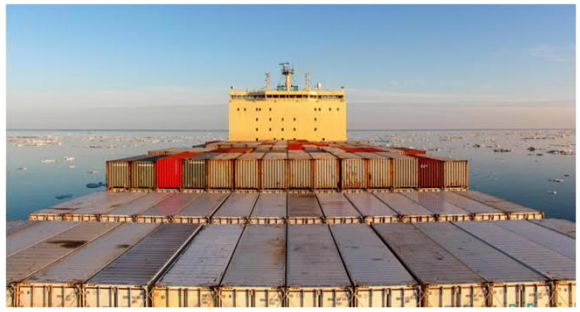
Huuhtanen, J., 2018. *Collection and analysis of arctic maritime accident data,* Espoo: Aalto University.

Risk-based design framework demonstration

Demonstration case together with Aker Arctic

- Design of a 5,000 TEU containership for an extended summer season (July – December) operation along the Northern Sea Route
- Application of our new approach for risk/goal-based design of Arctic ships developed within SEDNA
  - *Focus on hull structural design*
    - Weight comparison between a standard ‘rule-based’ and a new ‘risk/goal-based’ structural design

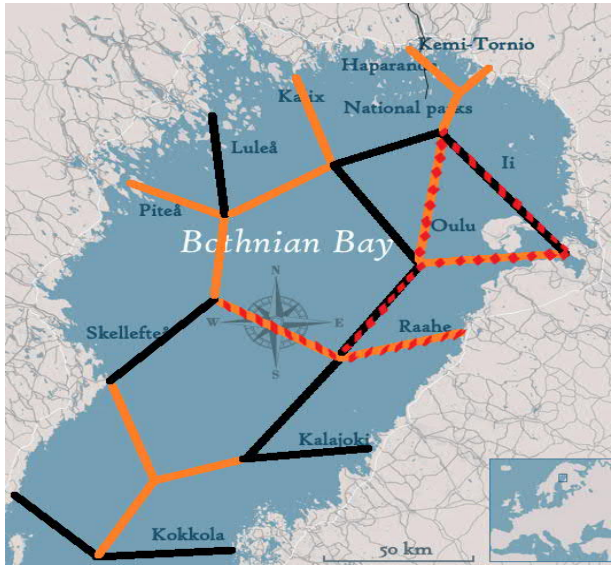




The Venta Maersk on the Northern Sea Route in September 2018. (Source: Courtesy of Maersk)

Other Ongoing Research

- Simulation model for winter navigation system of Finland, funded by LVM, Väylävirasto, TRAFICOM, Research question: How many icebreakers we need on 2030 ?
- INFUTURE , Future potential of Inland Waterways, 2018-2021, The South-eastern Finland – Russia CBC 2014-2020
- SIMREC, Simulators for improving cross-border oil spill response in extreme conditions, 2019-2022. South-East Finland-Russia CBC program.



Courtesy: Aker Arctic

New Opportunities as part of Marine X

To use Wasaline's Aurora Botnia and Sir David Attenborough (UK) to test new technologies for gathering and processing ice (environmental) information to feed into decision making for efficient operation in ice

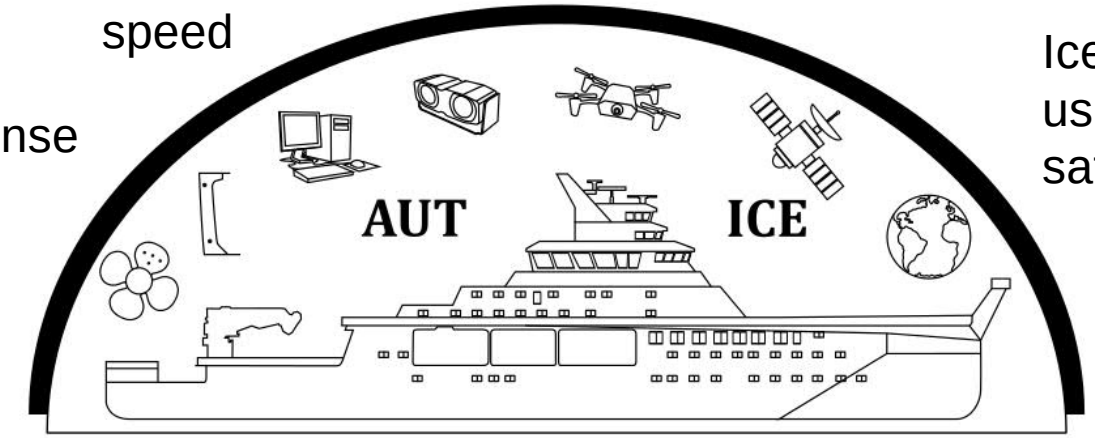
Analysis and processing for safe speed

Ice properties using stereo cameras /EM

Ice conditions using drones for routing

Hull response loads

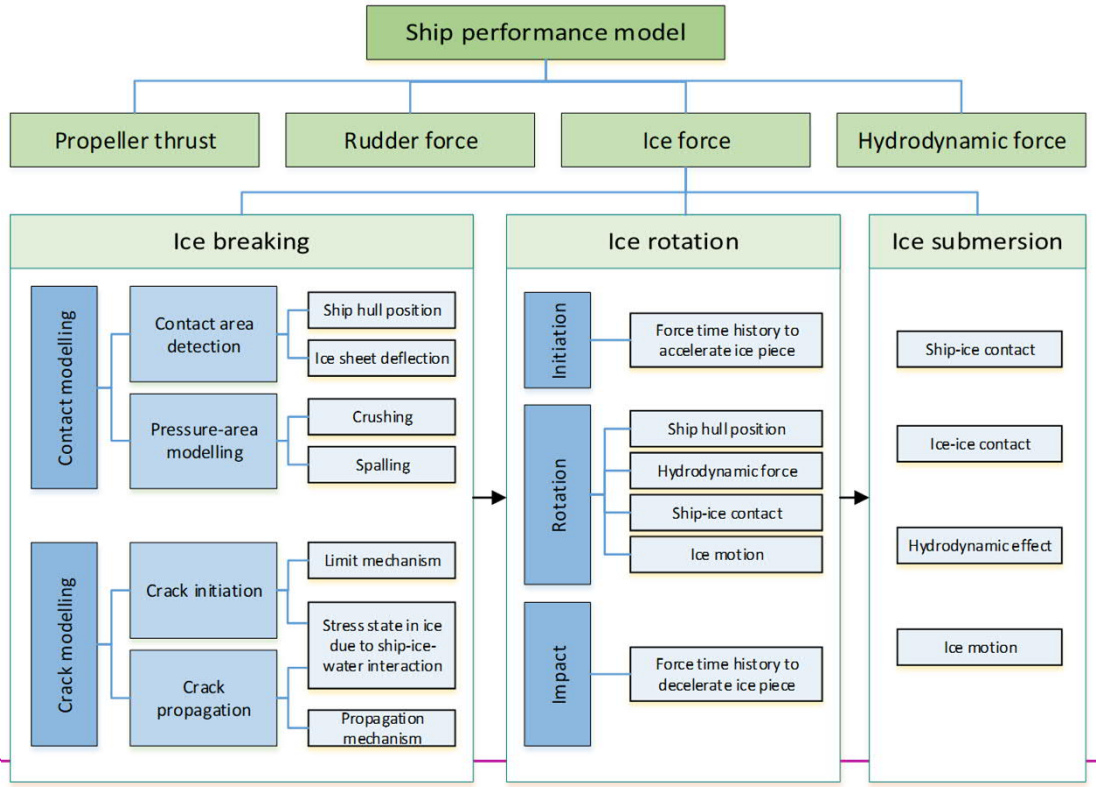
Ice imaging using satellites



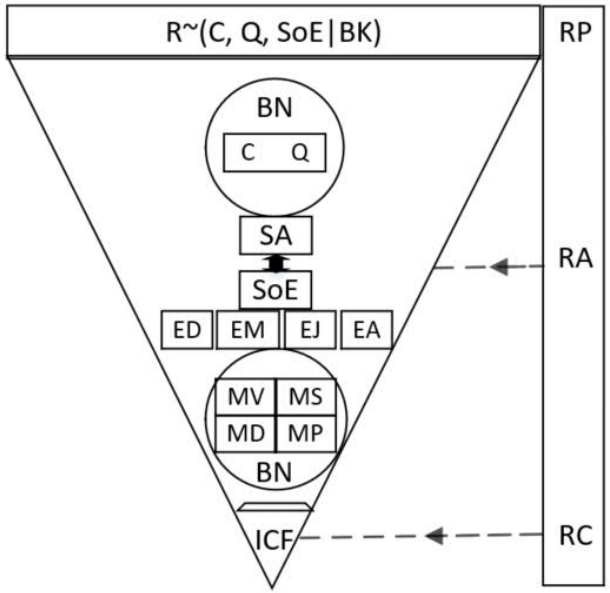
Propeller and shaft loads

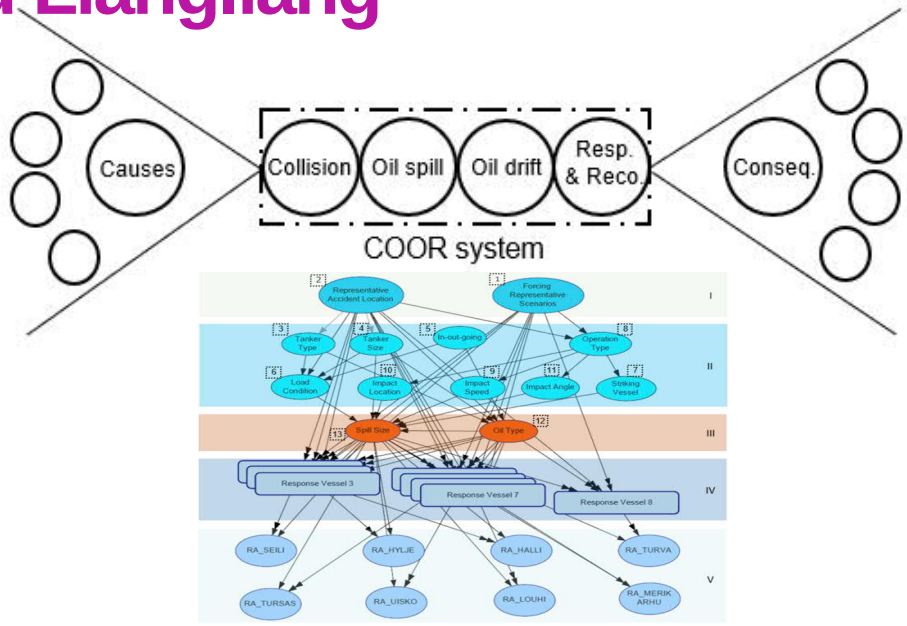
Main partners: Aker Arctic, RMC

New doctor thesis, 6.11.2020
Li Fang: Ship performance simulation model



Risk management of ship-source oil spill in ice conditions in NBSby Lu Liangliang





Step 1: Methodology - develop risk-based framework and method for risk management

Step 2: Modelling - develop firstly an oil response and recovery model and then COOR system model

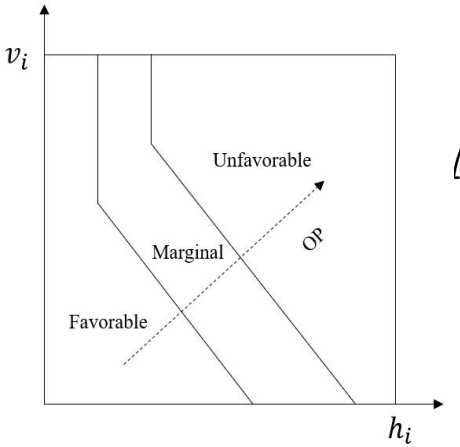
Step 3: Apply risk-based framework and method (step 1) to COOR system model (step 2) to identify critical factors in the system

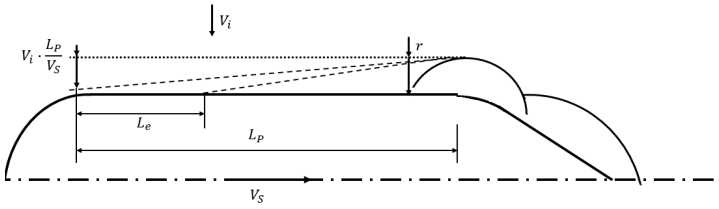
Lu. L., Goerlandt, F., Valdez Banda, O.A., Kujala, P., Höglund, A., Arneborg, L. 2019. A Bayesian Network risk model for assessing oil spill recovery effectiveness in the ice-covered Northern Baltic Sea. MPB.

Lu. L., Goerlandt, F., Tabri, K., Höglund, A., Valdez Banda, O.A., Kujala, P., 2020. Critical aspects for collision induced oil spill response and recovery system in ice conditions: A model-based analysis. *JLPPI*.

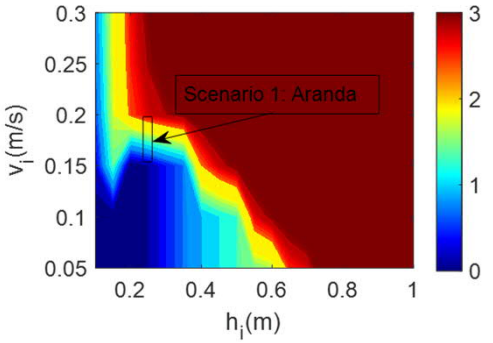
Risk management of ship-source oil spill in ice conditions in NBS

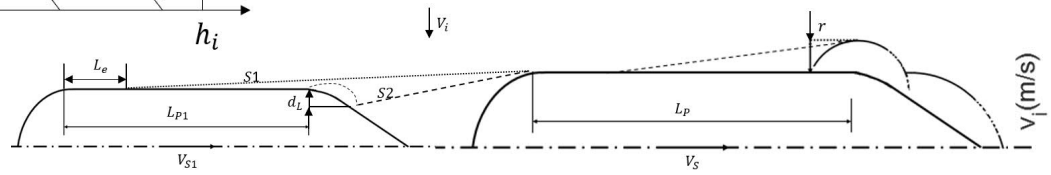
Step 4: Risk control - develop transit model and operability index for response vessel in dynamic ice



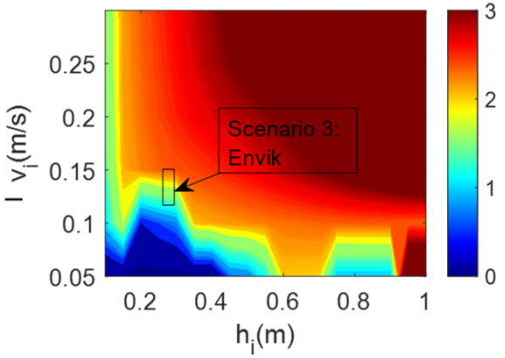


Independent navigation





Escort



Lu. L., Kujala, P., Goerlandt, F., 2020.
A method for assessing ship operability in dynamic ice for independent navigation and escort operations. Submitted to OE.

THANK YOU FOR YOUR ATTENTION !