



AIF - Risk Mitigation Strategies for Subsea Infrastructure

It is believed that over 25% of the world’s petroleum reserves are in arctic and other ice frequented regions. As world energy demand increases, development of oil and gas resources in these harsh ice environments is being increasingly considered. Current engineering strategies to protect offshore seabed infrastructure from the keels of ice ridges or icebergs are costly, adversely affecting the economics of smaller offshore developments. C-CORE has launched a multi-million dollar program to address these challenges and improve the economics of marginal offshore reserves.

C-CORE was successful in an application to Atlantic Canada Opportunities Agency (ACOA) to develop the “Risk Mitigation Strategies for Subsea Infrastructure” program under the Atlantic Innovation Fund (AIF). The work will see C-CORE expand on recent efforts to develop analysis and design capability to assess the risk of ice feature on facilities, and provide appropriate mitigation and protection strategies. The work will be performed in partnership with engineering companies, as well as academic and government researchers, to build on the region’s existing expertise in ice hazards management. A number of internationally recognized specialist consultants will help meet program objectives.

The program will develop engineering models required to provide a world-class capability for engineering services and design recommendations used to manage protection and risk strategies for subsea infrastructure in ice environments (see figure I).

The risk assessment will consider two groups: subsea components, such as wellheads, production trees and manifolds,

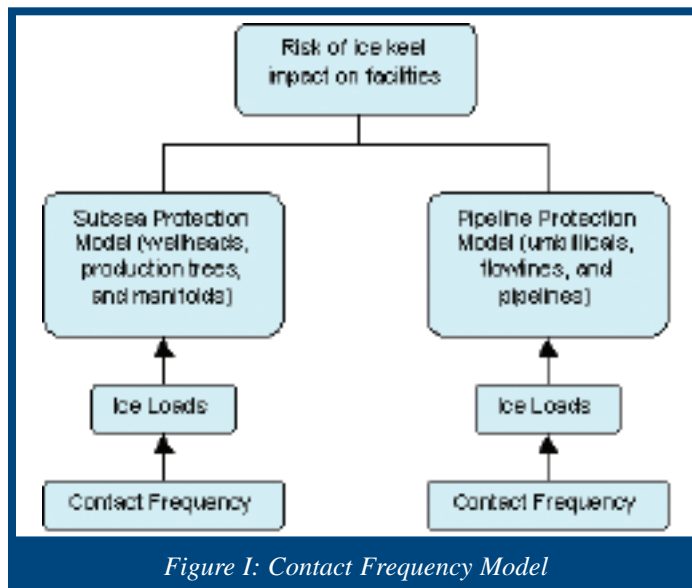


Figure I: Contact Frequency Model

and pipeline components, such as umbilicals, flowlines and pipelines.

Determining risk requires quantifying event frequency and consequence. To that end, the program will develop four engineering risk-based models:

- The Contact Frequency Model will determine the frequency at which iceberg or ice ridge keels make direct contact with the seabed or seabed structures.
- The Ice Load Model will calculate probabilistic design ice loads for interaction events between ice features and the seabed or subsea infrastructure.
- The Pipeline Protection Model will be used to determine the consequence of ice keel interaction with a pipeline, including the effect of sub-gouge deformation of the soil and resulting mechanical behaviour of the pipes - this will allow optimum pipeline burial depth requirements to be determined.
- The Subsea Protection Model will be used to develop concept design cases for the protection of wellhead structures to resist impact from an ice feature – this can be achieved either by reducing the risk or by providing physical protection systems.

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Event frequency, combined with event consequence will be used to calculate risk for each of the scenarios of interest. The approach will be to adopt accepted industry methodologies and associated computer programs to generate engineering models for use on a commercial basis. The best available field and experimental data will be processed and characterized as inputs into each associated model. Models will be calibrated with data from centrifuge and large-scale tests carried out as part of the program, with available field data also used as appropriate. The resulting engineering models will increase the level of understanding and confidence in undertaking design of sub-sea components in ice infested waters. In turn, this will allow oil and gas production systems to be optimized in terms of safety, environmental impact and cost.

Initial efforts will be directed at developing a generic framework detailing data requirements and processes for hazard assessment and mitigation. The models will be integrated as appropriate to examine specific fields requested by clients. The models will also

be used in the development of Engineering Practice Documents, providing guidance for design, construction and operational factors with respect to engineering surveys, subsea protection and risk mitigation strategies, and subsea intervention. C-CORE will develop these specialized services for both oil and gas operators, as well as engineering and construction organizations that design and supply the subsea installations for the offshore industry.

The project has a total value of \$8.5 million. Approximately 45% has been secured from ACOA, other government sources, and industry. The AIF contract provides up to \$3 million contingent on the leverage of industry support - the remaining financial requirements will be secured through joint participation agreements from oil and gas clients with interests in arctic and sub-arctic offshore production. It is anticipated that these contracts will be in place to allow the technical efforts to begin in earnest at the start of 2007. The total schedule for this work is 3 years, with deliverables produced in a phased approach to address industry's needs as development plans progress.

Honouring Dr. Jack Clark

On Wednesday October 11, 2006, C-CORE renamed its Centrifuge Building the Dr. Jack Clark Geotechnical Engineering Building. Dr Clark, O.C., FCAE, Ph.D., P.Eng., is C-CORE's first President & CEO and former Principal Consultant. He is internationally renown for his tremendous contributions to geotechnical engineering.

C-CORE's current President & CEO, Dr. Charles Randell hosted the ceremony which included more than 100 colleagues and friends from across the country who came to honour Dr. Clark. Dr. Randell stated that "It is with great admiration and respect that I, and everybody at C-CORE wanted to name the Centrifuge Building the Dr. Jack Clark Geotechnical Engineering Building. Jack, your dedication to C-CORE and tireless efforts to build the organization serve as a model for all of us."

Dr. Clark is a graduate of Acadia University, the University of Alberta and the Technical University of Nova Scotia. He began his career in 1957 as a geotechnical engineer working in the Arctic and faced challenging construction projects that began his love for cold regions and their problems. Jack moved to Calgary where he began his consulting engineering practice that included many civil engineering and pipeline projects. From 1972 to 1977, Jack was

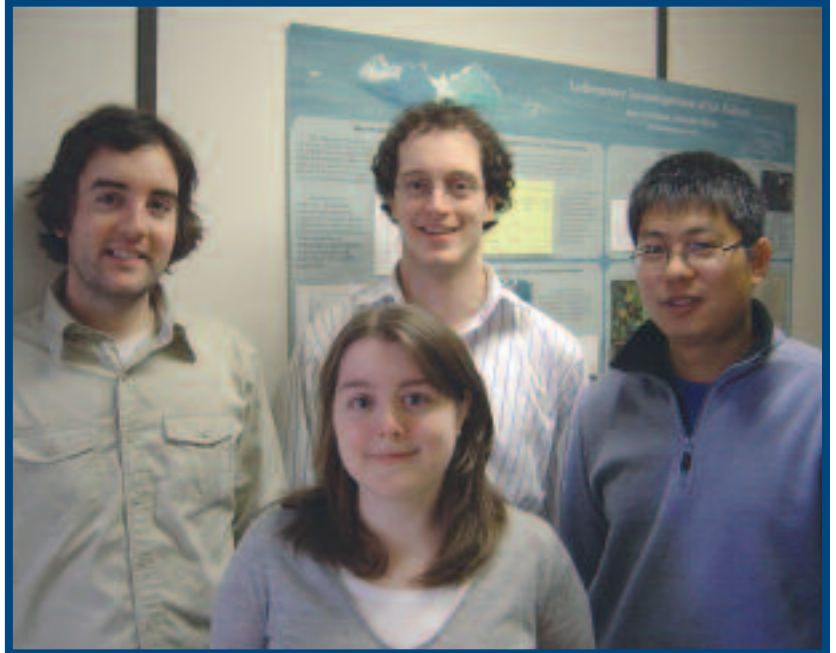
director of geotechnical and environmental studies for Northern Engineering Services, consultants to the Canadian Arctic Gas Study for a proposed pipeline from the Arctic to the US. He was involved in the Berger hearings in support of this development. Jack joined C-CORE in 1984 and grew it into a world class research corporation. Jack also continued his research in geotechnical engineering, especially in the solution of permafrost problems. He has consulted on many major engineering projects in Canada including Hibernia, the Vancouver Sky Train, the Confederation Bridge and the Ekati diamond project in the NWT.



Advanced Training in Ice Mechanics at C-CORE

C-CORE has long been known for its ice engineering expertise. Sustaining the position of world leader in the provision of ice engineering solutions requires recruitment of experts, continual training of young engineers, and a commitment to leading-edge research. C-CORE's Director of Ice Engineering, Freeman Ralph and Principal Consultant in Ice Engineering, Dr. Ian Jordaan have long realized the value that new generations of ice engineers bring to C-CORE and our clients. By supporting the training and mentoring of young engineers, and conducting rigorous in-house research, C-CORE ensures its engineering services are underpinned by the most current knowledge while directing R&D toward solving future client problems. During the fall of 2006 the team of young engineers and scientists (see picture) trained at C-CORE included: Richard Harvey, Jennifer Wells, Jonathon Bruce, Chuanke Li, Rocky Taylor.

These students are working on projects related to local and global ice loads, probabilistic aspects of ice loads, fracture mechanics of ice, scale effect in ice - reduction of global pressure with area, and ice environment in various parts of the world.



From L-R Richard Harvey, Jennifer Wells, Jonathon Bruce, and Chuanke Li (Missing from photo, Rocky Taylor)

C-CORE Wins Space Agency Contract to Investigate New Satellite for Pipeline Surveillance

The team of C-CORE and Calgary's VisiTrack Integrity Assessment (**via+**) recently kicked off a new contract to investigate the capabilities of the RADARSAT-2 satellite for pipeline monitoring. Of 22 proposals received by the Canadian Space Agency for this round of its Earth Applications Development Program, C-CORE was ranked highest. The project will also receive support from the Energy Infrastructure Protection Division of Natural Resources Canada and El Paso Energy (Houston, Texas).

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Pipeline emergencies can be avoided through new contract

C-CORE Wins Space Agency Contract to Investigate New Satellite for Pipeline Surveillance

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C-CORE will investigate the new polarization modes of RADARSAT-2 for detection of unauthorized vehicles along pipeline right-of-ways. These modes work in much the same manner as sunglasses that allow the separation and removal of different types of polarized light waves. In this case, the RADARSAT-2 polarimetric data separates the different polarizations of microwaves into two or four channels that allow operators to classify different types

of objects on the ground. There is particular interest in identifying different types of heavy excavation equipment from other non-threatening targets. Being capable of direct contact with buried pipelines, heavy excavation equipment is a particular threat.

The use of repeat coverage satellite monitoring for unauthorized third-party activities has been shown to potentially provide better overall mechanical damage prevention compared with conventional

practices such as field observations and air patrol. C-CORE and via+ have been working with the pipeline industry, advancing this capability to a commercial service.

ORICA & C-CORE: Aiding Automation Down Under

C-CORE continues to be active in the global community, providing world class engineering expertise to all corners of the globe. This expertise is currently being exploited by Orica Mining Services in Australia. The Automated Delivery System (ADS) development will bring to industry the first mobile charging unit with a new automated control system.

The extraction of ore from underground mining operations provides a challenging and inherently risky working environment. While the majority of modern mining operations sustain admirable safety records, efforts continue to improve performance and reduce risks to personnel. The ADS project is aimed to do both, and in a big way. Modern equipment and technology provide a vast improvement over the days of manual (i.e. pick and shovel) mining; however, modern miners are still intimately involved in the operation of equipment and remain exposed to the dangers present at the production face. The intent of the ADS project is to provide the operator with the tools and necessary interfaces to allow loading of explosive emulsion for a production round from the safety of the vehicle cabin. Enabling the operator to work from within the vehicle, rather than alongside, lowers exposure to dangers in the environment and from the equipment itself. The result is a much lower overall risk to the operator.

C-CORE has, for many years, been active in the underground mining industry and has been involved in numerous projects dealing with improvements to equipment and processes through its intelligent sensors expertise. In the past these projects were predominantly sponsored by mining companies as research technology demonstrations

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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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ORICA & C-CORE: Aiding Automation Down Under

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with reduced focus on continued development to bring the technologies into regular operational use. The ADS project changes this. ADS is a continuation of the original Automation of Charging (AOC) project started by Orica and the Emulsion Loader Automation Project (ELAP) consortium that ended in December 2002. The project is envisioned as a multistage effort with development stages designed to implement the technology based on customer requirements. The first stage will provide in-cab operation of the unit, while the second stage will provide automated operation of the unit.

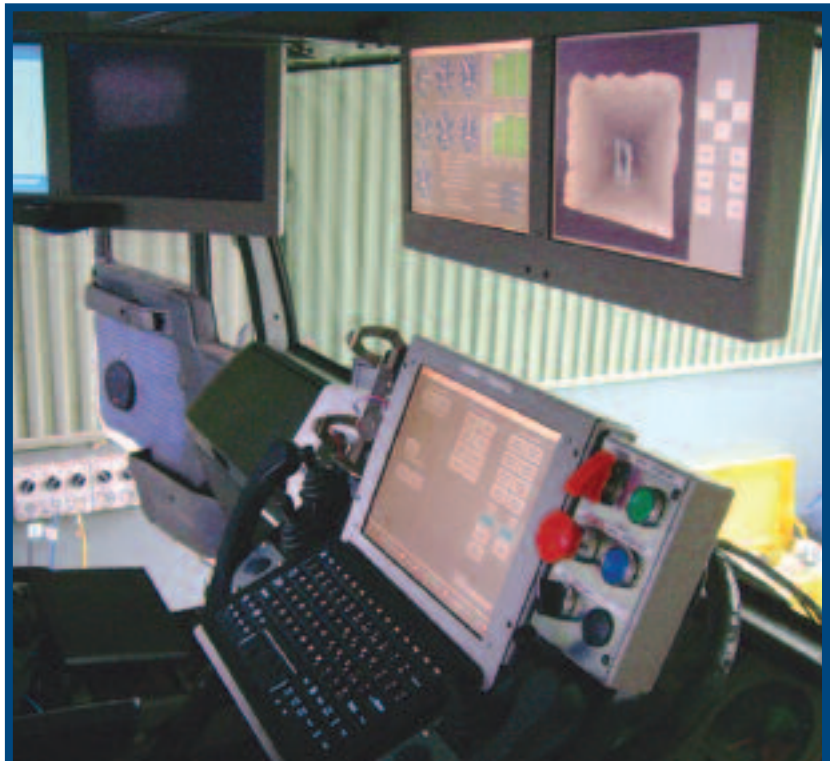
In addition to C-CORE, Orica engaged the expertise of Australia's CSIRO (Commonwealth Scientific and Industrial Research Organization). C-CORE is responsible for development of two key software components, the MCG (Main Control GUI) and the LPS (Loading Process Supervisor). The MCG functions as the primary operator interface to the machine and incorporates a multi-function human-machine interface and underlying subsystem status monitor. The LPS, in the current project, has a limited role in machine operation, but will serve as the backbone for full machine automation envisioned for the second stage of the project. CSIRO is primarily responsible for the robotic boom system.

On September 15, a technology demonstration was held at the development site of Orica's Automated Delivery System in Australia. The demonstration was made to over forty representatives from the mining industry and was deemed to be a "smashing success". It provided the audience with a high level overview of the machine capabilities and tied together elements of the robotic boom system, the initiating explosive assembly mechanism and the low level vehicle control. All these individual subsystems were commanded through C-CORE's MCG.

The remainder of the 2006 calendar year saw the completion of development activities in preparation for system integration activities which will occur early in 2007. The project is expected to be completed by the end of the first quarter of 2007.



Mobile Command Unit



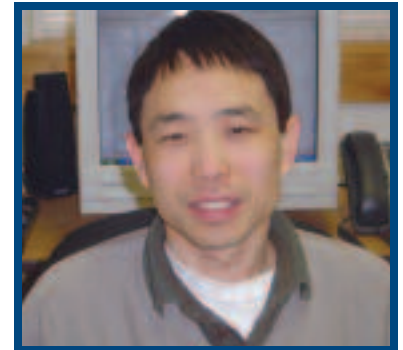
Operator interface for Mobile Command Unit

New Employees

Rocky Taylor is a Project Engineer with the Ice Engineering Department at C-CORE. He holds a M. Eng. degree in Ocean and Naval Architectural Engineering and a B. Eng. in Mechanical Engineering, both from Memorial University.



Jian Huang (Bachelor of Electrical Engineering, Graduate Diploma Computer Science) joins C-CORE's software team. Jian has 7 years work experience as a Software Developer.



Hesham Dief starts his position at C-CORE as a project engineer with the geotechnical team. He holds a Ph.D. in geotechnical engineering from the Department of Civil Engineering at Ohio's Case Western Reserve University.

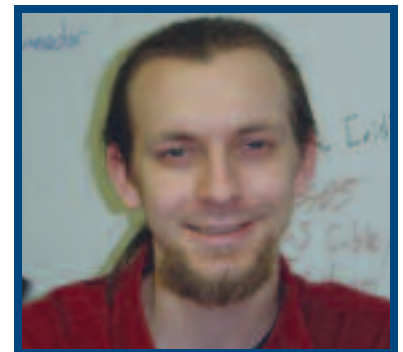


Tanya Ivany (B. Comm., MIR) joins C-Core as Director of Human Resources. She brings 10 years of human resource management experience to C-CORE.

Gary Piercey (B.Sc.) joins the Geospatial Systems and Intelligent Sensors group. He has software development experience in marine navigation, commercial fisheries and telecommunications.



David Green (M.Eng.) joins C-CORE's hardware team. He has significant experience in applied electromagnetics, power electronics, and digital hardware design.



Dr. D'Arcy Hart (Ph.D.) joins C-CORE's GeoSIS team, bringing with him 12 years of experience in project management and 14 years in the space industry.



Dr. Mark Fuglem joined C-CORE's Ice Engineering team in February 2007. Mark has 20 years of experience in risk analysis and ice engineering.

Trip to Siberia

For many of us, international travel has become so routine that we do it with no more excitement than we have for the regular morning commute; but every now and then there's a necessity to travel someplace new, intriguing and "off the beaten path". Such was the case last year (2006) when C-CORE's Polar View program required that I be in the Sakha Republic - Siberia - in March.

As reported in previous issues of C-CORE News, Polar View is an international consortium led by C-CORE to provide satellite

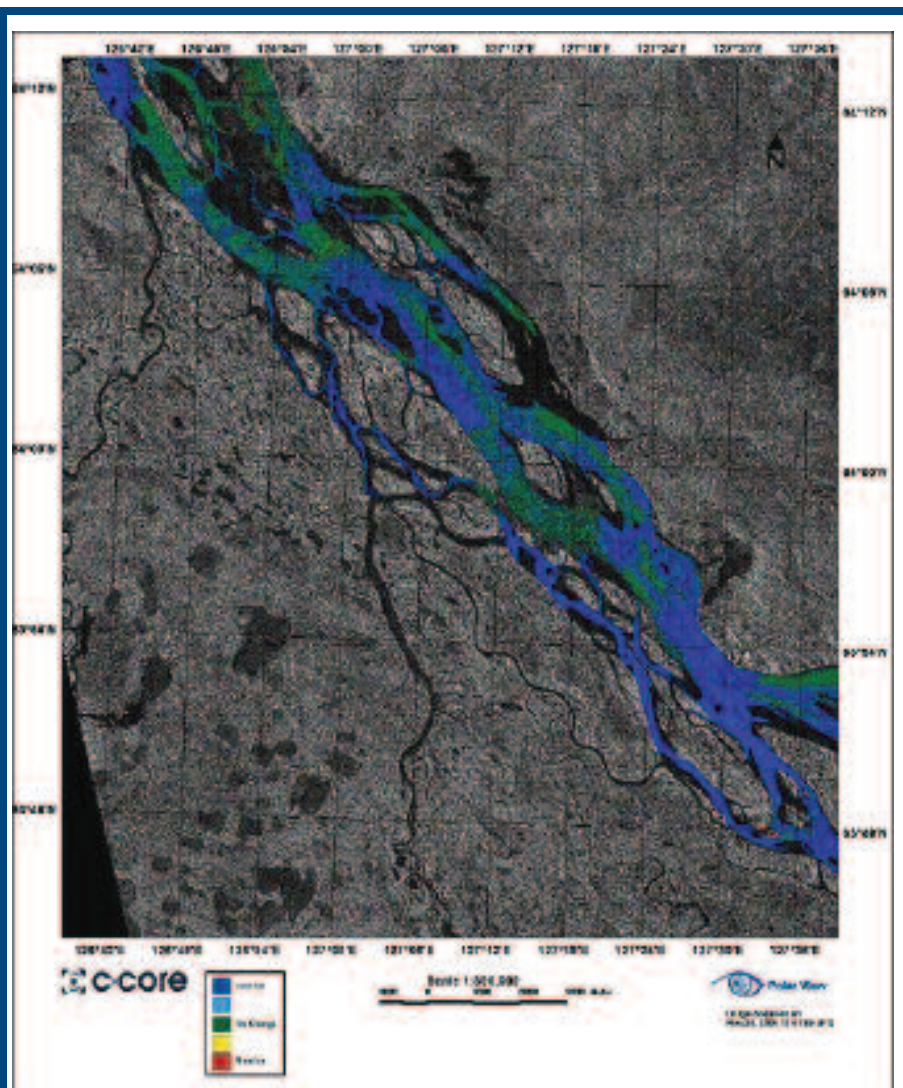
(earth observation) monitoring and forecasting services for high latitude regions (see www.polarview.org). The team includes service companies, system developers, government agencies, research institutes, and end-users from Canada, Denmark, France, Finland, Germany, Iceland, Italy, Norway, Russian, Sweden, United Kingdom, and the United States. Each organization brings diverse and complementary skills in earth observation technology and applications.

One of the Polar View services, river ice monitoring, has been employed in various regions of Canada and the United States. We were urged by The Northern Forum to consider expansion into Siberia. The Northern Forum is an internationally sanctioned organization whose mission is to support sustainable development and the implementation of cooperative socio-economic initiatives among Northern regions; and to improve the quality of life of Northern peoples by providing a means to share their knowledge and experience. The river ice monitoring service provides regular updates on river ice conditions and advanced warning of ice break-up. Pictured is a typical product in this case depicting structural changes in the ice cover along a section of the Lena River between May 20 and May 24, 2006. In delivering operational river ice monitoring services, C-CORE works with clients to deliver custom-tailored solutions.

Sakha is rich in raw materials producing 100% of Russia's antimony, 99% of its diamonds (accounting for over 23% of the world's diamond production), 24% of its gold, and 33% of its silver. There are also more than 30 known oil and gas fields in the republic. Culturally, it is also stunningly rich.

The Sakha Republic experienced catastrophic spring floods in 1998 and 2001. C-CORE's river ice service aids in forecasting and either preventing the recurrence of such events or providing advance warning for evacuation. The previous floods have been fatal. A

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Ice cover change on the Lena River derived from satellite radar imagery

Trip to Siberia

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workshop in the Sakha capital, Yakutsk to address this was hosted by the Ministry of Environmental Protection, the Ministry of Emergencies and the Ministry of Foreign Relations of the Sakha Republic. Yakutsk is built on the Lena River which runs from the Baikal Mountains, northeast for 4400 km to the Arctic Ocean. The Lena was C-CORE's first Siberian target for monitoring.

Getting to Yukutsk was half the adventure. After 30+ hours of travel, I arrived at Sheremetyevo airport in Moscow and was getting close – just an hour drive to Vnukovo airport and another six hour flight!

Yakutsk is reportedly one of the coldest cities on earth with mid-winter temperatures averaging -45C. Perfect for a field trip. After two days of meeting, deliberating, eating, and toasting (in the Russian tradition), I was looking foreword to physical activity. The Ministry of Emergencies organized a field trip to demonstrate preventive measures used on the Lena River to avoid flooding. No physical exertion required. A helicopter brought us from an air base to the river, and specially equipped vehicles took us out on the ice. We were shown several approaches to ice management. A water bomber-type aircraft dropped coal dust over long reaches to help soften the ice, and coal was trucked out and dumped on the frozen river. The ice was also cut using a long blade, about 20 cm wide, deployed from a tractor. It was not cut through, but weakened by cutting diamond patterns around areas prone to ice jams. We also witnessed training and rescue exercises by emergency rescue teams who rappelled from a helicopter. Finally, we were retreated to the comfort of the cold weather rescue tents and (Canadian) all-weather stoves for further eating (and toasting).

Later, we were hosted at the training center to watch the rescuers practice rappelling and climbing techniques. When the



A shot taken during Charles Randell's trip to Yakutsk, 2006.

commanding General asked if any of the guests would like to try it, I couldn't resist. I had no second thoughts until I entered the helicopter at the top of the training tower and discovered my instruction would be in Russian. After animated crouching, hand gestures, jumping and simulated crashing, I was ready to depart the "aircraft". I probably didn't get points for style, but the descent to the ground was controlled and the landing uneventful.

The next day we went back to working out the details of the monitoring program and getting the paperwork in place. Before leaving Yukust, as a sign of appreciation for the service C-CORE was providing I was presented with general's epaulets by a General from the Ministry of Emergencies.

C-CORE provided the ice monitoring service during the next ice. We were informed by Northern Forum representatives that it worked exceptionally well and provided the desired advanced warnings.

Dr. Charles Randell is C-CORE's President and Chief Executive Officer

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