C-CORE
Innovative Engineering Solutions

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Ice Gouging and Offshore Pipeline Safety

The development of offshore oil and gas resources in arctic and northern ice environments is gaining renewed interest. For ice features with sufficient draft to contact the seabed, ice gouging (scouring) may occur. The penetration of an ice keel, moving under environmental driving forces, into the seabed can occur for significant distances. This interaction event develops seabed reaction forces that can be an order of magnitude greater than those experienced with other pipeline/soil interaction events. Due to these forces, the resulting soil failure mechanism generates a spoil mound at the front face of the advancing keel with soil clearing processes developing lateral spoil berms, as shown in Figure 1. These observations from a physical model test of the ice gouge process are very similar to what is observed in the field with actual seabed gouge features. What is not directly apparent are the resulting subgouge soil deformations. For ice gouge environments, a significant engineering challenge is to establish solutions to address the integrity and safety of offshore pipelines and subsea infrastructure.

The Pressure Ridge Ice Scour Experiment (PRISE) program, led by C-CORE, was a concerted effort by industry to address this engineering design challenge. PRISE was a proprietary, internationally funded program of focused studies directed towards the protection of offshore oil and gas pipelines from the effects of sea ice and iceberg gouging. Through analytical, physical and numerical modelling investigations, PRISE developed semi-empirical models to evaluate seabed reaction forces and subgouge deformations.

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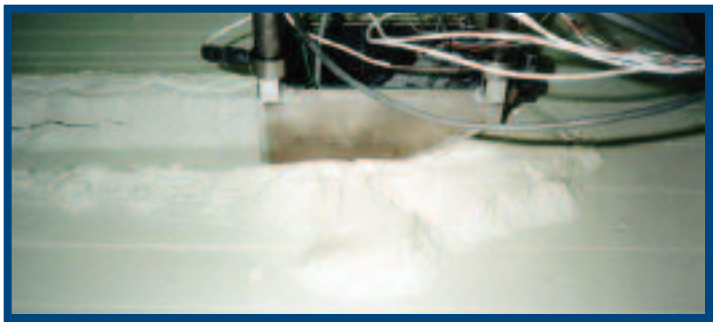

Figure 1 Ice Gouge Testing

Inside this Issue

New Vice President, Operations

Susan Kennedy, B.Comm., CMA
Vice President, Operations

C-CORE is pleased to announce the appointment of Susan Kennedy as Vice President, Operations. Susan is a Certified Management Accountant (CMA) with over 15 years of corporate and project level business management experience. Since 2001, Susan has been C-CORE's Chief Financial Officer responsible for the Corporation's financial performance, intellectual property management, human resource strategies and operational policies. As Vice-President, Susan works with C-CORE's talented team of engineers, scientists and business experts to develop corporate strategies to continue to grow and position C-CORE as Newfoundland and Labrador's premiere corporation delivering innovative engineering solutions to clients worldwide.

MESSAGE FROM THE PRESIDENT

It's a new time. C-CORE is a thirty-one year success story and it is my privilege to assume leadership of this great corporation. C-CORE News is C-CORE's primary outreach vehicle so I would like to use my first column (as President and CEO) to introduce myself to those who don't know me. In future issues I look forward to sharing with you, evolving initiatives and a vision for C-CORE.

I began my professional career in 1981 in the oil and gas sector positioning seismic vessels. Global Position Systems were not generally accepted at that time for the accuracy needed so we used a system requiring a dedicated operator. From oil and gas I moved to the telecommunications industry and then had a stint with the academic community before landing at C-CORE. It is here that I've spent the majority of my career.

I began at C-CORE as an electronics technologist, then joined and ultimately became Director of the Remote Sensing Team in 1995. My first responsibility was to rebuild the team, after the HF radar research, that had been the team's focus, was "spun out" for commercialization and most of the people went with it. I got lucky and correctly guessed – and it was a guess, that Canada was going to create an environment supporting commercial utilization of satellite monitoring. That, coupled with being located at the edge of "iceberg ally" was an obvious combination to be exploited. Thanks to the technical brilliance of our staff, C-CORE is now the world leader in ship/iceberg detection and classification and the remote sensing team has expanded into many other areas as you have read in C-CORE News.

I left C-CORE twice. The first time, my wife Deborah and I moved to Ontario to pursue a degree in electrical engineering. In 1990 we moved to Victoria, British Columbia to pursue graduate studies. I have an M.A.Sc. (with emphasis in underwater acoustics) and a Ph.D. (both from U. Vic.) for my work in underwater vision systems.

In 2000 I became Vice President of C-CORE and began working across all facets of the organization. Working closely with Judith Whittick on business development, management, planning, and strategy across the organization was great preparation for the role of Chief Executive.

After a national search, I was appointed C-CORE's third President and CEO effective March 1, 2006. Although a cliché, leadership of C-CORE is a thrill and an honour. The C-CORE team is committed to generating practical, pragmatic solutions for our clients. We have world experts in Ice Engineering, Intelligent Systems, Geotechnical Engineering and Remote Sensing, and combining these diverse technologies into complete solutions is a competency – just one of the many traits that makes C-CORE a unique and successful organization.

C-CORE has a brilliant future with significant growth potential. I look forward to reporting how we're doing in subsequent issues of C-CORE News.

Sincerely

Congratulations to the Faculty of Engineering and Applied Science at Memorial University

The faculty has received a 6-year accreditation for all five undergraduate programs from the Canadian Engineering Accreditation Board (CEAB), the maximum period awarded to a minority of programs in Canada. "Full accreditation for all of the faculty's engineering programs is an outstanding accomplishment, an accomplishment rarely achieved," said Dr. Axel Meisen, President of Memorial University and past chair of CEAB. At C-CORE, we recognise the quality of the undergraduate program at the Faculty of Engineering. Many of our staff are graduates of the program.

Congratulations!

Ice Gouging and Offshore Pipeline Safety

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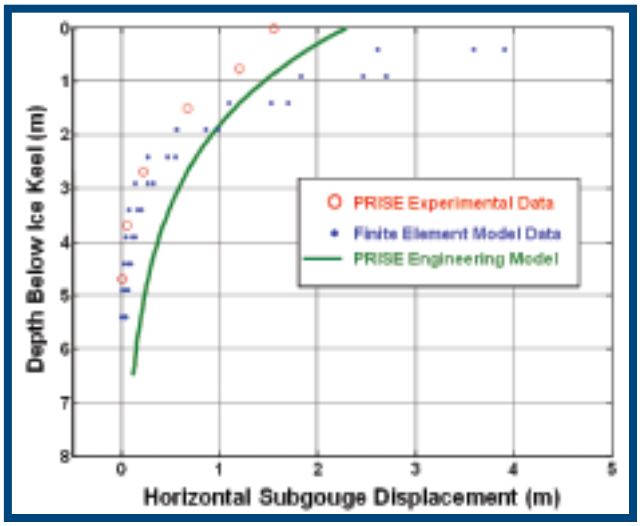
Through PRISE, engineering procedures were also developed to calculate the pipeline structural response for ice gouge events. The PRISE engineering model assumes that the ice keel/seabed/pipeline interaction process can be decoupled into separate ice keel/seabed and pipeline/soil interaction events. This model was the first of its kind. The PRISE model has been a valuable tool for the engineering community and has, in part, been used as the engineering design basis to determine burial depth protection requirements in ice gouge environments for several offshore pipelines projects. Some of these projects include the BPXA Northstar, ExxonMobil Sakhalin I, Shell Sakhlin II and the proposed Millenium pipeline crossing of Lake Erie. The PRISE engineering model was further developed by C-CORE to incorporate a probabilistic and reliability based design approach.

Although a valuable engineering tool, application of the PRISE engineering model can be bounded by technical constraints and uncertainty for some design scenarios and ice environments. C-CORE continues to advance risk mitigation and protection strategies for subsea infrastructure in ice environments.

We recently conducted numerical modelling studies of ice keel/seabed interaction events using three-dimensional continuum finite element methods, which were based on Lagrangian formulation using adaptive mesh techniques. The finite element analysis was able to attain a steady-state ice gouge event, capture soil failure and subgouge deformation mechanisms consistent with PRISE experimental observations. Comparison of horizontal subgouge displacements, measured during PRISE and computed by finite element analysis, is illustrated in Figure 2. The agreement between two independent investigative techniques, centrifuge modelling and continuum finite element analysis, provides confidence in the methodology and engineering tools used to model ice gouge processes.

These numerical modelling investigations indicated the normalization parameters, used in the existing PRISE model for subgouge deformations, may not be applicable for all engineering design applications; for example assessment of extreme ice keel depths or reduced pipeline burial depths where the pipeline crown is within close proximity to the base of the gouging ice keel. To address these and other issues, C-CORE has initiated a comprehensive program to examine protection and risk mitigation strategies for subsea infrastructure in ice environments. The primary goal is to reduce uncertainty, improve economics, and promote safe development of oil and gas resources in ice environments.



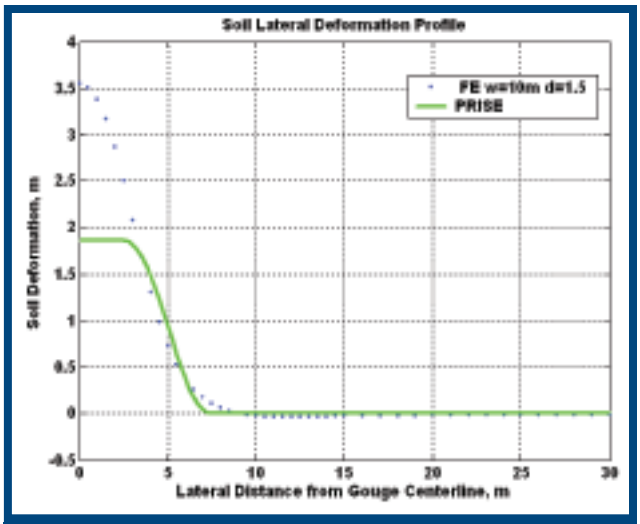


Figure 2 Comparison of the Distributions of Horizontal Subgouge Displacements

Components of the program include the advancement of ice keel/seabed/pipeline interaction models to address uncertainty, seabed failure mechanisms and structural pipeline response. Factors being examined include the effect of ice keel attack angle, ice keel shape, ice gouge width to depth ratio, and variation in soil properties on pipeline protection requirements. Issues such as ice keel compliance, ice keel failure and soil failure mechanisms that may define limits to ice gouge processes are also being investigated.

Other aspects of the program examines the significance of assuming a decoupled process. Numerical modeling studies have shown that fully coupled ice keel/seabed/pipeline interaction models predict a moderated pipeline response in comparison with analysis using an empirical subgouge deformation model and conventional structural-based finite element analysis. Although significant effort is required to calibrate this numerical procedure, the approach represents a viable modelling technique to improve engineering models that can evaluate field events on a more realistic basis.

Aeronautical Component Testing Capability

Expanding its centrifuge facilities operations outside of geotechnical engineering C-CORE is conducting high gravity (G) testing on aircraft electronic components. These components are typically tested at G levels of 40 g or less; well within the 200g capacity of the C-CORE centrifuge. C-CORE is uniquely equipped in Canada to acceleration test large components that could not be tested to specification on smaller centrifuges. These specifications limit the variation in gravitational force allowed over the height of a test component while in flight. C-CORE's centrifuge with a long boom arm, measuring 5.5 metres allows performance testing to very high tolerance and can accommodate components over a metre in length. The C-CORE centrifuge also offers a range of on-arm services including 64 channels of data acquisition, AC and DC power lines and electrical slip rings that can be specifically wired for client's needs. On board cameras monitor the components during their ride while accelerometers measure the accelerations imposed. These acceleration tests, carried out on a variety of electronic components, are a part of a testing and qualification process that can include additional tests such as vibration, shock, thermal, humidity and fluid susceptibility.

In the spring of 2005 C-CORE conducted crash safety and ultimate load tests on cockpit display units for L-3 Electronic Systems. This involved flying the electronics in the centrifuge, in both non-operational and operational states, to g-levels up to 40g. L-3 Electronic Systems was contracted by Boeing Integrated Defense Systems to produce the cockpit displays for the F/A-18 aircraft. The displays are to be installed in Canadian and Australian F/A-18A/B aircraft as part of Australia's Hornet Upgrade Program and Canada's F/A-18 Incremental Modernization Project. The upgraded displays provide navigation reference, digital tactical imagery and enhanced graphics and video imagery to the pilots.

C-CORE's acceleration tests are compliant with RTCA/DO-160D and MIL-STD-810E method 513.4 specifications.

C-CORE's Geotechnical Centrifuge

C-CORE is an innovative engineering solutions provider based in St. John's, NL, Canada.

We publish *C-CORE News* twice a year for our partners, clients, and associates.

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Satellite Monitoring for Water Resource Management in Africa

C-CORE has been awarded two new projects to monitor water resources in Africa. “Satellite Hydrogeology for Water Resource Management – Northern Ghana” is contracted by the Canadian Space Agency (CSA) under the Earth Observation Applications Development Program (EOADP). The lack of adequate potable and agricultural drinking water inhibits the progress of many developing countries and is the cause of human suffering worldwide. This project focuses on the use of optical and radar satellite imagery to identify the most optimum drilling locations for adequate groundwater resources in Northern Ghana. Golder Associates in Mississauga, Ontario is the project lead, with World Vision Canada, World Vision Ghana and the University of Ghana’s Centre for Geographic Information Systems (CERMES) as the potential end users of the products. C-CORE provides Synthetic Aperature Radar (SAR) expertise and creation of digital elevation models (DEMs) to obtain the relative topography of the area, while identifying geological lineaments and performing land cover classification. The final product is Integrated Hydro-geological Exploration Model to determine optimum drilling locations for ground water.

Thomas Puestow (middle) the project manager, and local stakeholders during a recent field trip to Egypt in February, 2006

The second African project “Satellite Monitoring of Lake Water Quality in Egypt” is funded by the European Space Agency (ESA) under the Tiger program. C-CORE is leading the project with partners from the Water Resources Management Division (WRMD) of the Newfoundland Department of Environment and Conservation; the National Water Research Center in Cairo, Egypt, and the Finnish Environment Institute (SKYE). Responding to an acute need for reliable and accurate information on lake water quality, it is the objective of the project to design, and implement an Earth Observation (EO) - based capacity for the operational monitoring of water quality in Lake Manzalah, Egypt.

OceanSAR 2006 - Spaceborne Radar for Maritime Operations

OceanSAR 2006, the Third Workshop on Coastal and Marine Applications of SAR (Synthetic Aperture Radar), will be held in St. John's (Newfoundland and Labrador) on October 23-25. The workshop will focus on applications of space-borne radar, a technology that allows vast area monitoring in a cost-effective manner and also provides cost-effective information, day and night in all weather conditions and complements ground, air and sea-based resources.

Maritime information needs and requirements are cross-sectorial (transport, ocean resources, security, MetOc, etc.), cross-disciplinary (security, meteorology, oceanography, biology, and economy), and cross-functional (monitoring, surveillance, science) and have to serve the objectives of both operational and scientific stakeholders. To build on the science activities in support of the operational mandates and to address topics in an integrated fashion (from data to information and knowledge), the workshop is segmented into 5 themes organized around key maritime issues:

1. Stewardship of Coastal and Marine Environments
2. Monitoring and Surveillance for Security and Domain Awareness
3. Operational Ocean Management
4. National & International Collaborations and Programs
5. Advances in SAR Information Extraction

The Canadian Space Agency, the Canadian Ice Service, C-CORE and MDA are organizing the event. For more information visit www.oceansar2006.com or contact Desmond Power: des.power@c-core.ca.

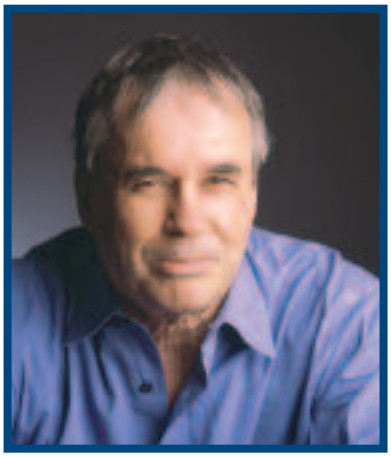
Appointments at C-CORE

Ryan Phillips Ph.D., P.Eng. Principal Consultant - Geotechnical Engineering

Ryan has over 25 years of geotechnical engineering experience. He has been involved in a wide range of industrial research projects including soil - pipeline interaction and performance of offshore foundations, performance of production platforms, thaw-induced settlement of pipelines in permafrost, and wave action on submerged causeways. Ryan is an expert in geotechnical physical modeling and has carried out numerous applied research programs for industry.

Vincent Morgan, MSc., P. Eng. Director, Geotechnical Engineering

Vince has been with C-CORE for the past four years and has a background in geotechnical engineering with over 10 years direct industrial experience in the offshore oil and gas and onshore construction sectors. His past work involved the planning and management of offshore geotechnical site investigations for pipelines and platform foundations, as well as subsequent interpretation and engineering design. Recent activity at C-CORE includes project management of experimental and numerical modeling of foundations, pipelines and arctic structures, as well as providing technical advice on design issues relating to oil and gas development.



Ian Jordaan FCAE, Ph.D., P.Eng. Principal Consultant - Ice Engineering

In September 2005, Ian became a principal consultant to C-CORE. He is an Honorary Research Professor at Memorial University of Newfoundland. Until 2005 he was University Research Professor, and for the period 1986 - 1996 was NSERC-MOBIL Industrial Research Professor of Ocean Engineering. Previously he served as a Professor at the Department of Civil Engineering, at the University of Calgary, and worked for several years at Det norske Veritas (Canada) Ltd., ending as Vice-President (Research and Development) in 1986. He has been involved extensively in developing methodology for engineering design criteria, and in the use of probability theory and risk analysis applied to engineering problems.

Ian has received the Horst Leipholz Medal for contributions to mechanics, and the P.L. Pratley Award for the best paper on bridge engineering, both from the Canadian Society for Civil Engineering. In 2005 he was elected as a Fellow of the Canadian Academy of Engineering.

NOTEWORTHY

Congratulations Ryan

On behalf of all of us, it is a pleasure to congratulate Dr. Ryan Phillips on being inducted as a Fellow of the Engineering Institute of Canada.

This is a considerable honour which is awarded for exceptional contributions to engineering in Canada. Ryan is the only person from this province to be selected this year.

Welcome Back

C-CORE welcomes Daryl Burry back to the Ice Engineering Group. Born in Corner Brook, he now resides in St. John's. He was co-owner of a drafting and graphic design firm servicing government and the offshore oil industry in the "exploration days" of the 80's and worked extensively on the Hibernia EIS and Development Plans for Mobil Oil and partners. He graduated from the civil engineering program at MUN in 2004. During his time at C-CORE he has worked on projects including the Bergy Bit Impact Study, Iceberg Sinking Towline, Improved Above Water Iceberg Characterization, Single and Multi-Vessel Iceberg Towing Procedures, Ice Damage Mitigation Measures at Finfish Farms in Nova Scotia, Barents Sea Ice Loads and Makkovik Bank Iceberg Grounding Model.

New to our Remote Sensing Team

Mike Lynch is the newest member of the Remote Sensing team at C-CORE. Originally from Paradise, NL his background includes a B.Sc. (geography) from Memorial University of Newfoundland and an Advanced Diploma in GIS from the Centre of Geographic Sciences in Lawrencetown, NS. Mike has considerable training in Remote Sensing and previous employment was with a forest engineering company based out of Portugal Cove as a GIS Specialist.

THE LOG BOOK

Off the Beaten Path - St. Petersburg, Russia

Everyone talks of a trip, expedition, weekend, etc. that took them beyond the “ordinary” and gave them a different perspective and outlook on life. For me it was a trip to St. Petersburg, Russia.

An IAHR Symposium in St. Petersburg in 2003 lured me to this part of our world. I presented a paper on the analysis of iceberg impact data from the Grappling Island iceberg impact experiment.

Being my first trip beyond London, UK, I was somewhat apprehensive but nonetheless up for the adventure. The two imminent challenges were language and currency conversion - US dollar to Russian ruble. On arriving in any airport you often see individuals with simple signs bearing a traveler’s name. This trip was one occasion where I was hoping that someone had, at the very least, scribbled “Ralph Freeman.” While it would have been a little more comforting, I was not surprised that my sign did not exist. I was on my own.

Once outside the airport, I was soon in the back of a classy Mercedes cab and for $50 US, I was off to the hotel. As a boy, I remember diving in our local lake wearing goggles and fins pushing my lung capacity to hold my breath underwater. I thought I could hold out for approximately 1 minute … until this trip. I realized it was a 20 minute drive to get to the hotel.

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Off the Beaten Path - St. Petersburg, Russia

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It was the first time that street lines, speed limits, “no U-turns”, and traffic lights were apparently optional. Those who know me know that I have no trouble talking to anyone. However, at that moment the only topic of conversation the cab driver and I could muster was the Calgary Flames. My driver was a NHL fan and the Calgary Flames was his team, communicated by him pointing to a hockey figurine wearing a Calgary Flames jersey, hanging from the mirror along with a “thumbs up” gesture.

I discovered early the next morning that my adventure was just beginning. As mentioned earlier, communication was initially a challenge. Desperate to quench my thirst, I approached the first street vendor I saw. A failed attempt to communicate my desire while ensuring I paid a fair price (informed to be cautious) resulted in paying far too much for a bottle of spring water. I later realized that the vendor was simply trying to advise me that ice cream was a better choice for such a hot day. Never before was I so happy to see the large yellow M in the distance! At least I could point to the menu.

I later decided I’d better get my bearings and establish the location of the conference commencing the next morning. After some time searching, I approached a gentleman, who much to my surprise could communicate quite well … He was a navy guy from Britain … a lucky break! When I asked for directions however, I got an even bigger surprise. He informed me that for two weeks of each year he gets extremely drunk … and this was one of those times. Hence, as he suggested, he would be of little help. I did get directions a short time later from some helpful students who were very fluent in English.

Apart from the navigation challenges, St. Petersburg was great. The architecture was spectacular and the artwork, elegantly displayed, in the former residence of Catherine the Great was breathtaking. As I reflect, I am reminded of a particular piece of artwork. The artist created a circular picture measuring approximately 24 inches in diameter using colored grains of sand. In modern terms it would be equivalent to forming a piece of art, starting with individual pixels at a very high resolution. We were informed that an individual would devote approximately 15 years of their life to complete such a piece as a token of honor to Peter the Great.

Freeman on the Neva River

The architecture displayed on the streets was no less exhilarating. It was part of the development strategy of Peter the Great that no palace or structure would have the same features as another within the same vantage point.

On a tour bus our attention was drawn to the big building across the river which was named the “Big Building.” I learned that this was the former KGB headquarters. I must admit, upon walking past the structure sometime later on a personal excursion, it was chilling to reflect on possible stories that the walls could tell.

A trip that was originally a source of some apprehension is now remembered as being very rewarding. I thoroughly enjoyed the people I met, hospitality I shared and places I visited. I am glad I had the opportunity to correct my original naïve thoughts and I look forward to future opportunities to visit to this unique country, whether for business or pleasure.

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