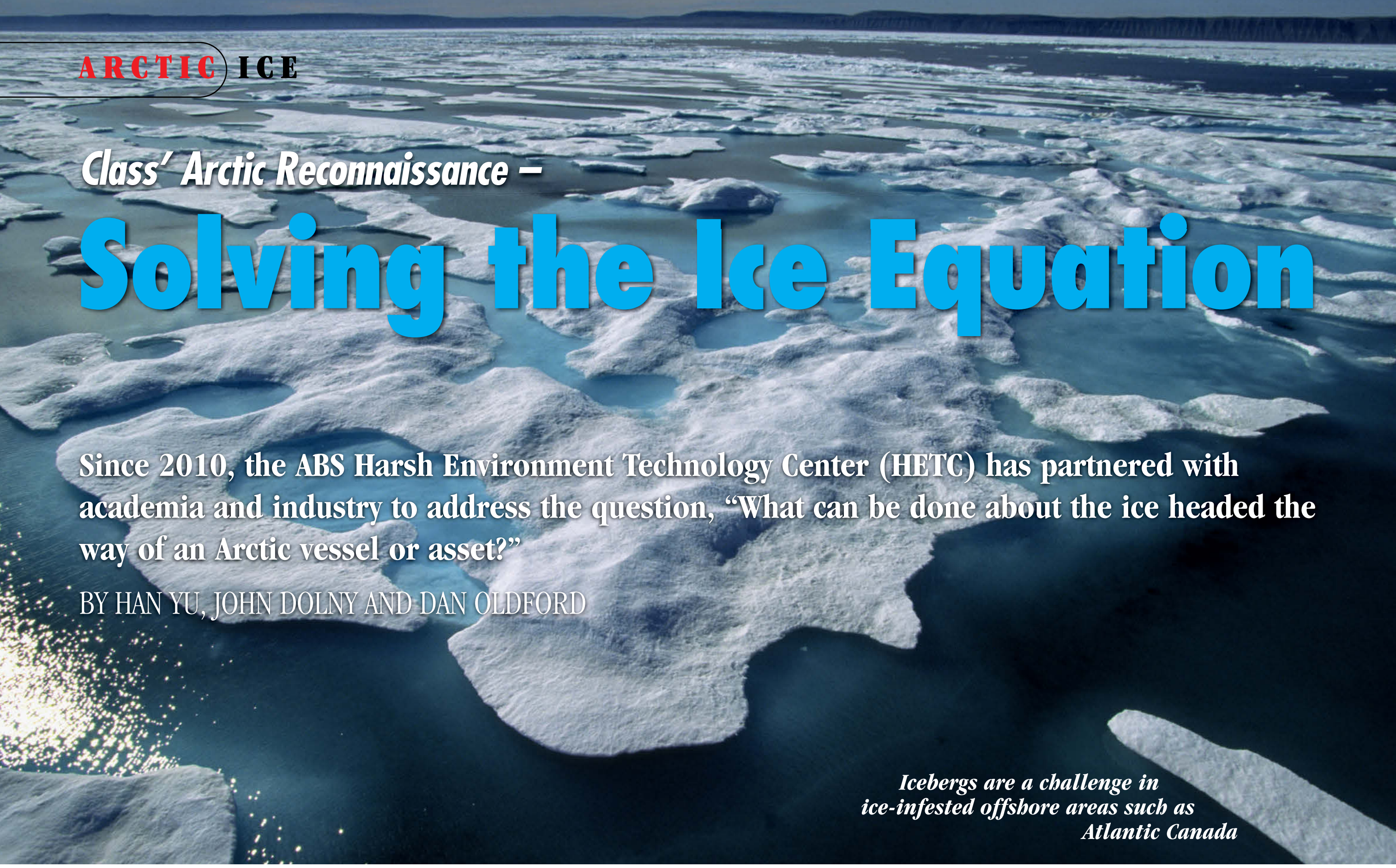
Class' Arctic Reconnaissance –

Solving the Ice Equation

Since 2010, the ABS Harsh Environment Technology Center (HETC) has partnered with academia and industry to address the question, "What can be done about the ice headed the way of an Arctic vessel or asset?"

BY HAN YU, JOHN DOLNY AND DAN OLDFORD



Icebergs are a challenge in ice-infested offshore areas such as Atlantic Canada

Since the inception of modern Arctic operations, classification society ABS has researched the effects of ice on extreme low temperature transiting structures. The not-for-profit organisation developed the first set of polar classification rules, classing the *SS Manhattan*, the world's first commercial ice breaking tanker, which transited the North West Passage in 1969. ABS was the primary class society for Arctic drilling programs in the 1980s, classing such units as the Arctic drilling rig MOLIQPAK, built to ABS class in 1984 for exploration in the Beaufort Sea and refitted under ABS class for service in Russia's Sakhalin I Field in 1999, and the KULLUK, built to ABS class in 1983 in Japan.

The National Research Council (NRC) of Canada provides innovation and research support with the goal of improving efficiency, safety and security in the Arctic and works to further sustainable resource development, marine safety technologies and advancements in cold region infrastructure and transportation – a model scale DP drillship (shown) undergoes station-keeping tests in the NRC's ice tank (photo: NRC)

In 2006, ABS expanded on ice class rule requirements for hull and machinery, publishing the Guide for Vessels Operating in Low Temperature Environments (LTE Guide) to cover winterisation for vessels. Class rules and guides continue to evolve to help industry move into high-risk environments that pose challenges that must be resolved before wide-scale operations can begin. The latest LTE Guide is dated February 2014.

Today, ABS is collaborating with several industry partners in extensive R&D activities that target Arctic operations. An example is the Risk-Based Winterisation project, which is a methodology for using risk assessment as the basis for design choices or for evaluating design options. Another example is the Sustainable Technology for Polar Ships and Structures (STePS2) project, which includes laboratory experiments and numerical experiments being conducted to develop new design tools for assessing future Polar Class units. Additional projects have resulted in high-speed ice/structure and ice/ice interaction simulation through the use of graphical processor units for the discrete element method (DEM) as well as GPU-based event mechanics (GEM).

Project Roundup

Arctic research supported by ABS is under way at Memorial University of Newfoundland (MUN) in St. John's, where ABS established its Harsh Environment Technology Center (HETC) in partnership with MUN in 2009. Researchers at HETC are evaluating ways ships and offshore structures can be designed and operated safely and effectively in Arctic environments. Research is focusing on gathering data related to technical challenges such as ice-hull interaction and ice loads as well as the effect of beyond frigid temperatures on equipment and equipment winterisation. Joint industry efforts are targeting several of these key technical areas.

Ice-Hull Interaction

ABS is contributing to Joint Industry Projects (JIPs) in which

Modelling work taking place in Canada will continue to assess more complex interactions such as floe splitting, floe submergence, rubble pile-up, and mooring systems

full-scale structural arrangements close to Polar Class strengthening levels are being subjected to ice samples shaped as ice cones and loaded on hydraulic rams to more than 300 metric tonnes of force.

The results of tests carried out to validate numerical simulations of both ice and structural deformation are providing valuable insight into the plastic overload capacity of typical ice-belt structures. Ice-hull interaction experiments include high-energy collisions using a novel double pendulum collision apparatus, capable of swinging more than nine metric tonnes of ice and steel at a closing speed greater than 10 metres/second.

Ice Management

HETC is managing the first phase of a JIP aimed at closing knowledge gaps that exist in understanding ice loads on floating structures.

ABS-hosted workshops in St. John's have facilitated a comprehensive review of different structural configurations, interaction scenarios, ice management, station-keeping systems, numerical models, model testing procedures, design codes, full scale data, and operational experience. Areas of uncertainty identified by workshop participants will be explored to provide recommendations toward a dedicated full-scale measurement campaign that will be coupled with physical model testing and numerical modelling efforts targeting prioritised areas of development.

Event Mechanics

A new paradigm for simulation called GEM simulates a long and spatially extensive process as a series of events. Unlike continuum mechanics, which focuses on the fine mechanical detail of material behaviour, event mechanics allows modelling of complex problems as a mesh of events rather than as a mesh of elements.

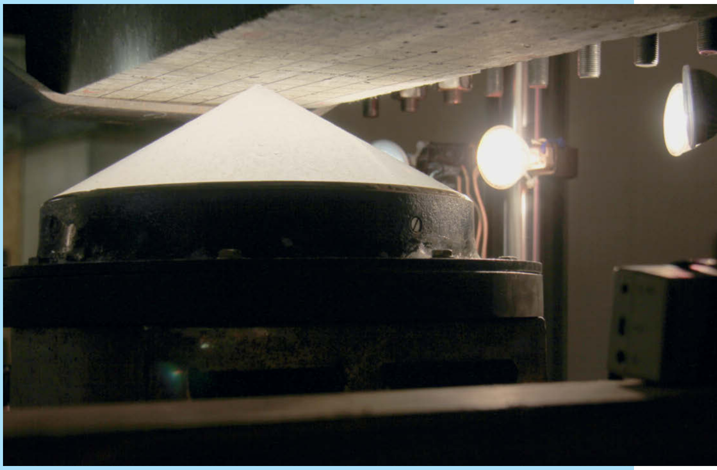
A simulation domain containing hundreds or thousands of discrete and interacting ice floes can be modelled easily. Each ship/ice impact is modelled along with every ice/ice interaction. This simulation approach allows engineers to calculate time histories of vessel resistance, speed, orientation, and position. The performance of ice breakers in various ice conditions executing different tactical manoeuvres as they protect an offshore asset can be assessed.

Work at MUN has demonstrated the ability to achieve simulation speeds faster than real time, which vastly exceeds the speeds achievable by standard continuum mechanics models. Far from finished, the work will continue to include more complex interactions such as floe splitting, floe submergence, rubble pile-up, and mooring systems.

Winterisation

The ABS LTE Guide represents a set of mostly prescriptive requirements based on assumptions about vessel operations. This approach is used extensively in areas such as the Gulf of St. Lawrence or the Baltic Sea. However, companies require an approach to safety that can allow for demonstrating competence in dealing with risk without following prescribed action.

Through HETC, ABS is developing a risk-based winterisation approach to vessel design that delivers a low level of risk while permitting the use of practical



Understanding the ice load capacity of Arctic ships and offshore structures was one of the key aims of the USD 7.2 million STePS2 project at MUN. The STePS2 team has carried out three ice impact tests by striking a 1-metre diameter ice cone against a specially designed Ice Impact Module developed by Dr Robert Gagnon, a physicist at the NRC of Canada's Ocean, Coastal and River Engineering facility in St. John's. When the tests on the Impact Module are complete, the next series of tests will measure ice impact on steel structural panels with the goal of determining the strength and overload capacity of ice class structures. (photo: STePS2) solutions. This approach is being applied collaboratively with a designer to a new vessel design intended for harsh-environment operations, where the operators have a long history of safe operations. Areas of noncompliance with the prescriptive requirements are being highlighted and risks evaluated based on probability and consequences of failure. ABS is using valuable feedback from this exercise to enhance the LTE Guide, while the client is using the feedback to make informed decisions in the detailed design phase.

Arctic Operations Handbook

Work concluded at the end of 2013 on a 15-member JIP established the previous year to develop an operations handbook that addresses safety and sustainability of offshore operations in the Arctic. The JIP focused on operational activities associated with transporting and installing fixed, floating, and subsea units as well as dredging, trenching, pipe laying, and floating oil and gas production in Arctic and cold-weather conditions. Potential risks that could arise in specific Arctic conditions were identified to improve the understanding of the operational challenges involved.

Arctic Operational Limitations

Through the International Association of Classification Societies (IACS), ABS is working at the forefront of regulatory regime initiatives to assist IMO with its proposed international code of safety for ships operating in polar waters (Polar Code).

As a member of IACS, ABS is helping to develop the new Polar Operational Limitations Assessment Risk Indexing System (POLARIS). POLARIS provides guidelines for prudent operations in a range of ice environments based on a vessel's ice class notation and the associated notional capability. Work is on-going to create tools for its application.

As the offshore industry considers the best method to venture safely into ice-prone areas to develop oil and gas resources, class is working in step with academia and industry to verify that frontier vessel designs are constructed to contend with this dynamic and challenging environment. ■

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