SEDNA – Safe maritime operations under extreme conditions: the Arctic case

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https://sedna-project.eu/
http://appmech.aalto.fi/en/research/marine_technology
SEDNA overview

SEDNA - Safe maritime operations under extreme conditions: the Arctic case

• Goal: An innovative and integrated risk-based approach to safe Arctic navigation, ship design and operation
• 13 partners (6 different countries including China)
• Duration: 3 years (06/ 2017 – 06/2020)
• Budget: 6.7 M€ (EU contribution: 6.5 M€)
• Coordination: BMT Group (UK)
SEDNA approach - Overview
SEDNA technologies (1/5)

‘Safe Arctic Bridge’
• A human-centered bridge using Augmented Reality (AR) technology for improved situational awareness and decision making
  - Reduced head down time
  - Information management → Information overflow avoidance
  - Efficient integration of technologies and applications
SEDNA technologies (2/5)

Arctic voyage planning tool

• Multi-objective
  - Voyage costs
  - Voyage time
  - Risks
  - ...
• Big data analysis
SEDNA technologies (3/5)

Anti-icing coating

• Two different types
  a) A low-cost, tough coating for application on the superstructure and other large areas
  b) A transparent coating for lifeboat surfaces and windows

- A nature inspired approach (e.g. penguin coat)
- Real-world testing onboard COSCO and STENA ships
SEDNA innovations (4/5)

Use of Low Flash Point Fuels (LFPFs)

- Advantages
  - Lower emissions
  - Biodegradable $\rightarrow$ Reduced risk of accidental spills
  - Liquid at room temperature (advantage over LNG)

- To ease the use of flash point fuels $\rightarrow$ development of generally acceptable procedures for their use in Arctic
  - Safety Assessment $\rightarrow$ Recommendations to the IMO

- Builds on experience from Stena Germanica, the world’s first methanol-powered ferry
SEDNA innovations (5/5)

A holistic goal-based design framework

• Aims to integrate the goal-based regulations of the Polar Code into a holistic design process
• System thinking
  - A ship is treated as a component of a wider maritime system (system of systems)
• Discrete event simulation based Monte Carlo simulations
  - Probabilistic performance assessment considering multiple stochastic factors
  - Simulation of data → Performance assessment

The International Code for Ships Operating in Polar Waters (Polar Code)

• First international regulatory framework mitigating arctic shipping related risks
• Enforced January 1, 2017
• Aim: to provide for safe ship operation in polar waters and the protection of the polar environment
• Its mandatory safety provisions are largely goal-based
SEDNA design framework - Interaction with the Polar Code

Polar Code: mandatory safety provisions determined in terms of an overall goal, functional requirements to fulfil the goal, and regulations

• A solution can be accepted
  - As a standard design that comply with all the regulations associated with the related functional requirements
    • References to IACS Polar Class standards
  - Or as an alternative design that has been reviewed in accordance with IMO guidelines and found to meet the intent of the goal and functional requirements concerned and provides an equivalent level of safety

• Challenges
  - Lack of agreed on safety performance metrics
  - Lack of well-proven performance assessment methods or ‘testing standards’
SEDNA - Goal-based structural design

**Route / Operating**

**Stochastic data**

**Discrete event simulation**

**Simulated data**

**Design context**

**Stochastic data**

**Design tool(s)**

**Probabilistic ice pressure assessment**

\[ z \approx [4.6 + \ln(xf)]CA^D \]

*Method by (Jordaan et al., 1993)*

**Design input / data**

**Probabilistic ice loading**

- E.g. 30 year maximum

**Functional requirement**

- Maximum acceptable damage frequency
  - E.g. ice damage allowed max once in 30 operating years
- Minimum required strength margin
  - With regards to the expected max ice loading during a ship’s expected operational lifetime (e.g. 30 years)

SEDNA - Goal-based structural design

Work to be done

• Validation using full-scale ice load measurements measured onboard S. A. Agulhas II

• Extension of the applicability of the probabilistic ice load tool
  - Consideration of other hull parts than the bow area

• Integration of multiple ice load assessment tools
  - Different methods are suitable for different ice conditions
SEDNA - Holistic Arctic ship design

Prescriptive (traditional) regulations
• Prescribe a specific solution
  - Straight forward to apply and to verify compliance
  - Might act as design constraints
  - Efficiency of the solution depends on the efficiency of the rules

Goal-based regulations
• Prescribe a specific function / performance
  - Potentially expanded feasible design space, enabling new and innovative solutions
  - Supports holistic safety-thinking, both passive (design) and active (measures taken by the crew) safety measures considered
SEDNA - Holistic Arctic ship design

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SEDNA - Holistic Arctic ship design

Consideration of specific technologies:

Anti-icing coating
• Examples of potential benefits
  - Replacement of traditional anti-icing measures such as speed reduction or adjustment of the bearing → Higher transport capacity
  - Reduced need for manual de-icing → Reduced Manning demand

‘Safe Arctic Bridge’ using Augmented Reality (AR) technology
• Examples of potential benefits
  - Extended safe range of operating conditions for specific manoeuvres (e.g., entering/leaving port, docking)
  - Reduced ice exposure

Multi-objective voyage optimization tool
• Examples of potential benefits
  - Minimized voyage time, ship wear (repair costs), fuel costs, or accidental risk → Might influence the required ship/fleet size to meet a specific transport task

Summary

• SEDNA → An integrated risk-based approach to safe Arctic navigation, ship design and operation

  - Development of new technologies
    • (1) a ‘Safe Arctic Bridge using Augmented Reality (AR) technology, (2) an Arctic voyage planning tool, (3) Anti-icing coating, (4) Safe use of Low Flash Point fuels

  - Development of a framework for holistic goal-based design of Arctic ships
    • Aim: to facilitate a well informed and purposeful design process enabling a safe, sustainable and cost-efficient Arctic ship operations

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Thank you for your attention!
Questions?