
*Memorial researchers involved in the Sustainable Technology for Polar Ships and Structures (STePS$^2$) may change the way ships and offshore structures are built to withstand severe ice conditions.*

PHOTO: The Canadian Press/Jonathan Hayward

# WATER, ICE AND STEEL

BY ANDREW SAFER

**There is a 50 per cent chance of finding 83 billion barrels of oil north of the Arctic Circle, according to the US Geological Survey. At $100 per barrel, that is valued at $8.3 trillion, plus the value of natural gas and minerals. The potential of these substantial petroleum and mineral deposits in the Arctic make the business case for STePS$^2$.**

Currently in the second year of a five-year initiative at Memorial University's Ocean and Naval Architectural Engineering Department, STePS$^2$ is a $7.2 million project focused on developing a toolset that will enable Arctic ship and offshore structure designers, operators, and engineers to evaluate a range of scenarios involving interactions between water, ice and steel, to specify optimal design parameters.

"To make the economics of operating in the Arctic work, oil companies will want year-round production," explains Dr. Roger Basu, director, Shared Technology, American Bureau of Shipping (ABS) in Houston, one of STePS$^2$ private sector supporters. "So we need year-round shipping. Industry today is being challenged to design ships and offshore structures to operate in the Arctic year-round, but current information is incomplete. STePS$^2$ will help fill the gaps." ABS established a Harsh Environment Technology Centre at Memorial University in 2009, and currently has a company researcher on-site working on STePS$^2$.

"The toolset for STePS$^2$ will be designed for year-round Arctic operations with potentially very large vessels and structures, beyond current experience," reports Dr. Claude Daley. He is chair of the Ocean and Naval Architectural Engineering Department, professor of Engineering, and director of the BMT Ocean and Arctic Structures Research Program at Memorial. Dr. Daley makes the point that one of the big worries regarding the Arctic is uncertainty about current technology performance in extreme cold and ice conditions. "If we do the legwork to raise the level of our technology and lower the worry, we can have a significant effect on whether these projects are seen as viable. This can affect whether our Arctic is developed, and how it's developed."

And judging by the support from the private sector, they agree with Dr. Daley's assessment. In addition to the American Bureau of Shipping, the $STePS^2$ project has attracted industry investment from Husky Energy Inc., Samsung Heavy Industries Co. Ltd., Rolls-Royce Marine and BMT Fleet Technology.

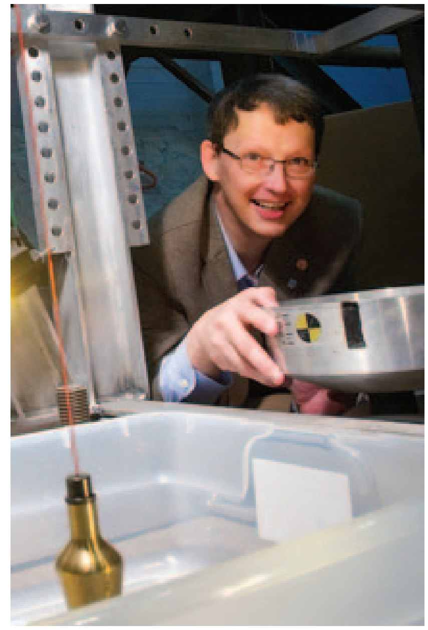
Thirty-five people are currently working on $STePS^2$: 10 undergraduate students, 12 graduate students, five faculty members, four principal researchers from the National Research Council-Institute of Ocean Technology (NRC-IOT), and four staff. An estimated 40 to 50 graduate and work-term students will be involved over the course of the project.

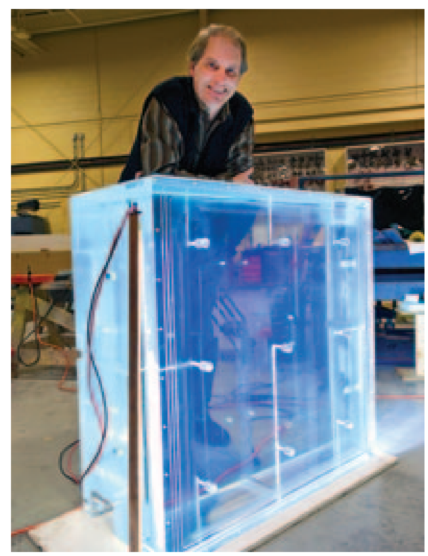
Between 1979 and 1993 Dr. Daley worked for BMT Fleet Technology, a Kanata, Ontario-based applied engineering technology company that specializes in marine and Arctic technology. During this time he worked on the development of the latest Canadian Arctic Shipping Pollution Prevention Regulations. Through a sponsored exchange program, he also obtained a doctor of science degree in ice mechanics and arctic naval architecture at the Helsinki University of Technology. In 1995 he joined the Faculty of Engineering and Applied Science at Memorial.

Between 1992 and 2008 Dr. Daley helped develop the structural standard for the polar class rules, an international safety framework for ships operating in polar waters. Through his work as an ice-engineering specialist he met representatives of the American Bureau of Shipping, Samsung Heavy Industries Co. Inc. and Husky Energy, Inc., operator of Newfoundland's White Rose oilfield. All of them took an interest in $STePS^2$ and joined the project. After Rolls-Royce Marine opened its commercial marine service centre in Mount Pearl in September 2010, they heard about $STePS^2$ and became the most recent industry partner.

In addition to the $1.2 million private-sector investment, $STePS^2$ has also received $3 million through the Atlantic Canada Opportunities Agency's Atlantic Innovation Fund. The Research and Development Corporation Newfoundland and Labrador is investing $800,000 through the Collaborative R&D Academic Program. Memorial University is contributing approximately $130,000 through the School of Graduate Studies for student bursaries. And research funding agencies such as MITACS and the Natural Sciences and Engineering Research Council of Canada (NSERC) are expected to provide approximately $500,000 through various programs that fund graduate student support. The NRC-IOT is the technical partner for much of the equipment design and experimentation. In-kind partner contributions total $1.59 million.

The way that ice, "a visco-elastic semi-brittle solid", responds to major impact forces is complex, Dr. Daley explains, and not well understood. Standing next to a model of a double-pendulum apparatus in the Faculty of Engineering's Structures Lab (see top right photo), he says his team of





TOP RIGHT: *Dr. Claude Daley poses next to a model of a double-pendulum apparatus in the Faculty of Engineering Structures Lab.*

BOTTOM RIGHT: *This is the thickest block of acrylic in the world. A key component in Dr. Robert Gagnon's impact module during experiments in the Structures Laboratory, it is used to measure and record the impact forces and pressure distribution when ice and steel collide. A camera sees through the acrylic and photographs the event.*

researchers will build one that is four times larger to conduct ice-crushing tests. These tests will enable researchers to understand the impact forces when ice collides with steel travelling at up to 15 knots — actual speeds in the high Arctic.

Dr. Robert Gagnon, B.Sc.(Hons.)'78, M.Sc.'81, PhD'87, a physicist who heads up the IOT-NRC technical partnership with STePS[2], developed the impact module and experimental techniques that will be used to measure the pressure distribution changes over very short distances during the ice-crushing and impact tests. While Dr. Daley was studying damage to ship structures associated with ice collisions and helping develop structural standards for polar class rules, Dr. Gagnon had for several years been developing technologies for measuring load and pressure, formulating new experimental techniques to study ice crushing behaviour and developing numerical simulations of ice/ship collisions. Dr. Daley was able to capitalize on these strong and complementary backgrounds when drafting the STePS[2] proposal.

Dr. Daley explains that at 10 knots, the ship would be moving five metres per second. Most experiments to date to measure large forces have been conducted at lower speeds.

In the Thermodynamics Lab (cold room), research students are currently formulating recipes for cone-shaped ice for the double-pendulum apparatus tests. They will also conduct experiments in a wet tank in the Fluids Lab, where a ship's hull will be placed in a dynamic environment with varying types and concentrations of ice underneath. "There are legal requirements to strengthen the deep wet parts of a hull," notes Dr. Daley, "but we don't know the physics of what's causing those loads." He says that's okay for current designs that have been proven over time, but when designing on a much larger scale, such as the hull of a liquid natural gas ship which displaces 10 times the mass of current ships, an understanding of the physics is vital.

Researchers will collect data during the experiments, validate their applications of the data in a high-performance computing environment, and proceed to model full-scale field scenarios in order to develop the design tools that will be the project's key deliverable. ■