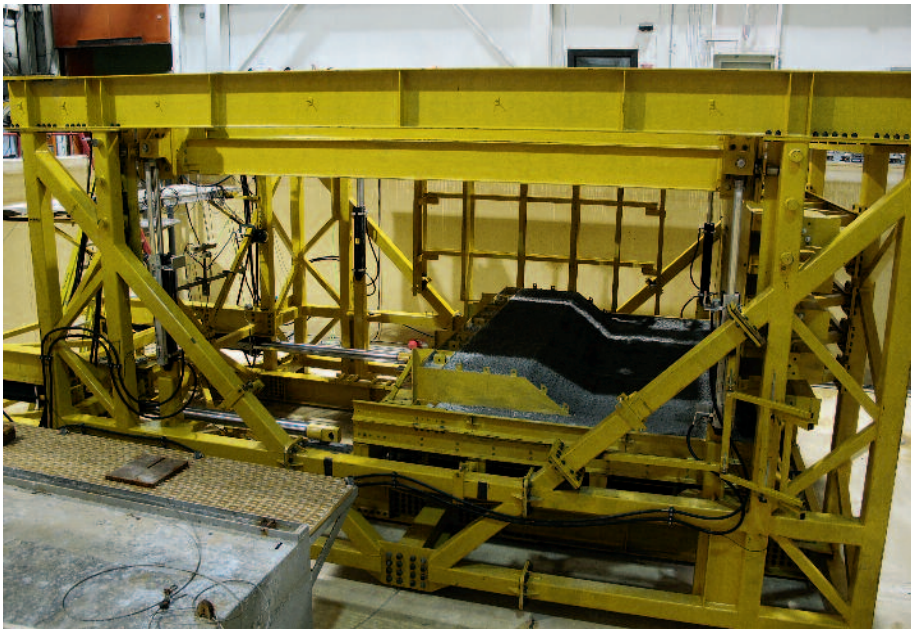
Centre for Arctic Resource Development tackles priorities in ice research

Arctic environments present formidable obstacles to hydrocarbon development. Canada's Centre for Arctic Resource Development is engaged in important research aimed at removing these barriers. Andrew Safer reports

Fifteen full-time researchers at the Centre for Arctic Resource Development (CARD) in St John's, Newfoundland, Canada, are engaged in five R&D projects to address the challenges inherent in developing oil and gas projects in ice- and iceberg-prone regions. Focused on ice mechanics, station-keeping in ice and ice management, the four- and five-year projects address priorities identified in CARD's Arctic Development Roadmap, a gap analysis that was designed to address Arctic challenges over a five- to 20-year time horizon.

C-CORE, an applied R&D corporation in St John's with world-class expertise in remote sensing, ice engineering and geotechnical engineering for harsh, cold environments, established CARD in June 2011 to undertake medium- to long-term arctic research in areas of interest to the oil and gas industry. The Hibernia and Terra Nova projects have each committed CA$6.25 million (GB£4 million) over five years – CA$1.25 million (GB£800,000) each per year – to support research programmes and technology development. The Research & Development Corporation of Newfoundland and Labrador has contributed CA$4 million (GB£2.6 million) under its R&D Platforms Initiative to enable C-CORE to enhance its facilities at Memorial University to accommodate the new researchers and laboratories. The two-floor, 12,500-square-foot (1161-square-metre) expansion is slated for completion in the spring.

CARD's industry advisory committee, which includes representatives from the sponsoring partners as well as other industry and research organisations, is what distinguishes it from other arctic R&D centres, says executive director Dr David Murrin. In order to develop their Arctic Development Roadmap of research priorities, his team consulted industry representatives in St John's, Calgary, Houston and Norway. "They've helped us identify the essential considerations, key challenges and barriers that are preventing development in the Arctic," he adds. CARD considered development scenarios in Labrador, Southwest Greenland and the Beaufort Sea, and the (1) acquisition and exploration, (2) appraisal and pre-development, and (3) development and construction phases of Arctic development projects. Five hundred R&D opportunities were identified, which they prioritised according to industry relevance, geographic

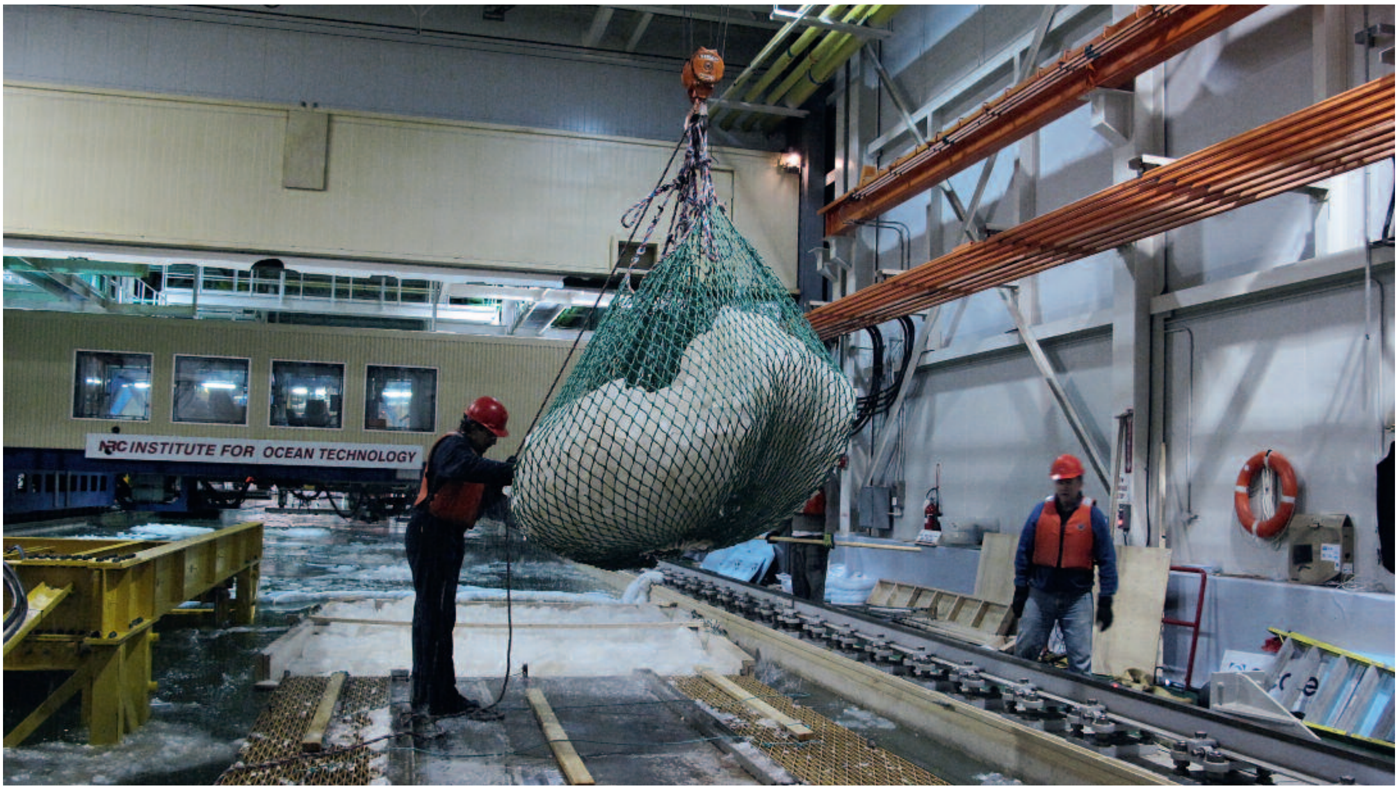


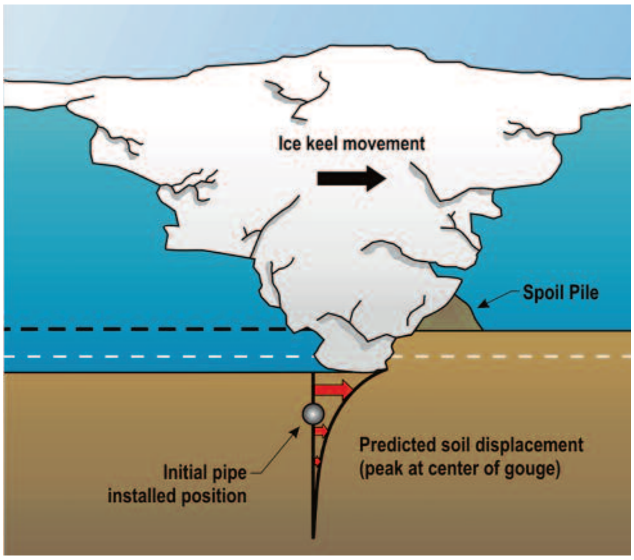
Ice keel test bed (above) and ice rubble (below and previous page) used in the PIRAM project. Photos: C-CORE

range of applicability, expected R&D impact with regard to either improving safety or reducing risk or cost, time to implementation and the state of knowledge (relative size of knowledge gap).

Of significant interest to industry is gaining a better understanding of the forces and conditions that contribute to both ice keel strength and failure as it interacts with the seabed. Dr Eleanor Bailey, who received her PhD in Ice Research at University College London, UK, before joining CARD in 2011, is the project manager of the four-year Development of Ice Ridge Keel Strengths (DIRKS) programme. "What we're investigating is how an apparently weak first-year ice keel can develop sufficient resistance to create a gouge and impose risks to subsea infrastructure," she says. "Scientists don't understand how a keel that is not well consolidated – blocks of ice that are weakly bonded – can become strong enough to cause significant damage. The fact that the ice rubble strength is dependent on so many parameters, many of which are continually changing with time, makes it an incredibly difficult material to understand." She notes there is a theory that once the keel is digging into the soil it becomes confined, which increases the keel's strength. DIRKS will provide a means to test this theory.

This project is based on a similar series of tests that were conducted as part of the Pipeline Ice Risk Assessment and Mitigation (PIRAM) joint industry project, which was led by C-CORE and supported by several oil and gas companies. The results of these tests showed that the initial temperature of the keel was a key factor in determining keel strength. Dr Bailey reports that while most of the tests were conducted at -5 degrees Celsius, the last two tests were conducted at -20 degrees, which resulted in the formation of keels that could withstand much stronger loads. "With colder ice," Dr Bailey says, "there is more potential for freezing in the rubble (blocks of sea ice), which will increase the global strength of the rubble matrix." In the DIRKS programme, tests will be conducted primarily using the colder -20-degree ice at ice temperatures varying from -5 to -18. Another theory that will be tested is that slow-moving keels can exert higher loads than those moving at higher speeds because there is more time for the keel to





Research findings will assist oil and gas companies in establishing physical limits of an ice keel gouge and influence the design criteria for subsea pipelines

dig into the soil.

Dr Bailey's team is currently producing approximately 116 metric tons of freshwater ice rubble, which will be used to construct nine 1.5-metre high ice keels (4.5 metres long x 3.5 metres deep). "These will be some of the largest keel-soil interaction tests ever performed in an ice tank," says Dr Bailey. The keels will be deformed using a custom-built frame that will load the keel in the vertical with pressures ranging from 25kPa to 75kPa while the soil tray is displaced horizontally into the keel at a rate of five millimetres to 10 millimetres per second. Completion of the first testing phase is planned for late March.

Research findings from DIRKS will assist oil and gas companies in establishing physical limits of an ice keel gouge (depth and width) and influence the design criteria for subsea pipelines and infrastructure in areas prone to ice gouging.

The other R&D projects CARD researchers are engaged in include:

- Compressive Ice Failure and Distributed Damage – refining and modernising an existing damage-based model to produce improved performance in modelling high-speed events in ship-ice interactions;
- Fracture and Scale Effect – developing fracture research programmes to learn more about interaction geometry and the interplay between fracture and microstructural damage in ice;
- Data Analysis – using a ship-ice interaction model to study a ship's response when impacting a single ice feature; and
- Modelling Ice Management – developing both an icebreaking and management model and a discrete floe model to simulate broken ice floe interactions, and floe interactions with vessels.

Andrew Safer is a freelance writer, editor and communications consultant based in St John's, Newfoundland; email: asafer@nf.sympatico.ca; website:www.andrewsafer.com