Operations in Low Temperature & Ice Infested Environments

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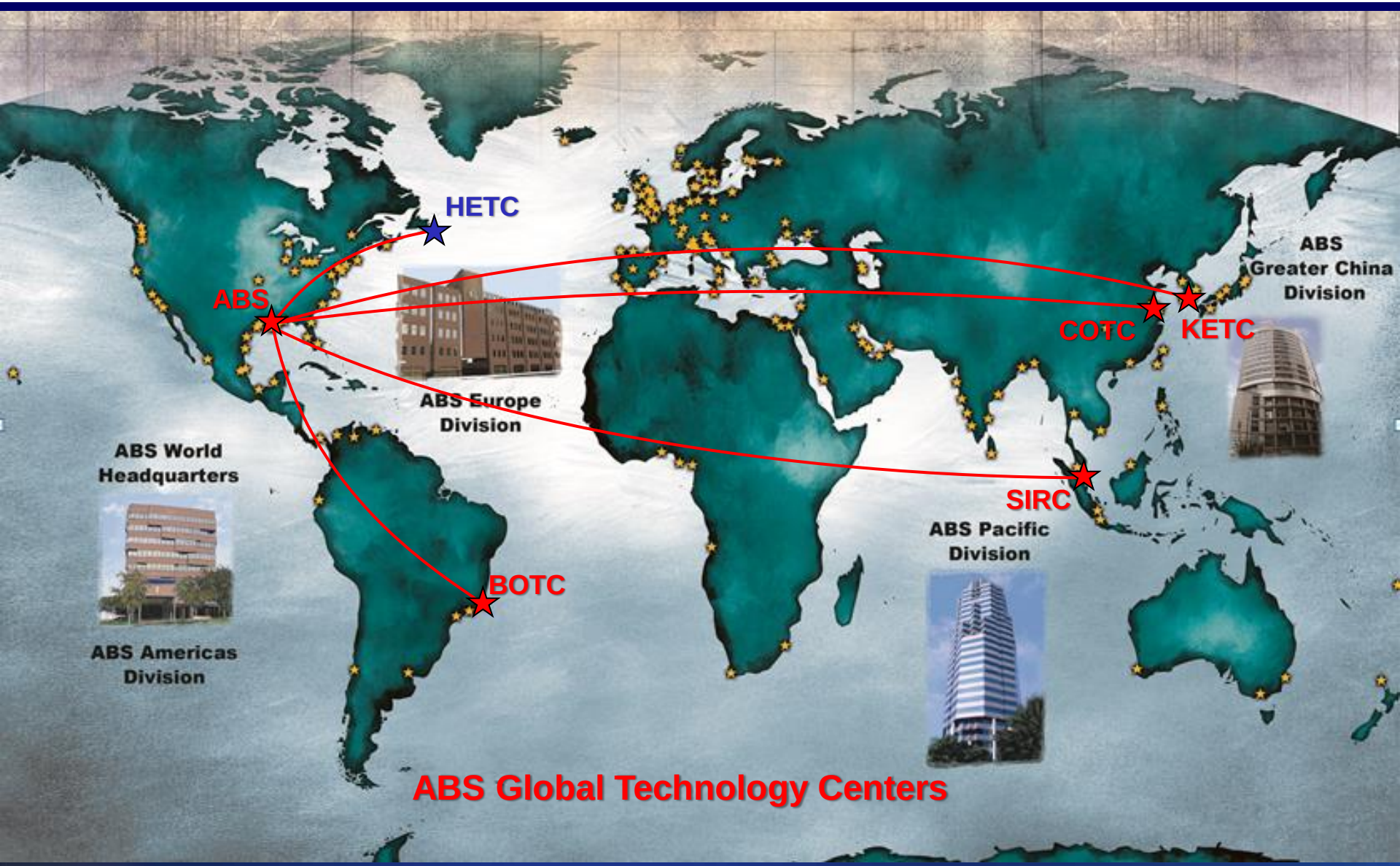
Outline

- ABS Technology
- Some personal experiences
- ABS History in the Arctic and Sub-Arctic
- ABS Guide for Vessels Operating in Low Temperature Environments (LTE)
- Recent and Present Projects
  - Risk-based winterization
  - Hydrophobic coatings
  - STePS2
  - High speed simulation

ABS Technology

- Research and development arm of ABS
- Projects address technical issues
  - Industry demands
  - Enhance ABS technical capabilities
  - Support ABS divisions
- Collaborative approach
  - Joint development project (JDPs)
  - Joint industry projects (JIPs)
  - Industry, academia and government partners
- Global reach
  - Technology centers

ABS Worldwide Network



ABS History in Cold Regions

- Arctic
  - Manhattan
  - Glomar Beaufort Sea 1
  - Moliqpak
  - SSDC
  - Kulluk
- Sub Arctic
  - Glomar Atlantic (NL)
  - Sedco 710 and 706 (NL)
  - Rowan Juno, Gorilla III, Gorilla V (NS)
  - GSF Galaxy II (NS)

Effects of Cold: Machinery

Bursting by expansion

Clogging

Brittle fracture

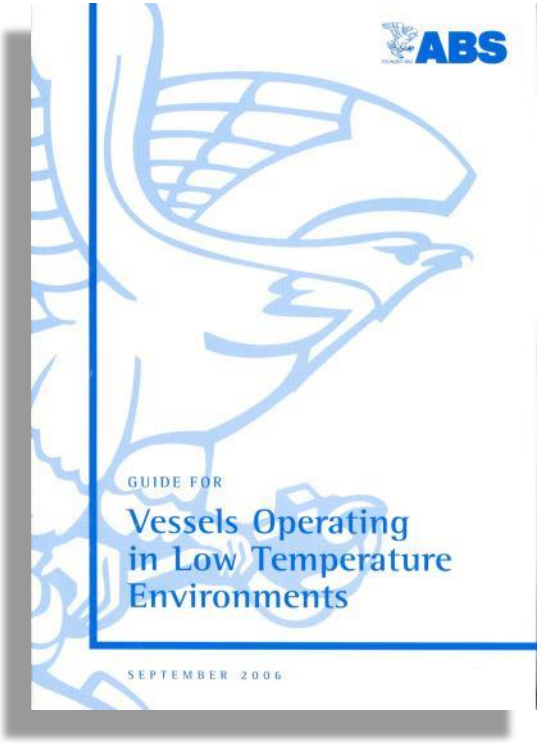
Effects of Cold: Machinery

Brittle fracture

Cover stuck to coaming

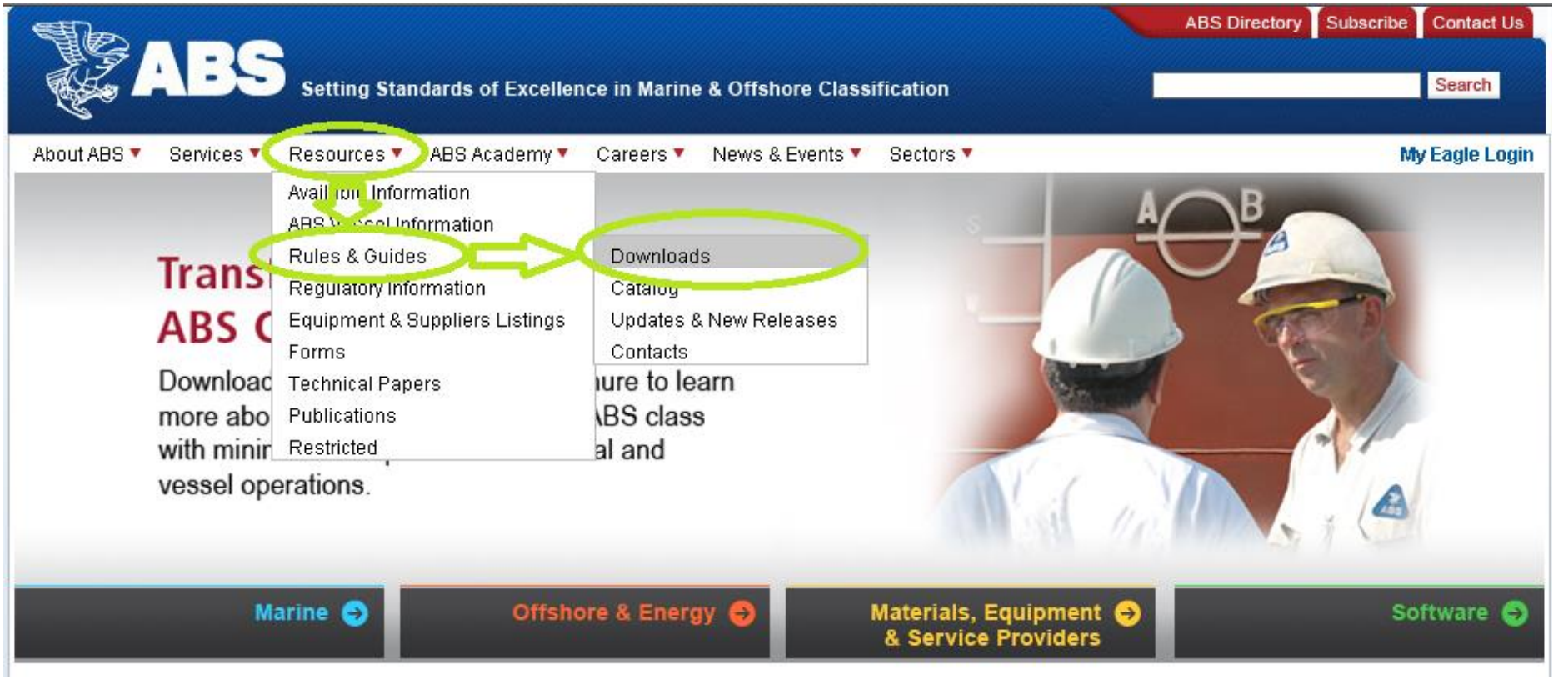
ABS LTE Guide

- Guide for Vessels Operating in Low Temperature Environments (LTE)
- Address winterization issues not covered by ice class
  - Response to client feedback; unsatisfactory equipment performance on ice class vessels
  - Increased trade in Arctic and Baltic regions
- Developed with
  - Internal personnel with Baltic and polar experience
  - Input from ice experts and shipbuilders
- Originally published September 2006
- Updated May 2012



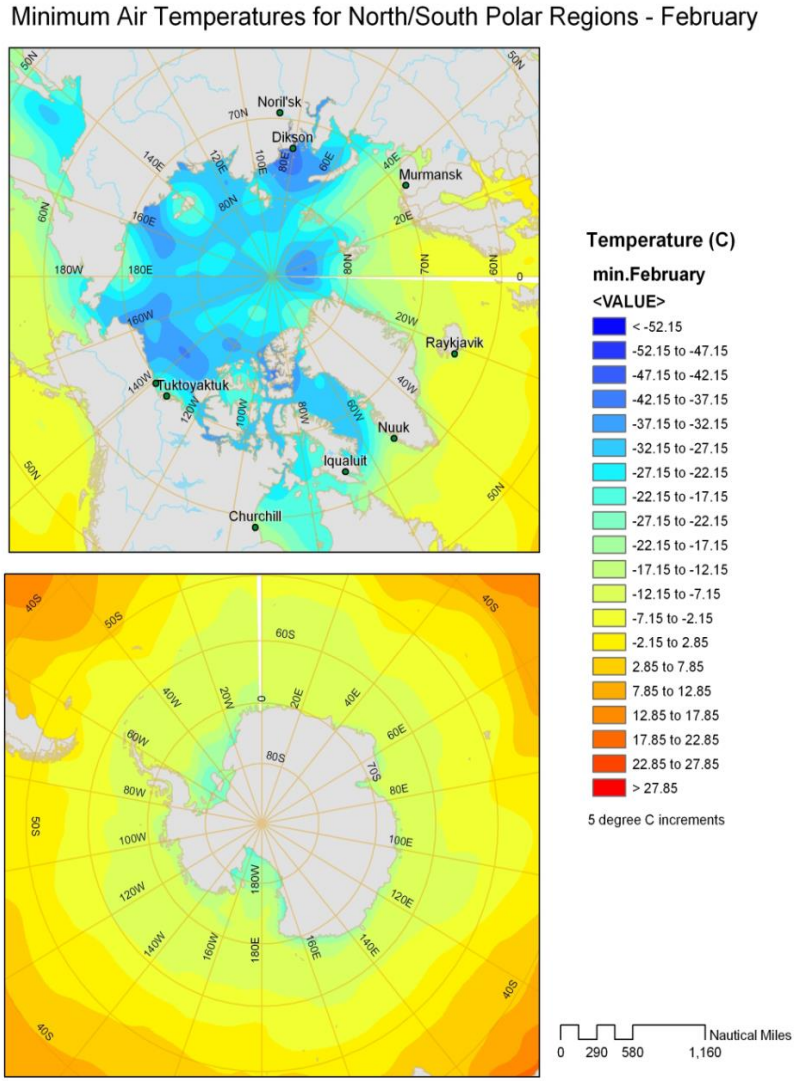
Where to Get the ABS LTE Guide?

- Apple App store – “ABS Bookshelf”
- It’s a free download at www.eagle.org see Publication No. 151



ABS LTE Guide

- Two documents in one
  - Guide – requirements
  - Guidance Notes – as appendices with additional explanations
- Supplementary information
  - Weather conditions
  - Additional reference materials
  - Administration listings
  - Meteorological organization listings



General Section

- Application
  - Any vessel or marine structure operating in cold area
  - Ice-covered or non-ice covered seas
  - Exposed hull structure materials must be suitable
  - Design service temperatures ≤ -10°C
- Objective
  - Improve vessel and system performance

Temperature Definitions - DST

Commonly used Definitions of Temperature

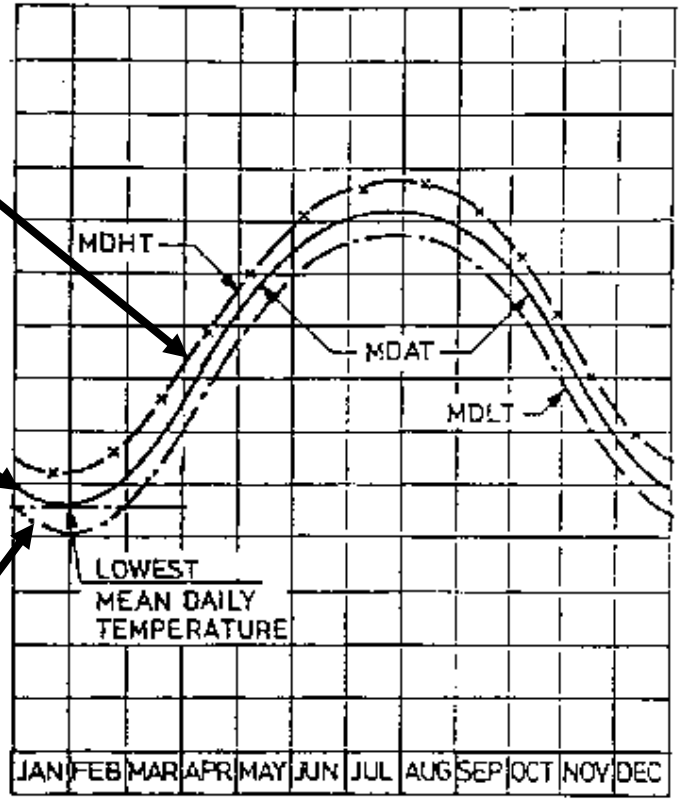
Mean:
Over observation period (min. 20 years)

Average:
During one day and one night

MDHT
Mean Daily High Temp.

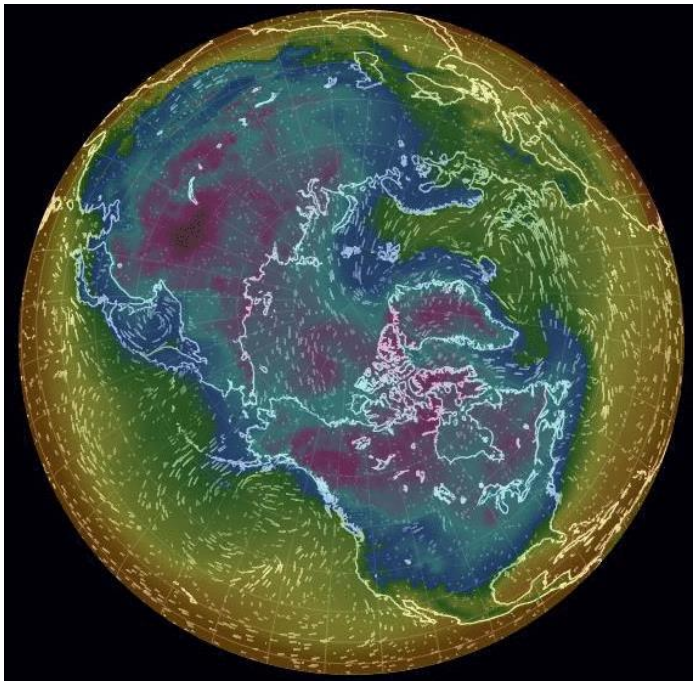
MDAT
Mean Daily Average Temp.

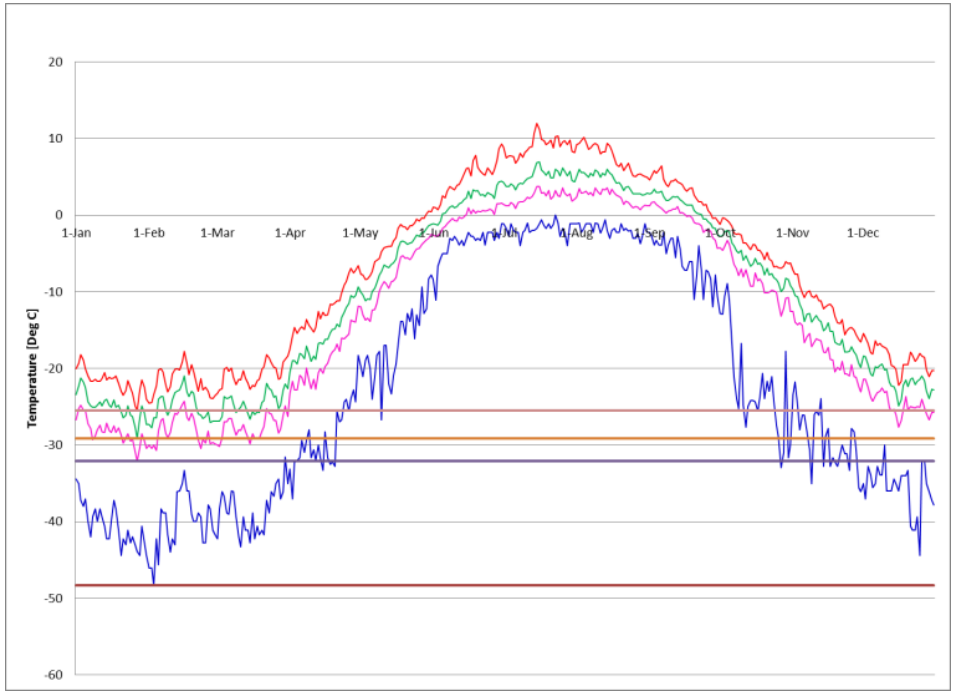
MDLT
Mean Daily Low Temp.



Temperature Definitions - MAT

- Minimum Anticipated Temperature (MAT)
  - Specified by the owner, designer, shipyard
  - In absence of temperature data -20°C lower than DST for exposed machinery (MAT = DST -20)
  - Generally used for machinery requirements





Materials Selection

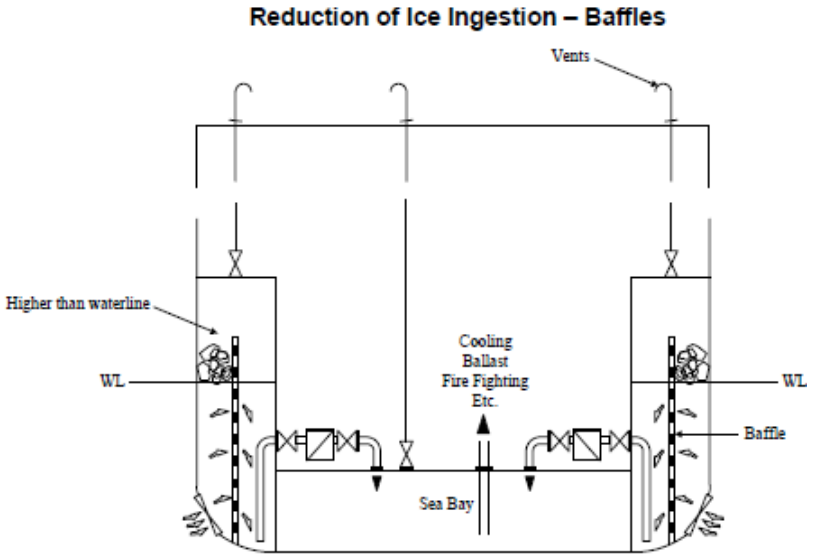
- Material grade selection basis
  - Temperature
  - Application
  - Material thickness
- Hull structural members
  - Design Service Temperature (DST)
- Exposed machinery and associated foundation components (load bearing)
  - Minimum anticipated temperature (MAT)
  - Cranes have their own low temperature requirements

Tanks

- Fuel Oil Tanks
  - Location will determine heating requirements
  - Heating calculations to show sufficient heat transfer capacity
  - POT class notation
- Fresh Water Tanks
  - Practice is to avoid contact with shell
  - Turbulence system or heating coils
- Ballast Water Tanks (Preload)
  - Antifreezing DST from -10°C to -30°C
  - Requiring heating coils for DST < -30°C
  - Tank heating calculations

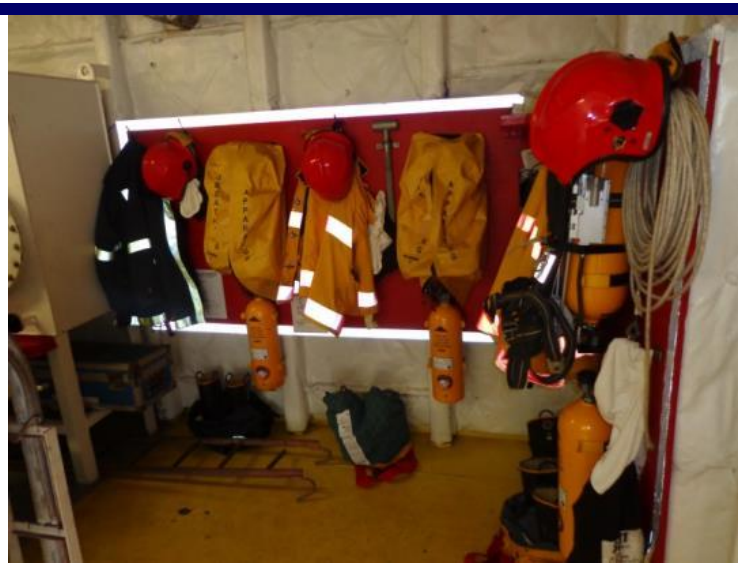
Systems & Machinery: Engines

- Low power operation considerations for auxiliary equipment
- Combustion air – direct ducting and preheating
- Turbochargers
- Lubricating oil systems
- Pre-heating and cooling systems



Systems & Machinery

- Piping
  - Materials suitable for MAT
  - Piping arranged to drain fluids
  - Keep pipes from freezing
- Fire safety systems
  - Fixed extinguishing systems
  - Portable extinguishers
  - Fire mains
- Electrical
  - Emergency source
  - Motors
  - Cables
- Propellers



Safety Systems

- Heating for survival
- Lifesaving appliances
  - Protective clothing
  - Life boats
    - Larger size
    - Heaters
    - Engine starting
  - Life rafts
  - Launching arrangements
  - Alarms and communications
- Drills and emergency instructions

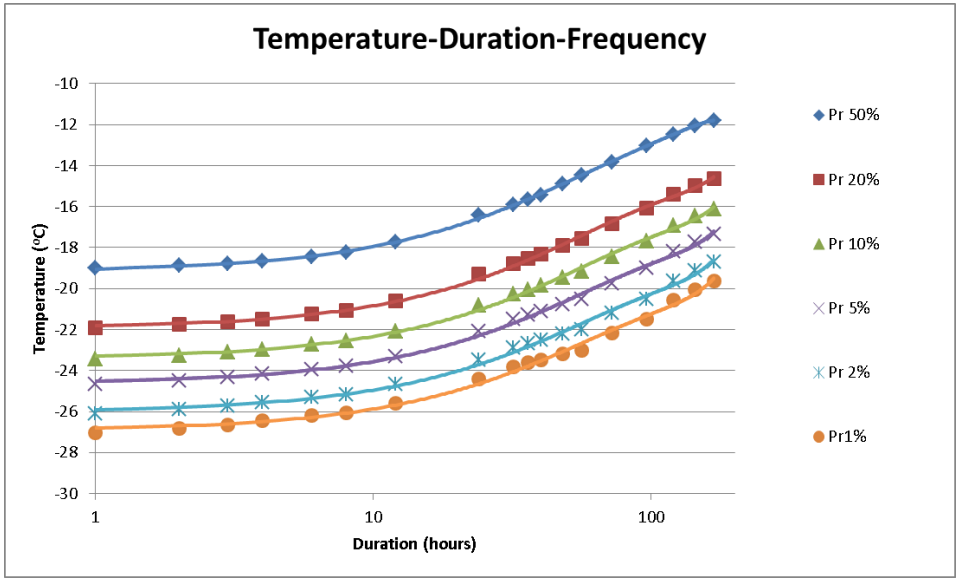
LTE Guide Appendices

- Effects of wind, such as ice accretion (Appendix 3)
- Experience based solutions to machinery problems (Appendix 4)
- Human factors (Appendix 8)
- Training and Documentation (Appendix 9)
- Temperatures and climatic information (Appendix 10)
- Notes on vessel operations (Appendix 11)

Risk-based Winterization

- Project with experts from Memorial University of Newfoundland
- In line with ABS Novel Concepts Guide
- Define acceptable risk for given system and the unit as a whole
- Environmental loading is a fluctuating random variable
- Design winterization solution to minimize the risk
- Example: Crane
  - Temp < design temp

PROBABILITY \ CONSEQUENCE	Insignificant (0-2)	Marginal (2-4)	Moderate (4-6)	Critical (6-8)	Catastrophic (8-10)
Definitely (0.1-1)	High	High	Very High	Very High	Very High
Likely (10^{-2}-10^{-1})	Medium	High	High	Very High	Very High
Occasional (10^{-3}-10^{-2})	Low	Medium	High	Very High	Very High
Seldom (10^{-4}-10^{-3})	Low	Low	Medium	High	Very High
Unlikely (<10^{-4})	Low	Low	Medium	High	High



Ice Accretion is a Critical Safety Issue

Air intakes & Vents

Navigation & Communications

Evacuation & Helidecks

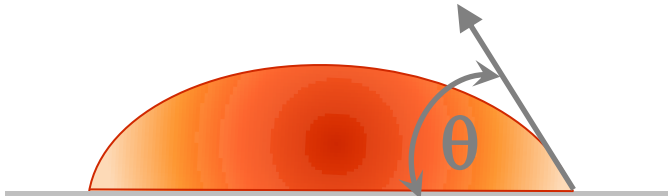
Ladders & Lifesaving Devices

Electrical/Equipment Panels

Derricks & Drilling Equipment

Controlling the Contact Angle

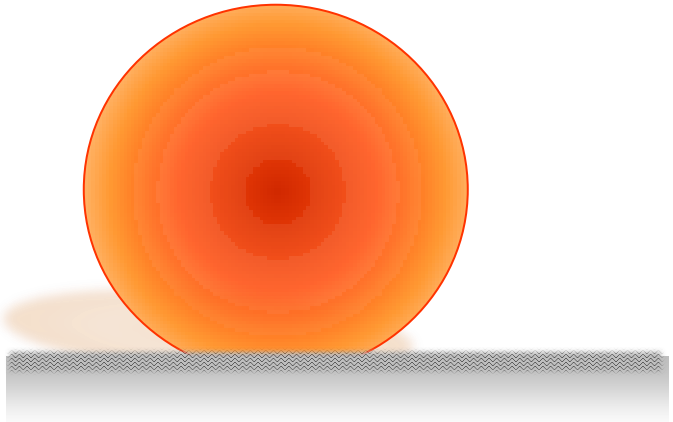
- Super-hydrophobicity combines low surface energy and roughness
- First step, GWU examined the correlation between ice adhesion strength and contact angle



θ < 90° hydrophilic

θ > 90° hydrophobic

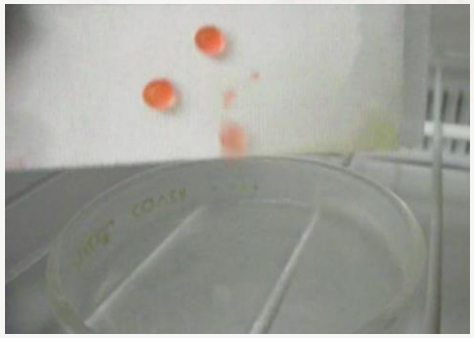
θ > 120° superhydrophobic

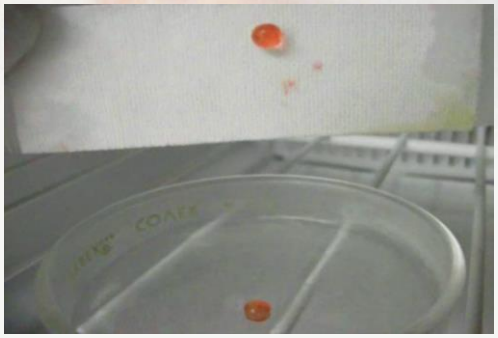


George Washington researchers obtaining contact angles over 155 °

Icephobic Nano-Structured Coatings & Surfaces

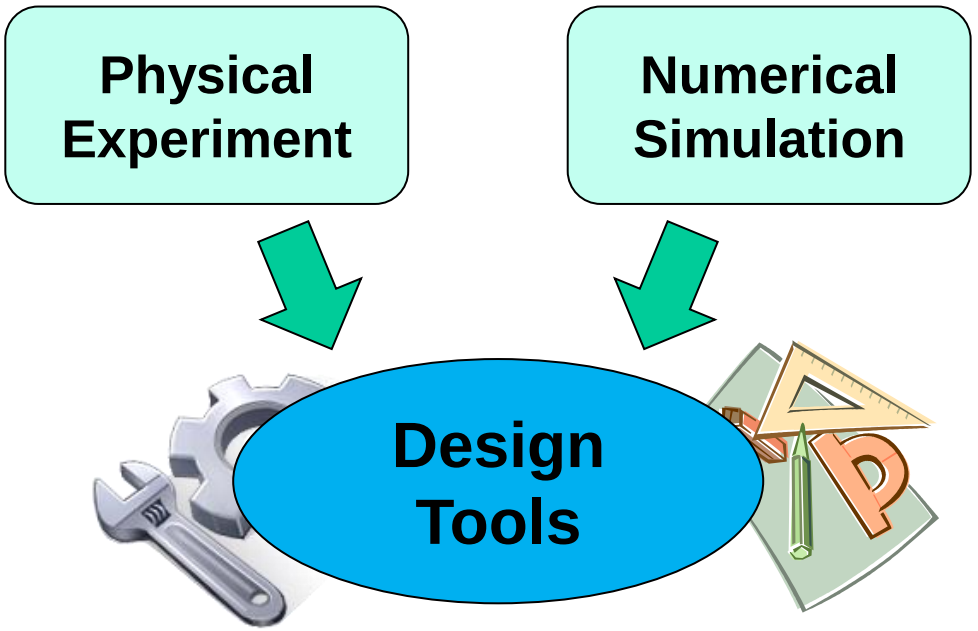
Early success of ABS funded research at George Washington University on icephobic surfaces – but main aim is to develop a performance evaluation standard



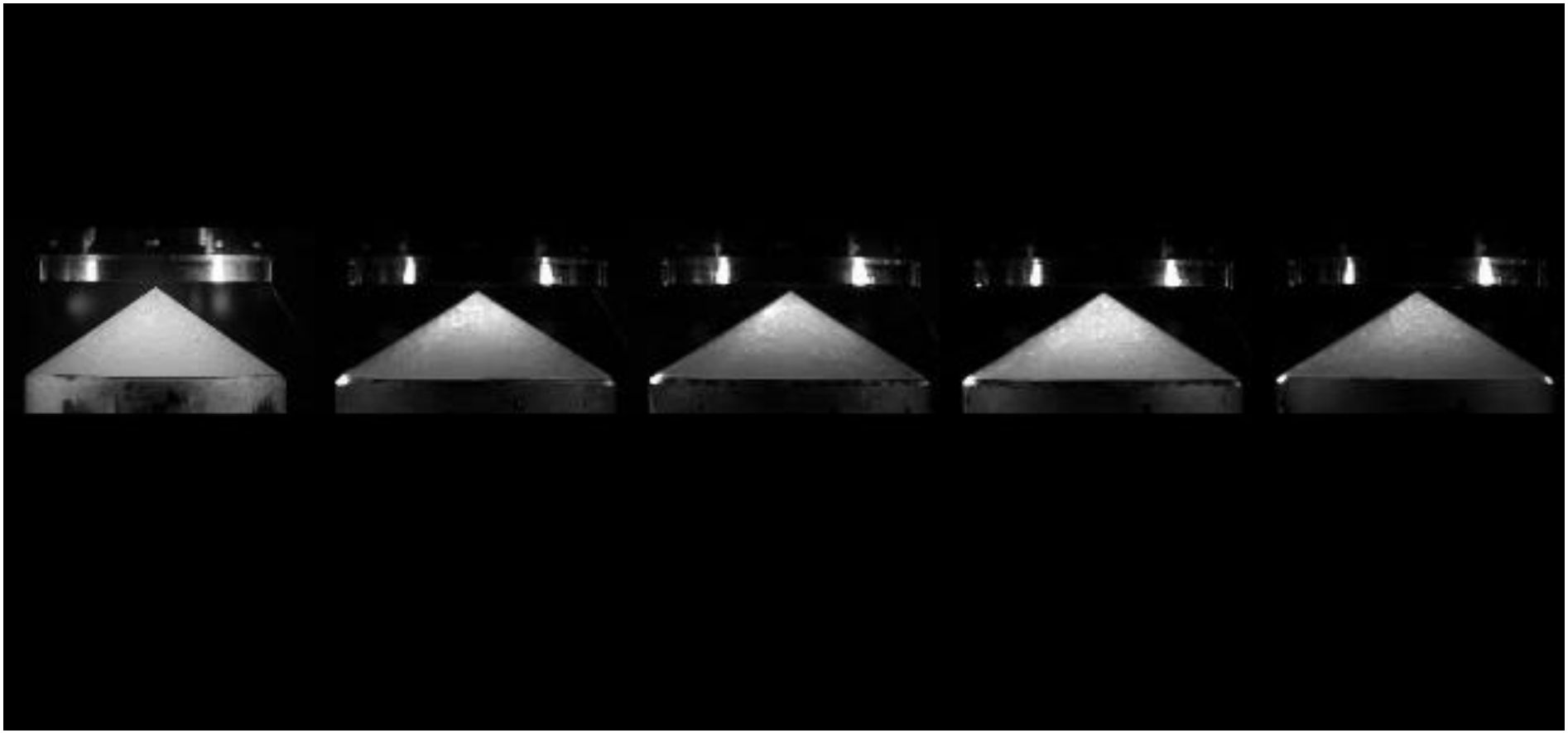


STePS² Project

- Developing direct design tools for the next generation of polar ships and structures
- Major funding from industry, Canada government agencies
  - 5-year (2009 – 2013), $7 million program – wrapping up over next few months
  - 5 industry partners
- Focus on
  - Physical experiments
  - Numerical simulations
  - Design tools

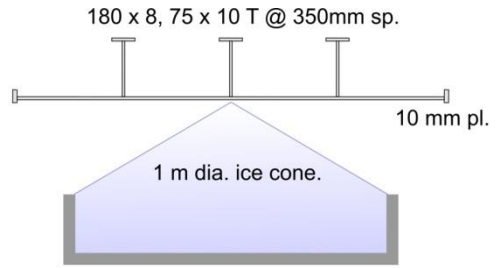


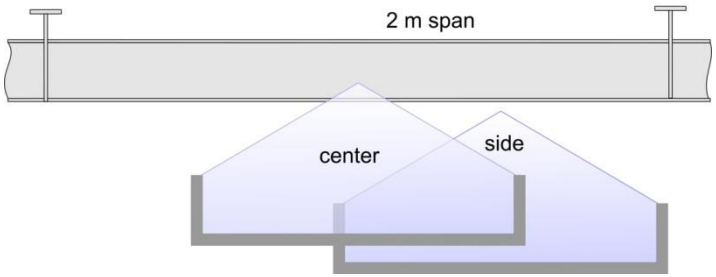
Ice Cone Crushing Tests

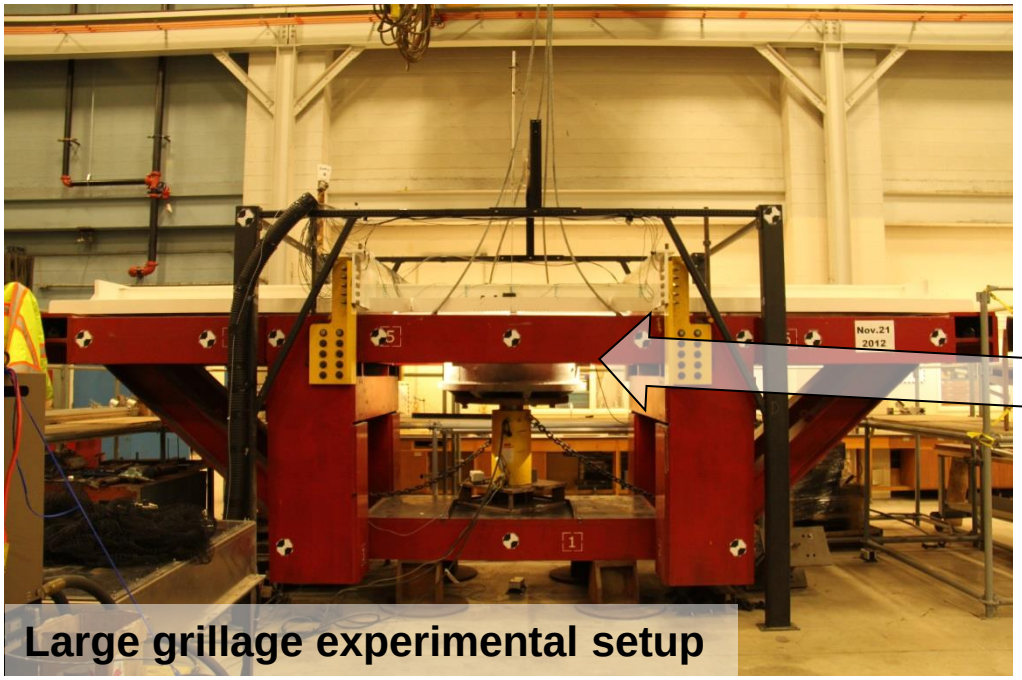


STePS² Large Grillage Experiments

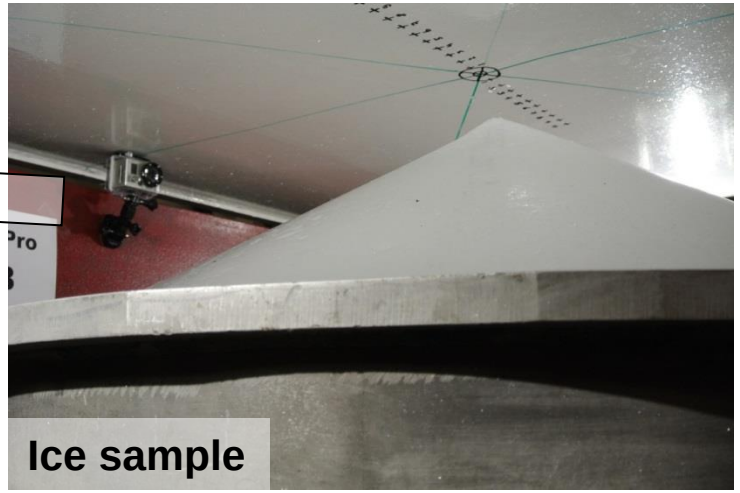
- Structure
  - ~PC6/7 midbody icebelt scantlings
- Ice
  - Lab-grown polycrystalline ice
  - Controlled and repeatable





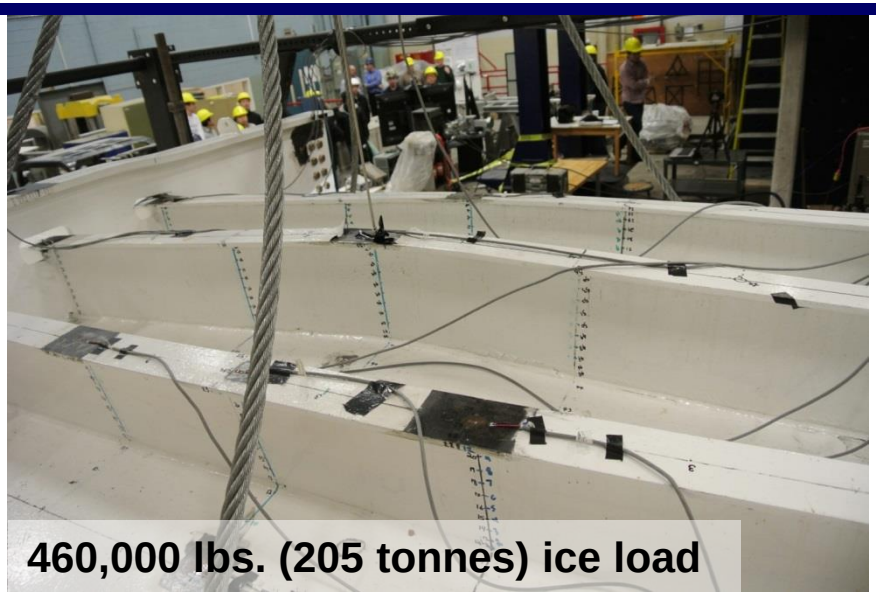


Large grillage experimental setup

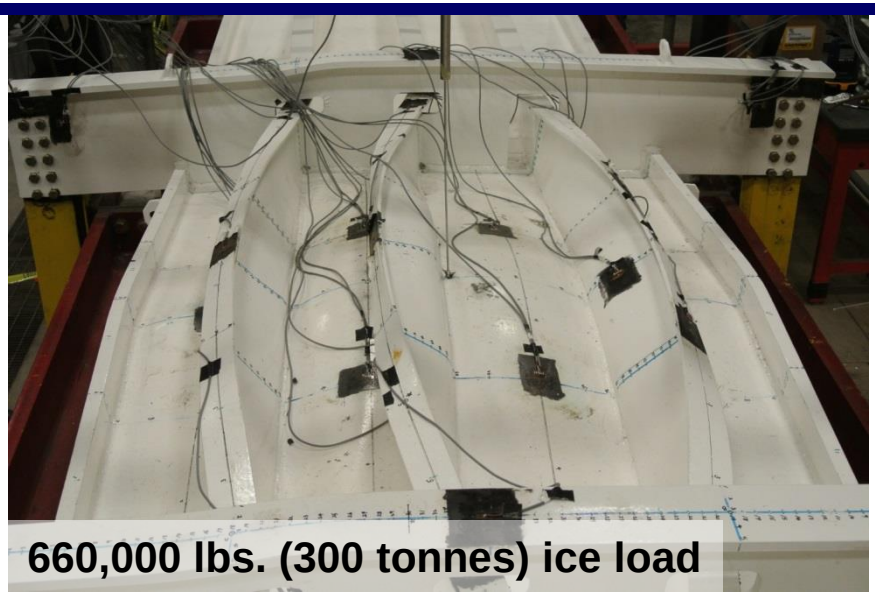


Ice sample

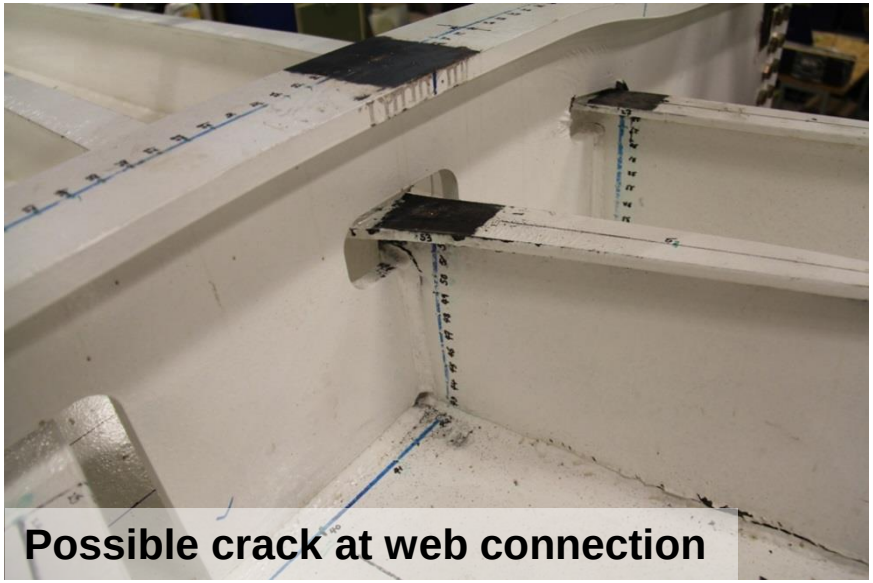
STePS^2 Large Grillage Experiments



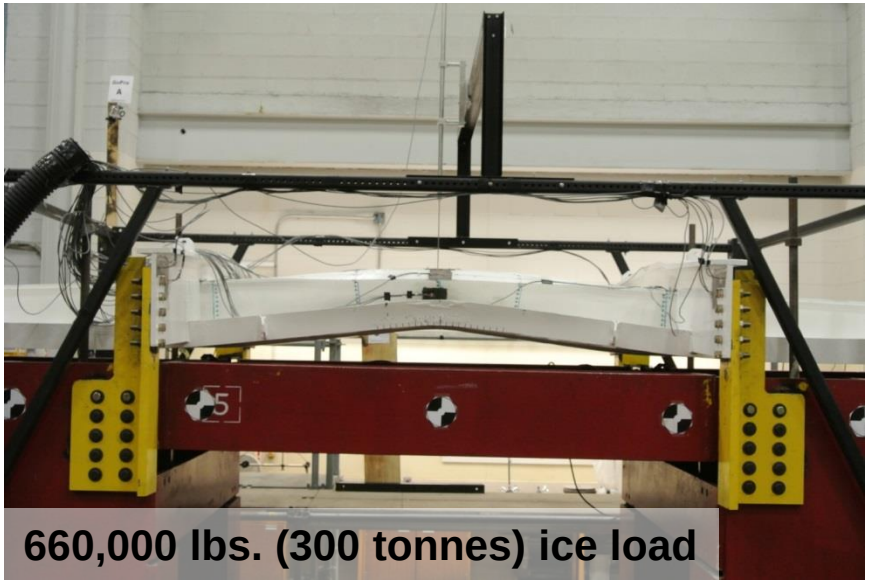
460,000 lbs. (205 tonnes) ice load



660,000 lbs. (300 tonnes) ice load



Possible crack at web connection

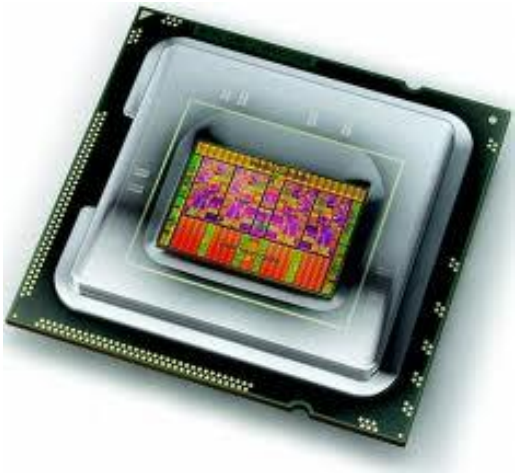


660,000 lbs. (300 tonnes) ice load

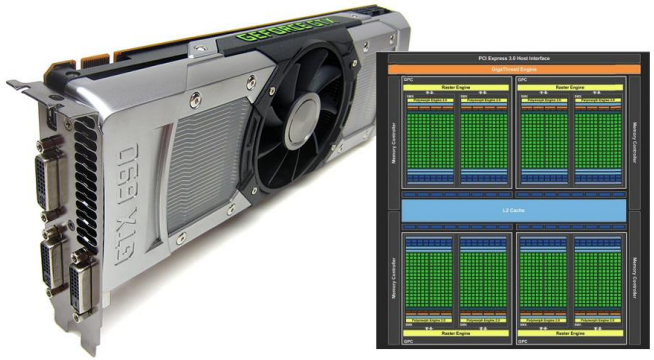
Ice Interaction Simulation using GPU Computing

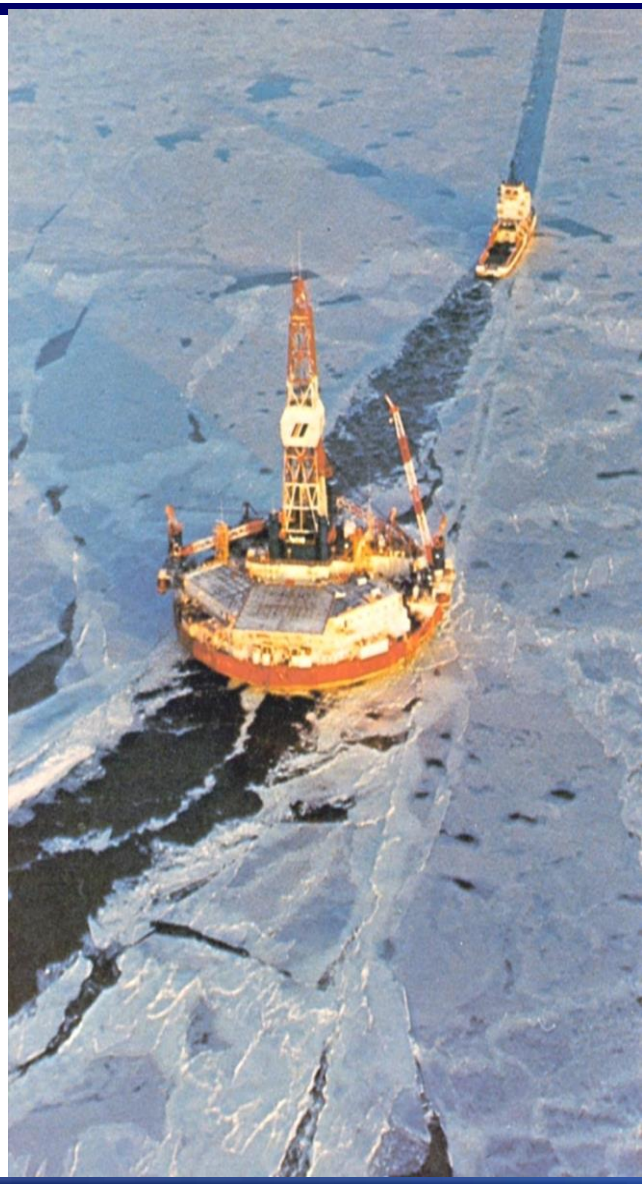
- Graphic Processing Units (GPU) are used
  - Thousands of processors
  - Movies and computer games

Intel i7 chip (4 cores)



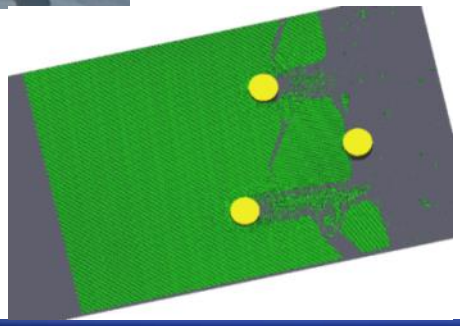
NVIDIA GTX690 GPU
(3072 cores)

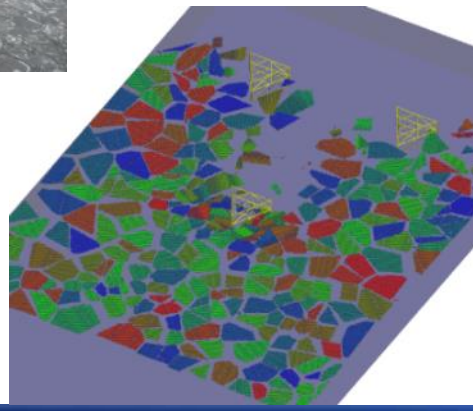




GPU-based Discrete Element Method (DEM)

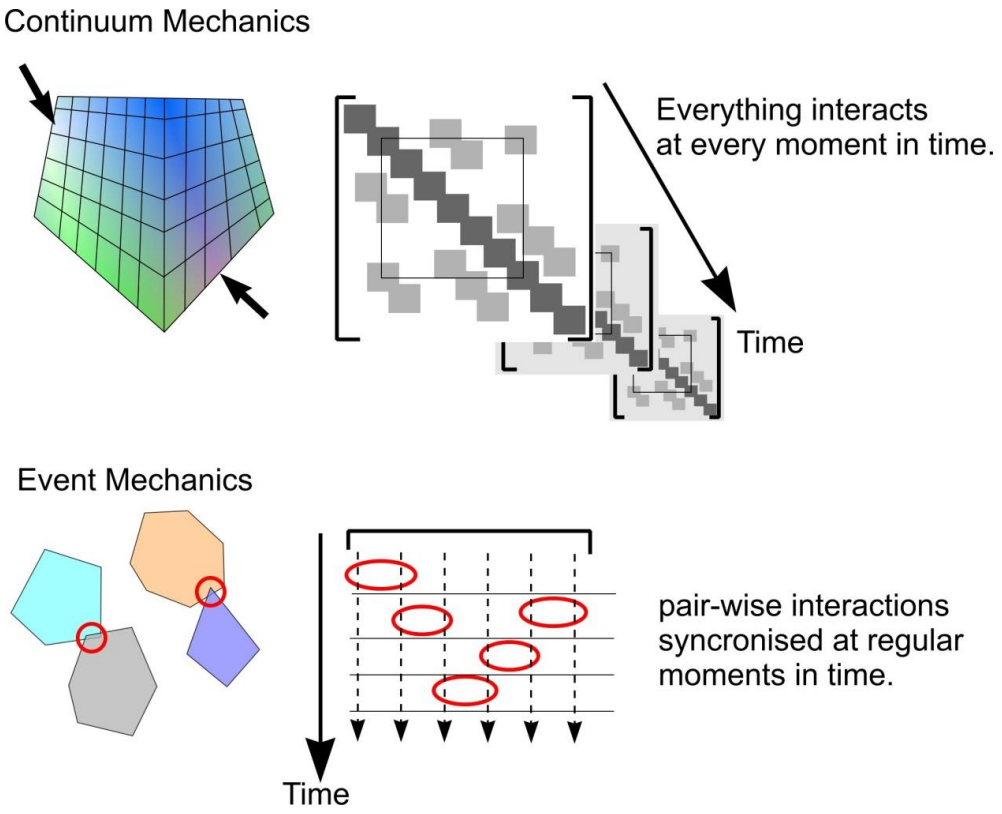
- Objective: To develop a practical and advanced tool for assessing the loads on offshore structures from various ice features
- Approach: Discrete Element Method (DEM) jointly developed by ABS and Dalian University of Technology





GPU-based Event Mechanics (GEM) Simulation

- Large number of separate solids:
  - Discrete impact events (10N contacts)
- Body kinematics between events



Questions?

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